DEPARTMENT OF THE ARMY TECHNICAL MANUAL

TM 11-5511A

ELECTRONIC MULTIMETER TS-505A/U

DEPARTMENT OF THE ARMY

1955

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. Electronic Multimeter TS–505A/U 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.

c. Common Names. Throughout this manual, the word *multimeter* refers to the major component (par. 6) of Electronic Multimeter TS–505A/U. The *rf adapter* refers to Test Prod MX–1797/U.

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 $\mu\mu$f 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 percent of full scale on dc voltage; ±6 percent of full scale for ac sinusoidal input from 30 cps to 5 mc on ac range; ±6 percent of full scale for rf sinusoidal input from 1 mc to 200 mc using rf adapter (error may exceed ±6% of full scale for rf sinusoidal input from 200 mc to 500 mc using rf adapter); ±4 percent 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. For a sine wave, the meter indication is the rms value of the sine wave; but for 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 export or domestic shipment (fig. 4).

a. Export Shipment. For export shipment, the TS–505A/U is placed in a corrugated sleeve. The corrugated sleeve is protected by two corrugated trays and is placed, together with the spare parts carton and two manuals, in a corrugated carton. The corrugated carton is then sealed with gummed tape. The multimeter thus packaged, comprises a unit package. Six unit packages then are placed in a wooden packing case. The wooden packing case is nailed closed and secured with metal straps.

b. Domestic Shipment. For domestic shipment, four unit packages are placed in a corrugated shipping carton. The corrugated shipping carton is then sealed with gummed tape. The dimensions and weights of the packages are listed in the table below.

Electronic Multimeter 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	$\frac{7}{16}$	$\frac{5}{16}$		
Miniature probe tip (.040 in. dia. tip).	3	⅞	¼			
Rf adapter (Test Prod MX–1797/U).	1	3⅝	⅝			
Spare parts (par. 8)	1 set					

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

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. All con-

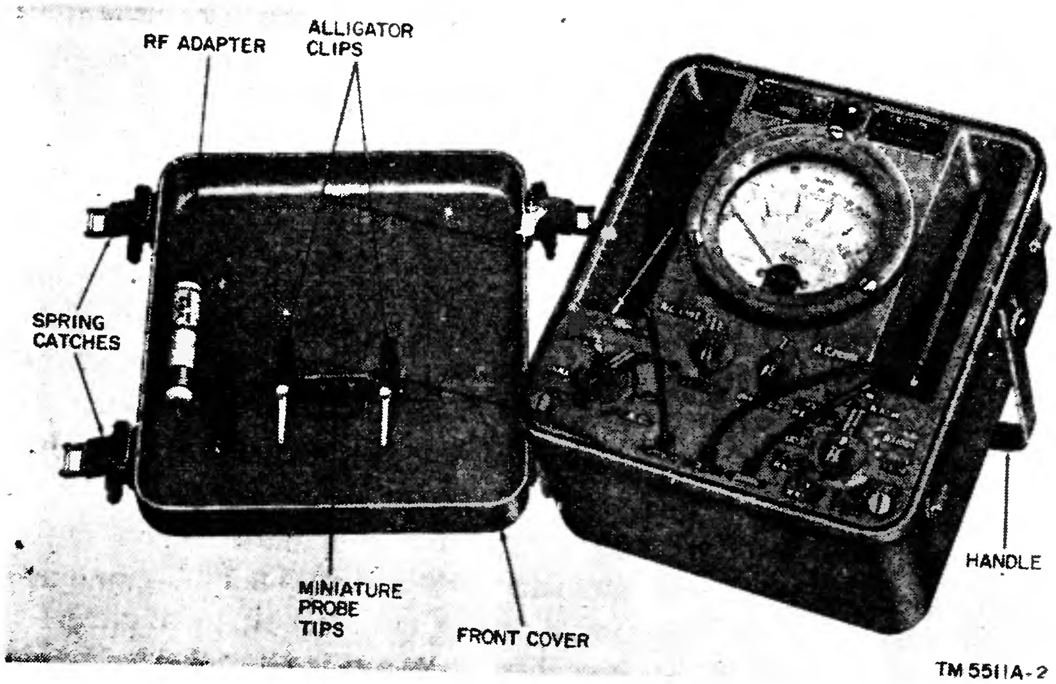


Figure 2. Electronic Multimeter TS–505A/U, cover removed.

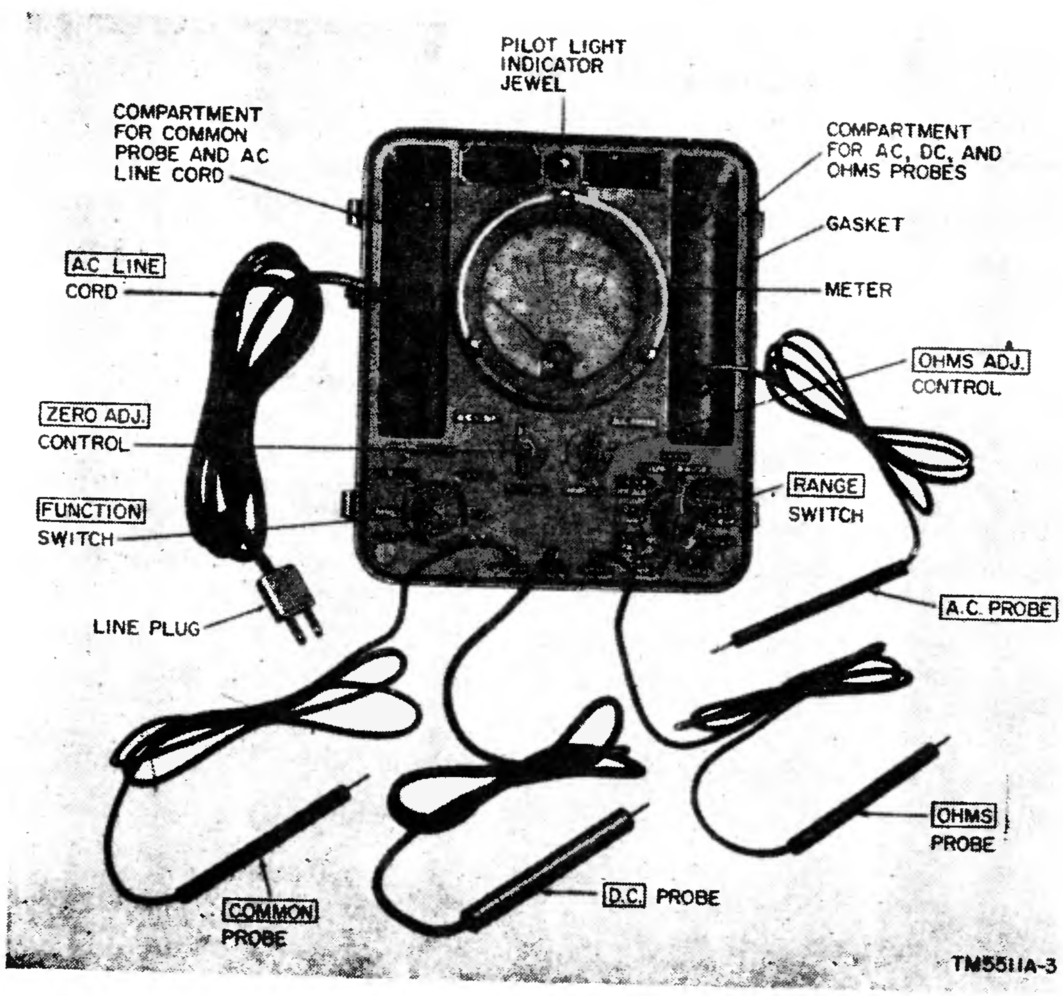


Figure 3. Multimeter, less cover, front view.

trols, the meter, and the pilot light indicator jewel are mounted on the front panel. The four test leads and the AC 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 miniature circuits or congested chassis.

(3) *Rf adapter.* The rf adapter 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 chart 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

CHAPTER 3
OPERATION

Section I. CONTROLS AND INSTRUMENTS

12. General

Haphazard operation or improper setting of the controls can cause damage to electronic equipment. It is important, therefore, to know the function of the meter and the controls on the multimeter. Operating instructions are contained in paragraphs 14 through 23.

13. Controls and Their Uses
(fig. 5)

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

Control or instrument	Function
FUNCTION switch	Selects the type of multimeter operation desired and turns the multimeter on or off.
RANGE switch	Selects various voltage or resistance measurement ranges.
ZERO ADJ. control	Controls pointer of indicating meter. Used to set the meter pointer at zero on the +dc, —dc, ac, or OHMS scale, or to midscale on the ±dc scale.
OHMS ADJ. control	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	Indicates the value of voltage or resistance measured.
AC LINE cord	Connects multimeter to ac power source.
COMMON probe	Connects the ground, or common circuit of the multimeter, to the equipment under test.
Dc 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.
AC PROBE	Connects equipment under test to the ac measuring circuits of the multimeter.
Pilot light indicator	Lights when power is applied to the multimeter.

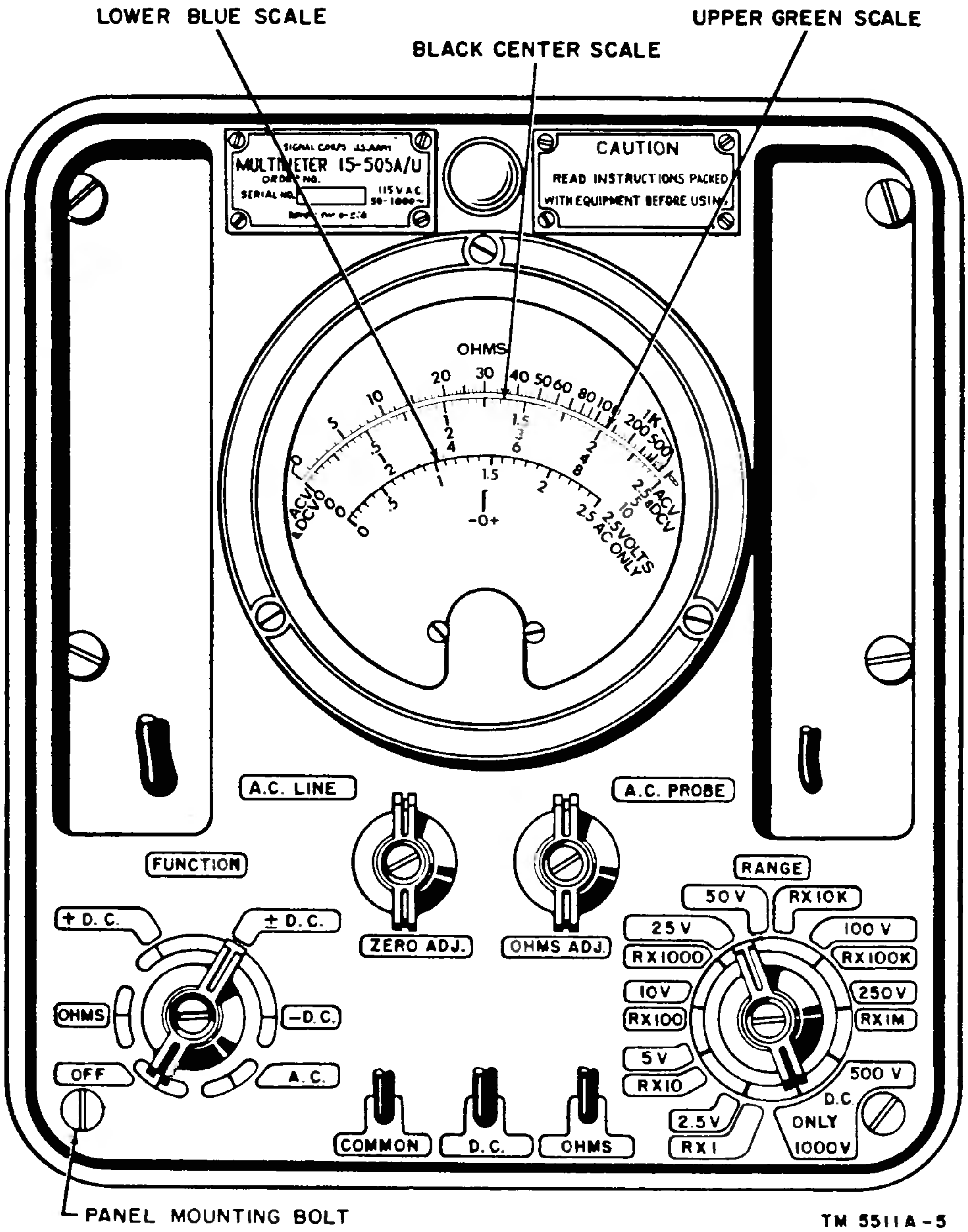


Figure 5. Multimeter, front panel.

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 AC 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 AC 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.

15. Reading and Measuring +Dc and —Dc Voltages

a. Reading Dc Voltages. Read positive or negative dc voltages on the black center scale of the meter (fig. 5). For maximum accuracy in dc voltage measurements, use a setting of the RANGE switch that will produce a deflection as close to full scale as possible.

b. Zeroing Meter for + Dc and — Dc Measurements.

(1) Perform the starting operations outlined in paragraph 14.

(2) Turn the FUNCTION switch to the + dc position for making plus dc or rf measurements. The details of rf measurement are treated in paragraph 18. Turn the FUNCTION switch to the — dc position for making — dc measurements. After the multimeter has warmed up, the meter pointer will probably be near, but not at, 0 scale reading.

(3) Turn the RANGE switch (fig. 5) to the 2.5 V–RX1 position.

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

c. Measuring Dc Voltages.

(1) Turn the RANGE switch to a voltage scale higher than the voltage to be measured. If the magnitude of the voltage to be measured is unknown, turn the RANGE switch to the 1,000 V-dc ONLY position. If necessary, the RANGE switch can be rotated to a lower scale. This procedure will protect the multimeter from a severe overload, which might damage the meter movement when measuring dc voltage.

(2) Connect the COMMON probe tip to the nearest ground-potential point of the voltage to be measured. Connect the dc 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.

(3) If the meter pointer deflects below 0 turn the FUNCTION switch to the — dc position if it was previously in the + dc position, or to the + dc position if it was previously in the — dc position.

(4) 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 dc voltage scale. This is the most accurate portion of the dc voltage scale.

(5) Read the meter.

16. Reading and Checking on the ±Dc Scale

a. Reading ± Dc Voltages. When the FUNCTION switch is turned to the ± dc 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 ± dc position.* The purpose of the ± dc 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.

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

b. Zeroing Meter for ± Dc Range.

(1) Perform the starting operations outlined in paragraph 14.

(2) Turn the FUNCTION switch to the ± dc position for making + dc or — dc measurements. The meter pointer should be within plus or minus one scale division of midscale.

(3) Turn RANGE switch (fig. 5) to the 2.5 V–RX1 position.

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

c. Checking Voltages on the ± Dc Zero Center Scale.

(1) Turn the RANGE switch to a voltage scale higher than the voltage to be checked. If the magnitude of the voltage to be checked is unknown, turn the RANGE switch to the 1,000 V–DC ONLY position. If necessary, the RANGE switch can be rotated to a lower scale. This procedure will protect the multimeter from a severe overload which might damage the meter movement.

(2) Connect the COMMON probe tip to the nearest ground potential point of the voltage to be measured. Connect the dc 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.

(3) If the meter pointer moves to the left, the input voltage is negative. If the meter pointer moves to the right, the input voltage is positive. If the meter pointer does not move, the input voltage is 0 volt.

17. Reading and Measuring 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 18.

a. 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 2.5 V–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 ac voltage scale.

Note. The meter scales are calibrated to indicate .707 of the peak voltage of an ac sine wave or a complex wave. For 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. For further information on the measurement of complex waves, refer to paragraph 19.

b. Zeroing Meter for Ac Measurements.

(1) Perform the starting operations outlined in paragraph 14.

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

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

c. Measuring Ac Voltages.

(1) Turn the RANGE switch to a higher voltage scale than the voltage to be measured. If the magnitude of the voltage to be measured is unknown, turn the RANGE switch to the 250 V–RX1M position. If necessary, the RANGE switch can be rotated to a lower scale. This procedure will protect the multimeter from a severe overload which might damage the meter movement when measuring ac voltage.

Caution: The maximum ac voltage which can be measured by the multimeter is 250 volts rms. RANGE switch panel markings 500 V-DC ONLY and 100 V-DC ONLY apply to dc voltage measurements only.

(2) Connect the COMMON probe tip to the low potential point of the voltage to be measured. Connect the AC 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.

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

(4) Read the meter.

18. Reading and Measuring Rf Voltages

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

a. 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 dc voltage scale.

Note. The meter scales are calibrated to indicate .707 of the peak voltage of an ac sine wave or a complex wave. For a sine wave, the meter indication is the rms value of the sine wave. For a complex wave, the meter indication is not the rms value of the complex wave. For further information on measurement of complex waves refer to paragraph 19.

b. Zeroing Meter for Rf Measurements.

(1) Perform the starting operations outlined in paragraph 14.

(2) Turn the FUNCTION switch to the + dc position for making rf 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 2.5 V–RX1 position.

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

c. Measuring Rf Voltages.

(1) Turn the RANGE switch to a higher voltage scale than the voltage to be measured. If the magnitude of the voltage to be measured is unknown, turn the RANGE switch to the 50 V–RX1OK position. If necessary, the RANGE switch can be rotated to a lower scale. This procedure will protect the multimeter from a severe overload which might damage the meter movement when measuring rf voltages.

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

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

(3) 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.

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

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

(6) Read the meter.

19. Turnover Effect

Complex ac or rf voltage wave forms may have *positive* peak values which are different from the *negative* peak value. If this condition occurs, the multimeter will indicate a certain reading when the rf adapter or AC PROBE and COMMON probes of the multimeter are applied to the circuit under test. A different reading will be obtained if the rf adapter or AC PROBE and COMMON probes of the multimeter are transposed. This condition is referred to as *turnover effect*. If this condition is suspected, use the following procedures:

a. Make an ac or an rf measurement as described in paragraphs 17 and 18 respectively. Observe and note the reading of the multimeter.

b. Transpose the connections of the multimeter to the circuit under test. Observe and note the reading of the multimeter.

c. Disconnect the multimeter from the circuit under test.

d. The readings obtained in *a* and *b* above may be used to calculate the mean voltage or the actual peak-to-peak voltage of the complex wave. Proceed as follows:

(1) To obtain the mean voltage, add the two readings (*a* and *b* above) and divide the sum by 2. The quotient is the mean voltage value.

(2) To obtain the peak-to-peak voltage, multiply each reading (*a* and *b* above) by 1.414, and add the products. The sum is the peak-to-peak voltage value.

20. Reading and Measuring Dc Resistance

a. *Reading Dc Resistances*. Read resistance on the upper 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 OHMS scale. The resistance reading is determined by multiplying the meter reading by the resistance multiplier value indicated opposite the RANGE switch setting. For example, if the meter reading is 30 and the RANGE switch is at the 50 V–RX10K position, the resistance measured is 30 times 10,000, or 300,000 ohms.

b. *Zeroing Meter for Resistance Measurements*.

(1) Perform the starting operations outlined in paragraph 14.

(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 2.5 V–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.

c. Measuring Dc Resistance.

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

(1) Connect the COMMON probe to the end (nearest to the ground point) of the unknown resistor, and connect the OHMS probe to the other end of the resistor. For example, when 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.

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

(3) Read the meter.

21. Stopping Procedure

a. Turn the RANGE switch (fig. 5) to the 1,000 V-DC ONLY position.

b. Turn the FUNCTION switch to the OFF position.

c. Remove the AC 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 AC PROBE, the OHMS, and dc probes and leads in the right-hand recessed compartment; stow the AC 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

22. 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

23 describes the general precautions to be observed under any unusual climatic conditions.

23. 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. Cold air cools the amplifier tubes or 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 inspecton 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 cause 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.

31. Rustproofing and Painting

a. Scarred Surfaces. When the finish on the case or meter panel has been scarred or damaged, prevent corrosion by touching up bared surfaces. Before touching up damaged surfaces, use No. 000 sandpaper to clean the damaged portions down to the bare metal. Obtain a bright, smooth finish and apply paint with a small brush.

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

b. Corroded Surfaces. If portions of the multimeter case or panel are corroded, remove rust by cleaning the corroded metal with cleaning compound. In severe cases, it may be necessary to complete the preparations for painting with sandpaper. Clean the surfaces down to the bare metal and apply paint with a small brush. Paint used will be authorized and consistent with existing regulations.

Section IV. TROUBLESHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

32. General

a. The troubleshooting 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 33 through 35 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.

33. Test Equipment Required for Organizational Maintenance

Electron Tube Test Set TV–7/U and Multimeter TS–297/U are required for testing the multimeter. If these equipments are not available, other types of equipment having equal accuracy and corresponding characteristics may be used.

34. Organizational Troubleshooting Procedures

a. General. The first step in troubleshooting is to sectionalize the fault to the circuit responsible for the abnormal operation of the multimeter. The second step is to localize the fault by tracing it to the part responsible for the abnormal condition.

b. Sectionalization of Trouble. The troubleshooting procedure at the organizational maintenance level will determine in which circuit the trouble exists. This can be done by checking voltages and resistances in each stage.

c. Localization of Trouble. After the trouble has been isolated to a single circuit (*a* above), trace the fault to the defective part. This may be possible at the organizational maintenance level if the trouble exists in a pluck-out part or if the trouble sectionalization procedures have located the defective part. If it is not possible to localize the trouble to the defective part and to make a repair, field maintenance is necessary.

35. 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 AC LINE cord or no voltage at the outlet into which the AC LINE cord is plugged.

(2) Burned-out fuses.

(3) Wires broken because of excessive vibration.

(4) Defective tubes (open filaments par. 37).

(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 (*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.

36. Removal of Plug-Out Parts

a. Tubes. Tubes are mounted on the chassis (fig. 18) and are easily accessible by removing the rear cover of the multimeter. To remove a tube, remove the chassis from the case (par. 29*b*(1)) and proceed as follows:

(1) Remove the tube shield by pressing down on the shield and rotating counterclockwise until it is released.

(2) Use a tube puller to remove the tube. If a tube puller is not available, allow the tube to cool, grasp it, and pull the tube straight up.

(3) If the tube marking has become illegible, label the tube as soon as it is removed.

b. Removal of Lamps. The indicator lamp is located at the rear and top of the chassis assembly. To remove the lamp, disassemble the back cover of the multimeter (par. 29*b*(1)) and proceed as follows:

(1) Press the lamp (which has a bayonet base) inward.
(2) Rotate the lamp counterclockwise.
(3) Withdraw the lamp from its socket.

c. Removal of Fuses. Line fuses F1 and F2 (fig. 18) and spare fuses F3 and F4 (fig. 17) are cartridge-type fuses. All fuses are located on the chassis and are accessible after removal of the chassis from the case (par. 29*b*(1)). The fuses are mounted on spring clips. To remove a fuse, use enough force to overcome the spring tension.

Caution: All the fuses are rated at 1 ampere each. When replacing a fuse, be careful to use a fuse of the same rating.

37. Election Tube Replacement Techniques

a. Many tubes are discarded before their effective life expires. The effective life of tubes can be prolonged by observing the following precautions:

(1) Inspect all wiring and general condition of the multimeter before removing tubes.

(2) Isolate the trouble, if possible, to a particular section of the multimeter circuit.

(3) If a tube tester is available, remove and test one tube at a time. Substitute new tubes only for those that are defective.

(4) If a tube tester is not available, troubleshoot by following the tube substitution method.

(*a*) Replace the suspected tubes, one at a time, with new tubes. Note the sockets from which the original tubes were removed. If the equipment becomes operative, discard the last tube removed.

Note. Some circuits, the amplifier circuit for example, may function with one tube and not another, even though both are new. If practicable, retain any removed tube until its condition is checked by a suitable test instrument.

(*b*) Reinsert the remaining original tubes, one at a time, in the original sockets. If equipment failure occurs during this step, discard the last original tube. *Do not leave a new tube in a socket if the equipment operates with the original tube.*

(5) If there is an insufficient number of spare tubes to follow the procedures outlined in (4) above, substitute a new tube for the original tube. If the multimeter continues to be inoperative, replace the new tube with the original tube. Similarly, check each original tube, in turn, until the defective one is located.

Note. If a replacement for a bad tube soon becomes defective, check the adjustment and condition of component parts of the tube circuit. Otherwise, continued tube replacement will effect only temporary repair and more serious troubles may result.

b. If tube substitution does not correct the trouble, *reinsert the original tubes in the original sockets* before forwarding the defective equipment for higher echelon repair.

c. Discard tubes when tube testers show that the tubes are defective. Tubes may be discarded when the tube defect is obvious; for example, a broken envelope or a broken filament.

(1) Do not discard tubes merely because they have been used for a specified length of time. Satisfactory operation in a circuit is the final proof of tube quality. The tube in use may work better than a new one. It has behind it a history of satisfactory performance whereas the new tube has no reputation as an individual entity.

(2) Do not discard tubes merely because they fall on or slightly above the minimum acceptability value when checked in a tube tester. It must be recognized that a certain percentage of new tubes fall near the low end of their acceptability range of the tube specification and therefore start their operational life at a value fairly close to the tube tester retention limit. These tubes may provide satisfactory performance throughout a long period of operational life at this *near limit* value.

d. Be careful when withdrawing a miniature tube from its socket. Do not rock or rotate the top of a miniature tube when removing it. Pull the tube straight out. The external pin and the wire lead sealed in the glass base are two different metals that are butt-welded together where the pin appears to enter the glass. Rocking or rotating the tube causes bending, which may break this weld or cause a resistance or intermittent joint to develop.

38. Interchangeable Tubes

The older type tube listed in the first column of the following chart can be used interchangeably with the corresponding preferred type tube listed in the third column. The second column lists the stage or stages in which the tubes can be used interchangeably in Electronic Multimeter TS–505A/U. The older type tube should be used until the stocks are exhausted.

Older type tube	Application	Preferred tube
6AL5	Ac signal rectifier and balancing diode	5726/6AL5W
6X4	Rectifier	6X4W

39. Troubleshooting Using Equipment Performance Checklist

a. General. The equipment performance checklist (par. 40) 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 which 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, troubleshooting 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.

Caution: Be careful when inspecting, checking, testing, or replacing tubes. They are fragile and easily damaged. Refer to paragraphs 36 and 37.

40. Equipment Performance Checklist

a. Volts Scales, +Dc.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	FUNCTION switch	Turn to OFF position	Meter pointer should be within ½ scale division of zero.	Turn in equipment for repair.
	2	AC LINE cord	Connect to 98- to 132-volt, single-phase, 50- to 1,000-cps ac power source.		
START	3	FUNCTION switch	Turn to +dc position	Pilot lamp lights	Check AC LINE cord and plug. Check ac power source. Check fuses F1 and F2. Replace pilot lamp. Turn in equipment for repair.
			Allow equipment to warm up (min of 3 min.).	Meter pointer deflects rapidly and gradually settles at or near 0.	Check tubes V1, V2, V3, V4, and V5. Check meter M1. Turn in equipment for repair.
	4	RANGE switch	Turn to 2.5 V–RX1 position		
	5	DC and COMMON probes	Short tips together	Meter points deflects to within ½ of 1 scale division of zero.	
	6	ZERO ADJ. control	Rotate until meter indicates zero (par. 15*b*(4)).		Turn in equipment for repair.

EQUIPMENT PERFORMANCE	7	DC probe and COMMON probe.	Apply 2.5 volts dc between DC and COMMON probes.	Meter indicates 2.5 volts	Turn in equipment for repair.
STOP	8	FUNCTION switch	Turn to OFF position	Pilot light goes out. Meter pointer is within ½ scale division of zero.	
	9	RANGE switch	Turn to 1,000 V-DC ONLY position.		
	10	AC LINE cord	Disconnect from ac power source.		

b. Volts Scales, —Dc.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Perform steps 1 and 2 of *a* above.			
START	2	FUNCTION switch	Turn to —dc position Allow equipment to warm up (min of 3 min.).	Pilot lamp lights Meter pointer deflects rapidly and gradually settles at or near 0.	Check AC LINE cord and plug. Check ac power source. Check fuses F1, and F2. Replace pilot lamp. Turn in equipment for repairs.
	3	RANGE switch	Turn to 2.5 V–RX1 position.		

	Item No.	Item	Action or condition	Normal indications	Corrective measures
START	4	DC and COMMON probes	Short tips together	Meter pointer reads within ½ of 1 scale division of zero.	
	5	ZERO ADJ. control	Rotate until meter indicates 0 (par. 15*b*(4)).		Turn in equipment for repair.
EQUIPMENT PERFORMANCE	6	DC and COMMON probes	Apply —2.5 volts dc between DC and COMMON probes.	Meter indicates —2.5 dc volts.	Turn in equipment for repair.
STOP	7	Perform steps 8, 9, and 10 of *a* above.			

c. Zero Center Scale, ±Dc.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Perform steps 1 and 2 of *a* above.			
START	2	FUNCTION switch	Turn to ±DC position	Pilot lamp lights	Check AC LINE cord and plug. Check ac power source. Check fuses F1 and F2. Replace pilot lamp. Turn in equipment for repair.

START			Allow equipment to warm up (min of 3 min.).	Meter pointer deflects to midscale within ±1 scale division on dc scale.	Check tubes V1, V2, V3, V4, and V5. Check meter M1. Turn in equipment for repair.
	3	RANGE switch	Turn to 2.5 V–RX1 position.		
	4	DC and COMMON probes	Short tips together.		
	5	ZERO ADJ. control	Rotate until meter pointer is at midscale position (par. 16*b*(4)).	----------	Turn in equipment for repair.
EQUIPMENT PERFORMANCE	6	DC and COMMON probes	Apply +1.25 volts dc between DC and COMMON probes.	Meter deflects full scale to right.	Turn in equipment for repair.
			Apply —1.25 volts dc between DC and COMMON probes.	Meter deflects full scale to left.	Turn in equipment for repair.
STOP	7	Perform steps 8, 9, and 10 of *a* above.			

d. Volts Scales, AC.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Perform steps 1 and 2 of *a* above.			

	Item No.	Item	Action or condition	Normal indications	Corrective measures
START	2	FUNCTION switch	Turn to A.C. position	Pilot lamp lights	Check AC LINE cord and plug. Check ac power source. Check fuses F1 and F2. Replace pilot lamp. Turn in equipment for repair.
			Allow equipment to warm up (min of 3 min.).	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 repair.
	3	RANGE switch	Turn to 5 V–RX10 position.		
	4	AC PROBE and COMMON probe.	Short tips together.		
	5	ZERO ADJ. control	Rotate until meter indicates zero (par. 17*b*(3)).		Turn in equipment for repair.
EQUIPMENT PERFORMANCE	6	AC PROBE and COMMON probe.	Apply 5 volts dc between COMMON probe and AC PROBE.	Meter indicates ac voltage	Turn in equipment for repair.
STOP	7	Perform steps 8, 9, and 10 of *a* above.			

e. Rf Voltage Scales.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Perform steps 1 and 2 of *a* above.			
START	2	FUNCTION switch	Turn to +DC position	Pilot lamp lights	Check AC LINE cord and plug. Check ac power source. Check fuses F1 and F2. Replace pilot lamp. Turn in equipment for repair.
			Allow equipment to warm up (min of 3 min.).	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 repair.
	3	RANGE switch	Turn to 2.5 V–RX1 position		
	4	DC (with rf test prod) and COMMON probes.	Short tips together.		
	5	ZERO ADJ. control	Rotate until meter indicates zero (par. 18*b*(4)).		Turn in equipment for repair.
EQUIPMENT PERFORMANCE	6	COMMON probe and DC probe with rf test prod.	Apply rf voltage between COMMON probe and DC probe with rf test prod.	Meter indicates rf voltage	Turn in equipment for repair.
STOP	7	Perform steps 8, 9, and 10 of *a* above.			

f. Resistance Scales. Perform the following procedure for each resistance scale. A different resistor must be used for each scale. In each case, use a resistor with a tolerance of ±1 percent. Use the following resistor values for the indicated scale: 2.5 V–RX1, 300 ohms; 5 V–RX10, 3,000 ohms; 10 V–RX100, 30,000 ohms; 25 V–RX1000, 300,000 ohms; 50 V–RX10K, 3 megohms; 100 V–RX100K, 30 megohms; 250 V–RX1M, 300 megohms.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Perform steps 1 and 2 of *a* above.			
START	2	FUNCTION switch	Turn to OHMS position	Pilot lamp lights. Meter pointer deflects to, or near, full scale reading (∞).	Check AC LINE cord and plug. Check ac power source. Check fuses F1 and F2. Replace pilot lamp.
			Allow equipment to warm up (min of 3 min.).	Meter pointer deflects rapidly and gradually settles at or near full scale reading.	Check tubes V1, V2, V3, V4, and V5. Check meter M1.
	3	RANGE switch	Rotate to desired resistance range.	Meter pointer reads at, or near, full scale reading at each RANGE switch position.	Turn in equipment for repair.
	4	OHMS and COMMON probes.	Short tips together	Meter pointer deflects rapidly and gradually settles near or at zero.	
	5	ZERO ADJ. control	Turn until meter pointer rests at zero (par. 20*b*(5)).	----------	Turn in equipment for repair.
	6	OHMS and COMMON probes.	Separate tips	Meter pointer deflects to or near full scale reading (∞).	
	7	OHMS ADJ. control	Rotate until meter pointer is at full scale reading. (par. 20).	Meter pointer at ∞.	Turn in equipment for repair.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
EQUIPMENT PERFORMANCE	8	OHMS and COMMON probes.	Connect to desired resistor---	Meter reads within ±5% of known value of resistor.	Turn in equipment for repair.
STOP	9	Perform steps 8, 9, and 10 of *a* above.			

CHAPTER 5

THEORY

41. Block Diagram

The block diagram (fig. 8) is described in *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 +dc or —dc voltages, and thus provides 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 +dc voltages, and thus provides 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. Dc Probe. The dc probe 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 rectify the applied rf voltage into a dc voltage.

m. AC PROBE. The AC PROBE 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 AC 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 that is 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, and thus provides for coarse zero adjustment of the meter pointer.

r. OHMS Probe. The OHMS probe 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.

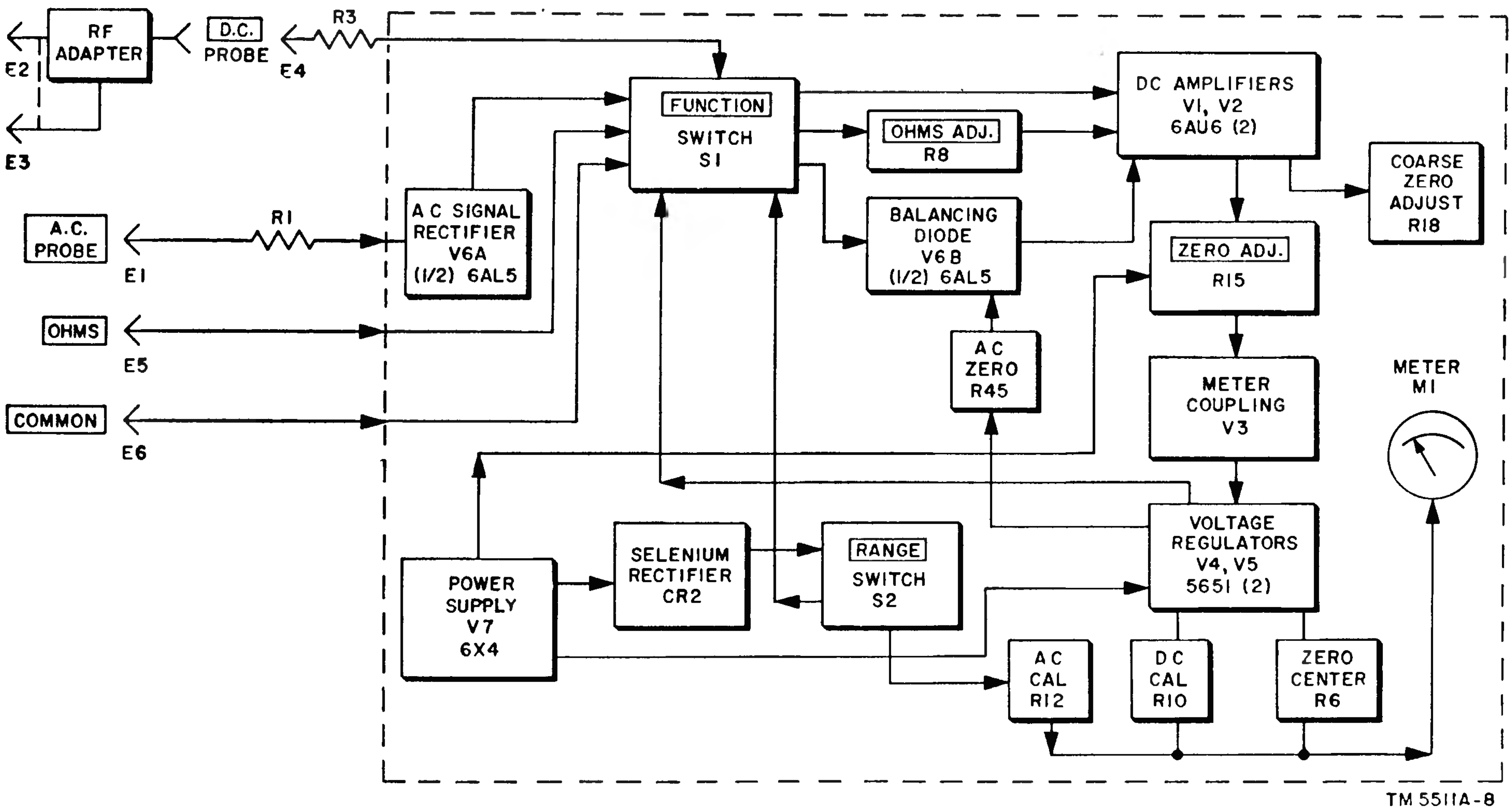


Figure 8. Electronic Multimeter TS–505A/U, block diagram.

u. COMMON Probe. The COMMON probe is a test prod that 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.

42. 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. This circuit, however, 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.

b. 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. The use of 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

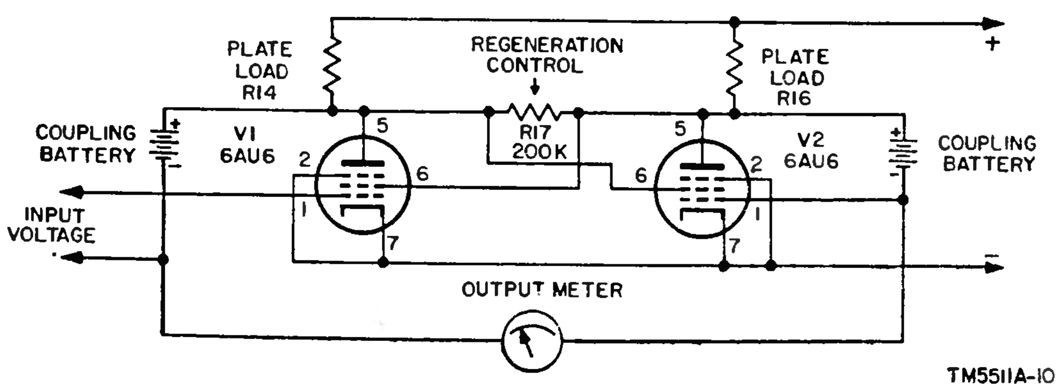


Figure 9. Amplifier operation, simplified circuit diagram.

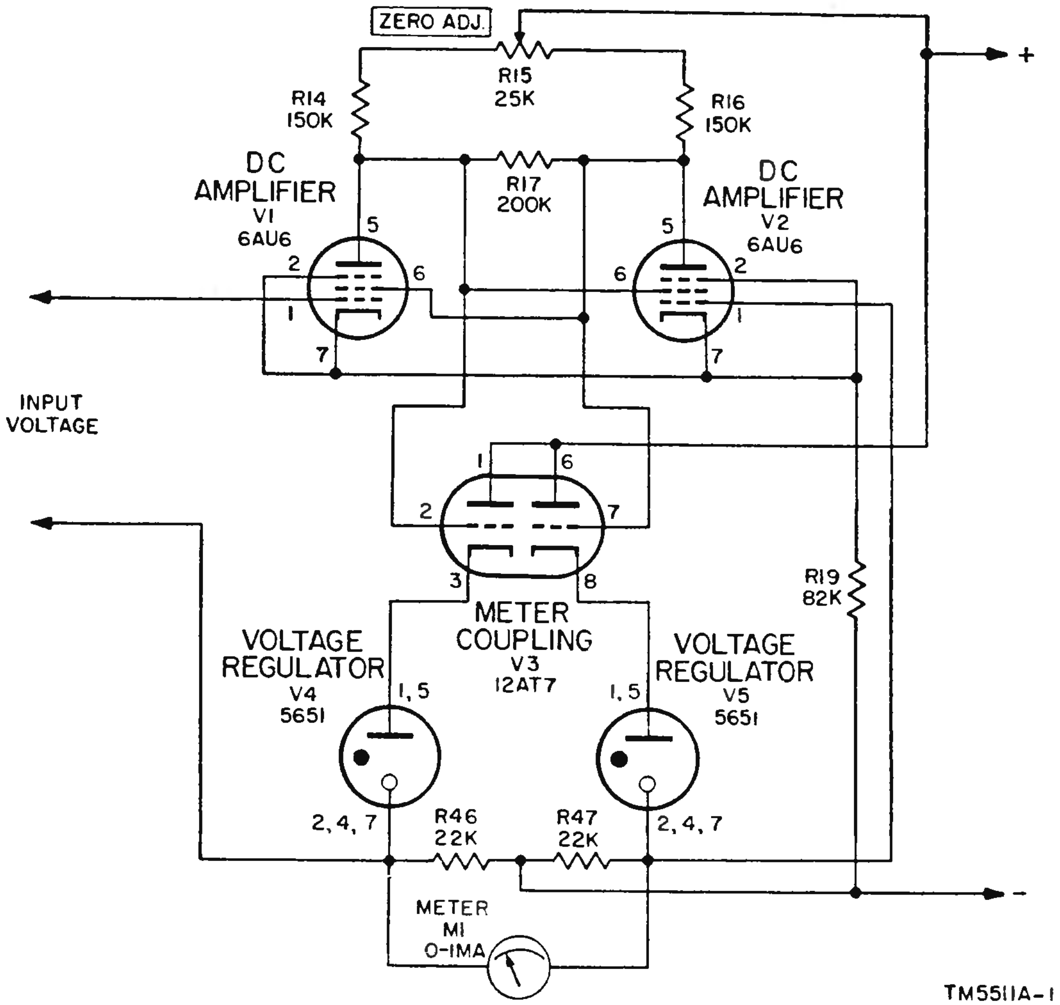


Figure 10. Amplifier, simplified schematic diagram.

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 the tube 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.

43. Dc Voltage Measurement Circuit (fig 11)

a. All dc voltages to be measured are applied across the DC and COMMON probes. The dc probe is electrically shielded to prevent pickup of stray rf voltages near or at the test point. Resistor R3 is located at the point of measurement (within the dc 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–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–R29) to provide a voltage between 0 and 1.875 volts at the grid of the 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–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 VI 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 42.

e. Section 3 of FUNCTION switch S1 controls the connection of input voltage to the meter. In the +dc 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, and it produces a negative voltage at the cathode of tube V5. In the —dc 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; this reverses the connection of the meter terminals with respect to the +dc position. Current is drawn from the cathode of tube V5 through the meter to ground; this causes the meter pointer to deflect upscale. The amount of deflection is directly proportional to the magnitude of input voltage.

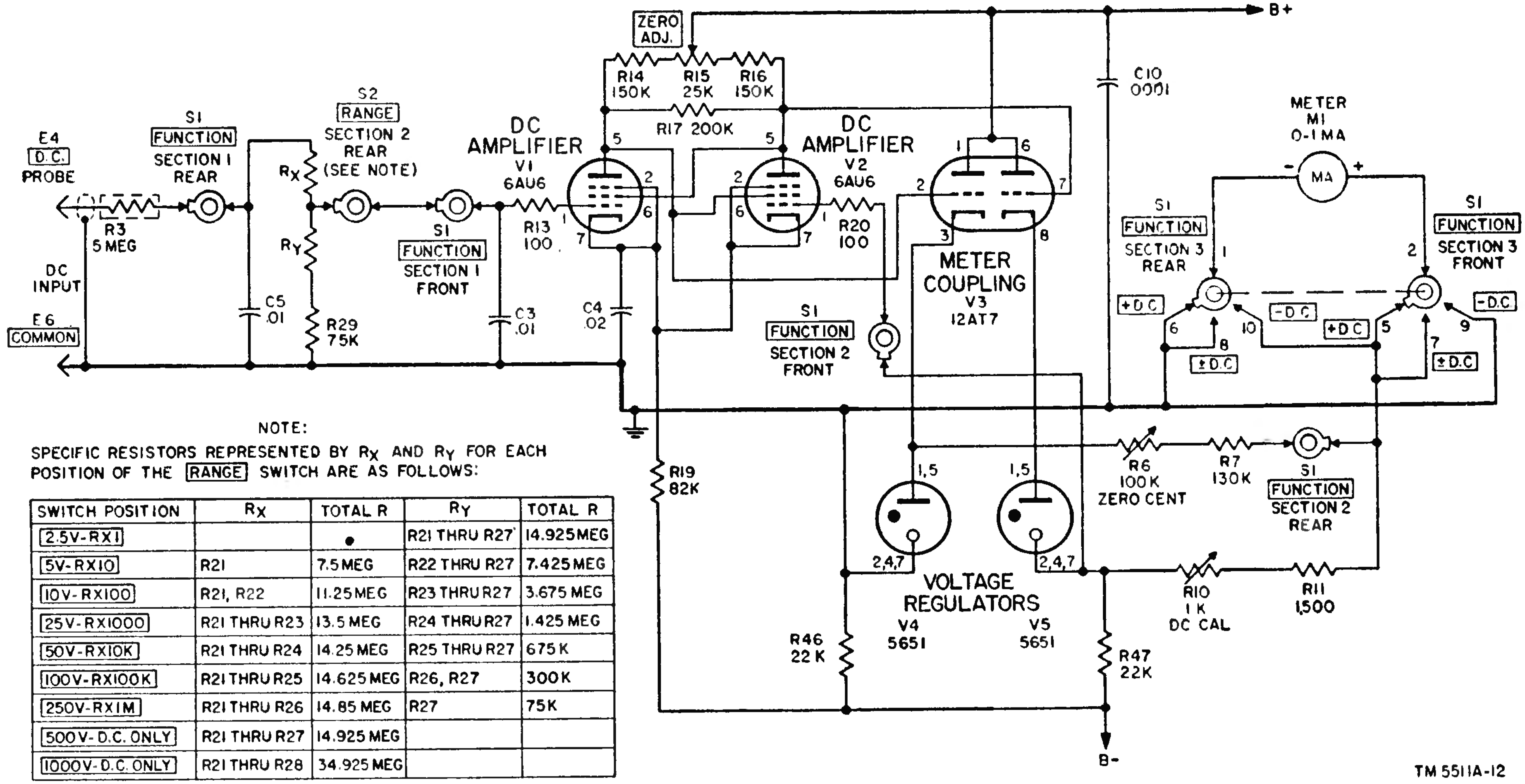
g. In the +dc and —dc positions of the FUNCTION switch, potentiometer R10 is in the meter circuit. This potentiometer is the dc calibration control and regulates the deflection of the meter pointer for any given input voltage by varying the amount of resistance in series with the meter.

h. In the ±dc 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 is drawn from ground through the meter to the plate of tube V5, and causes 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, and thus increases the current flow through the meter and causes 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, and thus decreases the current flow through the meter and causes the meter pointer to deflect to the left (below midscale).

44. 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 43 and illustrated in figure 11. Rf voltages are measured with FUNCTION switch in the +dc 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 dc 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, and terminal E3 is connected to the low potential side. The shield around the rf adapter parts



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	14.925MEG
5V-RX10	R21	7.5MEG	R22 THRU R27	7.425MEG
10V-RX100	R21, R22	11.25MEG	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	300K
250V-RX1M	R21 THRU R26	14.85 MEG	R27	75K
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.

is connected to the multimeter ground, or common, circuit through the shield around the dc probe. Both terminal E3 and the negative side of germanium diode CR1 are thus connected to the multimeter ground circuit.

c. The negative half-cycles of the wave form applied to terminal E2 cause germanium diode CR1 to conduct, and thus charge capacitor C1. Positive half-cycles of the wave form applied to terminal E2 cause capacitor C1 to discharge through R2, dc probe resistor R3, and precision attenuator (R21–R27 and R29) to ground; this produces a positive pulsating dc input voltage at the control grid of tube V1. Resistor R2 is a matching resistor which adjusts the total resistance of the precision attenuator (resistors R21–27 and 29) 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 sinusodial, the meter will not indicate an equivalent voltage. The meter, however, can be used to determine the peak value of the positive applied input. 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 percent, the error in reading may be from +5 to —5 percent.

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

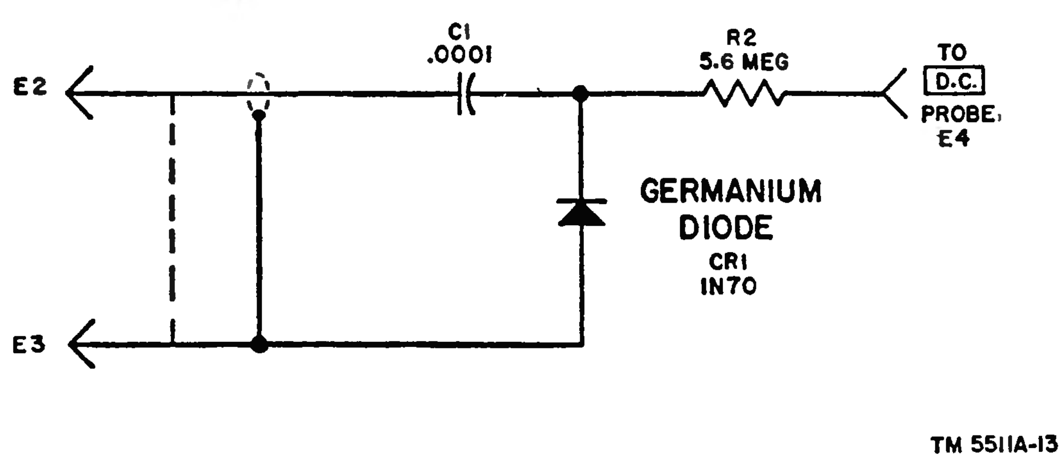


Figure 12. Rf adapter, simplified schematic diagram.

45. Ac Voltage Measurement Circuit
(fig. 13)

a. Ac voltages at frequencies from 30 cps to 5 mc may be applied across the AC PROBE and COMMON probe and measured by the ac voltage measurement circuit shown in figure 13. The AC 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 half-cycles of the wave form applied to the AC PROBE charge capacitor C2 through the conduction of tube V6A. Negative half-cycles of the waveform applied to the AC PROBE cause capacitor C2 to discharge through resistor R5 and precision attenuator (resistors R21–R27 and R29) to ground, and produce a negative pulsating dc input voltage at the control grid of tube V1. Resistor R5 is a matching resistor which adjusts the total resistance of precision attenuator (resistors R21–R27, and R29) for ac voltage measurement.

c. When in ac position, section 1 of FUNCTION switch S1 couples the pulsating dc input voltage from the precision attenuator (resistors R21–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–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–R27 and R29) to supply a voltage of between 0 and —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.

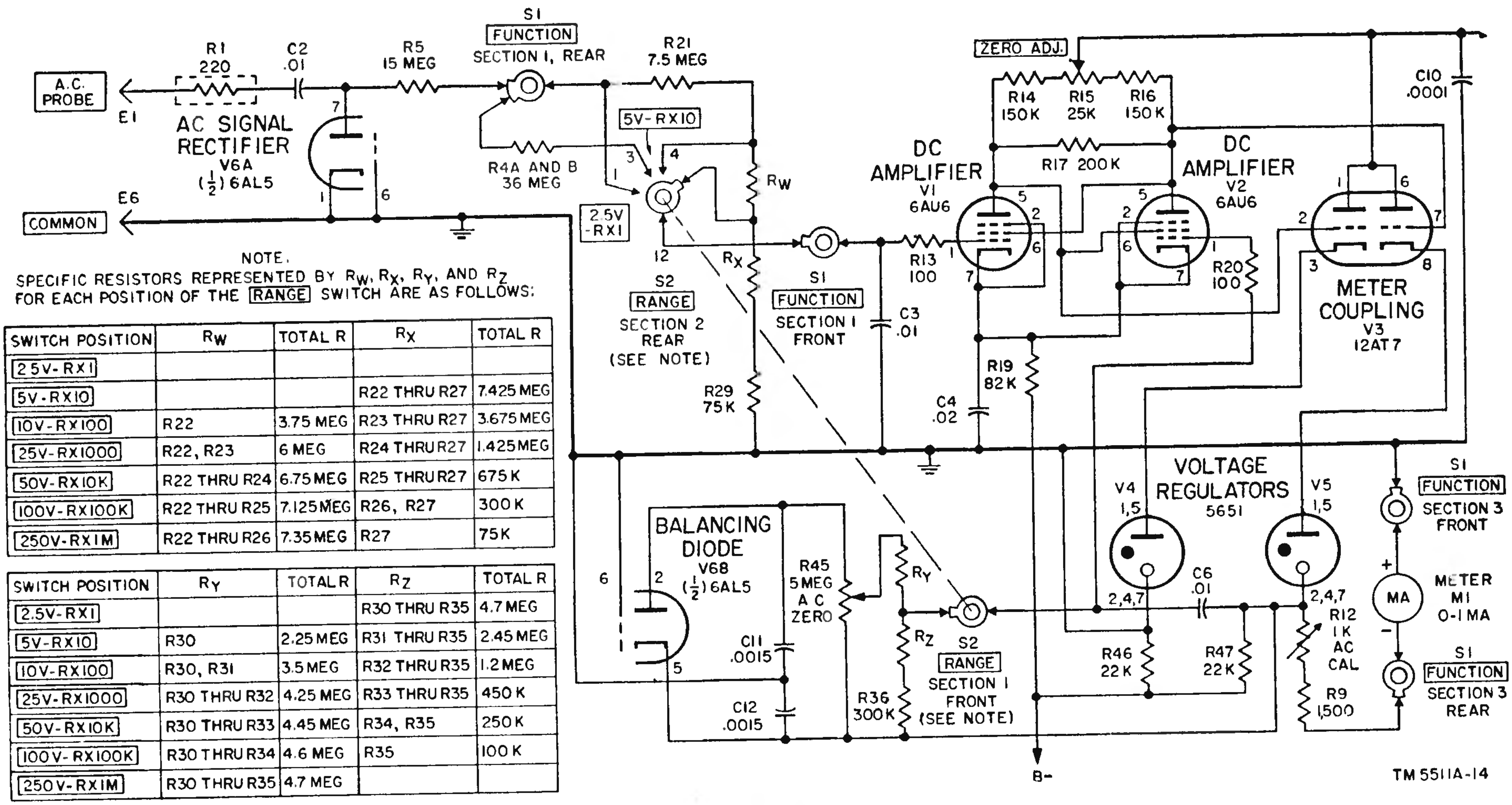
e. By action of the amplifier circuit, a dc voltage applied to the control grid of tube V1 is reproduced as a voltage across the low impedance at regulator tubes V4 and V5. The operation of the amplifier circuit, tubes V1 through V5, is explained in paragraph 42.

f. Ac signal rectifier V6A is always conducting, even with no voltage applied to the AC PROBE, because of the contact potential in the tube. Current flows through tube V6A, resistor R5, and the precision attenuator (resistors R21–R27 and R29) to ground; this applies a constant negative voltage to the control grid of tube V1. To cause the meter pointer to read 0 volt with *no* ac voltage applied to the AC PROBE, 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–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. Because 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 ac position, section 3 of 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. 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 mount of input voltage.

i. In the ac 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.



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	75K

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.

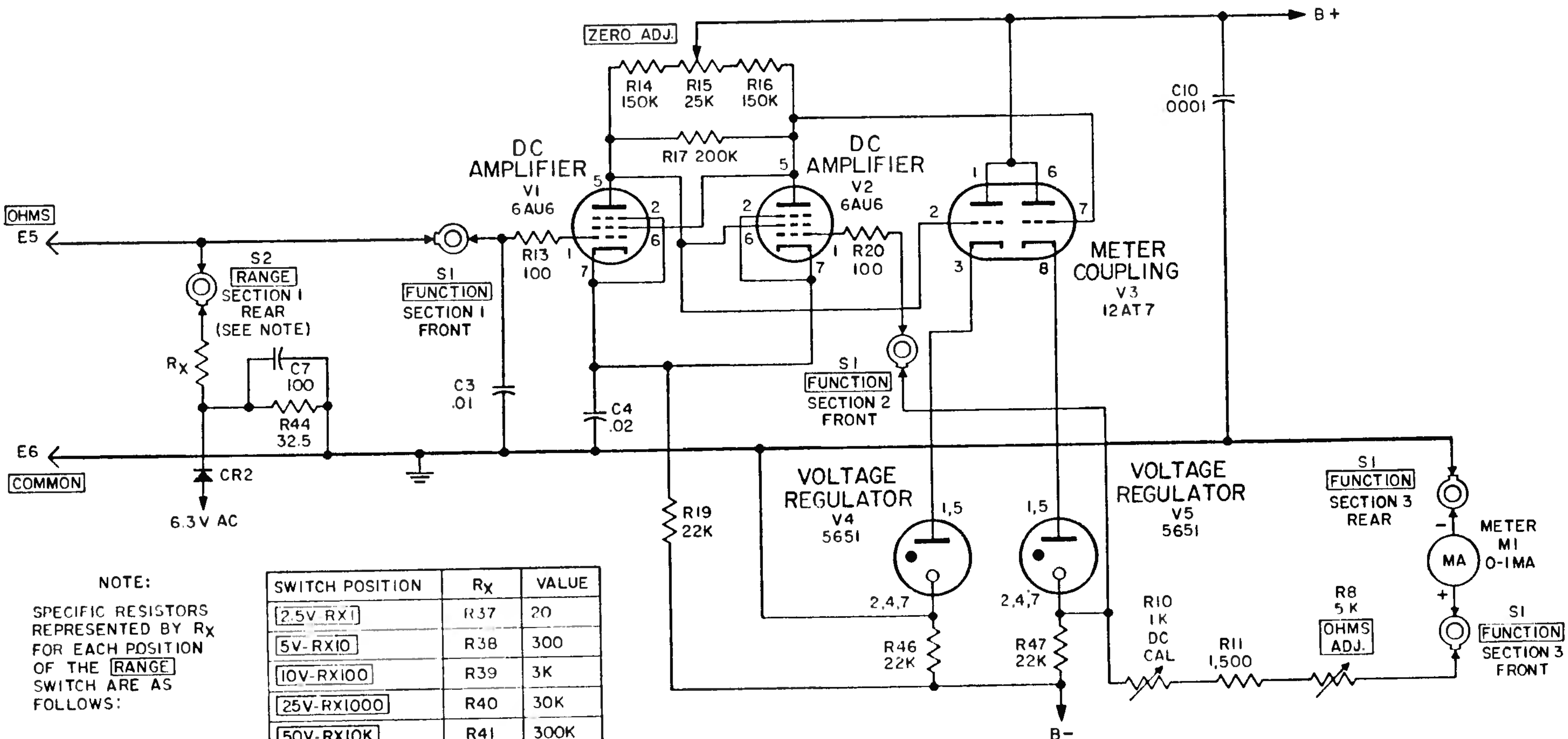
46. Ohmeter Circuit
(fig. 14)

a. Selenium rectifier CR2 receives a 6.3-volt ac input from the filament winding of transformer T1 and produces a dc output voltage across resistor R44 and 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 42.

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. The voltage supplied by selenium rectifier CR2 is dropped across resistor Rx (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 the 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 through the precision resistor selected by section 1 of switch S2. This current flow causes a voltage drop across the resistor being measured and across precision resistor Rx (fig. 14) selected by switch S2. The voltage drop across the resistor being



NOTE:

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

SWITCH POSITION	Rx	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.

measured is applied to the control grid of tube V1; this causes deflection of the meter pointer, because only a portion of the positive voltage from selenium rectifier CR2 is applied to the grid of tube 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 that are high compared to resistor Rx will have a higher voltage drop, which will cause 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 is increased, 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.

47. Power Supply
(fig. 15)

a. The power supply uses a full-wave rectifier tube 6X4 (V7) to supply 310 volts at 12 milliamperes 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 (I 1), 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. Swith 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 I 1 indicates whether the multimeter is on. The light is covered by a colored lens.

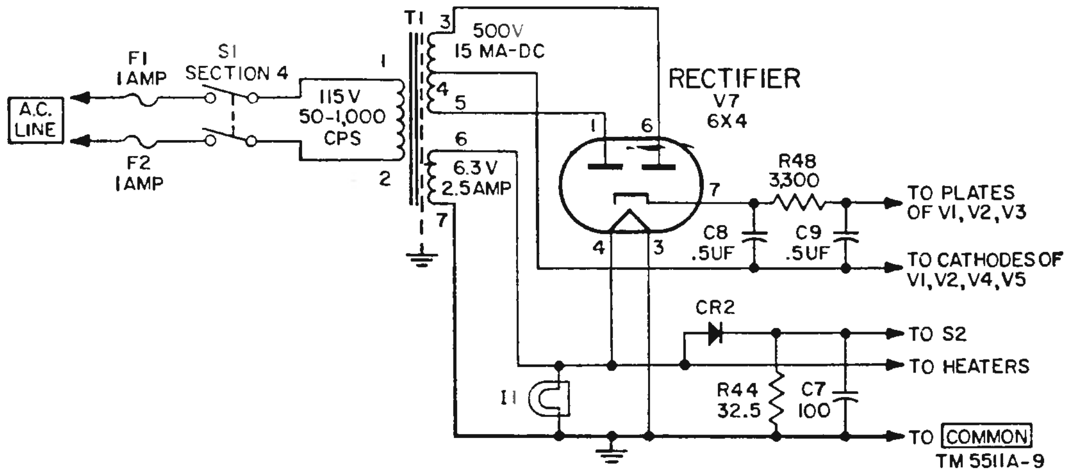


Figure 15. Power supply, simplified schematic diagram.

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. TROUBLESHOOTING 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.

48. Troubleshooting 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. 35) 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, 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. 52) for possible shorts before the equipment is tested with the 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 checklist (par. 40).

(4) *Troubleshooting chart.* The trouble symptoms listed in this chart (par. 54) will aid greatly in localizing trouble.

(5) *Intermittent troubles.* In all these tests, the 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.

49. Troubleshooting Data

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

Fig.	Par.	Title
8		Electronic Multimeter TS–505A/U, block diagram.
11		Dc voltage measurement circuit, simplified schematic diagram.
13		Ac voltage measurement circuit, simplified schematic diagram.
14		Ohmmeter circuit, simplified schematic diagram.
17		Multimeter, case removed, rear view.
18		Multimeter, case removed, top view.
19		Multimeter, showing parts and subassemblies removed from panel.
20		Rf adapter, exploded view.
22		Multimeter, tube socket voltage and resistance diagram.
23		Multimeter, terminal board voltage and resistance diagram.
27		Electronic Multimeter TS–505A/U, schematic diagram.
28		Electrical Multimeter TS–505A/U, wiring diagram.
	35	Visual inspection.
	40	Equipment performance checklist.
	54	Troubleshooting chart.
	55	Power transformer, voltage output and resistance.

50. Test Equipment Required for Troubleshooting

The test equipment required for troubleshooting the multimeter is listed in the table below. If these equipments are not available, equipments with similar characteristics may be substituted.

Test equipment	Technical manual
Electron Tube Test Set TV–2/U	TM 11–2661
Multimeter TS–352/U	TM 11–5527
Meter Test Equipment AN/GSM–1B	TM 11–2535A
Resistor Decade ZM–16/U	TM 11–5102

51. 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 the connecting leads. Be careful not to kink or strain any wires or leads.

d. Do not overtighten screws or packing glands when assembling the 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 the installation of the 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.

52. 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 AC LINE cord is disconnected from the power source, that the FUNCTION switch is set at the +dc position, and that the RANGE switch is set at the 2.5 V–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 percent 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.

53. Gas Checks

a. The performance and accuracy of the multimeter largely depends on the degree of balance between the 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 the tubes are not gassy.

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

(1) Connect the multimeter AC LINE cord into the ac power source (98–130 volts, 50–1,000 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 2.5 V–RX1 position. Connect the dc probe and COMMON probe tips together.

(3) Loosen the lock nut on potentiometer R18 (fig. 16). Use a screwdriver and turn potentiometer R18 until the meter pointer is within one-half scale division of zero. Wait approximately 1 minute between settings, because 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 —dc 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 (1) through (6) above. If the shift of the meter pointer is still greater than one scale division from zero, replace tubes V1 and V2. Check the replacement tubes by repeating the instructions in (1) through (6) above.

54. Troubleshooting 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.

Switch position		Symptom	Probable trouble	Correction
FUNCTION switch	RANGE switch			
Any except OFF.	Any	1. Pilot light does not go on; no movement of meter needle; line voltage normal.	*a.* AC LINE cord plug is not properly inserted in socket.	*a.* Insert correctly.
			b. Burned-out fuse F1 or F2	*b.* Replace defective fuse (fig. 18).
			c. Defective AC LINE cord disconnected from plug.	*c.* Replace or repair cord.
			d. Defective switch S1, section 4	*d.* Replace or repair switch (fig. 19 and par. 56*g*).
			e. Defective transformer T1 (par. 55).	*e.* Replace transformer (fig. 17).
			f. Short across filament winding of transformer T1 (par. 55).	*f.* Locate and remove short (fig. 17).
			g. Pilot lamp I 1 burned out	*g.* Replace pilot lamp I 1 (fig. 19).
+Dc	Any	2. 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. 56*h*).
			d. Defective potentiometer R10	*d.* Replace potentiometer (fig. 19 and par. 56*l*).

			e. Defective or dirty switch deck	*e*. Clean or replace defective switch (pars. 27*b* or 56*g*).
			f. Line voltage low	*f*. Apply correct line voltage.
			g. No voltage at cathode of tube V7.	*g*. Check transformer T1 (par. 55); replace if defective (par. 56*e* and fig. 18).
+Dc	2.5 V-RX1	3. 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 paragraph 59*c* and *d*; 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).
+Dc	*a*. 1000 V-DC ONLY.	4. 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 pars. 27*b* or 56).
	b. 500 V-DC ONLY.		*b*. Same probable fault as in *a* above.	*b*. Same as *a* above.

Switch position		Symptom	Probable trouble	Correction
FUNCTION switch	RANGE switch			
	c. 250 V–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. 27*b*).
	d. 100 V–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. 56*g* and fig. 17).
	e. 50 V–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. 27*b* and 56*g* and fig. 17).
	f. 25 V–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 (pars. 27*b* and 56*g* and fig. 17).

	g. 10 V–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 (pars. 27*b* and 56*g* and fig. 17).
	h. 5 V–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 (pars. 27*b* and 56*g* and fig. 17).
	i. 2.5 V–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 (pars. 27*b* and 56*g* and fig. 17).
+Dc	2.5 V–RX1	5. Application of 2.5 volts ±1 percent to meter results in error greater than 5 percent.	*a.* Potentiometer R10 set incorrectly or defective.	*a.* Refer to paragraph 59*d*; replace potentiometer R10 (fig. 19).
			b. Resistor R17 open	*b.* Replace resistor R17 (fig. 19).
			c. Resistors R21 through R29 are not within 1 percent of correct value.	*c.* Find defective resistor or resistors and replace them (fig. 17).
			d. Meter M1 error greater than ±2 percent.	*d.* Replace meter (par. 56*h*).

Switch position		Symptom	Probable trouble	Correction
FUNCTION switch	RANGE switch			
+Dc	500 V–RX100K	6. Apply approximately 500 volts between DC and COMMON probes, and then turn FUNCTION switch to 1000 V position. Meter pointer does not read 500 volts on 1000 V range.	Resistor R28 short-circuited	Repair or replace switch S2, section 2 wafer; replace resistor R28 (par. 56*g* and fig. 17).
±Dc	Any	7. Meter pointer not at mid-scale.	*a*. Potentiometer R6 set incorrectly or defective. *b*. Resistor R7 open or shorted	*a*. Refer to paragraph 60*a*; replace potentiometer R6 (fig. 19). *b*. Replace resistor R7 (fig. 19).
±Dc	See item 4 above	8. Meter pointer drifts until off scale.	See item 4 above	See item 4 above.
—Dc	See item 4 above	9. Meter pointer drifts until off scale.	See item 4 above	See item 4 above.
—Dc	2.5 V–RX1	10. Meter pointer set to zero on —dc 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 53 (fig. 17).
+Dc, ±dc, or —dc.	Any	11. No deflection of meter pointer with dc voltage applied.	*a*. Resistor R3 open	*a*. Replace resistor R3 (par. 57*b* and fig. 21).

			b. Loose mechanical connection between resistor R3 lead and dc probe tip.	*b.* Inspect resistor lead and tighten probe tip.
			c. Test lead open	*c.* Replace test lead.
			d. Dirty or open contact on switch S1 or S2.	*d.* Clean switch contact or replace defective switch (fig. 17 and par. 56*g*).
+Dc, ±dc, or —dc.	Various	12. Meter pointer shifts when changing setting of RANGE switch.	Tube V1 or V2 gassy	Refer to paragraph 53 (fig. 17).
+Dc, ±dc, or —dc.	Any	13. Meter pointer deflects in wrong direction.	Meter leads reversed	Reverse meter leads.
+Dc, ±dc, or —dc.	Any	14. Meter pointer unstable; for constant input voltage, meter indication keeps changing.	*a.* Tube V1 or V2 gassy	*a.* Refer to paragraph 53 (fig. 17).
			b. Resistor R17 open	*b.* Replace resistor R17 (fig. 19).
+Dc, ±dc, or —dc	Any	15. 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).
+Dc	Any up to 50 V–RX10K.	16. Apply rf voltage up to 40 volts, 1 to 500 mc. No deflection of meter pointer.	*a.* Capacitor C1 open or shorted	*a.* Replace capacitor C1 (fig. 20).
			b. Germanium diode CR1 open or shorted.	*b.* Replace germanium diode CR1 (fig. 20).
			c. Resistor R2 open	*c.* Replace resistor R2 (fig. 21).
Ac	2.5 V–RX1	17. Meter pointer cannot be set to zero with potentiometer R15 or R45 (no input voltage to AC PROBE).	*a.* Potentiometer R12 incorrectly set or defective.	*a.* Refer to paragraph 61*b*; replace potentiometer R12 (fig. 19).
			b. Potentiometer R15 or R45 defective.	*b.* Replace potentiometer R15 or R45 (fig. 19 and par. 56).

Switch position		Symptom	Probable trouble	Correction
FUNCTION switch	RANGE switch			
			c. Resistor R21, R22, R23, R24, R25, R26, R27, or R29 open or shorted or of incorrect value.	*c.* Replace defective resistor (fig. 17 and par. 56).
Ac	Any	18. No meter pointer deflection with ac voltage applied to AC PROBE.	*a.* Capacitor C2 open	*a.* Replace capacitor C2 (fig. 19 and par. 57*c*).
			b. Tube V6 burned out	*b.* Replace tube V6 (fig. 17).
			c. Resistor R1 open	*c.* Replace resistor R1 (par. 57*c*).
			d. Dirty or open contact on switch S1 or S2.	*d.* Clean switch contact or re-replace defective switch (fig. 19 and par. 27*b* and 56*g*).
			e. Defective test lead	*e.* Replace test lead (fig. 3 and par. 57*c*).
Ac	Any	19. Meter pointer deflects with dc voltage applied to AC PROBE.	Capacitor C2 defective	Replace capacitor C2 (fig. 19).
Ac	Any	20. Potentiometer R12 will not adjust meter for calibrating.	Potentiometer R12 defective	Replace potentiometer (fig. 1[illegible]
Ac	Any	21. Meter pointer deflects positive with no input voltage; rotation of potentiometer R45 has no effect.	*a.* Tube V6B inoperative	*a.* Replace tube V6 (fig. 17).
			b. Capacitor C11 or C12 shorted	*b.* Replace defective capacitor (fig. 19 and par. 51*f*(3)).

			c. Resistor R21, R22, R23, R24, R25, R26, R27, or R29 open or shorted or of incorrect value.	c. Replace defective resistor (fig. 17 and par. 56).
Ac	Any	22. Meter pointer deflects negative with no input voltage; rotation of resistor R45 has no effect.	a. Tube V6A inoperative	a. Replace tube V6 (fig. 17).
			b. Resistor R5 open	b. Replace resistor R5 (fig. 19).
			c. Resistor R45 defective	c. Replace resistor R45 (fig. 19).
OHMS	Any	23. 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. 56*g*).
			c. Selenium rectifier CR2 defective.	c. Replace selenium rectifier CR2 (fig. 17).
OHMS	a. 2.5 V–RX1	24. Meter pointer drifts upscale.	a. Resistor R37 open	a. Replace resistor R37 (fig. 18 and par. 56).
	b. 5 V–RX10		b. Resistor R38 open	b. Replace resistor R38 (fig. 18 and par. 56).
	c. 10 V–RX100		c. Resistor R39 open	c. Replace resistor R39 (fig. 18 and par. 56).
	d. 25 V–RX1000		d. Resistor R40 open	d. Replace resistor R40 (fig. 17 and par. 56).
	e. 50 V–RX10K		e. Resistor R41 open	e. Replace resistor R41 (fig. 17 and par. 56).
	f. 100 V–RX100K		f. Resistor R42 open	f. Replace resistor R42 (fig. 17 and par. 56).
	g. 250 V–RX1M		g. Resistor R43 open	g. Replace resistor R43 (fig. 17 and par. 56).
	h. Any		h. Resistor R44 open.	

Switch position		Symptom	Probable trouble	Correction
FUNCTION switch	RANGE switch			
OHMS	Any	25. Full clockwise rotation of OHMS ADJ. control does not bring meter pointer to ∞.	*a.* Selenium rectifier CR2 defective.	*a.* Replace selenium rectifier CR2 (fig. 17).
			b. Line voltage too low	*b.* Apply correct line voltage.
			c. Potentiometer R10 defective	*c.* Replace potentiometer R10 (fig. 19 and par. 56).
			d. OHMS ADJ. potentiometer R8 defective.	*d.* Replace potentiometer R8 (fig. 19 and par. 56*k*).
Any except OFF.	2.5 V–RX1	26. No B+ at cathode of tube V7; pilot light glows.	*a.* Tube V7 defective	*a.* Replace tube V7 (fig. 17).
			b. Capacitor C8 shorted	*b.* Replace capacitor C8 (fig. 18).
			c. High-voltage winding of transformer T1 open or shorted.	*c.* Replace transformer T1 (fig. 18 and par. 56*e*).
Any except OFF.	2.5 V–RX1	27. No B+ at plates of tube V3; pilot light glows.	*a.* Capacitor C9 shorted	*a.* Replace capacitor C9 (fig. 18).
			b. Resistor R48 open	*b.* Replace resistor R48 (fig. 17).
			c. Tube V7 defective	*c.* Replace tube V7 (fig. 17).

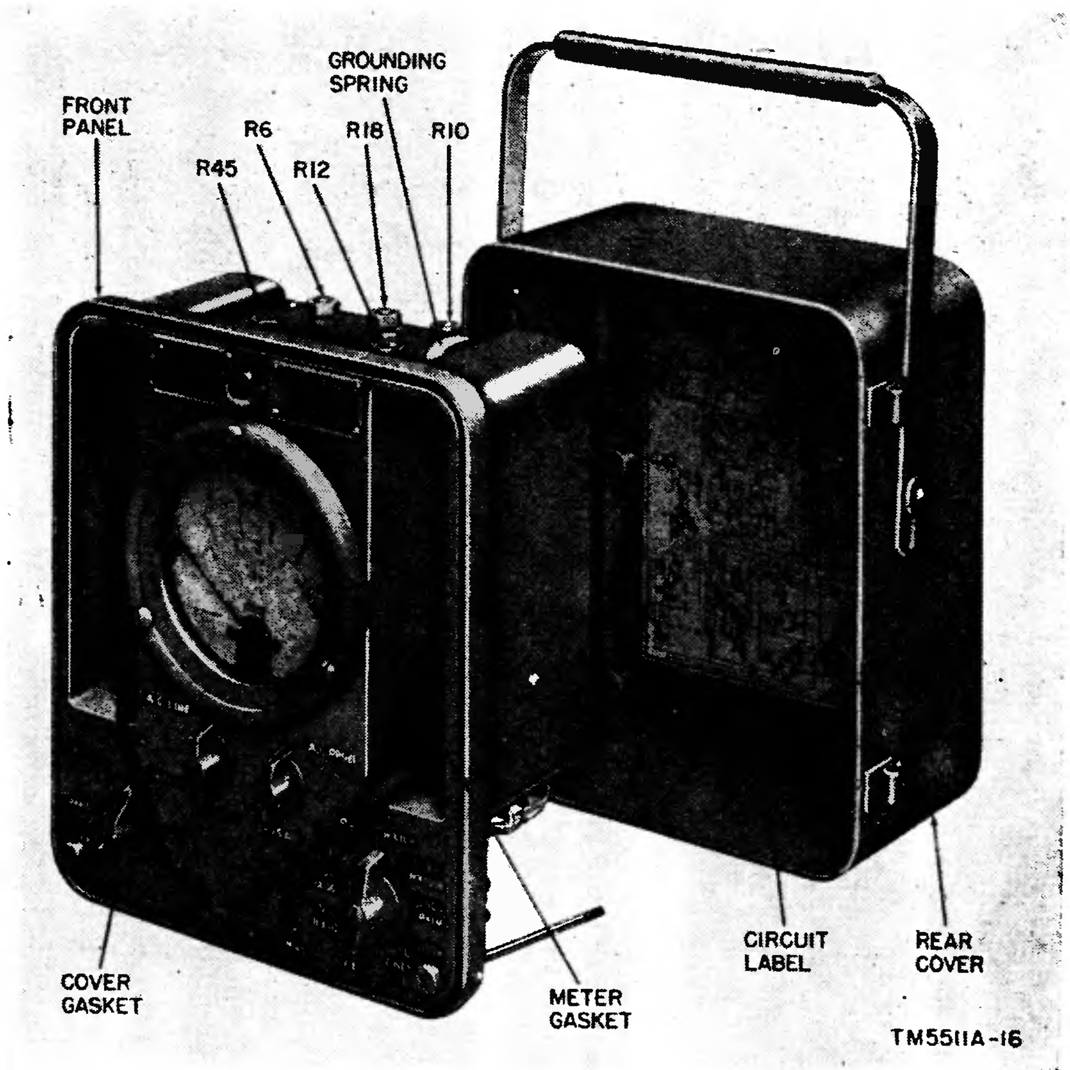


Figure 16. Multimeter, removed from case.

55. Power Transformer, Voltage Output and Resistance

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

Terminals	Resistance (ohms)	Voltage (ac)
1–2	34	
3–4	740	250
3–5	1480	500
4–5	740	250
6–7	.2	6.3

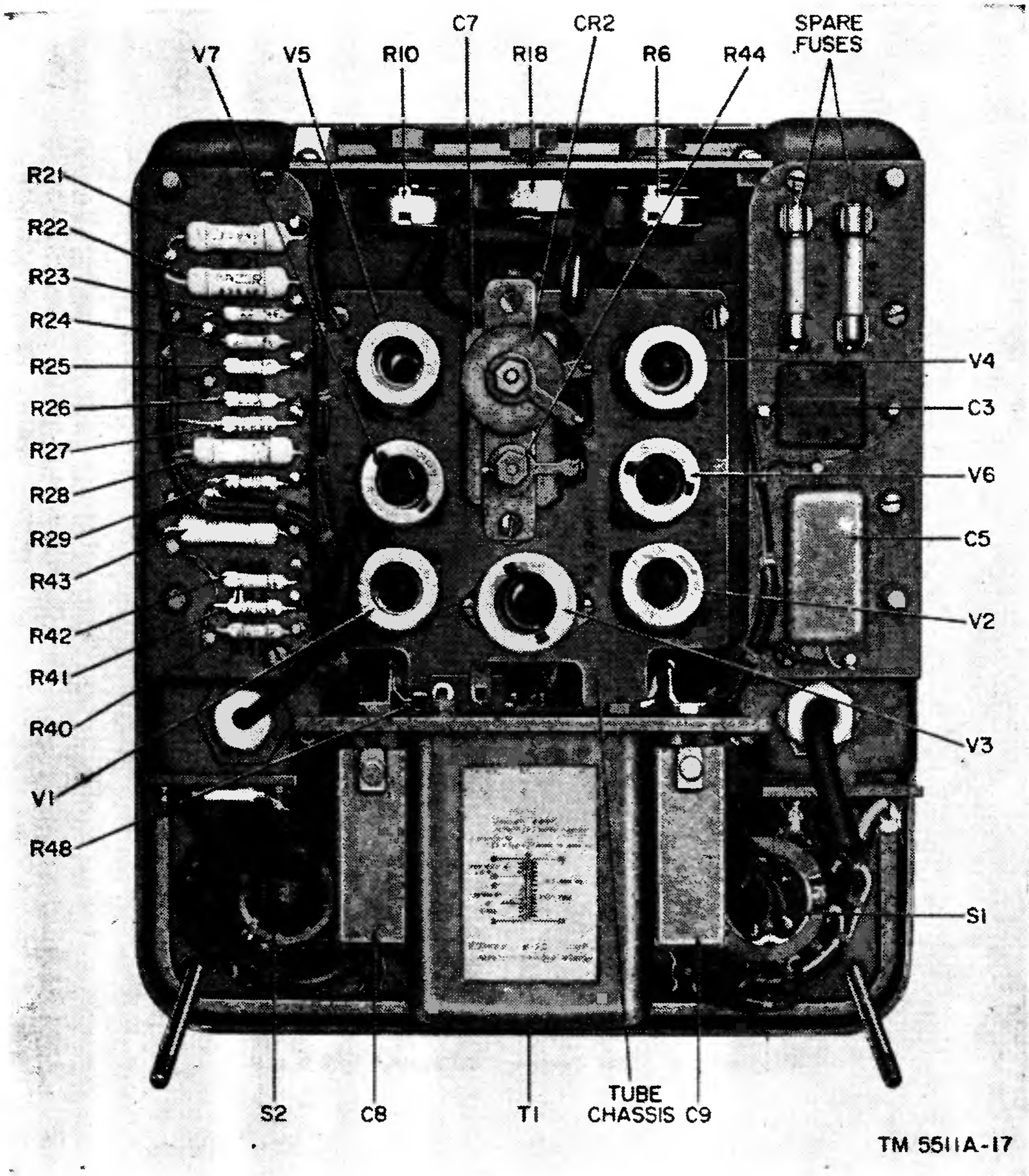


Figure 17. Multimeter, case removed, rear view.

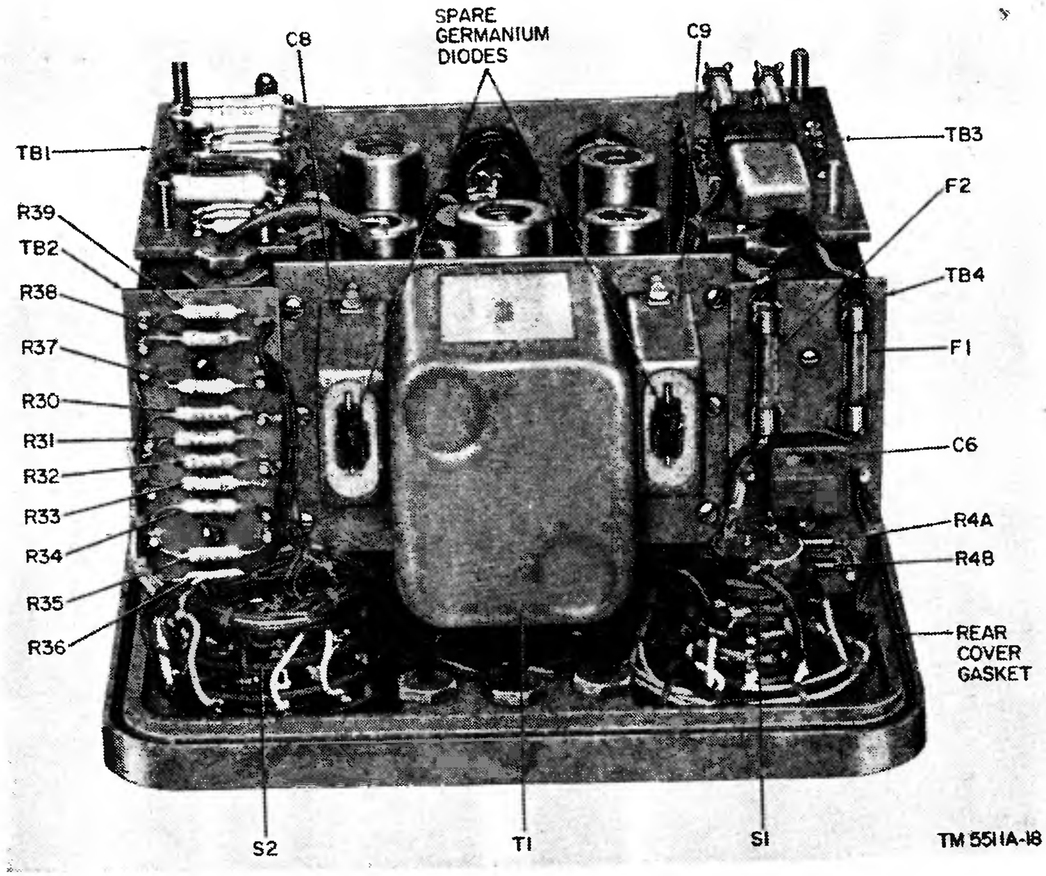


Figure 18. Multimeter, case removed, top view.

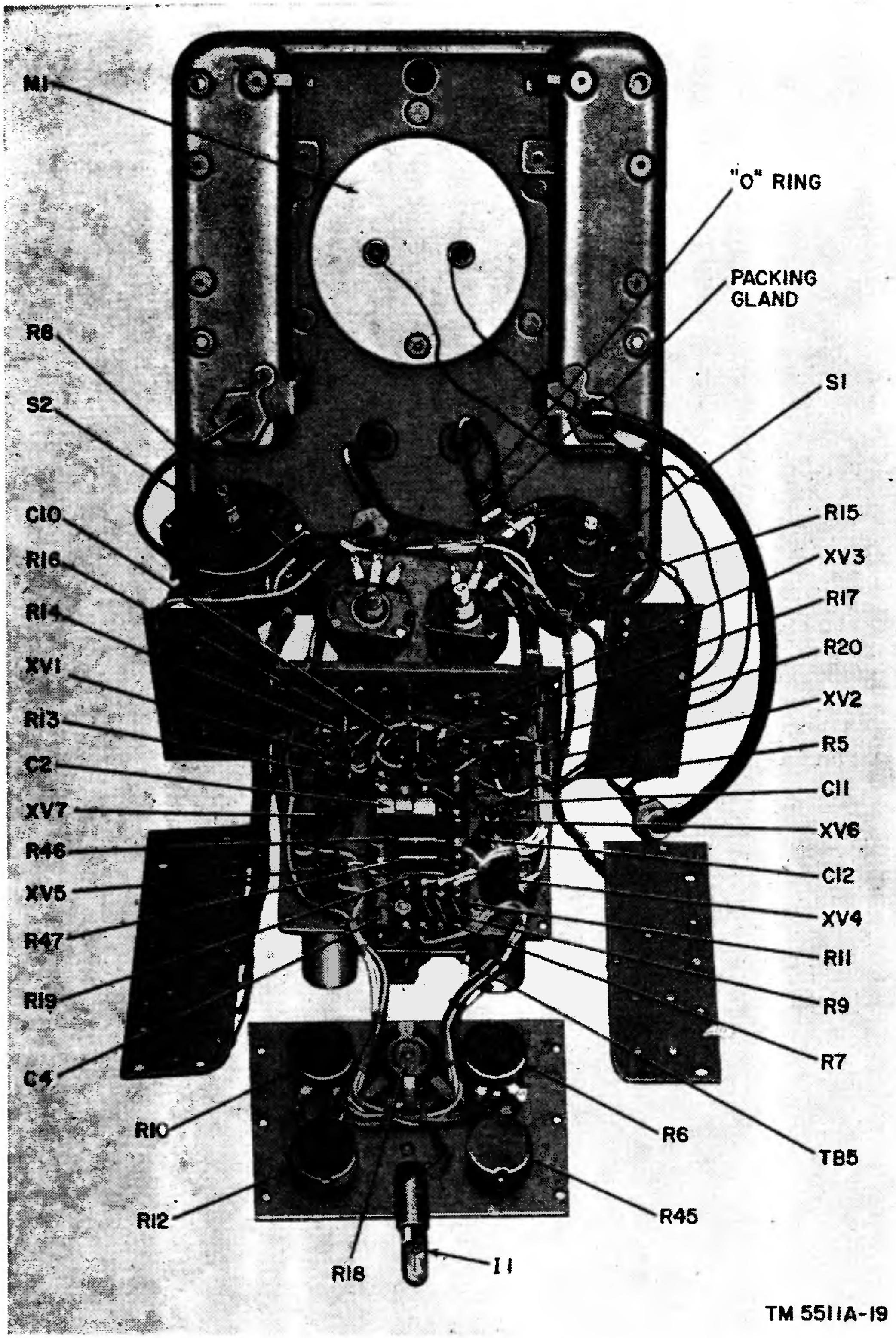


Figure 19. Multimeter, showing parts and subassemblies removed from panel.

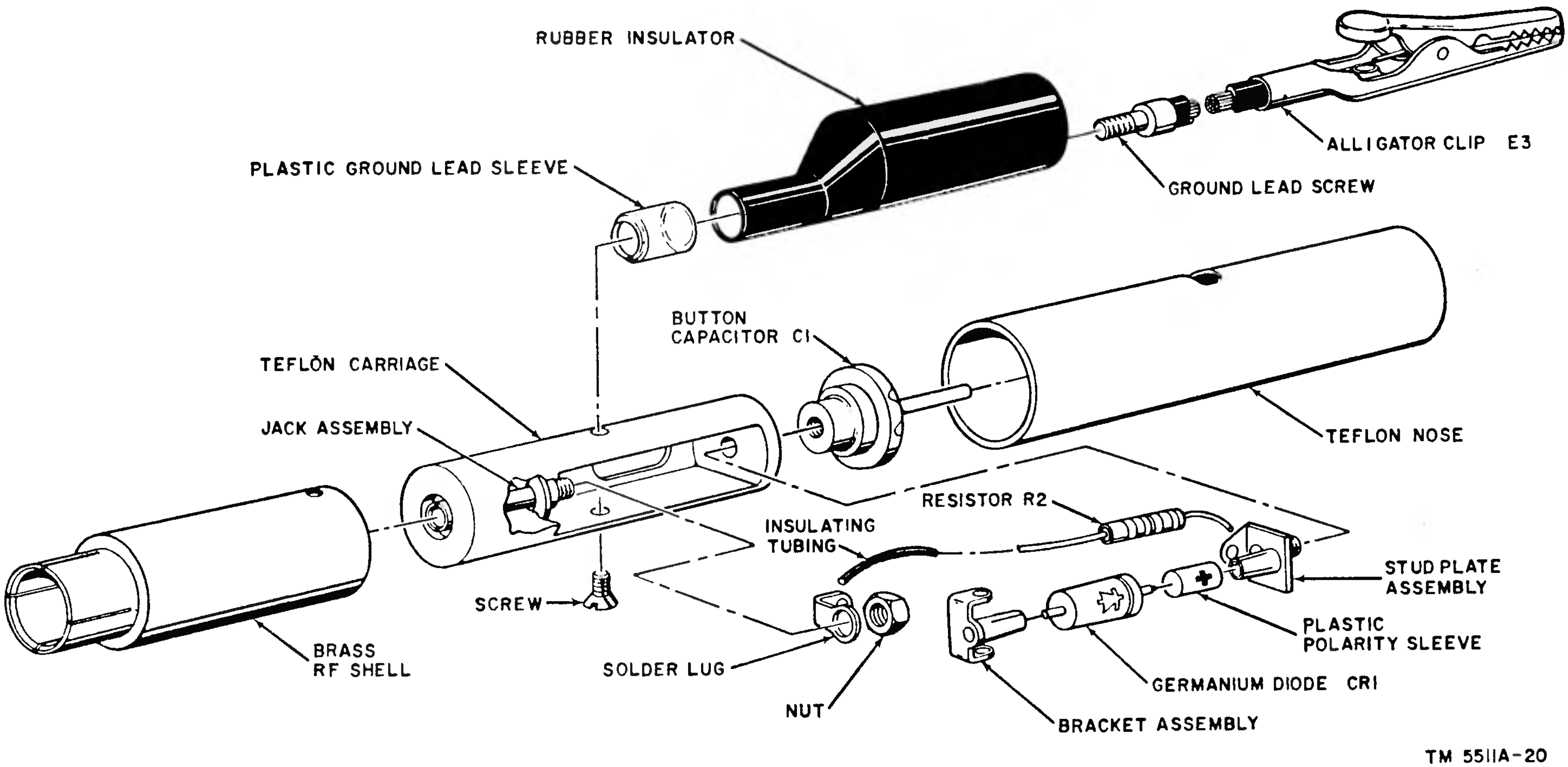


Figure 20. Rf adapter, exploded view.

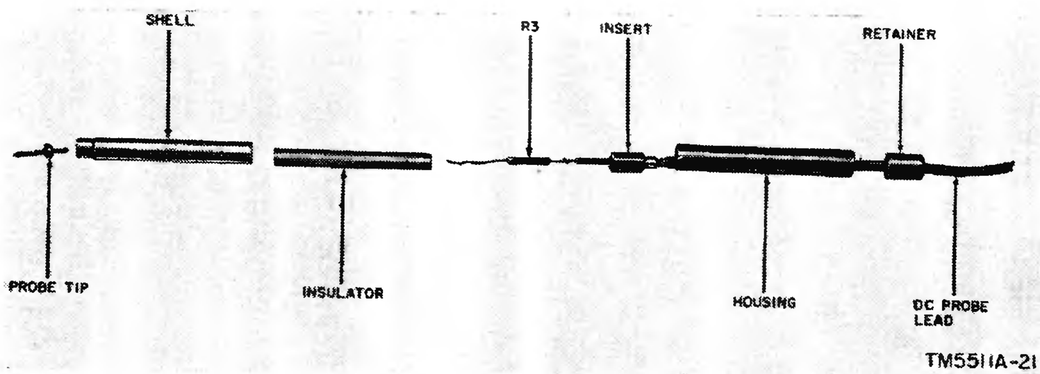
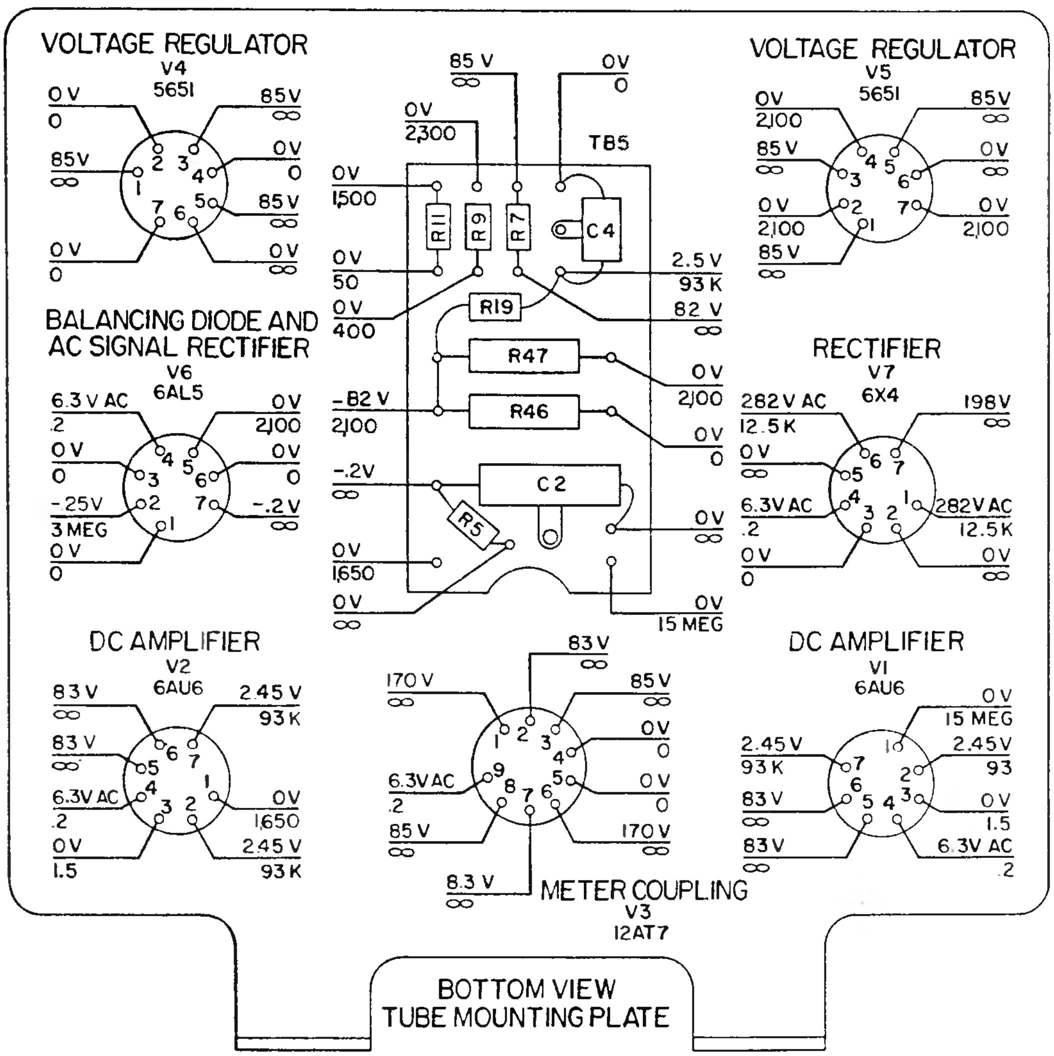


Figure 21. Dc probe, exploded view.



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.

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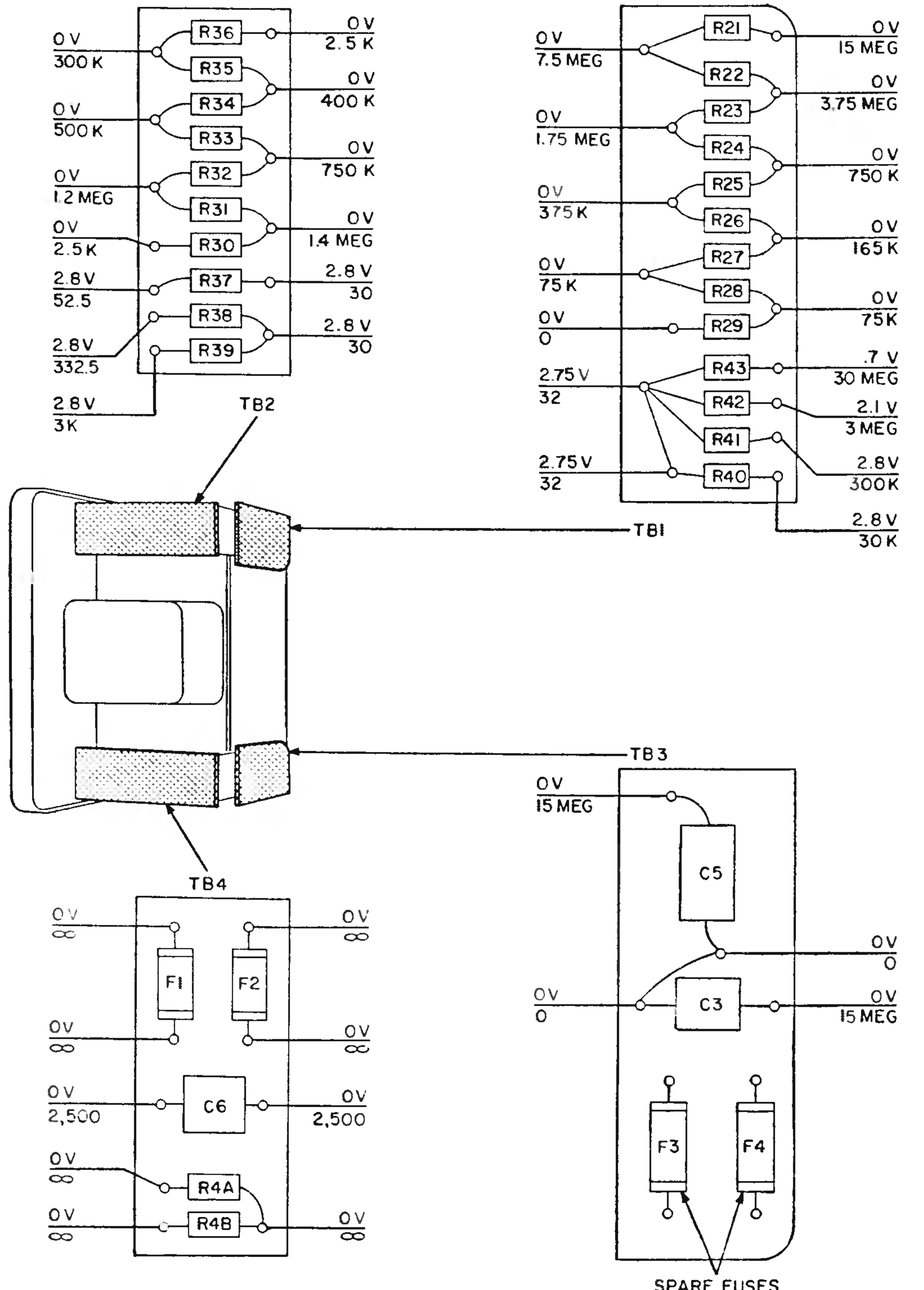
Figure 22. Multimeter, tube socket voltage and resistance diagram.



NOTES:

1. RANGE SWITCH POSITION 2.5 V-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.

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Figure 23. Multimeter, terminal board voltage and resistance diagram.

Section II. REPAIRS

56. Replacement of Parts

Note. Many resistors used in the multimeter 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 percent. If these resistors require replacement, use a resistor the *exact* value of the one removed. Even slightly different values will cause inaccurate calibration of the multimeter.

a. Removal of Front Panel and Chassis Assembly (fig. 18).

(1) To service the multimeter, first remove the front panel and chassis assembly as follows :

(*a*) Unscrew the six panel mounting bolts on the front end of the multimeter (fig. 5).

(*b*) Slide the front panel and chassis assembly out of the back cover.

(*c*) Turn the front panel over with its face down and lay it on the work bench or working area, with the chassis assembly exposed.

(2) To reassemble the front panel and chassis assembly and to install a front panel and chassis assembly, reverse the disassembly procedures given in (1) above.

b. Terminal Boards (fig. 19).

(1) To remove the terminal boards, proceed as follows:

(*a*) Remove the front panel and chassis assembly (*a* above).

(*b*) Remove the terminal boards by removing the retaining screws from the tapped holes in the panel casting.

(2) To reassemble and install all the terminal boards, reverse the disassembly procedures given in (1) above.

c. Mounting Plates (fig. 19).

(1) To remove the mounting plates, proceed as follows:

(*a*) Remove the front panel and chassis assembly (*a* above).

(*b*) Remove the mounting plates by removing the retaining screws from the tapped holes in the panel casting.

(2) To reassemble and install the mounting plates, reverse the disassembly procedures given in (1) above.

d. Tube Chassis (fig. 17).

(1) To remove the tube chassis, proceed as follows:

(*a*) To remove the front panel and chassis assembly (*a* above).

(*b*) Remove the tube chassis by removing the retaining screws from the tapped holes in the panel casting.

(2) To reassemble and install the tube chassis, reverse the disassembly procedures given in (1) above.

e. Power Transformer T1 and Power Supply Filter Capacitors C8 and C9 (fig. 17).

(1) To remove the power transformer and power supply filter capacitors, proceed as follows:

(*a*) Remove the front panel and chassis assembly (*a* above).

(*b*) Remove the retaining nuts from the underside of the mounting plates. These nuts are secured to studs on the power transformer and on the power supply filter capacitors.

(2) To reassemble and install the power transformer T1 and power supply filter capacitors C8 and C9, reverse the disassembly procedure given in (1) above.

f. Control Knobs (fig. 5).

(1) To remove the control knobs, proceed as follows:

(*a*) Remove the screw in the center of the control knob.

(*b*) Remove the control knob.

Note. The shafts of the controls are straddle milled; therefore, when removing a knob, mark its position so that it can be positioned correctly during installation.

(2) To reassemble and install the control knobs, reverse the disassembly procedure given in (1) above.

g. Wafer Switches S1 and S2 (fig. 19).

(1) To remove the wafer switches, proceed as follows:

(*a*) Remove the front panel and chassis assembly (*a* above).

(*b*) Remove the FUNCTION or RANGE switch control knob as outlined in *f* above.

(*c*) Remove the wafer switch from the panel.

Note. Carefully mark the wires connected to the wafers with tags to avoid misconnection when the new wafer switch is installed.

(2) To reassemble and install the wafer switches, reverse the disassembly procedures given in (1) above.

h. Meter.

(1) To remove the meter, proceed as follows:

(*a*) Remove the front panel and chassis assembly (*a* above).

(*b*) Remove the three screws on the flange that hold the meter to the front panel.

(*c*) Pull the meter out of the panel to expose the two wires on the back of the meter.

(*d*) To remove the meter glass, remove the 12 screws that hold the meter glass flange to the meter body.

Note. Do not attempt to repair the meter except for glass replacement. If the meter is defective, replace the entire meter. When replacing the meter, observe proper polarity when reconnecting the two wires on the back of the meter.

(2) To reassemble and install meter M1, reverse the disassembly procedures given in (1) above.

i. Potentiometer Plate (fig. 19).

(1) To remove the potentiometer plate, proceed as follows:

(*a*) Remove the front panel and chassis assembly (*a* above).

(*b*) Remove the mounting screws from the tapped holes in the panel casting.

(2) To reassemble and install the potentiometer plate, reverse the disassembly procedure given in (1) above.

j. Tube Chassis (*Internal*).

(1) To remove the internal parts of the tube chassis, proceed as follows:

(*a*) Remove the front panel and chassis assembly (*a* above).

(*b*) Remove the potentiometer (*i* above).

(*c*) Remove the terminal boards (*b* above).

(*d*) Remove the tube chassis (*d* above).

(*e*) Remove the power transformer and power supply filters (*e* above).

(*f*) Remove the control knobs (*f* above).

(*g*) Remove the five packing glands from the panel casting (fig. 19) and pull the leads through the panel to allow ample slack.

(*h*) Lift the tube chassis from the casting. Be careful to avoid damaging the wires connected to the chassis.

Note. Before reassembly, inspect the O-rings in back of the packing glands (fig. 19) and those surrounding the shafts of the four front panel controls for cracking, peeling, or signs of deterioration. Replace these O-rings if necessary.

(2) To reassemble and install the internal parts of the tube chassis, reverse the disassembly procedure given in (1) above.

k. Potentiometers.

(1) To remove potentiometers proceed as follows:

(*a*) Remove the front panel and chassis assembly (*a* above).

(*b*) Remove the potentiometer plate (*i* above).

(*c*) Remove the hexagonal nut that holds the potentiometer to the potentiometer plate.

(*d*) Unsolder the wires that are connected to the potentiometer. Tag each wire so that there is no possibility of misconnection when replacing the potentiometer.

(2) To reassemble and install potentiometers, reverse the disassembly procedure given in (1) above.

57. Rf Adapter and Probes, Disassembly

a. Rf Adapter, Disassembly.

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

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

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

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

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

(*e*) Use a small pointed tool, such as an awl, and 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.

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

(*g*) 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.

(2) *Rf adapter, assembly.*

(*a*) Reassemble the rf adapter in the reverse order of disassembly given in (1) above. 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. Damage will result.

(*b*) 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.

(*c*) 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).

b. Dc Probe, Disassembly.

(1) To disassemble the dc probe, proceed as follows (fig. 21):

(*a*) Unscrew the probe tip by turning it counterclockwise.

(*b*) 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.

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

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

(2) Reassemble the dc probe in reverse order of disassembly given in (1) above. 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 it snugly. Use a pair of pliers, to insure good mechanical connection between the probe tip and the loop wire. Avoid damaging the probe tip when tightening.

c. COMMON and OHMS Probes and Ac PROBE, Disassembly.

(1) The construction of the AC PROBE and the COMMON and OHMS probes is identical, except that the AC PROBE contains precision resistor R1. To disassemble these probes, proceed as follows:

(*a*) Unscrew the probe tips.

(*b*) Slide the barrels back on their leads.

Note. When replacing resistor R1, use an exact replacement part.

(2) To reassemble and install COMMON and OHMS probes and the AC PROBE, reverse the disassembly procedure given in (1) above.

58. 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

Note. Electronic Multimeter TS–505A/U is calibrated during manufacture. After calibration, the calibration controls are locked in place and recalibration is not required unless tubes are replaced or it is definitely known that adjustments must be made.

59. Calibration of Dc Voltage Measuring Scales

a. Removal of Cover. In calibrating the multimeter it is necessary to remove the cover to expose the calibration controls. To do this, use the following procedure:

(1) Unscrew the six panel mounting bolts on the front panel (fig. 5).

(2) Slide the panel assembly out of the back cover. The potentiometer plate is on the top side of the multimeter (fig. 16).

b. Warm-Up Procedure. Connect the AC LINE cord plug of the multimeter into the power line socket (98–132 v, single phase, 50 to 1,000 cps). Turn the FUNCTION switch to the +dc position and allow the multimeter to warm up from 10 to 15 minutes.

c. Adjustment for Zero Deflection.

(1) Set the ZERO ADJ. control to its mechanical center.

(2) Connect the DC and COMMON probe tips together.

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

(4) Loosen the locknut on coarse zero adjustment control R18 (fig. 24).

(5) Turn coarse zero adjustment control R18 to the right or left a quarter of a turn. Wait one minute for a meter pointer indication because the action of this control is sluggish.

(6) Turn the control for further resetting as necessary. Wait one minute between each setting. Turn control R18 until meter pointer is within one-half scale division of zero.

(7) Tighten the locknut on control R18. Be careful not to disturb the setting of the control.

(8) Set the meter pointer to zero reading by turning the ZERO ADJ. control on the front panel.

Note. If the meter pointer cannot be set at zero by rotating the ZERO ADJ. control on the front panel, refer to item 3, paragraph 54, for corrective procedure.

d. Adjustment for Full-Scale Deflection.

(1) Leave the FUNCTION switch on the +dc position and the RANGE switch on the 2.5 V–RX1 position.

(2) Loosen the locknut on dc calibration control R10.

(3) Apply 2.5 volts dc ±1 percent across the DC and COMMON probes. Use Meter Test Equipment AN/GSM–1B as the voltage source.

(4) Turn dc calibration control R10 and wait one minute for a meter indication. The meter pointer should read full-scale deflection when correct adjustment has been made.

(5) When procedure indicated in (1) through (4) above is complete, disconnect the probes from the power source.

(6) Tighten the locknut on dc calibration control R10. Be careful not to disturb the setting of the control.

Note. If the meter pointer cannot be set to full-scale deflection after the resetting of dc calibration control R10, refer to item 4, paragraph 54, for corrective procedure.

60. Calibration of Dc Voltage, Zero Center Scale

Note. To prepare the multimeter for calibration refer to paragraph 59*a* and *b*.

a. Adjustment for Zero Centering.

(1) Turn the FUNCTION switch to the ±dc position. Turn the RANGE switch to the 2.5 V–RX1 position.

(2) Connect the DC and COMMON probe tips together.

(3) Loosen the locknut on zero centering control R6 (fig. 24).

(4) Turn the zero centering control R6 and wait one minute for a meter indication. The meter pointer should rest in the center of the scale.

(5) Turn the zero centering control R6 until the meter pointer rests in the center of the scale. Wait one minute between each setting because the control R6 is sluggish.

(6) Tighten the locknut on zero centering control R6. Be careful not to disturb the setting of the control.

Note. If the meter pointer cannot be set at the center of the meter scale, refer to item 7, paragraph 54, for corrective procedure.

b. Adjustments. There are no adjustments for full-scale deflection.

61. Calibration of Ac Voltage Measuring Scales

Note. To prepare the multimeter for calibration, refer to paragraph 59*a* and *b*.

a. Adjustment for Zero Deflection.

(1) Turn the FUNCTION switch to the ac position. Turn the RANGE switch to the 2.5 V–RX1 position.

(2) Set the ZERO ADJ. control to its mechanical center.

(3) Connect the AC PROBE tip and the COMMON probe tip together.

(4) Loosen the locknut on ac zero adjustment control R45.

(5) Turn adjustment control R45 to the right or left, one-quarter of a turn. Wait one minute for a meter pointer indication, because the action of this control is sluggish.

(6) Turn the adjustment control until the meter pointer is within one half scale division of zero. Wait one minute between each setting of the adjustment control.

(7) Tighten the locknut on adjustment control R45. Be careful not to disturb the setting of the control.

(8) Set the meter pointer to zero reading by turning the ZERO ADJ. control on the front panel.

b. Adjustment for Full Scale Deflection.

(1) Leave the FUNCTION switch on ac and turn the RANGE switch to the 5 V–RX10 position.

(2) Loosen the locknut on ac calibration control R12.

(3) Apply 5 volts ac at 60 cps ± 1 percent across the AC PROBE and the COMMON probe points. Use Meter Test Equipment AN/GSM–1B as the voltage source.

(4) Turn ac calibration control R12 and wait one minute for a meter indication. Meter pointer should read full scale deflection when correct adjustment has been made.

(5) When procedure indicated in (1) through (4) above is complete, disconnect the probes from the power source.

(6) Tighten the locknut on ac calibration control R12. Be careful not to disturb the setting of the control.

Note. If the meter pointer cannot be set to full-scale deflection after the resetting of ac calibration control R12, refer to item number 20, paragraph 54, for corrective procedure.

62. Calibration of Resistance Scale

Note. To prepare the multimeter for calibration refer to paragraph 59*b*.

a. Adjustment for full-scale deflection is as follows:

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

(2) Adjust the meter pointer to ∞ by turning the OHMS ADJ. control on the front panel.

b. Adjustment is made for zero deflection for each scale when the equipment is in use. No single adjustment will calibrate all the resistance scales. Refer to paragraph 20 for this procedure.

Note. If the meter pointer cannot be set for full-scale or zero deflection of the resistance scales, refer to item numbers 23, 24, and 25, paragraph 54, for corrective procedure.

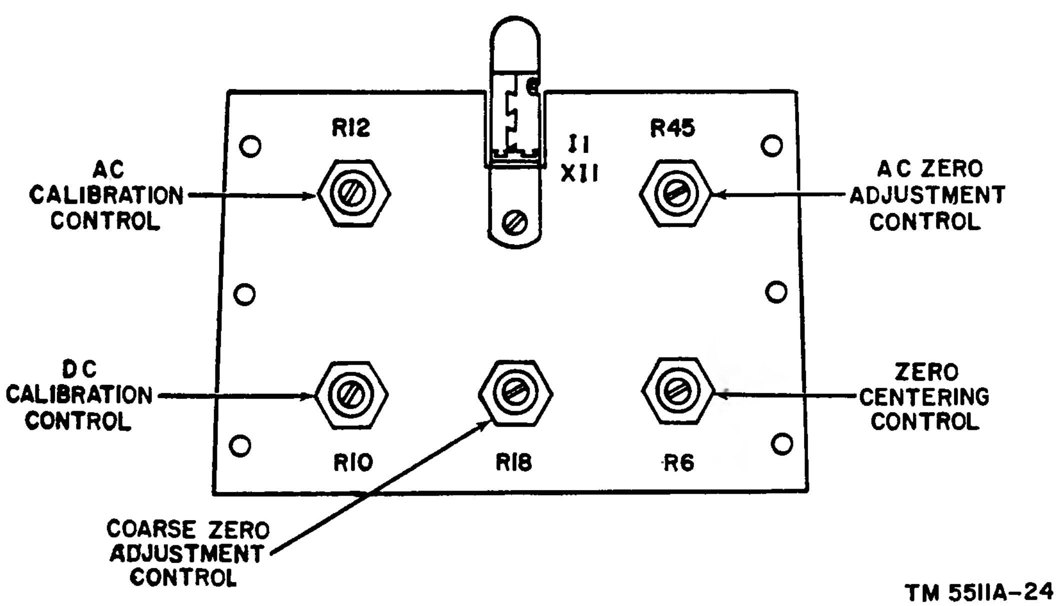


Figure 24. Electronic Multimeter TS–505A/U, calibration adjustment controls.

Section IV. FINAL TESTING

63. General

This section may be used as a guide in determining the quality of a repaired Electric Multimeter TS–505A/U. The minimum test requirements outlined in paragraphs 65 through 68 may be performed by maintenance personnel with adequate test equipment and the necessary skills. Repaired equipment meeting these requirements will furnish uniformly satisfactory operation.

64. Test Equipment Required for Final Testing

The following test equipment is required for final testing of Electric 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
Resistor Decade ZM–16/U	TM 11–5102

65. Testing Dc Voltage Measurement Circuit

a. Connect the multimeter, set the controls, and zero adjust the meter pointer as described in paragraph 15.

b. Apply 2.5 volts dc ±1 percent across the DC and COMMON probes. The meter pointer should read full scale within ±5 percent.

c. Repeat the procedure given in *b* above for each position of the RANGE switch and apply maximum voltage for each range setting (5 v. on the 5 V–RX10 position, 10 v. on the 10 V–RX100 position, etc.). In all instances, the meter pointer should read full scale ±5 percent.

66. Testing Rf Adapter

Note. Test the dc voltage measurement circuit as described in paragraph 65 before attempting to test the rf adapter.

a. Connect the multimeter, set the controls, and adjust the meter pointer as described in paragraph 18.

b. Plug the dc probe tip into the end of the rf adapter.

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

d. Repeat the procedure given in *c* above for the 5 V–RX10, 10 V–RX100, and 25 V–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 percent.

e. Turn the RANGE switch to the 50 V–RX10K position and apply 40 volts ±1 percent at 5 mc between the rf adapter tip and the alligator clip. The meter pointer should read 40 volts ±3 volts.

67. Testing Ac Voltage Measurement Circuit

a. Connect the multimeter and zero adjust the meter pointer as described in paragraph 17.

b. Turn the RANGE switch to the 2.5 V–RX1 position.

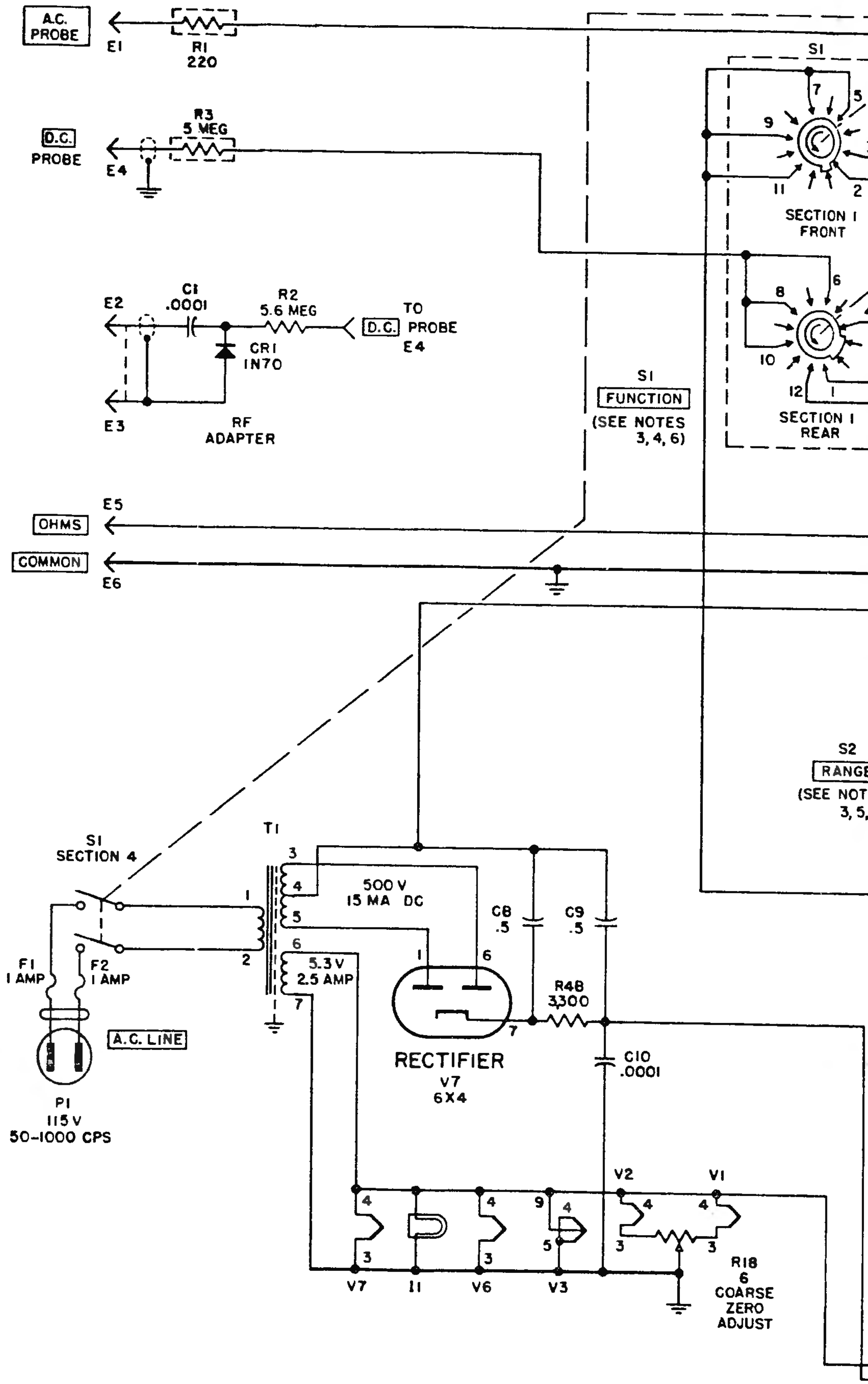
c. Apply 2.5 volts ±1 percent at 60 cps across the AC PROBE and COMMON probe. The 60 cps must have less than .5 percent distortion. The meter pointer should read full scale ±6 percent.

d. Repeat the procedure given in *c* above for the following positions of the RANGE switch: 5 V–RX10, 10 V–RX100, 25 V–RX1000, 50 V–RX10K, 100 V–RX100K, 250 V–RX1M. Apply maximum voltage for each range setting. In all instances, the meter pointer should read full scale ±6 percent.

68. Testing Ohmmeter Circuit

a, Connect the multimeter and adjust the meter pointer as described in paragraph 20.

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


A.C. PROBE
E1
R1 220
R3 5 MEG
D.C. PROBE
E4
S1
SECTION 1 FRONT
C1 .0001
R2 5.6 MEG
E2
CR1 1N70
TO D.C. PROBE E4
E3
RF ADAPTER
S1 FUNCTION (SEE NOTES 3, 4, 6)
SECTION 1 REAR
E5
OHMS
COMMON
E6
S2
RANGE
S1 SECTION 4
T1
500 V 15 MA DC
C8 .5
C9 .5
F1 1 AMP
F2 1 AMP
5.3 V 2.5 AMP
R48 3,300
A.C. LINE
RECTIFIER V7 6X4
C10 .0001
P1 115 V 50-1000 CPS
V2
V1
V7
I1
V6
V3
R18 6 COARSE ZERO ADJUST

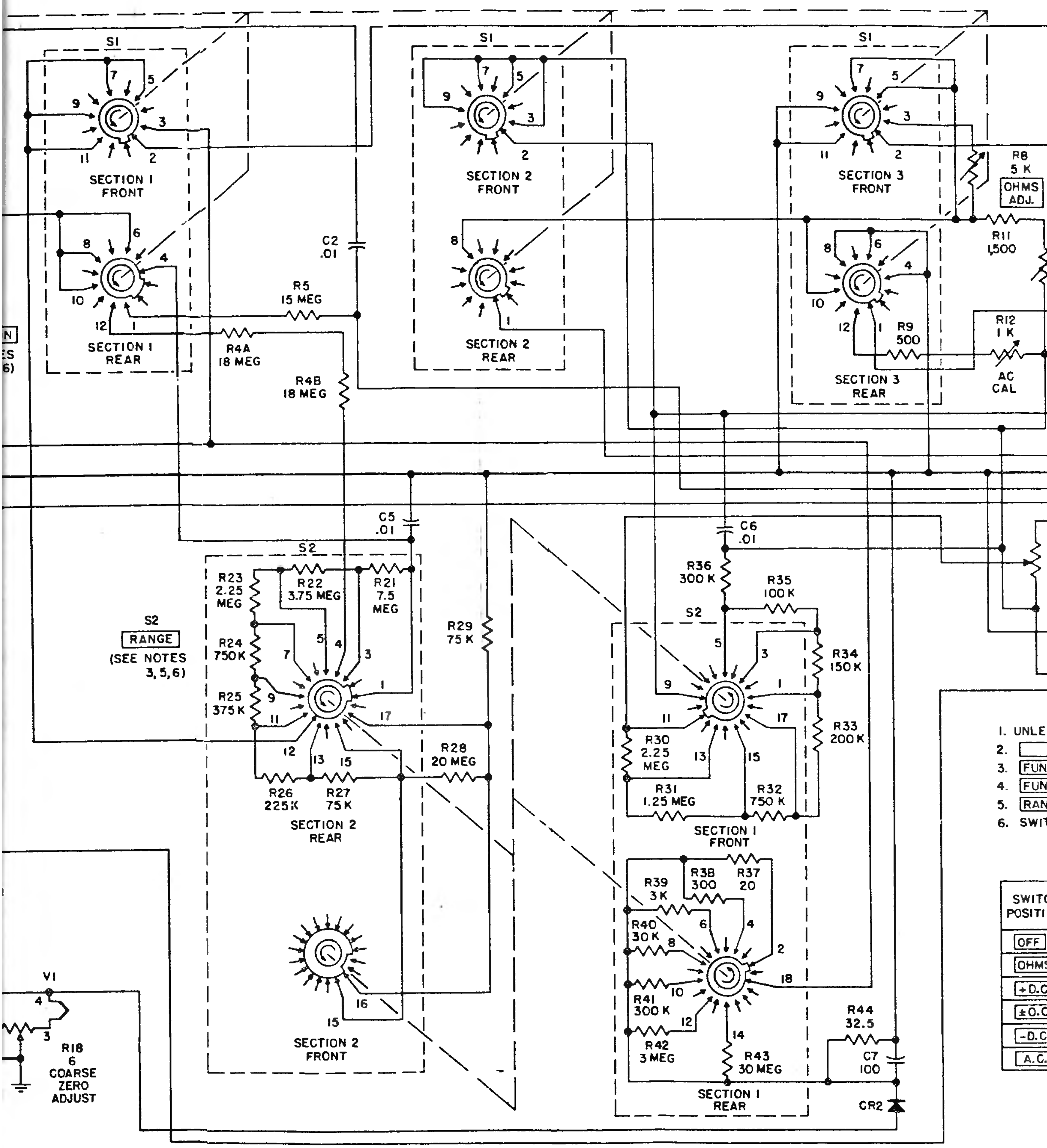
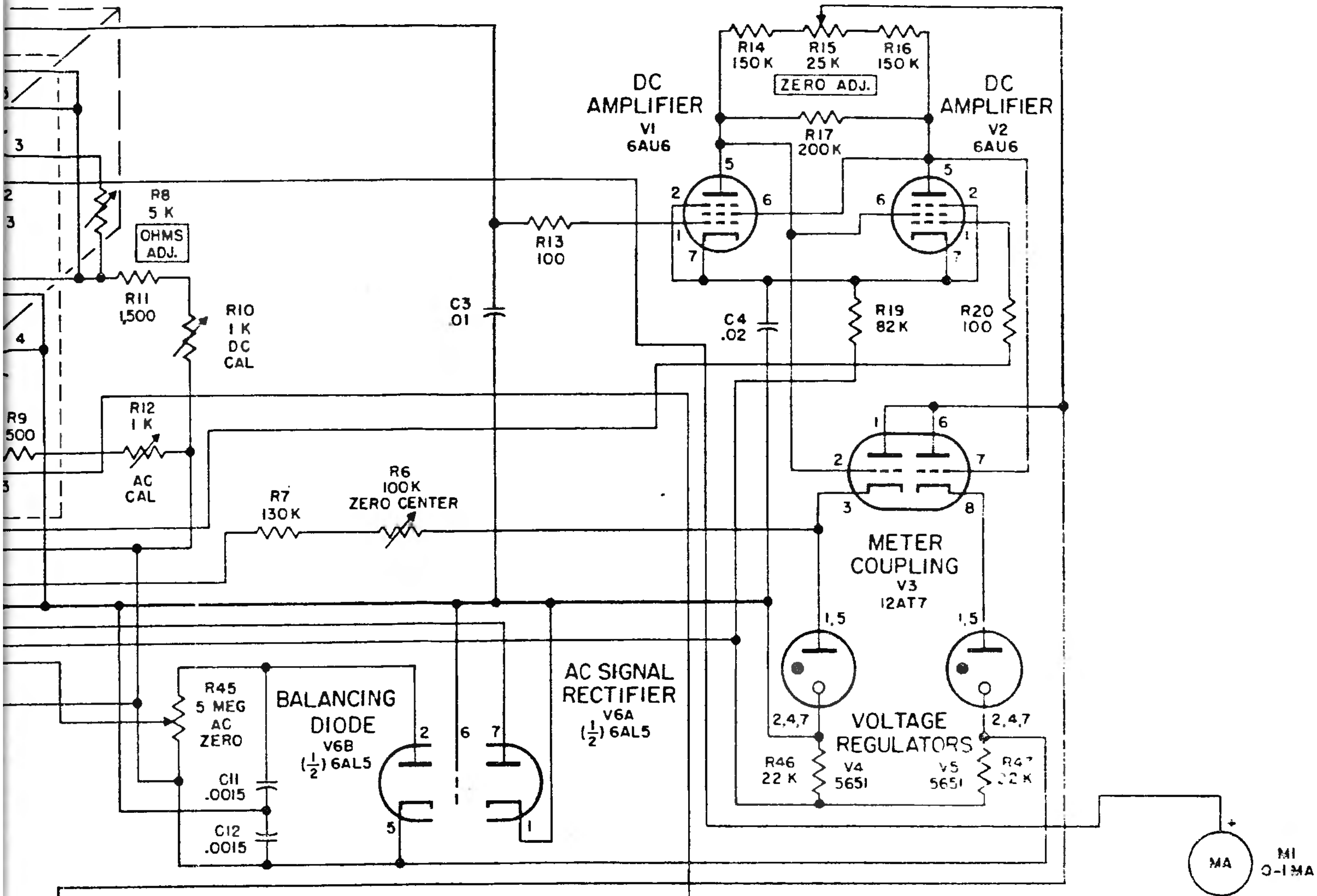


Figure 27. Electronic Multimeter TS–505A/U, schematic diagram.



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

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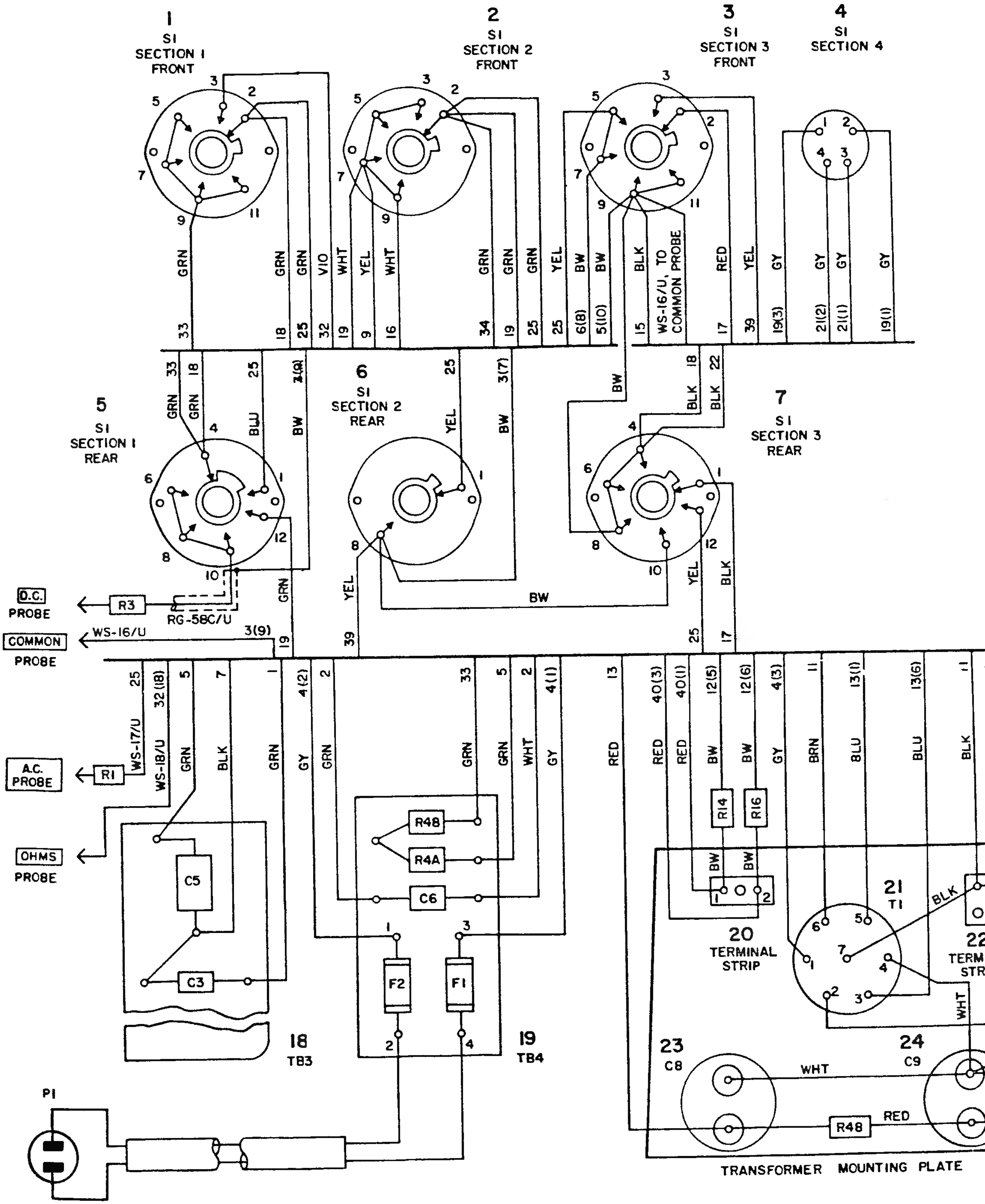
gram.


1
S1
SECTION 1
FRONT
2
S1
SECTION 2
FRONT
3
S1
SECTION 3
FRONT
4
S1
SECTION 4
5
S1
SECTION 1
REAR
6
S1
SECTION 2
REAR
7
S1
SECTION 3
REAR
D.C.
PROBE
R3
RG-58C/U
COMMON
PROBE
WS-16/U
WS-16/U, TO
COMMON PROBE
A.C.
PROBE
R1
WS-17/U
WS-18/U
OHMS
PROBE
C5
C3
18
TB3
R48
R4A
C6
F2
F1
19
TB4
P1
R14
R16
20
TERMINAL
STRIP
21
T1
22
TERM
STR
23
C8
24
C9
R48
TRANSFORMER MOUNTING PLATE

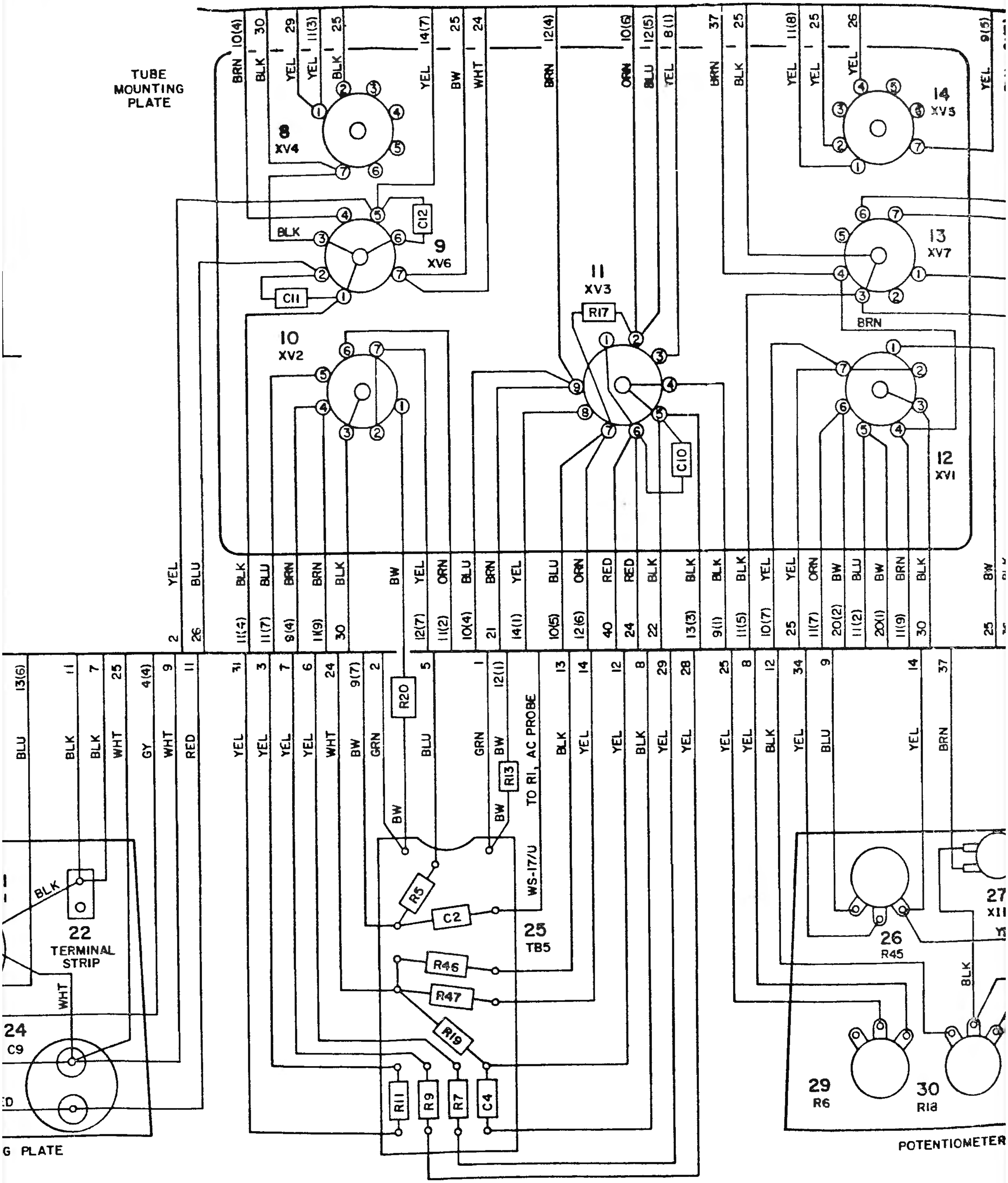
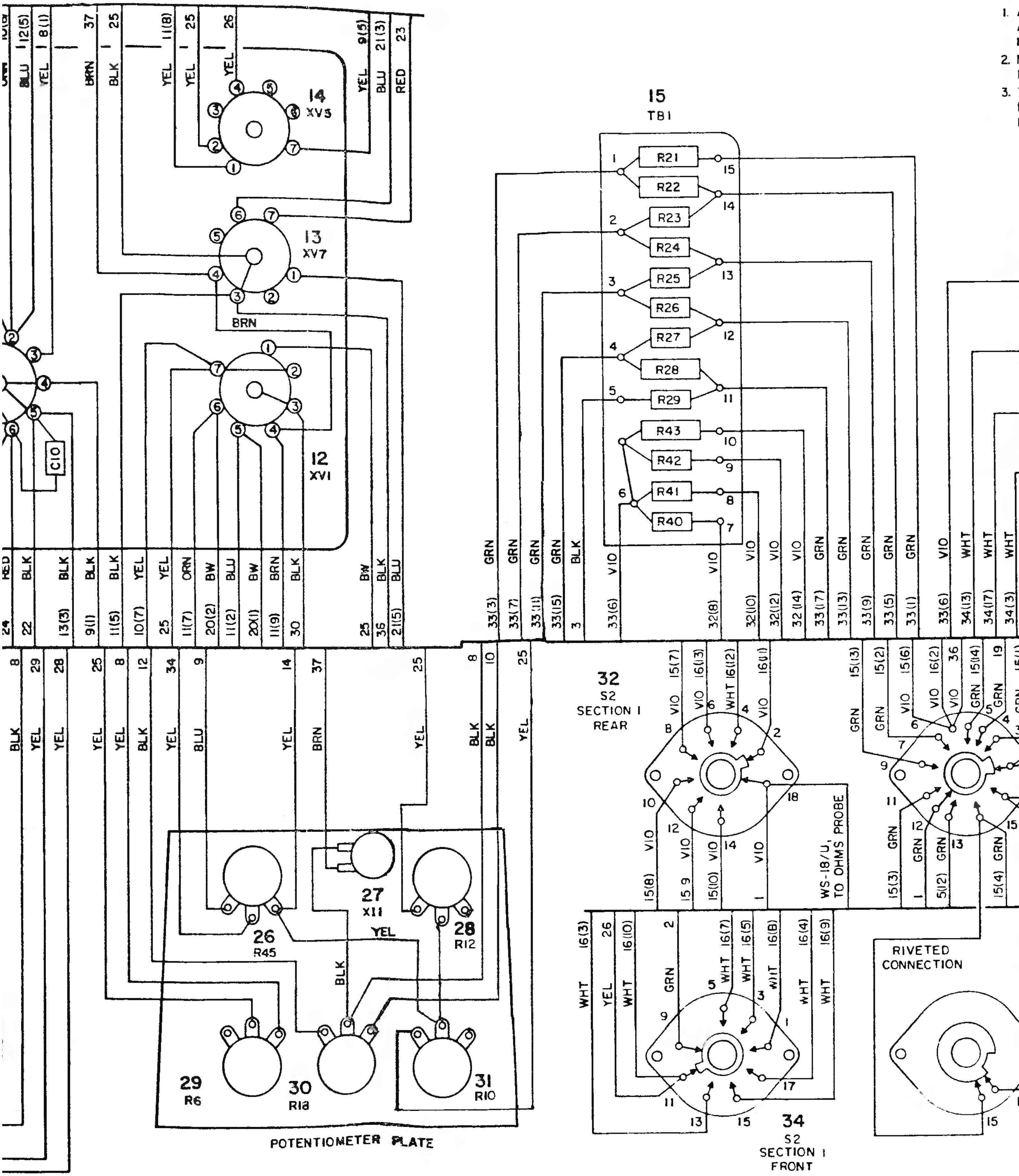


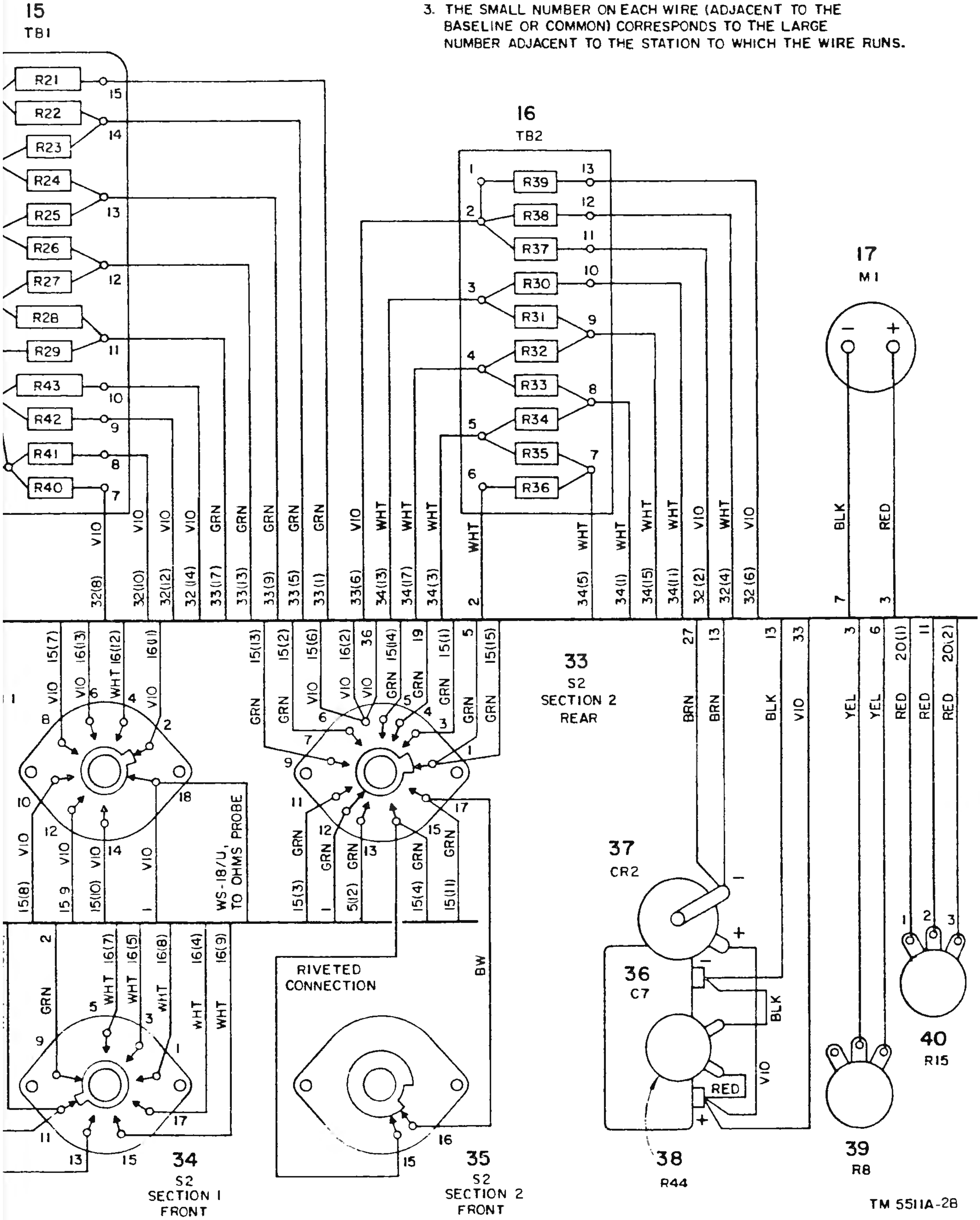
Figure 28. Electronic Multimeter TS–505A/U, wiring diagram.



nic Multimeter TS–505A/U, wiring diagram.

NOTES

1. ALL TERMINAL NUMBERS EXCEPT THOSE OF T1 ARE ARBITRARILY ASSIGNED TO ASSIST IN IDENTIFYING WIRES.
2. NUMBERS IN PARENTHESIS NOTED ON CERTAIN WIRES INDICATE SPECIFIC TERMINAL CONNECTIONS.
3. THE SMALL NUMBER ON EACH WIRE (ADJACENT TO THE BASELINE OR COMMON) CORRESPONDS TO THE LARGE NUMBER ADJACENT TO THE STATION TO WHICH THE WIRE RUNS.



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