TECHNICAL MANUAL
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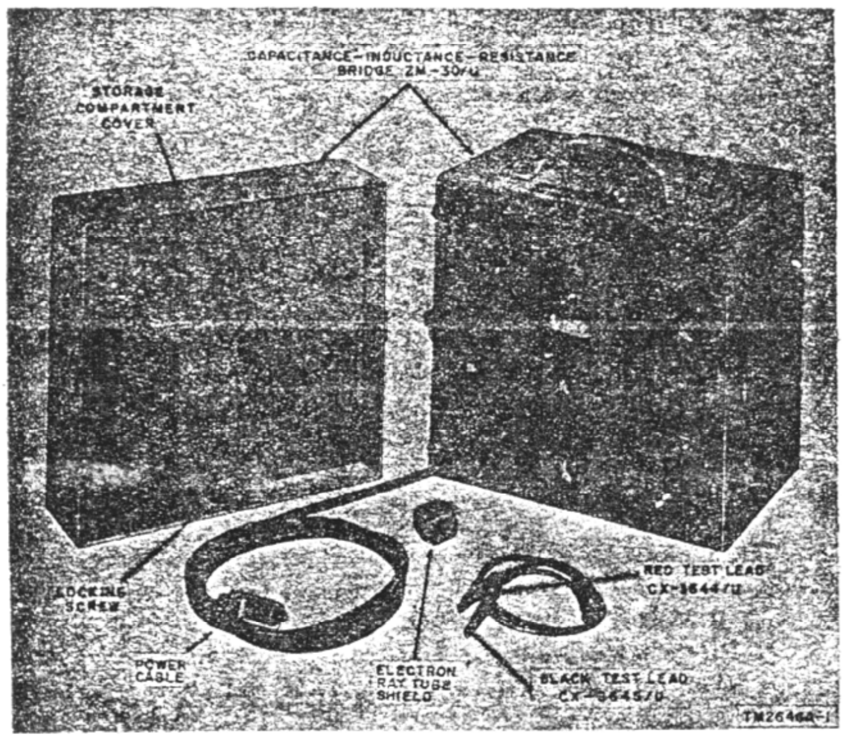
CAPACITANCE – INDUCTANCE – RESISTANCE TEST SET AN/URM-90


CAPACITANCE-INDUCTANCE-RESISTANCE
BRIDGE ZM-30/U
STORAGE
COMPARTMENT
COVER
LOCKING
SCREW
POWER
CABLE
ELECTRON
RAY TUBE
SHIELD
RED TEST LEAD
CX-3644/U
BLACK TEST LEAD
CX-3645/U

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Scope

a. This manual contains the information necessary to install, operate, maintain, and repair Capacitance-Inductance-Resistance Test Set AN/URM-90.

b. Forward all comments on this manual to the Commanding Officer, The Signal Corps Publications Agency, Fort Monmouth, New Jersey.

2. Forms and Records

a. Unsatisfactory Equipment Reports.

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

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

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

c. Preventive Maintenance Forms.

(1) DA Form 11–238, Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 13).

(2) DA Form 11–239, Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 14).

Section II. DESCRIPTION AND DATA

3. Purpose and Use

Capacitance-Inductance-Resistance Test Set AN/URM-90 is a self-contained instrument used in electrical and electronic work where the values and characteristics of resistors, capacitors, and inductors must be accurately measured. The test set is used to make direct measurements of resistance, capacitance, inductance, dissipation factors of capacitors, and the storage factors of inductors.

4. Technical Characteristics

Input voltage	115 volts ac.
Input frequency	50 to 1,000 cps.
Phase	Single.
Power consumed	18 watts.
Fuse rating	3 amperes.
Tubes (number and function)	One 12AT7 oscillator-amplifier (V1). One 6U5 electron ray tube (V2). One 12AX7 amplifier (V3).
Internal oscillator frequency	1,000, ±10 cps.
Operating frequency range	100 to 10,000 cps.
Internal detectors:	
Ac measurements	Type 6U5 electron ray tube (V2).
Dc measurements	Galvanometer.
Galvanometer data:	
Range	7.5 to 0 to 7.5 microamperes.
Accuracy (full-scale)	20%.
Internal resistance	1,000 ohms.
Ranges:	
Resistance	0.1 milliohm to 11 megohms.
Capacitance	0.1 uuf to 1,100 uf.
Inductance	0.1 microhenry to 1,100 henrys.
Dissipation factor (R/X, or D)	0.001 to 1.05.
Storage factor (X/R, or Q)	0.02 to 1,000.
Accuracy: (effective only for normal conditions of operation, heat, and humidity).	
Resistance	±(.15% + 1 division on the LRC inner dial).

Capacitance	....	±(.5% + 1 division on the LRC inner dial).
Inductance	....	±(1% + 1 division on the LRC inner dial).
Dissipation factor (D)	...	Expressed in terms of its reciprocal Q, ±(5% + .0025) for capacitance values greater than .01 uf.
Storage factor	....	Expressed in terms of its reciprocal D, ± (5% + .0025).

5. Common Names

The following common names have been assigned to nomenclatured items to simplify test material.

Nomenclature	*Common name*
Capacitance-Inductance-Resistance Test Set AN/URM-90	Test set
Capacitance-Inductance-Resistance Bridge ZM-30/U	Bridge
Red Test Lead CX-3644/U	Red test lead
Black Test Lead CX-3645/U	Black test lead
Electron ray tube shield	Tube shield

6. Components

(fig. 1 and 2)

The components listed below are supplied as part of Capacitance-Inductance-Resistance Test Set AN/URM-90. This list is for general information only. Refer to appropriate supply publications for information pertaining to requisition of spare parts.

Component	Required No.	Height (in.)	Width (in.)	Depth (in.)	Weight (lb)
Capacitance-Inductance-Resistance Bridge ZM-30/U	1	10½	11½	11	20¾
Red Test Lead CX-3644/U	1		19 lg		
Black Test Lead CX-3645/U	1	(elliptical)	19 lg.		
Electron ray tube shield	1				
Allen set screw wrenches No. 8	2				
Allen set screw wrenches No. 10	2				
Set of spare parts consisting of:	1				
Electron tube, 12AX7	1				
Electron tube, 12AT7	1				
Electron ray tube, 6U5	1				
Fuses (3-ampere)	4				
Pilot Lamps LM-52	3				

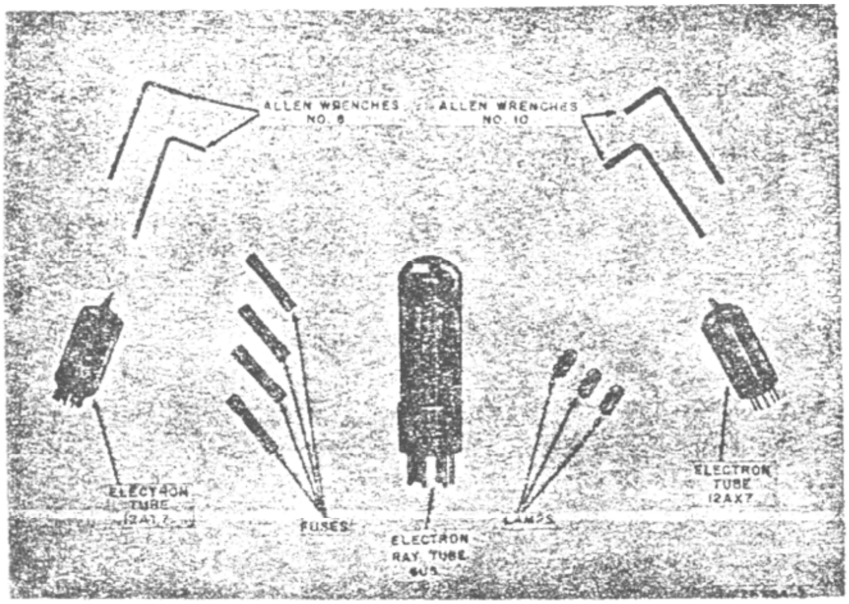


Figure 2. Tools and spare parts of Capacitance-Inductance-Resistance Test Set AN/URM-90.

7. Description of Test Set

(fig. 1)

a. Bridge. Capacitance-Inductance-Resistance Bridge ZM-30/U is housed in an aluminum case which has a detachable case cover. All controls are located and identified on the front panel. A carrying handle is mounted on the top of the case. The detachable cover, which protects the operating controls when the test set is not in use, contains a storage compartment for the spare parts, tools, and minor components supplied with the test set.

b. Test Leads. There are two test leads, 19 inches long; one colored red the other colored black, for identification purposes. One end of each test lead is terminated with a pin incased in a colored (red or black) plastic case. The other ends are provided with alligator clips partially incased in a protective plastic case.

c. Tube Shield. The tube shield is round and made of black anodized aluminum. One end is angled slightly to provide a more effective shield against outside light when making measurements. The relatively short over-all length (1⅛ inches) allows the tube shield to remain in place, around the electron ray tube, when the case cover is attached.

d. Tools. Special tools (fig. 2), two No. 8 and two No. 10 Allen wrenches, are supplied with the test set for disassembly purposes.

8. Additional Equipment Required

The following equipments are *not* supplied with the test set, but are required to perform some of the tests listed in chapter 3.

Additional equipment	Use	Technical manual
Audio Oscillator TS–382/U	External generator for frequencies other than 1,000 cycles per second.	TM 11–2684
Headset (Navy type head-set CW–49507, Signal Corps stock No. 2B955)	Audio detector for ac measurements.	
Voltmeter ME–30A/U	Meter detector for ac measurements.	
Multimeter TS–297/U	Milliammeter for current measurements.	TM 11–5500
Laboratory Standard AN/URM–2	Standard precision capacitors and inductors for ac measurements.	
Decade Resistor TS–679A/U	Calibrated decade resistor for extending D–Q range of bridge and for use when measuring paralleled capacitance and resistance of a capacitor.	TM 11–5520

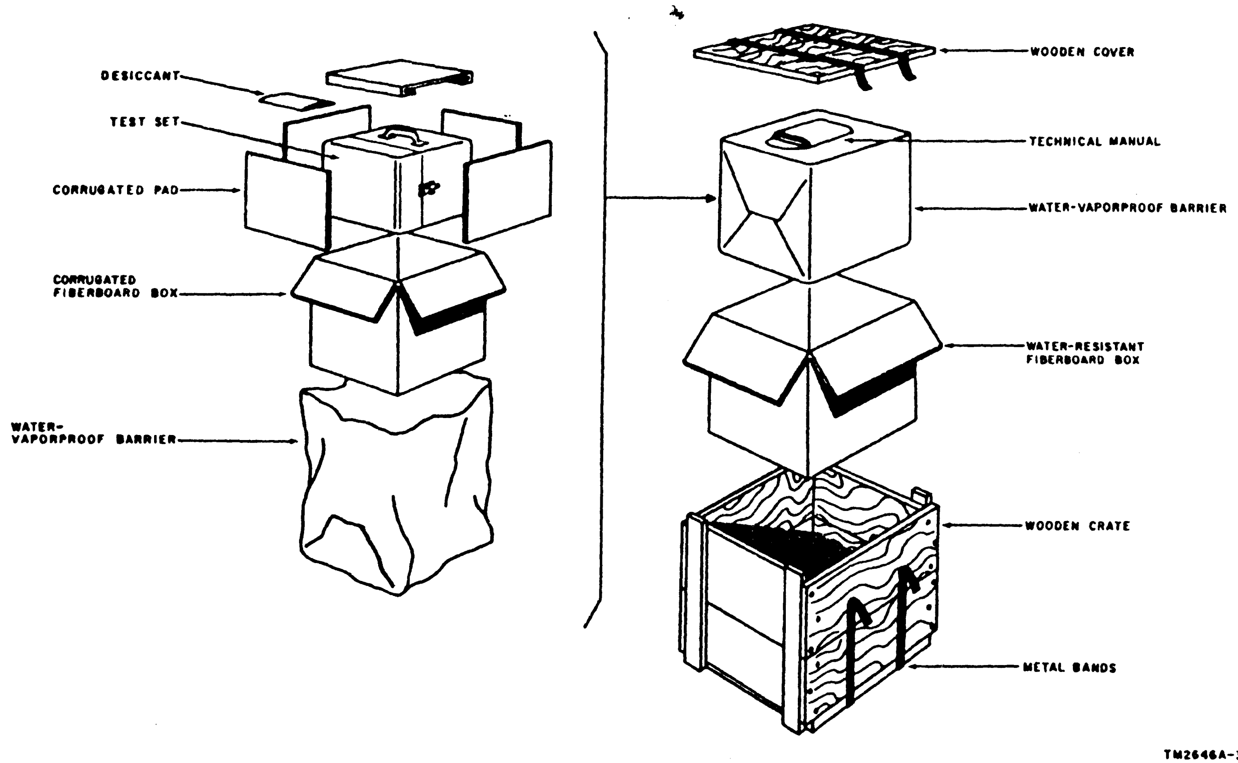


Figure 3. Capacitance-Inductance-Resistance Test Set AN/URM-90, packaging diagram.

CHAPTER 2

INSTALLATION

9. Uncrating and Unpacking New Equipment

a. Packaging Data (fig. 3). The tools, spare parts, and accessories furnished with each test set are wrapped and packed in the compartment on the inside of the test set cover. The test set is packed in a sealed corrugated fiberboard carton, wrapped in water-vaporproof barrier material and packed in a second water-resistant fiberboard carton. The sealed package is then packed in a nailed wooden crate. Test sets packed for export shipment are strapped with metal bands; test sets packed for domestic shipment are not strapped. The shipping package, before it is unpacked, is 22 inches high, 14 inches wide, 10 inches deep; has a volume of 1.8 cubic feet; and weighs 57 pounds.

b. Removing Contents.

Caution: Be extremely careful when unpacking the test set. Do not thrust tools into the container. Damage may result. The test set is a precision instrument and mishandling can easily cause damage to the equipment.

(1) Cut the metal bands at a point just below the wooden crate cover.

(2) Use a nail puller and remove the nails from the crate cover.

(3) Remove the wooden cover and take out the water-resistant fiberboard box. Cut through its three upper edges. The uncut edge will act as a hinge.

(4) Remove the set inclosed in the water-vaporproofed barrier from the fiberboard box. Loosen the water-vaporproofed barrier by cutting as close to the seal as possible.

(5) Carefully remove the barrier and open the inner carton by cutting its three upper edges.

(6) Take the corrugated pads and desiccant from around the test set and remove the test set from the corrugated fiberboard box.

10. Checking

a. Place the test set on a work bench and inspect its case for external damage.

b. Unlatch the two spring catches on the side of the test set and remove the case cover (fig. 1).

c. Examine the front panel for possible damage to controls, knobs, and galvanometer.

d. Open the storage compartment cover by loosening the locking screw and raising the cover.

e. Check the bridge and contents of the storage compartment with the master packing slip.

11. Installation of Equipment

a. Place the test set on a firm support, such as a bench or table, so that the controls on the front panel are convenient to the operator.

b. Connect the power cable to a power source of 115 volts alternating current (ac), 50 to 1,000 cycles per second, (CPS).

c. If the test leads are to be used, connect them to the appropriate pair of binding posts for the type of measurement to be made (fig. 1). (Regardless of the pair of binding posts used, connect the red test lead to the red binding post and the black test lead to the black binding post.)

d. Push the flat edge of the tube shield into the panel cut out around the electron ray tube.

12. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraphs 9 and 10 for uncrating, unpacking, and checking the equipment.

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

c. Perform the installation and connection procedures given in paragraph 11.

CHAPTER 3

OPERATION

Section I. CONTROLS AND INSTRUMENTS

Note. Haphazard operation or improper setting of the switches and controls can damage the bridge. For this reason, it is important to know the function of every control. Detailed operation of the bridge is discussed in paragraphs 17 through 44.

13. General

The controls of the test set (fig. 4) are listed and described in paragraphs 14 and 15 below. The functions of the bridge ratio dials and switches (CIRCUIT SELECTOR and Q, D–Q, & R DIAL MULTIPLIER, LRC DIAL MULTIPLIER, LRC dial, and the D and D–Q dial) are outlined in paragraph 14. The remaining controls and instruments are listed in paragraph 15. Binding posts and their uses are described in paragraph 16.

14. Bridge Ratio Dials and Switches and Their Uses

(fig. 4)

a. Circuit Selector Switch. The CIRCUIT SELECTOR AND Q, D–Q, & R DIAL MULTIPLIER (circuit selector switch) is a three-section, six-position switch of make-before-break type. The switch provides a method of altering the bridge circuitry for selection of the specific type bridge (Wheatstone, Maxwell, Hay, or capacitance) required for the measurement to be made. In addition, the circuit selector switch selects the proper test range for a particular bridge arm, consistent with the approximate value of the unknown component. A table of the circuit selector switch positions and their uses follows:

Circuit selector switch		Resultant bridge circuit	Electrical measurement	Read
Circuit indication (ckt)	Dial setting			
L	D–Q x 1	Maxwell inductance bridge.	Measures inductance of inductors having storage factors (Q) between .2 and 10.5.	Read inductance in henries from LRC dial and L reading on LRC DIAL MULTIPLIER.
L	Q x 100	Hay inductance bridge.	Measures inductance of inductors having storage factors (Q) between 9.5 and 1,000.	
R	R x 1	Wheatstone resistance bridge.	Measures resistance from 1 milliohm to 1.1 megohm.	Read resistance from LRC dial and R reading on LRC DIAL MULTIPLIER.
R	R x 10	Wheatstone resistance bridge.	Measures resistance from 1 megohm to 11 megohms.	
C	D–Q x .01	Capacitance bridge.	Measures capacitance of capacitors having dissipation factors (D) between .001 and .105.	Read LRC dial and C reading on LRC DIAL MULTIPLIER.
C	D–Q x 0.1	Capacitance bridge.	Measures capacitance of capacitors having dissipation factors (D) between .1 and 1.05.	

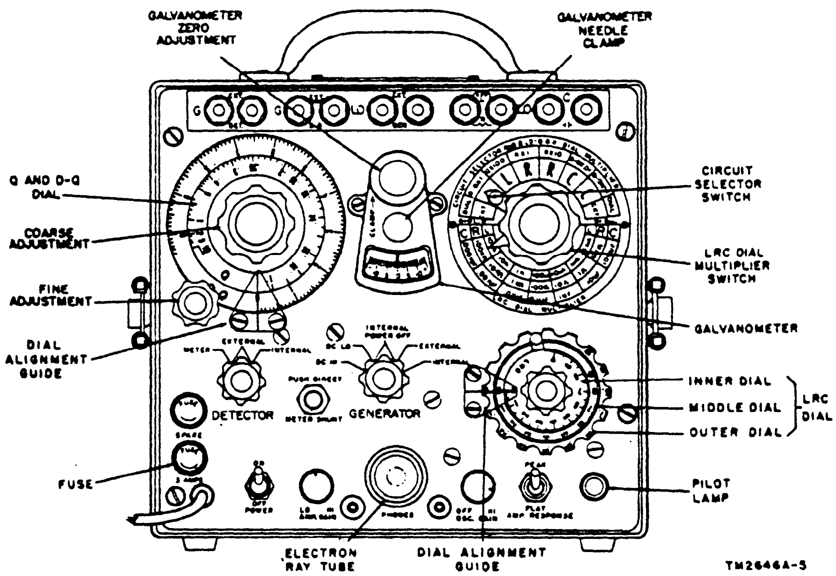


Figure 4   Bridge, showing front panel controls.

b. LRC DIAL MULTIPLIER. The LRC DIAL MULTIPLIER is a seven-position switch that provides a means of selecting the proper ratio factor to achieve bridge balance for component measurements. The switch indication, therefore, operates as the multiplying factor for the LRC dial (*c* below). The following table lists the proper scale when measuring resistance, capacitance, and inductance:

Type measurement	Scale	Multiplier range
Resistance	Middle scale marked R	0.1Ω to 100k
Capacitance	Outer scale marked C	.0001 uf to 100 uf
Inductance	Inner scale marked L	0.1 mh to 100 h

c. LRC Dial. The LRC dial is a three-section switch that controls the bridge arm decade resistors and a series potentiometer. The resistance controlled by the dial forms one of the bridge arms and is proportionally indicated on the face of the dial by three concentric calibrated scales. The scales are marked in tens, tenths, and hundredths as follows:

Dial scale	Calibrated range	Resistance range (ohms)
Tens (outer dial)	0 to 10	0 to 10,000
Tenths (middle dial)	0 to .9	0 to 900
Hundredths (inner dial)	0 to .105	0 to 105

d. Q and D–Q Dial. The Q and D-Q dial simultaneously controls three potentiometers. However, the potentiometer actually included in the bridge circuit for any individual measurement is dependent upon the position of the circuit selector switch (*a* above). The scales and ranges of the dial are as follows:

Scale	Read	Calibrated range
D–Q (outer black scale)	D or Q	0 to 10.5
Q (inner red scale)	Q	.095 to 10

Note. The red scale readings are always multiplied by 100; the black scale readings may be multiplied by 1, .1, or .01. It depends on the dial setting of the circuit selector switch (*a* above).

15. Controls and Instruments and Their Uses

The following chart lists the switches, controls, and instruments of the test set, except those listed in paragraph 14, and indicates their functions.

Controls and instruments	Description and function
POWER switch	A two-position toggle switch. ON position: Connects power to the bridge. OFF position: Disconnects power from the bridge.
DETECTOR switch	A three-position rotary switch that selects the proper detection circuit depending upon the measurement being made as follows: METER position: Connects the bridge detection circuits directly to the galvanometer (M1). EXTERNAL position: Connects the bridge detection circuits directly to the EXT. DET. binding posts for use of external detector. INTERNAL position: Connects the bridge detection circuits directly to the test set amplifier and electron ray tube.

Controls and instruments	Description and function
METER SHUNT switch	A two-position push-type switch which when depressed to PUSH DIRECT position, connects galvanometer M1 for increased meter sensitivity.
GENERATOR switch	A five-position rotary switch that controls the voltage distribution in the test set as follows: DC HI position: Connects approximately 250 volts dc from the high-voltage power supply to the bridge network excitation circuit. DC LO position: Connects approximately 10 volts dc from the low-voltage power supply to the bridge network excitation circuit. INTERNAL POWER OFF position: Disconnects all operating voltages from the test set operating circuits. EXTERNAL position: Permits plate voltage to be applied to electron tubes V1, V2, and V3; the excitation circuit of the bridge network is connected directly to the EXT. GEN. binding posts to permit use of an external power source. INTERNAL position: Connects plate voltage to electron tubes V1, V2, and V3 and the 1,000-cycle excitation voltage from transformer T1 directly across the bridge network excitation circuit.
AMP. GAIN control	A potentiometer used to increase or decrease the amplitude of the detection signal.
OSC. GAIN control and switch	A potentiometer incorporating a two-position switch is used to increase or decrease the amplitude of oscillator voltage. OFF position: The switch opens the plate voltage circuit of the oscillator-amplifier circuit thereby disconnecting oscillator-amplifier (V1).
AMP. RESPONSE switch	A two-position toggle switch that functions as follows: FLAT position: Disconnects the filter network from the amplifier circuit. PEAK position: Connects the filter network to the amplifier circuit to sharpen null indication.

Controls and instruments	Description and function
GALVANOMETER	Used to indicate the degree of balance of the test set when making dc resistance measurements. A zero adjustment knob cap provides a means of mechanically centering the needle. The needle clamp in the center of the galvanometer provides a means of locking the meter needle in the centered position, when operated in the direction of the arrow molded in the case.
Electron ray tube	Indicates an ac null in the bridge when the DETECTOR switch is in the INTERNAL position and inductance and capacitance are being measured.
Pilot lamp	A red lamp that lights when power is applied to the test set power supply and extinguishes when power is disconnected.

16. Binding Posts, Jacks, and Their Uses

(fig. 5)

The following chart describes the binding posts and jacks of the test set and indicates their functions:

Binding posts or jacks	Description and function
PHONES (jacks)	The two jacks provide means for connecting Navy type Headset CW–49507 for aural detection purposes.
EXT. DET.	The two posts provide means for connecting external detecting devices such as Voltmeter ME–30A/U.
EXT. D–Q	The two posts are provided to allow the extension of D–Q range (par. 38*b*). (During normal test set operation, the binding posts must be shorted with a busbar.)
EXT. GEN.	The two posts are used to connect an external dc voltage source or Audio Oscillator TS–382/U to the bridge.
L and R	The two posts are used to connect an unknown inductor or resistor to the bridge for measurement.
C	The two posts are used to connect an unknown capacitor to the bridge for measurement.

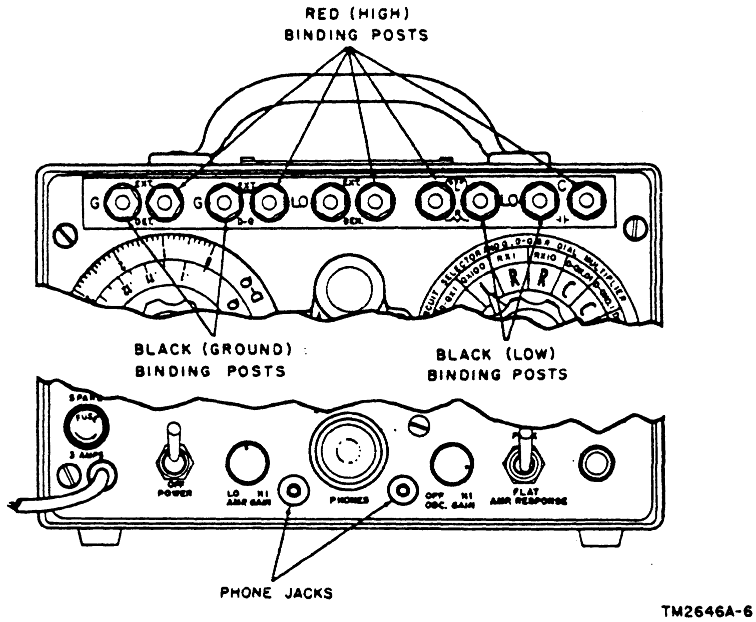


Figure 5. Bridge, showing binding posts and jacks.

Section II. OPERATION UNDER USUAL CONDITIONS

Note. Capacitance-Inductance-Resistance Test Set AN/URM–90 is a precision instrument designed for use under laboratory conditions. If the test set is used in areas of high humidity the accuracy of the instrument will be affected.

17. Starting Procedure

a. Push the POWER switch (fig. 4) to the ON position. The pilot lamp should light.

b. Turn the GENERATOR switch to the INTERNAL POWER OFF position.

c. Connect the particular component to be measured to the pair of binding posts, indicated by the test being performed (par. 18 through 44).

18. Dc Resistance Measurements

a. Lay the bridge on its back with the panel facing upwards and connect the unknown resistance (R_u) to the binding posts marked L and R (fig. 6). Release the galvanometer movement by moving the clamp in the direction opposite to that indicated by the arrow (fig. 4). If the galvanometer needle does not center, adjust it to zero as follows:

(1) Loosen the screw on the right-hand side of the galvanometer zero adjustment knob 1 full turn.

(2) Adjust the galvanometer zero adjustment knob until the needle indicates 0.

(3) Tighten the screw ((1) above).

b. Operate the circuit selector switch to the R and R x 1 position (fig. 6).

c. Operate the DETECTOR switch to the METER position.

d. Operate the GENERATOR switch to the DC LO position.

e. Adjust the LRC DIAL MULTIPLIER until the galvanometer needle is on scale with the least amount of deflection.

f. If the galvanometer needle cannot be adjusted to zero, place the circuit selector switch in the R and R x 10 position (fig. 7) and repeat the operation described in *e* above.

Note. If it is necessary to perform the procedure outlined in *f* above, the accuracy of the resistance measurement will be improved by operating the GENERATOR switch to the DC HI position before making the adjustments outlined in *e* above.

g. Beginning with the LRC dial set at 1.00 (outer dial set at 1., middle dial and inner dial each set on 0), adjust the outer dial until the galvanometer needle is as close to zero as possible. Adjust the middle dial until the galvanometer needle is closer to zero.

h. To make the final adjustment of the LRC dial, push in and hold the METER SHUNT switch and then adjust the inner dial until a zero reading is obtained on the galvanometer.

i. To obtain the value of the unknown resistor, multiply the LRC dial reading by the LRC DIAL MULTIPLIER setting and, if the circuit selector switch has been set at R and R x 10, multiply the product by 10. Refer to examples 1 and 2 below for the proper method of calculating measured resistance in each position of circuit selector switch.

Caution: Do not remove the resistor under measurement until the GENERATOR switch is turned to the INTERNAL POWER OFF position because damage may result to the galvanometer and internal resistors.

Example 1: Settings of controls in figure 6 are for the final balance positions of a dc resistance of .556 ohm. Observe and interpret the control readings as follows:

Circuit selector switch reads .... R and R x 1.
LRC DIAL MULTIPLIER reads .... 0.1Ω.
LRC dial reads .... 5.560.

Formula:

R_u = Circuit selector switch reading x
LRC DIAL MULTIPLIER reading x
LRC dial reading

Substituting:

$R_u = (1) \times (.1) \times (5.56)$

Therefore:

$R_u = .556$

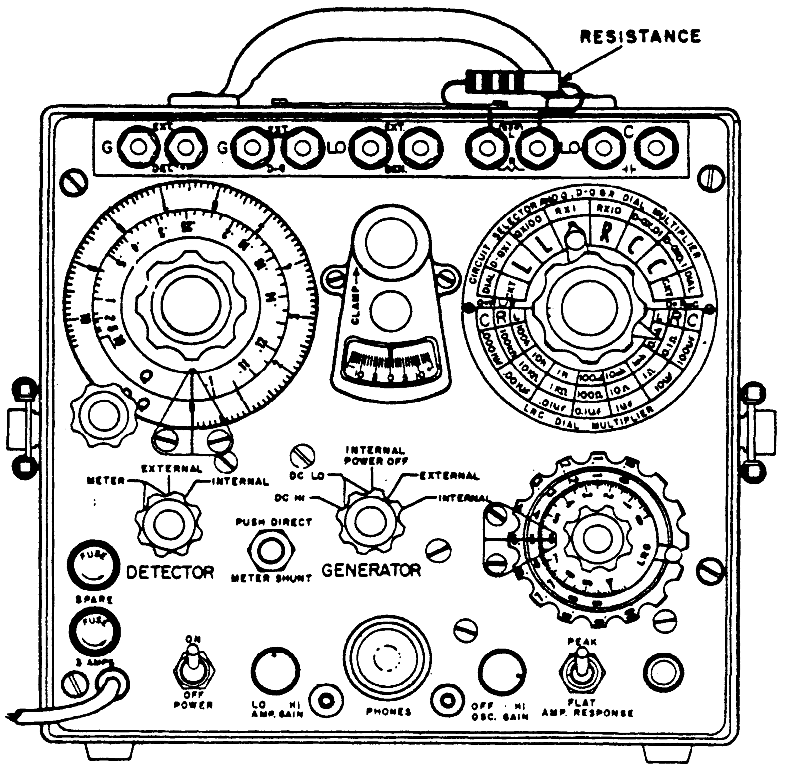


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Figure 6. Bridge controls set for measurement of dc resistance (.001 ohm to 1 ohm).

Example 2: Settings of controls in figure 7 are for the final balance position of a dc resistance of 1.151 megohms. Observe and interpret the control readings as follows:

Circuit selector switch reads .... R and R x 10.
LRC DIAL MULTIPLIER reads .... 100kΩ.
LRC dial reads .... 1.151.

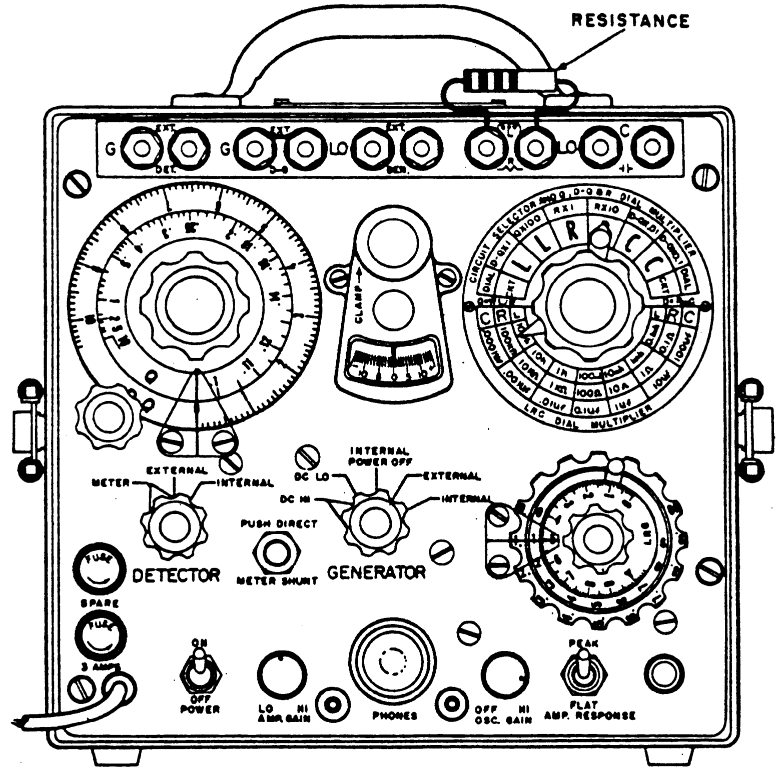

Figure 7. Bridge controls set for measurement of dc resistance (1 to 11 megohms).

Formula:

R_u = Circuit selector switch reading x
LRC DIAL MULTIPLIER reading x
LRC dial reading

Substituting:

R_u = (10) x (100,000) x (1.151)

Therefore:

R_u = 1,151,000 ohms or 1.151 megohms

19. Corrections for Internal Resistance of Bridge

Correction for internal resistance of the bridge are made when the bridge is used to measure resistances so low that the LRC DIAL MULTIPLIER is set at 0.1 on the R scale and the circuit selector switch is set at R and R x 1 as shown in figure 6 (resistances of less than 1 ohm). To make corrections for internal resistance of the bridge, proceed as follows:

a. If the test leads are connected to the L and R binding posts, short the alligator clips together.

b. If the test leads are not used, connect a short, heavy copper conductor (at least a #12 AWG, bare, copper wire) securely between the L and R binding posts of the bridge. These connections are made in the same way as those for the resistance shown in figure 6.

c. Measure and calculate the resistance as described in paragraph 18. This measured resistance is the internal resistance of the bridge.

d. To obtain the accurate resistance of the unknown resistance, subtract the measured internal resistance (*c* above) from that of any resistance of less than 1 ohm.

20. Accuracy of Dc Resistance Measurements

a. The error in resistance measurements will not exceed plus or minus (.15 per cent plus 1 division of the inner LRC dial) on all ranges, except the 0.1Ω and 100KΩ ranges, indicated by the LRC DIAL MULTIPLIER. On the 0.1Ω range, the error is plus or minus (.35 per cent plus 1 division on the inner LRC dial). On the 100KΩ range, the error is plus or minus (.2 per cent plus 1 division on the inner LRC dial).

b. When making measurements on the 0.1Ω range, make corrections for the zero resistance of the test leads, if used, and for the internal resistance of the test set (par. 19). Normally, the internal resistance is approximately .002 ohm.

21. Ac Resistance Measurements at 1,000 Cps

a. Connect the unknown resistor to the L and R binding posts.

b. Turn the circuit selector switch to the R and R x 1 position.

c. Turn the GENERATOR switch to the INTERNAL position.

d. If the electron ray tube is to be used as the null detector, turn the DETECTOR switch to the INTERNAL position and adjust the AMP. GAIN control for a minimum shadow width on the electron ray tube. Proceed with the steps outlined in *f* through *j* below.

e. If either the headset (Navy type headset CW–49507) or Voltmeter ME–30A/U is to be used as a null detector, omit the step outlined in *d* above and proceed as follows, before continuing with the operating procedure outlined in *f* through *j* below:

(1) When the headset is used, turn the DETECTOR switch to the INTERNAL position. Place the headset cord connectors in the PHONES jacks (fig. 5) at the bottom of the front panel. A null is indicated by minimum sound in the headset.

(2) When Voltmeter ME-30A/U is used, turn the DETECTOR switch to the EXTERNAL position and proceed as follows:

(*a*) Use the voltmeter test leads; connect one lead between the EXT. DET. G binding post on the bridge and the INPUT G terminal of ME-30A/U. Connect the second test lead between the EXT. DET. (high) binding post of the bridge and the unmarked INPUT terminal of the voltmeter.

(*b*) Move the ON-OFF switch of the voltmeter to the ON position.

(*c*) Set the voltmeter range switch to the 10 position. If the null signal (a minimum reading on the meter scale) cannot be readily detected at the 10 setting, adjust the voltmeter range switch gradually to lower ranges.

f. Turn the OSC. GAIN control clockwise from the OFF position. Adjust the OSC. GAIN control toward the HI position to increase the sensitivity of the null indication.

g. Turn the LRC dial to read approximately 1.00.

h. Adjust the LRC DIAL MULTIPLIER for minimum signal (widest shadow) on the electron ray tube.

i. Adjust the LRC dial (first outer dial, then middle dial and finally, inner dial) for the best null indication in *e* or *h* above. If a satisfactory minimum cannot be obtained with the LRC dial, readjust the position of the LRC DIAL MULTIPLIER, and again turn the LRC dial for minimum signal.

j. Calculate the ac resistance of the unknown resistor (R_u) by multiplying the LRC dial reading by the indicated resistance (R) value on the LRC DIAL MULTIPLIER; multiply the product of R_u and R by the multiplier indicated by the setting of the circuit selector switch. Refer to the example below.

Example: Settings of controls in figure 8 are for the final balance position of an ac resistance of 8,501 ohms. Observe and interpret the control readings as follows:

Circuit selector switch reads .... R and R x 1.
LRC DIAL MULTIPLIER reads .... 1kΩ.
LRC dial reads .... 8.501.

Formula:

R_u = Circuit selector switch reading x LRC DIAL MULTIPLIER reading x LRC dial reading

Substituting:

$R_u = (1) \times (1{,}000) \times (8.501)$

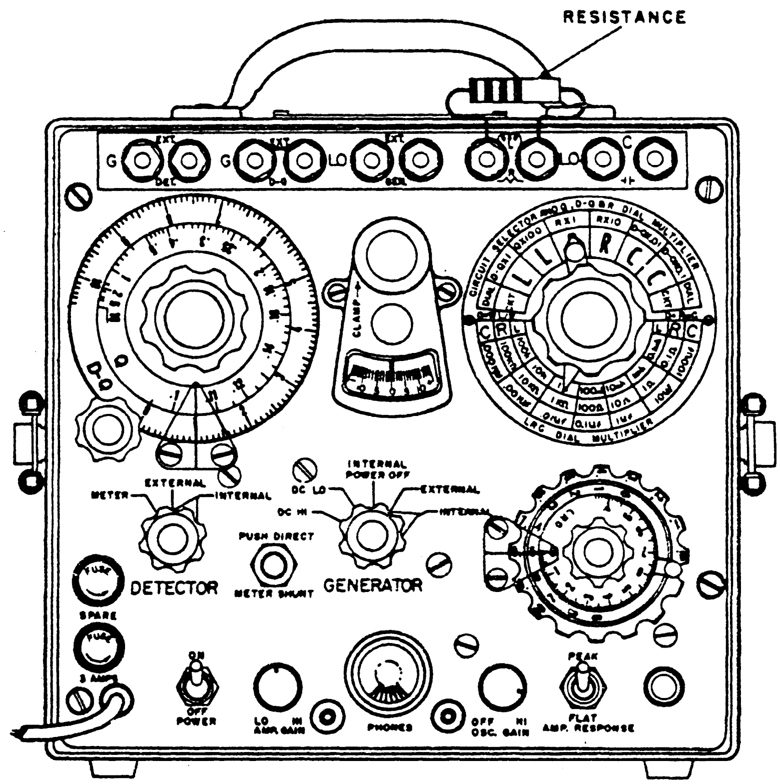

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Figure 8. Bridge controls settings for measurement of ac resistance.

Therefore:

$R_u = 8{,}501$ ohms

22. Accuracy of Ac Resistance Measurements

The error of ac resistance measurements is within plus or minus (.5 per cent plus 1 division on the inner LRC dial) from 1 to 100,000 ohms. The error may increase to plus or minus (1 per cent plus 1 division on the LRC inner dial) for values of resistance lower than 1 ohm (par. 19) and greater than 100,000 ohms.

Note. If a null cannot be obtained or is not sharply defined, it is probable that the resistance under measurement contains considerable reactance. A good balance can be obtained only when the unknown resistor has a small reactance comparable to that of the resistors which make up the bridge circuit. To measure resistors with appreciable reactance, refer to paragraph 32.

23. Capacitance Measurements at 1,000 Cps

a. Connect the unknown capacitor to the C binding posts. If polarized capacitors are being measured, connect the shield or outside foil (negative side of the capacitor) to the binding post marked LO.

b. Set the circuit selector switch to C and D–Q x .01 position (fig. 9) for capacitors that have dissipation factors (D) below .105 and to C and D–Q x 0.1 (fig. 10) position for capacitors that have dissipation factors between .105 and 1.05. If D is unknown and cannot be approximated, try to obtain a null in both positions of the circuit selector switch (*c* through *i* below). The setting that gives the best null indication is the correct setting for the circuit selector switch.

c. Operate the AMP. RESPONSE switch to PEAK.

d. Position the Q and D–Q dial at midscale (approximately 5.2 on the D–Q scale).

e. Turn the DETECTOR switch to the INTERNAL position.

f. Turn the GENERATOR switch to the INTERNAL position unless ME–30A/U is used as a null detector (par. 21*e*).

g. Turn the LRC dial to read 1.00.

h. Adjust the LRC DIAL MULTIPLIER for minimum signal (widest shadow on the electron ray tube).

i. Adjust the LRC dial and the Q and D–Q dial alternately until the best null indication is obtained. If a sharp null cannot be obtained, operate alternately in small increments, the AMP. GAIN and OSC. GAIN controls toward their HI positions until a sharp null is defined on the electron ray tube. If further operation of the Q and D–Q dial does not increase the shadow width on the electron ray tube, use Decade Resistor TS–679A/U to extend the D–Q range (par. 38*b*).

j. To determine the series capacitance (C_s) of the unknown capacitor, multiply the LRC dial reading by the reading on the LRC DIAL MULTIPLIER. Refer to examples 1 and 2 below.

Example 1: The controls as pictured in figure 9 are for the final balance positions of a capacitor with a capacitance of 832.1 uuf. Observe and interpret the control readings as follows:

Circuit selector switch reads	C and D–Q x .01.
Q and D–Q dial (D–Q scale) reads	1.10.
LRC DIAL MULTIPLIER reads	.0001 uf.
LRC dial reads	832.1.

Formula:

C_s = LRC dial reading x LRC DIAL MULTIPLIER reading

Substituting:

C_s = (8.321) x (.0001)

Therefore:

C_s = .0008321 uf or 832.1 uuf.

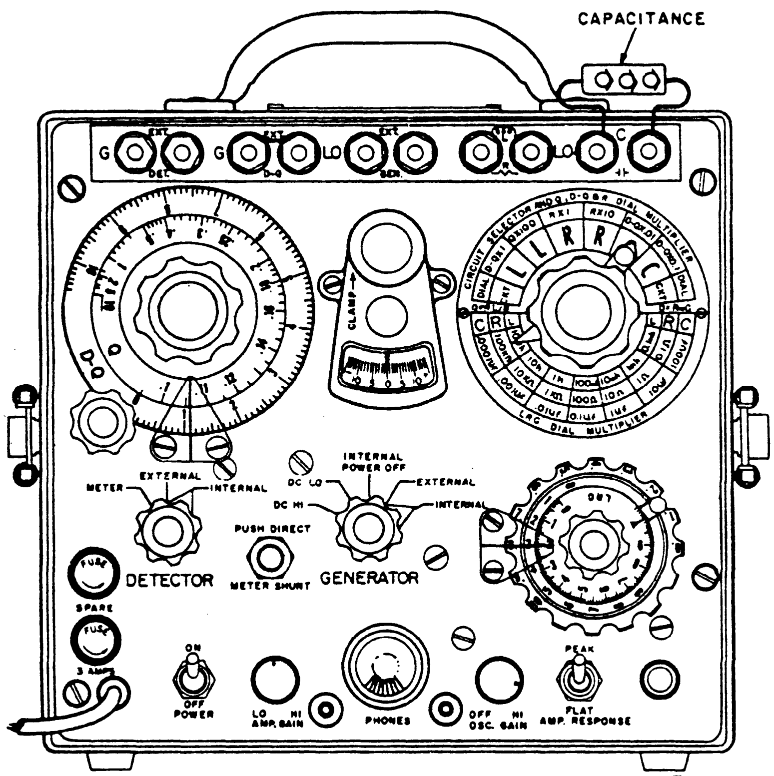

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Figure 9. Bridge controls set for measurement of capacitors with dissipation factors (.001 to .105).

Example 2: The controls as pictured in figure 10 are for the final balance positions of a capacitor with a capacitance of 109.3 uf. Observe and interpret the control readings as follows:

Circuit selector switch reads	C and D–Q x 0.1.
Q and D–Q dial (D–Q scale) reads	9.10.
LRC DIAL MULTIPLIER reads	10 uf.
LRC dial reads	10.930.

Formula:

C_s = LRC dial reading x LRC DIAL MULTIPLIER reading

Substituting:

$C_s = (10.93) \times (10)$

Therefore:

$C_s = 109.3$ uf

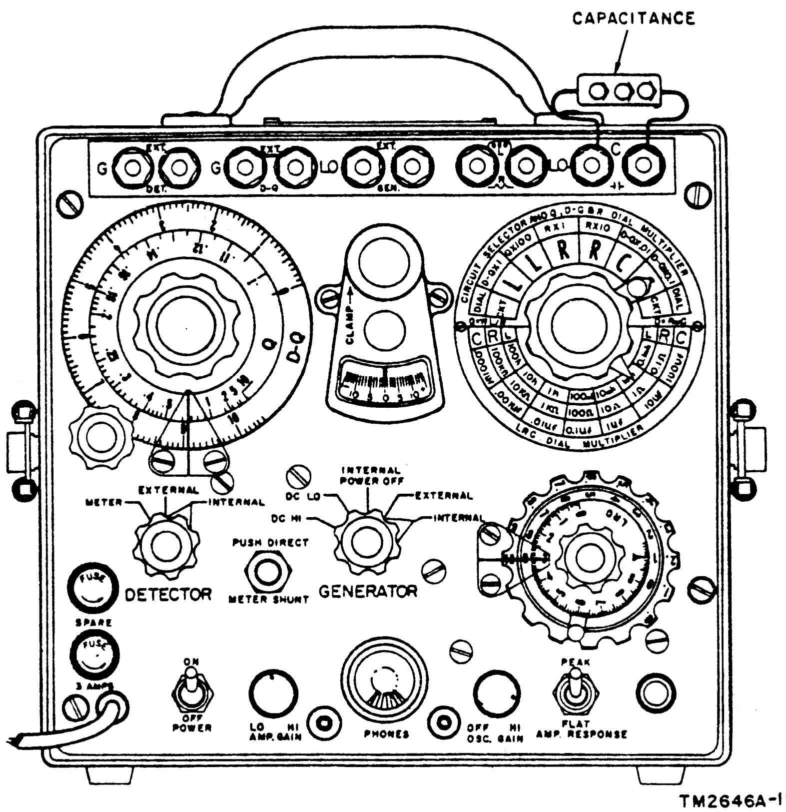

Figure 10. Bridge controls set for measurement of capacitors with dissipation factors of .1 to 1.05.

k. To find the dissipation factor ($D = R_s/X = R_s \omega C_s$; where R_s is the series resistance, ω is equal to $2\pi f$ (or 6.2832 x frequency), X is the reactance, and C_s is the capacitance) of the unknown capacitor, multiply the reading on the Q and D-Q dial by the multiplication factor indicated on the circuit selector switch. Refer to examples 3 and 4 below.

Example 3: The controls that are shown in figure 9 are for the final balance positions of a capacitor with a dissipation factor (D) of .0110. The control readings are observed as in example 1 above.

Formula:

D = Circuit selector switch reading x Q and D–Q dial reading

Substituting:

D = (.01) x (1.10)

Therefore:

D = .0110

Example 4: The controls that are shown in figure 10 are for the final balance positions of a capacitor with a dissipation factor (D) of .910. The control readings are observed as in example 2 above.

Formula:

D = Circuit selector switch reading x Q and D–Q dial reading

Substituting:

D = (9.10) x (.1)

Therefore:

D = .910

i. Parallel capacitance (C_p), series ac resistance (R_s), and parallel ac resistance (R_p) may be computed by use of the following formulas:

(1) Parallel capacitance, $C_p = \frac{C_s}{1 + D^2}$

(2) Series ac resistance, $R_s = \frac{D\omega}{C_s}$

(3) Parallel ac resistance, $R_p = \frac{1 + D^2}{D^2} R_s$ or $\frac{1 + D^2}{D\omega C_s}$

24. Accuracy of Capacitance Measurements at 1,000 Cps

a. The capacitance error is plus or minus (.5 per cent plus 1 division on the inner LRC dial) between 100 uuf (micromicrofarad) and 100 uf (microfarad), and may increase to plus or minus 2 per cent at values of capacitance above 100 uf. For smaller values of capacitance below 100 uuf, the error will be within 2 uuf if corrections are made for the internal capacitance of the bridge and test leads.

b. To measure the internal capacitance of the bridge only (approximately 2.5 uuf), open the C binding posts and follow the procedure outlined in paragraph 23.

c. To determine the capacitance of the bridge plus the test leads, disconnect the lead that is connected between the C (high) binding post and the capacitor under test at the capacitor terminal and measure the capacitance of the bridge and test leads (par. 23). Do not *disturb the relative position of the test leads; improper capacitance readings will result.*

25. Accuracy of Dissipation Factor Measurements

a. General. The accuracy of the dissipation factor measurements is dependent upon several factors. The most important of these factors are the value of the capacitor that is being measured, the capacitance characteristics of the particular test set, and the capacitance of the test leads, used for the measurements.

b. Capacitors Above .01 Uf. Dissipation factor error for capacitors above .01 uf is ± (5% + .0025).

c. Capacitors Above .001 Uf and Below .01 Uf. To determine the dissipation factor error for capacitors above .001 uf and below .01 uf, proceed as follows:

(1) Measure and note the dissipation factor (par. 23); use the .0001 uf position on the C scale of the LRC DIAL MULTIPLIER.

(2) Repeat the step in (1) above using the .001 uf position on the C scale of the LRC DIAL MULTIPLIER.

(3) Arithmetically subtract the reading on the Q and D–Q dial noted in (2) above from the reading noted in (1) above. The difference that results represents the dissipation factor error.

(4) Make all measurements of capacitors above .001 uf and below .01 uf using the .001 uf position on the C scale of the LRC DIAL MULTIPLIER and subtract the error computed in (3) above.

d. Capacitors Below .001 Uf. To determine the dissipation factor error for capacitors below. 001 uf, proceed as follows:

(1) Measure and note the dissipation factor (par. 23); use the .0001 uf position on the C scale of the LRC DIAL MULTIPLIER.

(2) Repeat the step in (1) above by using the .001 uf range.

(3) Arithmetically subtract the reading on the Q and D–Q dial noted in (2) above from the reading noted in (1) above. The difference that results represents the dissipation factor error.

(4) Make all measurements of capacitors below .001 uf by using the .0001 uf position on the C scale of the LRC

DIAL MULTIPLIER and subtract the error computed in (3) above.

26. Inductance Measurements at 1,000 Cps

a. Connect the unknown inductor to the binding posts marked L and R (fig. 11 and 12). Connect the shield, if any, to the binding post marked LO.

b. Set the circuit selector switch to L and D–Q x 1 for an inductor that has a storage factor (Q) of less than 10.5, and to L and Q x 100 for an inductor that has a storage factor between 9.5 and 1,000. If the approximate storage factor is not known, or cannot be determined, select either position of the circuit selector switch and try to obtain a null indication. If a null cannot be obtained in the position selected, the other position of the circuit selector switch is then the correct setting.

c. Position the Q and D–Q dial at midscale.

d. Turn the DETECTOR switch to the INTERNAL position unless an external detector (ME–30A/U) is used (par. 21*e*).

e. Turn the OSC. GAIN control clockwise from the OFF position approximately 1/4 turn.

f. Turn the GENERATOR switch to the INTERNAL position.

g. Move the AMP. RESPONSE switch to the PEAK position.

h. Turn the LRC dial to approximately 1.00.

i. Adjust the LRC DIAL MULTIPLIER for minimum signal on the electron ray tube (widest shadow). Make alternate adjustments of the LRC dial and the Q and Q–D dial for best null indication. If a sharp null indication cannot be obtained, alternately adjust the OSC. GAIN control and the AMP. GAIN control until a sharp null is obtained. (Adjustment of the OSC. GAIN control, when a null is noted, will narrow the shadow width on the electron ray tube and permit finer adjustment of the inner dial on the LRC dial and the Q and D–Q dial.) If further adjustment of the Q and D–Q dial fails to increase the shadow width on the electron ray tube, use Decade Resistor TS–679A/U to increase the range of the Q and D–Q dial (par. 38*b*).

j. To find the inductance of the unknown inductor, multiply the LRC dial reading by the reading of the LRC DIAL MULTIPLIER. This inductance is series inductance (L_s) when the circuit selector switch is in the L and D–Q x 1 position, and parallel inductance (L_p) when the circuit selector switch is in the L and Q x 100 position. Refer to examples 1 and 2 below for sample inductance calculations.

Example 1: The settings of the controls in figure 11 are for the final balance positions of an inductor that has an inductance of

.561 mh (millihenrys). Read and interpret the control readings as follows:

Circuit selector switch reads .... L and D–Q x 1.
Q and D–Q dial (D–Q scale) reads .... 2.30.
LRC DIAL MULTIPLIER reads .... 1 mh.
LRC dial reads .... 0.561.

Note. Read the D–Q (black) scale of the Q and D–Q dial when the circuit selector switch is in the L and D–Q x 1 position.

Formula:

L_s = LRC dial reading x LRC DIAL MULTIPLIER reading

Substituting:

$L_s = (0.561) \times (1)$

Therefore:

$L_s = 0.561$ mh

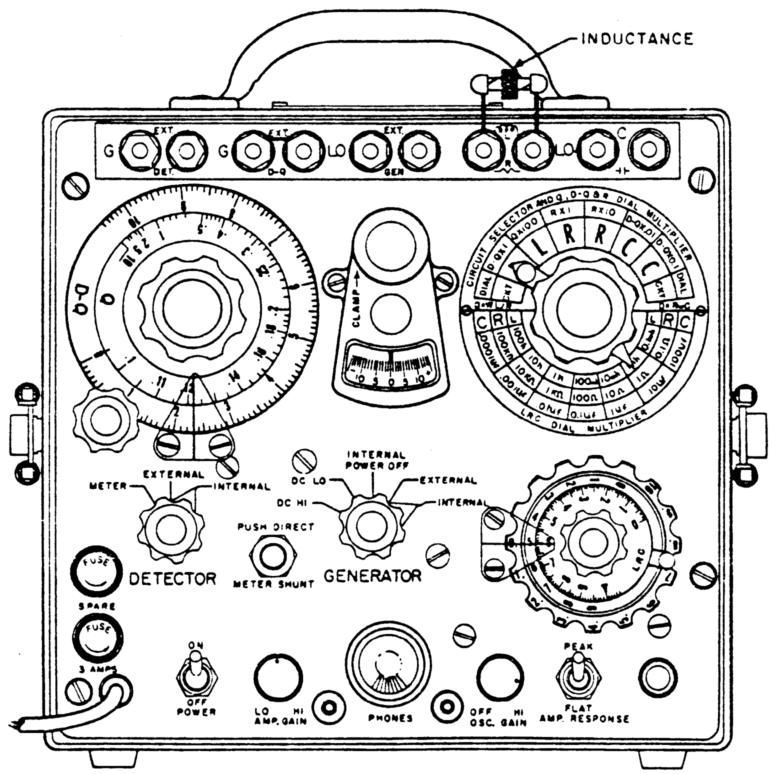

Figure 11. Bridge controls set for measurement of inductors with storage factors (.02 to 10.5).

Example 2: The settings of the controls in figure 12 are for the final balance positions of an inductor that has an inductance of 9.99 henrys. Read and interpret the control readings as follows:

Circuit selector switch reads	L and Q x 100.
Q and D–Q dial (Q scale) reads	.32.
LRC DIAL MULTIPLIER reads	1 h.
LRC dial reads	9.99.

Note. Read the Q (red) scale of the Q and D–Q dial when the circuit selector switch is in the L and Q x 100 position.

Formula:

L_p = LRC dial reading x LRC DIAL MULTIPLIER reading

Substituting:

$L_p = (9.99) \times (1)$

Therefore:

$L_p = 9.99$ h

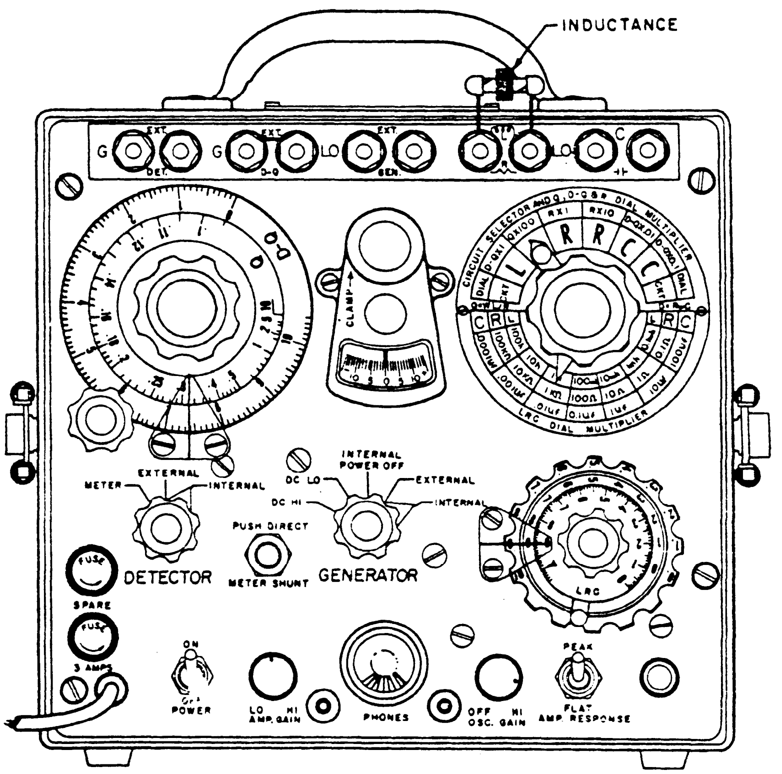

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***Figure 12.** Bridge controls set for measurement of inductors with storage factors (9.5 ' 1,000).*

k. To find the storage factor ($Q = X_s/R_s = \omega L_s/R_s$) of the unknown inductor, multiply the Q and D–Q dial reading by the factor that is indicated on the circuit selector switch. Refer to examples 3 and 4 below for sample calculations of Q.

Example 3: The settings of the controls that are shown in figure 11 are for the final balance positions of an inductor that has a storage factor (Q) of 2.30. The controls read as indicated in example 1 of *j* above.

Formula:

Q = Q and D–Q dial reading x circuit selector switch reading

Substituting:

Q = (2.30) x (1)

Therefore:

Q = 2.3

Example 4: The settings of the controls that are shown in figure 12 are for the final balance positions of an inductor that has a storage factor (Q) of 32. The controls read as in example 2 above.

Formula:

Q = Q and D–Q dial reading x circuit selector switch reading

Substituting:

Q = (.32) x (100)

Therefore:

Q = 32

l. To compute parallel inductance (L_p), series ac resistance (R_s), or parallel ac resistance (R_p) use the following formulas:

(1) Parallel inductance, $L_p = \frac{1 + Q^2}{Q^2} (L_s)$

(2) Series ac resistance, $R_s = \omega L_s/Q$

(3) Parallel ac resistance, $R_p = Q\omega L_p = (1 + Q^2) R_s$

Note. Series inductance refers to the effective inductance of a coil, at a given frequency, when it is considered to be in series with its ac resistance. Parallel inductance refers to the effective inductance of a coil, at a given frequency, when it is considered to be paralleled or shunted by the ac resistance of the coil.

27. Accuracy of Inductance Measurements at 1,000 Cps

The inductance error is plus or minus (1 per cent plus 1 division on the inner LRC dial) between 100 uh and 10 henrys. Above 10 henrys, the error may increase to plus or minus 10 per cent because of the increasing effect of the capacitances to ground associated with the inductor and the bridge arms. Below 100 uh, the error will be within plus or minus 2 uh.

28. Accuracy of Storage Factor Measurements

Storage factor error is always expressed in terms of its reciprocal (D) and is plus or minus (5 per cent plus .0025) for inductances up to 10 henrys. This error increases to plus or minus (5 per cent plus .015) at 100 henrys and to plus or minus (5 per cent plus .055) at 1,000 henrys. The increasing error appears with the increasing inductance. This is caused primarily by the small residual capacitances across the high impedance ratio arms.

Section III. MISCELLANEOUS TEST SET APPLICATIONS

29. Use of External Dc Power Source

Under certain conditions, it may be necessary to measure dc (direct-current) resistance by using an external source of dc power. This is accomplished as follows:

a. Turn the GENERATOR switch to the EXTERNAL position.

b. Connect the external dc power source in series with a resistance that will adequately limit the current to a value safely handled by the test set. To obtain the proper value of resistance for the power source, consult the following table:

Dc voltage of power source	Proper value of series resistance
6 to 25 volts	10 ohms per volt
26 to 100 volts	30 ohms per volt
101 to 250 volts	100 ohms per volt

Caution: Do not use a power source of less than 6 volts or more than 250 volts. Less than 6 volts may cause improper test set operation and more than 250 volts may cause damage to the equipment.

c. Connect the external power source with its series-connected resistance to the EXT. GEN. binding posts of the bridge. Connect the positive terminal to the EXT. GEN. binding post marked LO. If the connections are reversed, the galvanometer deflection will be reversed from the direction of deflection caused by the internal dc power supply.

d. Use the procedure described in paragraph 18 to measure the dc resistance of the unknown resistance.

30. Use of External Ac Generator

When it is desired to make tests for capacitance or inductance at frequencies other than the internally supplied 1,000 cps (from 100 to 10,000 cps), Audio Oscillator TS–382/U is connected to the bridge. To use the TS-382/U with the bridge, proceed as follows:

a. Electrically isolate the two units by placing each on a surface that is a nonconductor of electricity (an insulated surface).

Caution: If the metal cases, and consequently the chassis, of the bridge and the TS-382/U become connected to a common ground, improper readings on the bridge will result.

b. Connect the OUTPUT ground terminal of the TS-382/U to the EXT. GEN. binding post marked LO. Connect the red EXT. GEN. binding post to the other OUTPUT terminal of the TS-382/U.

c. Turn the GENERATOR switch to the INTERNAL POWER OFF position; operate the AMP. RESPONSE switch to the FLAT position, and apply power to the TS-382/U.

d. Select the desired frequency on the TS-382/U and proceed with the desired ac measurement (par. 23, 26, or 31).

31. Measurement of Ac Resistance at Frequencies Other than 1 Kc

a. Connect Audio Oscillator TS-382/U (par. 30) to the EXT. GEN. binding posts.

b. Set the GENERATOR switch to the EXTERNAL position.

c. Turn the DETECTOR switch to the INTERNAL position.

d. Measure the ac resistance as outlined in paragraph 21. If a good null balance cannot be obtained, proceed as outlined in paragraph 32.

32. Measurement of Ac Resistance with Reactance

To obtain a sharp null when measuring resistances that have appreciable reactance, connect a Standard Variable Capacitance, General Radio Type 722-D, (a component of Laboratory Standard AN/URM-2) across the appropriate bridge arm, or bridge component.

a. To measure resistances that have a considerable amount of associated capacitance, such as electrolytic capacitors, connect the standard variable capacitance across either the A or N arm of the bridge network as indicated in *d* below (fig. 20).

b. To measure resistances that have appreciable inductive reactance, such as some types of layer wound resistors, connect the standard variable capacitance across the B bridge arm as indicated in *d* below (fig. 20). The storage factor of the unknown impedance is of the form $R\omega C$ where R is the resistance of the bridge arm across which the standard variable capacitance is connected.

c. Unknown resistances that have appreciable associated inductive reactance also can be measured by connecting the standard variable capacitance in the U bridge arm either across the unknown resistance to make a parallel resonant bridge, or in series with the unknown resistance to make a series-resonant bridge (*d* below). The parallel or series inductance is calculated from the formula $L = 1/\omega^2 C$, where C is the capacitance read from the standard variable capacitance at the conclusion of the test.

d. A table showing proper placement of the standard variable capacitance for determining the reactive component of an ac resistance follows:

Bridge arm (as indicated in fig. 20)	Terminal connections for standard variable capacitor	Type of resistance	Type of reactance
A	C (high) and C_{Lo}	Parallel	Capacitive
N	L R (high) and G	Parallel	Capacitive
B	C (high) and G	Series	Inductive
U	L R (high) and L R_{Lo}	Parallel	Inductive
U	In series with unknown resistance R_u	Series	Inductive

e. Measurements of ac resistance with reactance are made as follows:

(1) Connect the unknown resistor to the L and R binding posts. Connect the variable standard capacitance to the appropriate binding posts as indicated in *d* above.

(2) Make the following switch settings:

(*a*) Turn DETECTOR switch to INTERNAL position.

(*b*) Turn GENERATOR switch to INTERNAL position.

(*c*) Turn LRC dial to approximately 1.00.

(*d*) Turn circuit selector switch to R and R x 1 position.

(3) Adjust the LRC DIAL MULTIPLIER for minimum signal (widest shadow).

(4) Alternately turn the LRC dial and the standard variable capacitance until a minimum signal (par. 21*e* or *h*) is obtained. If a balance cannot be obtained by using the LRC dial and variable capacitor, readjust the LRC DIAL MULTIPLIER ((3) above) and again adjust the LRC dial and standard variable capacitance for balance.

(5) To find the value of the unknown resistor, multiply the LRC dial reading by the indicated resistance value on the LRC DIAL MULTIPLIER.

33. Measurement of Parallel Capacitance and Resistance of Capacitor

a. Connect the unknown capacitor to the C binding posts with the shield or outside foil connected to the binding post marked LO.

b. Connect Decade Resistor TS–679A/U between the C (high) binding post and any binding post marked G.

c. Turn the circuit selector switch to C and D–Q x .01 or C and D–Q x 0.1.

d. Turn the DETECTOR switch to the INTERNAL position.

e. Turn the GENERATOR switch to the INTERNAL position.

f. Set the LRC dial to read approximately 1.00.

g. Adjust the LRC DIAL MULTIPLIER to obtain the widest shadow on the electron ray tube and adjust the LRC dial and the TS–679A/U alternately until the best null indication is obtained (par. 21*e*).

h. To find the parallel capacitance (C_p) of the unknown capacitor, multiply the LRC dial reading by the reading on the LRC DIAL MULTIPLIER. Read the capacitor resistance from the TS–679A/U.

i. Compute parallel resistance (R_p) from the following formula:

$$R_p = \frac{R_e \times R_a}{R_n}$$

where: R_e = the resistance of Decade Resistor TS–679A/U.

R_a = the resistance of ratio arm A (fig. 20) as read from the LRC DIAL MULTIPLIER when the test set is balanced.

R_n = the reading of the LRC dial multiplied by 1,000.

34. Measuring Capacitance of Three-terminal Capacitors

a. Connect the common terminal to any binding post marked G; connect the other two terminals of the capacitor to the C binding posts of the bridge.

Note. This places one section of the capacitance (the section connected between the C binding post marked LO and a binding post marked G) across the detector, and the second section of the capacitance (the section connected between the C (high) and G binding posts) across the standard .1 uf capacitor. The capacitance across the detection circuit will not disturb the measurement, while the capacitance across the standard capacitor will cause the test set to read low. The bridge will read low by the ratio of the added capacitance to the capacitance of the standard capacitor. For example, if the second section of the capacitance across the .1 uf standard capacitor is .0001 uf, the bridge will read .1 per cent low.

b. Measure the capacitance of the unknown capacitor (par. 23).

35. Measuring Capacitance of Electrolytic Capacitors

When measuring the capacitance of an electrolytic capacitor, apply a stabilizing (forming) voltage to the capacitor to obtain an accurate balance of the bridge. Place a dc polarizing battery, not greater than 200 volts, in series with the electrolytic capacitor being measured.

a. Connect the positive terminal of the battery to the C binding post marked LO. Connect the negative terminal of the battery to the negative terminal of the electrolytic capacitor.

b. Connect the positive terminal of the electrolytic capacitor to be measured to the red C (high) binding post of the test set.

c. Measure the capacitance of the unknown electrolytic capacitor (par. 23).

d. If the value of the leakage current is desired, set Multimeter TS–297/U to measure current in milliamperes (ma). Connect the TS–297/U in series with the positive battery terminal and the C binding post marked LO. The leakage current will be indicated on the TS–297/U.

36. Measuring Terminal Capacitance of Shielded Inductors

a. Connect the terminal of the inductor, the capacitance of which is to be measured, to the C binding post marked LO; connect the shield of the inductor to the C (high) binding post.

b. Connect the remaining terminal of the inductor to any binding post marked G.

c. Measure the unknown capacitance (par. 23).

d. Measure the capacitance of the other terminal by reversing the two inductor connections. Leave the shield connected to the C (high) binding post, and follow the operating procedure described in paragraph 23.

Note. The terminal capacitance of an inductor is measured across the standard .1 uf capacitor in the bridge. The error introduced is usually negligible (approximately .5 per cent) because terminal capacitance of shielded transformers rarely exceed 500 uuf.

37. Determining Resonant Frequency of Inductor or Tuned Circuit

a. Connect the unknown inductor or tuned circuit to the L and R binding posts, with the shield, if any, connected to the binding post marked LO.

b. Connect Audio Oscillator TS–382/U to the EXT. GEN. binding posts (par. 30).

c. Turn the circuit selector switch to the R and R x 1 position.

d. Operate the GENERATOR switch in the EXTERNAL position.

e. Adjust the LRC dial to read 1.00.

f. Adjust the LRC DIAL MULTIPLIER for minimum signal (widest shadow) on the electron ray tube. Alternately adjust the LRC dial and the audio oscillator frequency for the best null.

g. Read the resonant frequency of the tuned circuit or inductor from the TS–382/U.

38. Measurement of Dissipation Factor and Storage Factor at Frequencies Other than 1,000 Cps

a. General. The calibration of the LRC dial is independent of the frequency used in making measurements. Dissipation factor and storage factor depend on frequency. *The Q and D–Q scales can be read directly only at 1,000 cps* (the frequency of the internal oscillator); therefore, all dissipation or storage factor readings on the black D–Q scale (par. 26*j*, example 1) must be multiplied by the test frequency, in kc (kilocycles), to obtain the correct values of Q or D. Storage factor readings on the red Q scale (par. 26*j*, example 2) must be divided by the frequency, in kc (1,000 cps equals 1 kc), to obtain the correct values. At frequencies lower than 1 kc, the Q and D–Q scales do not overlap and the D and Q range must be extended (*b* below). At frequencies higher than 1 kc, the ranges of the variable resistors are more than sufficient to overlap.

b. Extending D and Q Range of Q and D–Q Dial.

(1) Connect Decade Resistor TS–679A/U to the EXT. D–Q binding posts (par. 16) to extend the range of the bridge resistors and provide sufficient resistance for the overlapping of ranges on the D–Q and Q scales when dissipation factor and storage factor are measured at frequencies below 10 kc.

(2) For storage factors below 10, connect the external resistance between the C (high) binding post and any binding post marked G. Short the EXT. D–Q binding posts. Set the Q and D–Q dial at 0, and set the circuit selector switch to L and Q x 100 position.

Note. The resistance values required for given values of dissipation factor and storage factor at typical frequencies are given in the table below. The values shown are the total resistance in series or series-parallel with standard capacitor C2 in bridge arm B (fig. 21, 22 and 23).

Typical measuring frequencies (kc)	Resistance (kΩ)[a]			
	When D=1 C and D-Q x .01)	When D=1 C and D-Q x 0.1)	When Q=10 or more (L and Q x 100)	When Q=10 or less (L and Q x 100)
.10	1.592	15.920	1.592	159.20[b]
.20	.796	7.960	.796	79.60
.50	.318	3.184	.318	31.840
2.00	.080	.796	.080	7.960
5.00	.032	.318	.032	3.184
10.00	.016	.160	.016	1.592

[a]The formula for calculating the proper resistance value when measuring Q is: R (kΩ) = 1.592/Qf (kc).

[b]The formula for calculating the proper resistance value when measuring D is: R (kΩ) = 1.592 D/f (kc). This resistance is not available in the TS–679A/U.

c. Measuring Dissipation Factor at Frequencies Below 1 Kc. Although the ranges of the Q and D–Q dial do not overlap below 1 kc, the dissipation factor of the unknown capacitor often will lie within the limited range of the bridge resistors. If a null can be obtained, multiply the black D–Q scale reading by the frequency, in kc, to obtain the correct dissipation factor (0). If a null cannot be obtained, proceed as follows:

(1) Connect Audio Oscillator TS–382/U to the EXT. GEN. binding posts (par. 30). Remove the shorting bar and connect Decade Resistor TS–679A/U to the EXT. D–Q binding posts. Refer to the applicable column of the table in *b* above to determine the necessary maximum resistance for the setting of the TS–679A/U. Connect the unknown capacitor to the C binding posts with the shield or outside foil connected to the LO binding post.

(2) Make the following switch settings:

(*a*) Turn the circuit selector switch to C and D–Q x .01 or C and D–Q x 0.1 position.

(*b*) Adjust the Q and D–Q dial to 0 on the black scale.

(*c*) Turn the GENERATOR switch to the EXTERNAL position.

(*d*) Turn the DETECTOR switch to INTERNAL position.

(*e*) Adjust the LRC dial to approximately 1.00.

(3) Adjust the LRC DIAL MULTIPLIER for a minimum signal on the electron ray tube, and alternately adjust the LRC dial (par. 21*i*) and the TS–679A/U for the best null indication.

(4) To find the series capacitance (C_s) of the unknown capacitor, multiply the LRC dial reading by the reading on the LRC DIAL MULTIPLIER. Read and note the resistance of the TS–679A/U.

(5) Compute the dissipation factor of the unknown capacitor by the following formula:

$$D = .628fR.$$

where: f = the frequency in kc.
R = the resistance of the TS–679A/U in kilohms (1,000 ohms equals 1 kilohm).

Caution: Be sure to reconnect the shorting bar across the EXT. D–Q binding posts after removing the TS–679A/U.

d. Measuring Storage Factor at Frequencies Below 1 Kc. Although the ranges of the Q and D–Q dial do not overlap below 1 kc, the storage factor of the unknown inductor often will lie within the limited range of the bridge resistors. Try to secure a null with the bridge resistors. If a null can be obtained, multiply the Q reading of the black D–Q scale by the frequency, in kc, to obtain the correct value if the circuit selector switch is in the L and D–Q x 1 positions. Divide the Q reading on the red Q scale by the frequency, in kc, to obtain the correct value if the circuit selector switch is in the L and Q x 100 position. If a null cannot be obtained on either scale, proceed as follows:

(1) Connect Audio Oscillator TS–382/U to the EXT. GEN. binding posts (par. 30). Remove the shorting bar and connect Decade Resistor TS–679A/U to the EXT. D–Q binding posts. Refer to the applicable column of the table in *b* above to determine the maximum resistance necessary for the Maxwell inductance bridge (fig. 22). This bridge circuit is used for inductors that have a storage factor below 10. Connect the unknown inductor to the L and R binding posts with the shield (if any) connected to the LO binding post.

(2) Make the following switch settings:

(*a*) Turn the circuit selector switch to the L and Q x 100 position.

(*b*) Adjust the Q and D–Q dial to 10.5 on the black side.

(*c*) Turn the GENERATOR switch to the EXTERNAL position.

(*d*) Turn the DETECTOR switch to the INTERNAL position.

(*e*) Adjust the LRC dial to approximately 1.00.

(3) Adjust the LRC DIAL MULTIPLIER for a minimum signal on the electron ray tube, and alternately adjust the LRC dial (par. 21*i*) and the TS–679A/U for the best null indication.

(4) Find the inductance of the unknown inductor by multiplying the LRC dial reading by the reading of the LRC DIAL MULTIPLIER. This inductance is parallel inductance (L_p) when the TS–679A/U is connected to the EXT. D–Q binding posts.

Note. Series inductance (L_s) can be measured by connecting the TS–679A/U between the red C (high) binding post and any G binding post. EXT. D–Q binding posts must be shorted.

(5) Read and note the resistance of the external variable resistor.

(6) Compute the storage factor of the unknown inductor by using one of the following formulas:

If the external variable resistor is connected between the EXT. D–Q binding posts:

$$Q = 1.592/fR$$

If the external variable resistor is connected between the C (high) and G binding posts:

$$Q = .628fR$$

where: f = the frequency in kc.
R = the resistance of the TS–679A/U in kilohms (1,000 ohms equals 1 kilohm).

e. Measuring Dissipation Factor or Storage Factor at Frequencies Above 1 Kc. Dissipation factor and storage factor balances above 1 kc can be obtained through the normal operating procedure (par. 23 and 26) by using the Q and D–Q dial. The range is more than sufficient to overlap at frequencies above 1 kc. All dissipation factor and storage factor readings from the black D–Q scale must be multiplied by the frequency, in kc, to obtain the correct values (par. 26*j*, example 1). All storage factor readings from the red Q scale must be divided by the frequency in kc to obtain the correct values (par. 26*j*, example 2).

39. Using LRC Dial as Calibrated Resistor

a. Operate the circuit selector switch to any L or R setting.

b. Remove all connections from the binding posts.

c. Turn the DETECTOR switch to the EXTERNAL position.

d. Turn the GENERATOR switch to the INTERNAL POWER OFF position.

e. Connect the test leads to the red L and R binding **post and** any binding post marked G. (Figures 20, 22, and 23 show that the LRC dial is available as a calibrated resistor.)

f. Multiply the LRC dial calibrations by 1,000 to read their resistance in ohms.

Caution: When using the LRC dial as a calibrated resistor, do not allow more than 23 ma to flow through it. Higher currents will damage the resistors and rheostat.

40. Using Resistors of Ratio Arm A as Precision Resistors

a. Turn the circuit selector switch to L and Q x 100 position.

b. Turn the GENERATOR switch to INTERNAL POWER OFF position.

c. Turn the DETECTOR switch to the EXTERNAL position.

d. Make connections to ratio arm A at the C binding posts.

e. Read the resistance from the R scale of the LRC DIAL MULTIPLIER. Seven values of resistance are available for use. Determine the resistance in ohms by multiplying the reading of the R scale of the LRC DIAL MULTIPLIER by 10. The circuit diagram, figure 23, shows the relationship of the C binding posts to ratio arm A.

41. Using Bridge Capacitor as Secondary Capacitance Standard

a. Operate the circuit selector switch to either the C and D–Q x .01 or C and D–Q x 0.1 positions.

b. Turn the GENERATOR switch to the INTERNAL POWER OFF position.

c. Turn the DETECTOR switch to the EXTERNAL position.

d. Adjust the Q and D–Q dial to 0 on the black (D–Q) scale.

e. Connect the test leads to the red C (high) binding post and to any binding post marked G. (Figure 21 shows that the .1 uf capacitor is available as a standard capacitor.) The capacitance between the red C binding post and any G binding post is .1000 uf, plus or minus .25 per cent at 1,000 cps and 25° C. The temperature coefficient of the capacitor is less than plus .01 per cent per degree centigrade between 15° and 60° C. With the Q and D–Q dial set at 0, the dissipation factor of the .1 uf capacitor is approximately .0005.

f. If desired, known dissipation factors can be introduced in the bridge capacitor when the circuit selector is set in the C and D–Q x .01 position by turning the Q and D–Q dial and reading the dissipation factor from the black scale.

Caution: Do not apply more than 350 volts to the capacitor at frequencies up to 20 kc. Above 20 kc, the allowable voltage decreases and is inversely proportional to the square root of the frequency.

42. Using Internal Oscillator as External 1,000 Cps Signal Generator

a. Turn the circuit selector switch to either the C and D–Q x .01 or C and D–Q x 0.1 position.

b. Turn the LRC DIAL MULTIPLIER to the 0.1 uf position on the C scale.

c. Turn the GENERATOR switch to the INTERNAL position.

d. Turn the DETECTOR switch to the EXTERNAL position.

e. Move the OSC. GAIN control to the ON position.

f. Remove shorting bar from the EXT. D–Q binding posts.

g. The output of the internal 1,000 cps, excitation voltage is available at the red L and R (high) and red C (high) binding posts. The frequency is 1,000 cps, plus or minus 1 per cent. The power available is approximately .48 watt across 300 ohms, at 12 volts.

43. Use of Bridge Galvanometer for Measurement of Small Dc Currents

a. Turn the circuit selector switch to L and Q x 100 position.

b. Turn the GENERATOR switch to INTERNAL POWER OFF position.

c. Turn the DETECTOR switch to the METER position.

d. The galvanometer is now available at any binding post marked G and either the L or C binding posts marked LO. With the DETECTOR switch in the METER position, the sensitivity of the meter is approximately 125 to 0 to 125 microamperes dc. With the METER SHUNT switch depressed and held, the sensitivity of the meter is approximately 7.5 to 0 to 7.5 microamperes dc.

Caution: Make sure that the current through the galvanometer does not exceed 125 microamperes dc before connecting the meter to the external circuit. If the current is unknown, connect the external test circuit between the C (high) binding post and any binding post marked G. Set the LRC DIAL MULTIPLIER to the 100kΩ position on the R scale. This places the 1-megohm resistor in series with the galvanometer as a protective resistor. Turn the LRC DIAL MULTIPLIER counterclockwise one step at a time to place lower values of resistance in series with the galvanometer if the meter needle does not deflect off scale.

44. Stopping Procedure

a. Turn the GENERATOR switch to the INTERNAL POWER OFF position.

b. Turn the DETECTOR switch to the EXTERNAL position.

c. Move the OSC. GAIN control to the OFF position.

d. Move the POWER switch to the OFF position.

e. Remove any exterior connections from the test set such as test leads, headset, or components that have been used to make measurements.

f. Move galvanometer clamp in the direction of the arrow.

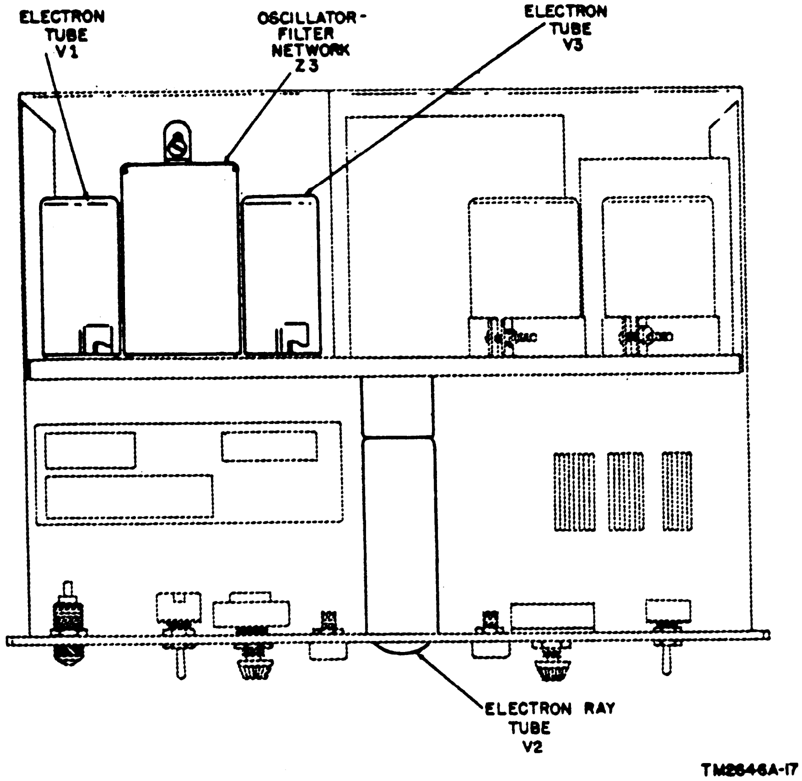


Figure 16. Bridge chassis, showing tube location.

55. Trouble shooting Using Equipment Performance Check List

a. General. The equipment performance check list (par. 56) will assist the repairman in locating trouble in the test set. These lists are provided in three parts, because the three primary measurements have different trouble indications. When trouble shooting by using the equipment performance check list, ask the operator of the equipment whether he was testing for inductance, capacitance, or resistance and use the proper operational test (par. 56*a*, *b*, or *c*). These check lists provide the item to be checked, the conditions under which the item is checked, the normal indications and tolerances or correct operation, and the corrective measures the operator can take. *To use these lists, 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 repairman should apply the recommended corrective measures.

d. Corrective Measures. This column indicates the action to be taken by the unit repairman if the normal indication is not obtained. Second echelon maintenance personnel are restricted to performing only the maintenance for which they are provided tools, test equipment, and replacement parts. References to paragraphs in this chapter indicate repairs to be made by the unit repairman. References to paragraphs in chapter 6 are for use by field maintenance personnel *only.*

56. Equipment Performance Check List

a. Resistance Measurements.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	POWER switch	Move to OFF position.		
	2	Line cord	Connect to 115-volt, single-phase, 50- to 1,000-cps power source.		
	3	DETECTOR switch	Turn to METER position.		
	4	GENERATOR switch	Turn to INTERNAL POWER OFF position.		
	5	EXT. D–Q binding posts	Short with shorting bar.		
	6	Circuit selector switch	Turn to R and R x 1 position.		
	7	LRC DIAL MULTIPLIER	Turn to .01 position on the R scale.		
	8	LRC dial	Turn to 1.00 position.		
	9	L and R binding posts	Connect resistor to be measured to L and R binding posts.		
	10	Galvanometer	Move clamp toward meter scale.	Meter needle should be centered at zero.	Adjust needle with galvanometer zero adjustment knob (par. 18*a*).

	Item No.	Item	Action or condition	Normal indications	Corrective measures
START	11	POWER switch	Move to ON position.	Pilot lamp lights.	Check power cord and plug (par. 53b(1)). Check ac power source. Check fuse F1 (par. 52b(2)). Check pilot lamp (par. 56). Turn in equipment for repair (par. 69, item 1).
EQUIPMENT PERFORMANCE	12	GENERATOR switch	Turn to DC LO position.		
	13	LRC DIAL MULTIPLIER	Turn slowly clockwise.	Galvanometer needle should be on scale with least amount of deflection.	Check galvanometer M1 for bent needle (par. 69, item 4). Check connections to L and R binding posts. Clean switch contacts (par. 50b(3)). Turn in equipment for repair (par. 69, item 8).
	14	Circuit selector switch	Turn to R and R x 10 position, if necessary (par. 18f).	Galvanometer needle should be on scale with least amount of deflection.	Clean switch contacts (par. 51b(3)). Turn in equipment for repair (par. 69, item 4).
	15	GENERATOR switch	Turn to DC HI position, if necessary (par. 18f).	Galvanometer needle should be on scale with least amount of deflection.	Turn in equipment for repair (par. 69, item 4).
	16	METER SHUNT switch	Push and hold switch.	Galvanometer needle deflection should increase.	Turn in equipment for repair (par. 69, item 9).

	17	LRC dial	Turn LRC outer dial, next the middle dial, and last the inner dial.	Zero reading on galvanometer.	Clean switch contacts (par. 51*b*(3)). Turn in equipment for repair (par. 69, item 7).
STOP	18	GENERATOR switch	Turn to INTERNAL POWER OFF position.		
	19	Galvanometer	Move clamp in direction of arrow.	Meter needle will center and hold.	
	20	POWER switch	Move to OFF position.	Pilot lamp goes out.	
	21	L and R binding posts	Remove resistor under measurements.		

b. Capacitance Measurements.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Perform steps 1 and 2 of *a* above.			
	2	DETECTOR switch	Turn to INTERNAL position.		
	3	GENERATOR switch	Turn to INTERNAL position.		
	4	EXT. D–Q binding posts	Short with shorting bar.		
	5	Circuit selector switch	Turn to C and D–Q x .01 position.		
	6	LRC DIAL MULTIPLIER	Turn to .0001 uf position on C scale.		

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	7	LRC dial	Adjust for reading of 1.00.		
	8	Q and D–Q dial	Turn to midscale.		
	9	C binding posts	Connect capacitor to be measured to C binding posts.		
START	10	Perform step 11 of *a* above.			
EQUIPMENT PERFORMANCE	11	LRC DIAL MULTIPLIER	Turn slowly counterclockwise (par. 23*h*).	Minimum signal (widest shadow) on electron ray tube.	Check tubes V1, V2, and V3 (par. 53). Clean switch contacts (par. 50*b*(3)). Turn in equipment for repair (par. 69, item 8).
	12	LRC dial	Turn LRC outer dial, next the middle dial, and last the inner dial (par. 23*h*).	Minimum signal (widest shadow) on electron ray tube.	Check tubes V1, V2, and V3 (par. 54). Clean switch contacts (par. 51*b*(3)). Turn in equipment for repair (par. 69, item 7).
	13	Q and D–Q dial	Turn as required (par 23*h*) in conjunction with LRC dial.	Minimum signal (widest shadow) on electron ray tube.	Check tubes V1, V2, and V3 (par. 54). Turn in equipment for repair (par. 69, item 11).

STOP	14	Perform steps 18 and 20 in *a* above			
	15	C binding posts	Remove capacitor under measurement.		

c. Inductance Measurements.

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Perform steps 1, 2, 3, and 4 of *b* above			
	2	Circuit selector switch	Turn to L and Q x 1 or L and Q x 100 as required (par. 26*b*).		
	3	LRC DIAL MULTIPLIER	Turn to 0.1 mh position on L scale.		
	4	Perform steps 7 and 8 of *b* above			
	5	OSC. GAIN control	Turn clockwise from OFF position.		
	6	AMP. RESPONSE switch	Move to PEAK position.		
	7	L and R binding posts	Connect inductor to be measured to L and R binding posts.		

	Item No.	Item	Action or condition	Normal indications	Corrective measures
START	8	Perform step 11 of *a* above			
EQUIPMENT PERFORMANCE	9	LRC DIAL MULTIPLIER	Turn slowly clockwise (par. 26*i*).	Minimum signal (widest shadow) on electron ray tube.	Check tubes V1, V2, and V3 (par. 54). Clean switch contacts (par. 51*b*(3)). Turn in equipment for repair (par. 69, item 8).
	10	LRC dial	Turn LRC (outer) dial, next the middle dial, and last the inner dial (par. 26*i*).	Minimum signal (widest shadow) on electron ray tube.	Check tubes V1, V2, and V3 (par. 54). Clean switch contacts (par. 51*b*(3)). Turn in equipment for repair (par. 69, item 7).
	11	Q and D–Q dial	Turn as required (par. 26*i*).	Minimum signal (widest shadow) on electron ray tube.	Check tubes V1, V2, and V3 (par. 54). Turn in equipment for repair (par. 69, item 11).
STOP	12	Perform steps 18 and 20 in *a* above			
	13	L and R binding posts	Remove inductor under measurement.		

57. Replacing Pilot Lamp

a. Remove the pilot lamp (fig. 4) by turning the jeweled lamp cover counterclockwise and unscrewing it from the front panel of the bridge. The lamp is located inside the lamp cover.

b. Slide the lamp from the lamp cover and replace it with a new one.

c. Screw the lamp cover that contains the new lamp into the panel of the bridge by turning it clockwise until the lamp cover is fingertight.

58. Fuse Replacement and Location

a. The bridge contains a protective fuse and a spare fuse. The fuses are located on the front panel of the bridge (fig. 4). The protective fuse is marked FUSE, 3 AMPS and the spare fuse is marked FUSE, SPARE. These fuses are 3-ampere, cartridge-type fuses and are mounted in extractor, post-type holders.

b. Remove either fuse by rotating the fuse cap ¼-turn in the direction of the arrow until the fuse cap springs up. Lift up the fuse cap; one end of the fuse will be wedged in the fuse cap.

c. Pull the fuse from the fuse cap and replace it with a new 3-ampere, cartridge-type fuse.

d. Replace the fuse cap that contains the new fuse in position on the front panel, push down, and twist in a clockwise direction until the fuse cap locks in position.

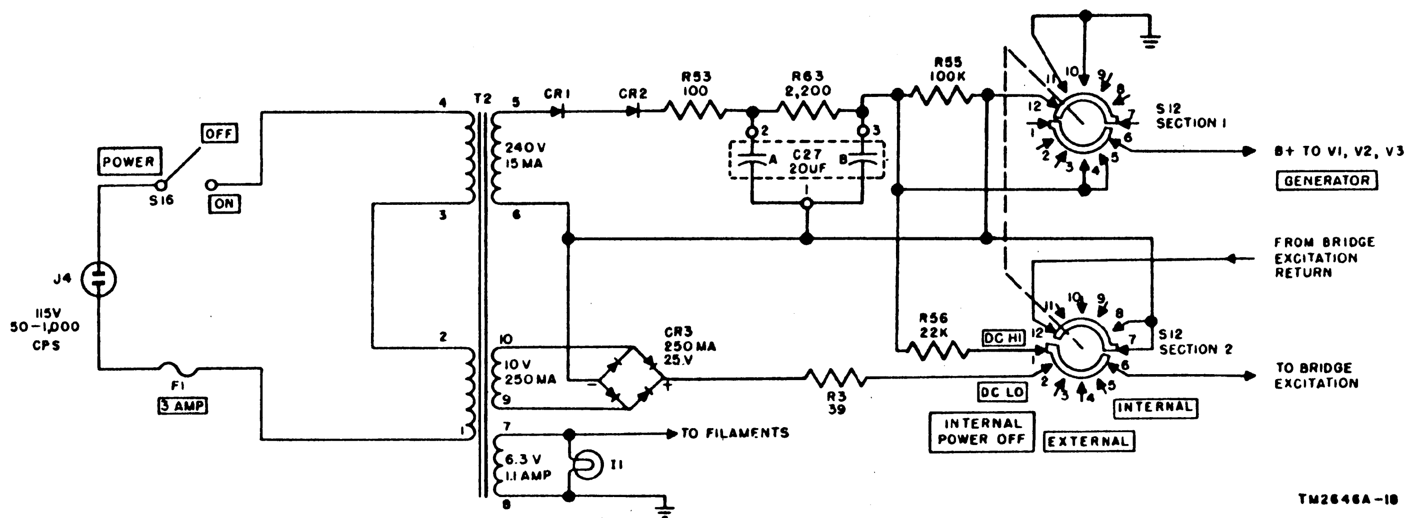


Figure 17. Power supply, simplified schematic diagram.

CHAPTER 5

THEORY

Note. A thorough knowledge of the operation of this equipment is necessary to understand the theory of the bridge.

59. Power Supply Circuit

(fig. 17)

a. The 115-volt ac input voltage is applied from receptacle J4 to the primary (1–4) winding of power transformer T2 through POWER switch S16 and protective fuse F1. Power transformer T2 operates over a frequency range of 50 to 1,000 cps at 115 volts.

b. The high-voltage secondary (5-6) winding of power transformer T2 steps up the line voltage to approximately 240 volts. Half-wave rectification is obtained through series connected selenium rectifiers CR1 and CR2, and filtered by the filter circuit consisting of resistors R53 and R63 and two-section electrolytic capacitor C27. Resistor R55 is the bleeder resistor for the filter network.

c. The low-voltage secondary (9-10) winding of power transformer T2 steps down the line voltage to approximately 10 volts. Full-wave rectification is obtained through bridge rectifier CR3. No filtering is used in the low-voltage power supply.

d. The secondary (7-8) filament winding of power transformer T2 steps down the line voltage to 6.3 volts. The current drain of the filament winding is approximately 1.1 amperes. Terminal 8 of the filament winding is grounded. Terminal 7 is connected directly to the filaments of tubes V1, V2, and V3 (fig. 37). Pilot lamp I 1 is connected directly across the filament winding (fig. 17) and lights when POWER switch S16 is turned to ON. The lamp is covered by a red lens.

e. Section 1 of GENERATOR switch S12 controls the application of B+ plate voltages to tubes V1, V2, and V3. Plate voltage is applied to the three tubes when GENERATOR switch S12 is in either the EXTERNAL or INTERNAL positions through terminals 4 and 5 respectively of section 1. Simultaneously, with the application of plate voltage in these positions, the negative side of the high-voltage power supply is grounded at contact 10 or 11 on switch S12, section 1.

f. Section 2 of GENERATOR switch S12, in part, controls the distribution of dc high and dc low excitation voltages across the bridge network when measuring resistors. Resistor R56 is a current-limiting resistor, which is switched in series with the bridge when S12 is in the DC HI position. Resistor R3 is a voltage-limiting resistor, which is switched in series with the bridge when S12 is in the DC LO position. Section 2 of GENERATOR switch S12 also functions in the oscillator-amplifier circuit (par. 60*d*).

60. Oscillator-amplifier Circuit

(fig. 18)

a. Oscillator V1A develops the 1,000 ±10 cps voltage for bridge excitation when the bridge is used to measure inductors and capacitors. The oscillator frequency is determined by its RC feed-back network (contained in oscillator filter assembly, Z3), which serves as the tuned circuit.

b. During operation, oscillator V1A produces a phase shift of approximately 180° across the RC circuit, and couples this out-of-phase voltage to the grid. This voltage causes oscillations to appear across plate-load resistor R64. These oscillations are sustained at a constant 1,000-cps rate when the tube is conducting normally. Cathode bias for oscillator V1A is obtained through resistor R48 and the C section of three-section bypass capacitor C26.

c. The oscillator output is coupled to oscillator-amplifier V1B through capacitor C24 and resistor R47 and across OSC. GAIN control R66. Cathode bias is provided by cathode-biasing resistor R50. The OSC. GAIN control provides a continuous adjustment for the amplitude of the 1,000-cps voltage. The output of the amplifier from the plate (pin 6) is impressed across the primary of isolation transformer T1. Switch S15 is an integral part of the OSC. GAIN control and, when in the OFF (extreme counterclockwise) position, disconnects B+ plate voltage from the oscillator-amplifier circuit. If an external oscillator is used, the OSC. GAIN control should be moved to the OFF position to remove any possibility of the extraneous oscillations being developed in the bridge.

d. The oscillator voltage appearing at the secondary of T1 is directly coupled to section 2 of GENERATOR switch S12 across contacts 11 and 5. In the INTERNAL position, the oscillator output is switched directly across the input of the bridge network.

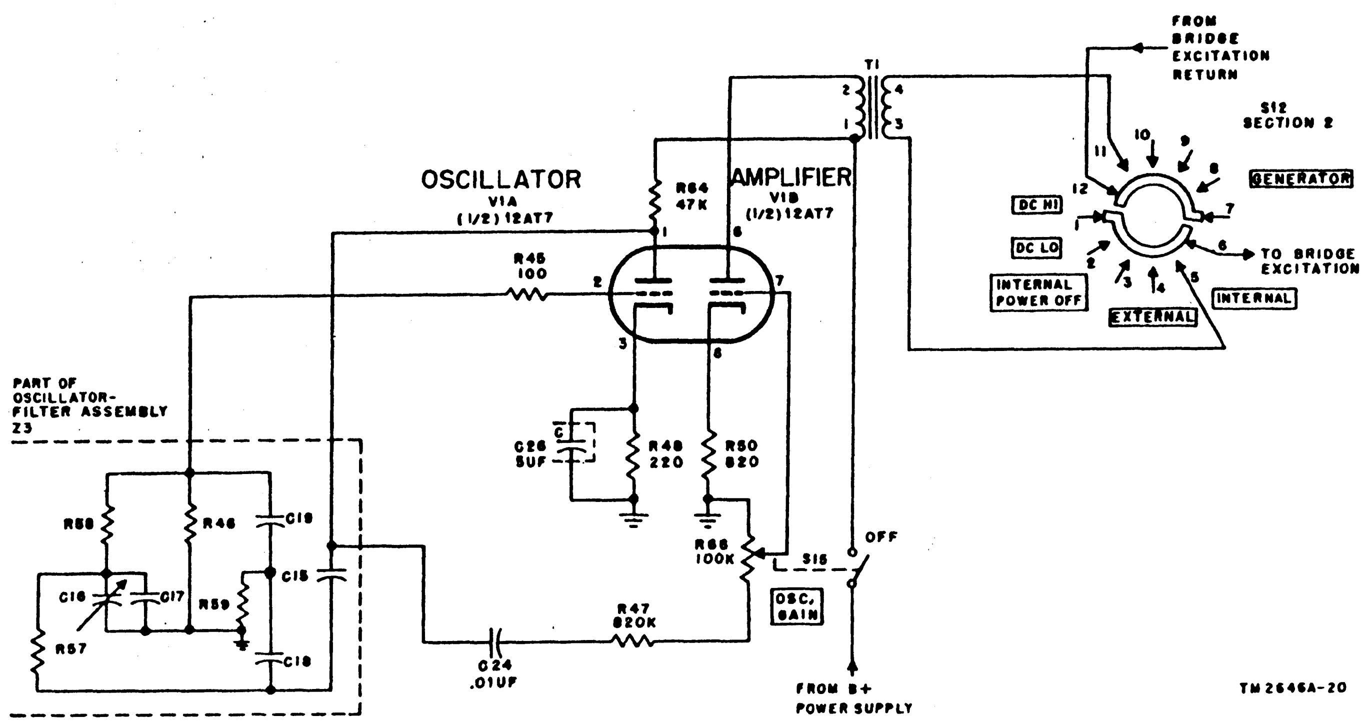


Figure 18. Oscillator-amplifier circuit, simplified schematic diagram.

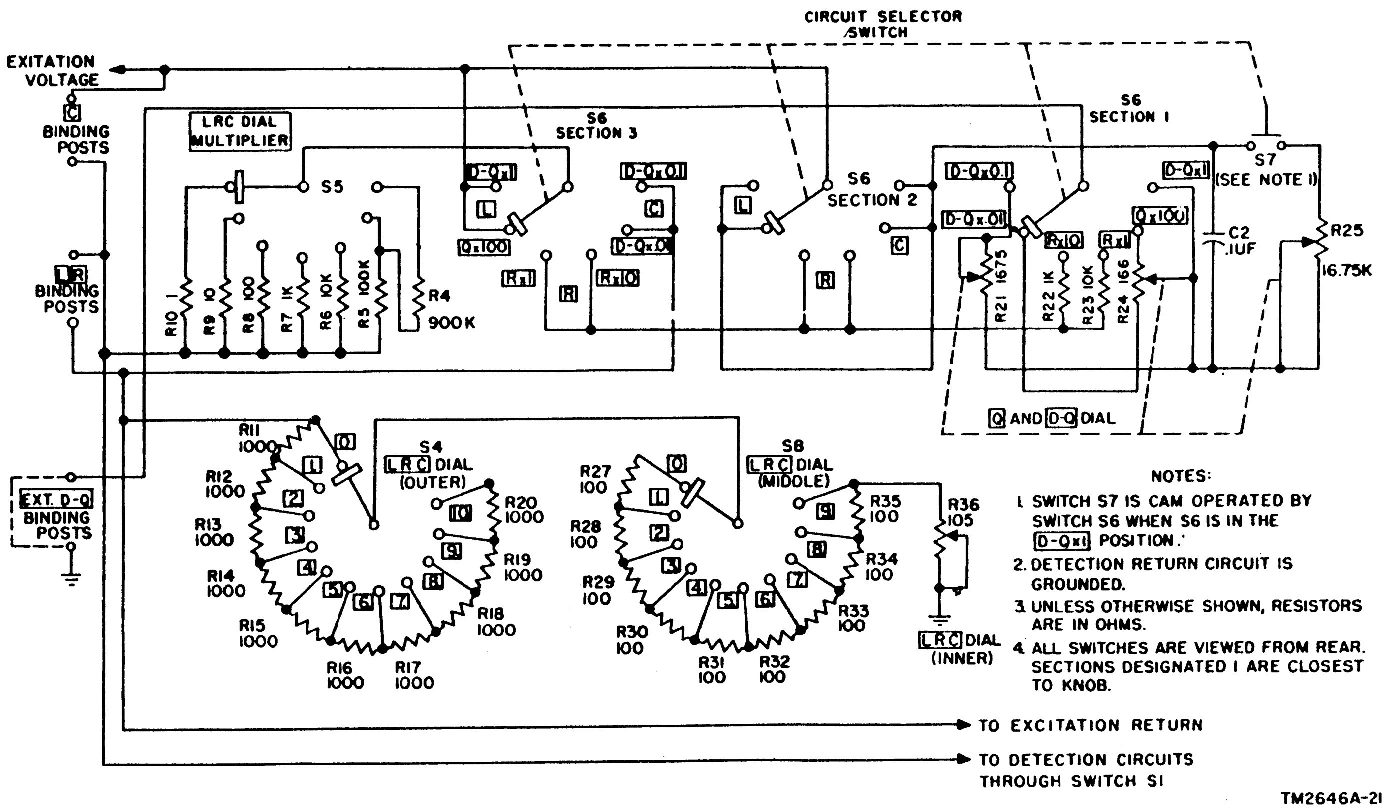
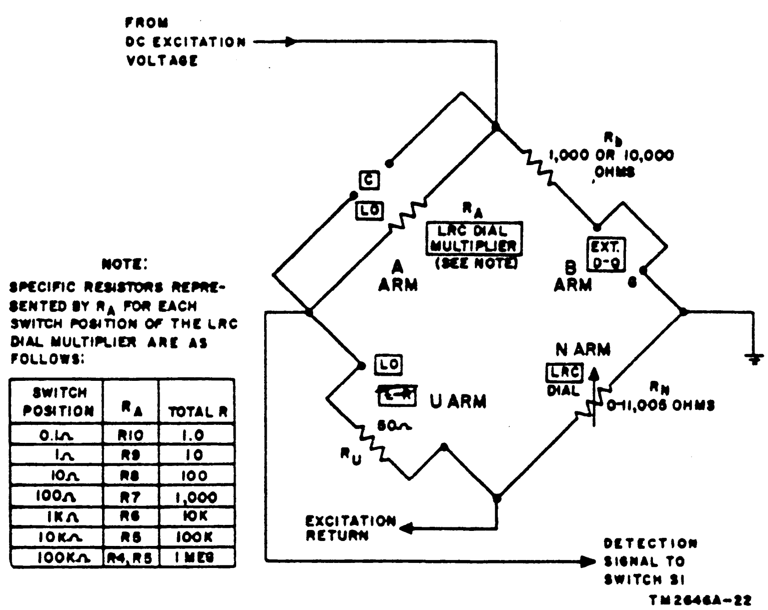


Figure 19. Bridge network circuit, simplified schematic diagram.

61. Bridge Network Circuit

a. General. The bridge network circuitry used for the various test set measurements is shown in figure 19. LRC DIAL MULTIPLIER S5 selects one of the ratio A arm (fig. 20) resistors R4 through R10 (fig. 19) to obtain a null balance. Resistors R21 through R25 in the ratio B arm (fig. 20) are selected by circuit selector switch S6, section 1. The Q and D-Q dial, consisting of rheostats R21, R24, and R25, controls these components in the ratio B arm. The circuit selector switch, with the conections to the binding posts, also alters the bridge network arrangement to the basic circuits shown in figures 20 through 23. Switch S7, actuated by a cam on the circuit selector switch, alters the bridge when measuring inductances when the circuit selector switch is in the L and D-Q x 1 position. Capacitor C2 is a precision component with a tolerance of ±.25 per cent and serves as the standard when measuring capacitors and inductors. The standard calibrated resistance against which components under measurement are compared is composed of resistors R11 through R20 (ratio arm N, fig. 21), selected by LRC outer dial switch S4; resistors R27 through R35, selected by LRC middle dial switch S8; and LRC inner dial potentiometer R36.



NOTE:
SPECIFIC RESISTORS REPRESENTED BY R_A FOR EACH SWITCH POSITION OF THE LRC DIAL MULTIPLIER ARE AS FOLLOWS:

SWITCH POSITION	R_A	TOTAL R
0.1Ω	R10	1.0
1Ω	R9	10
10Ω	R8	100
100Ω	R7	1,000
1KΩ	R6	10K
10KΩ	R5	100K
100KΩ	R4, R5	1 MEG

Figure 20. Wheatstone resistance bridge circuit, simplified schematic diagram.

b. Wheatstone Resistance Bridge Circuit (fig. 20). When measuring resistors, the bridge controls are adjusted as explained in paragraph 18. The network circuitry, when these adjustments are made, becomes a basic Wheatstone bridge composed of resistance arms R_u, R_a, R_n, and R_b. R_u represents the unknown resistor under measurement. When the voltage drop across resistance arm R_b equals the voltage drop across arm R_n and the voltage drop across resistance arm R_a equals the voltage drop across resistance arm R_u, no current flows in the detection circuit, and the bridge is considered to be balanced. The condition of balance may be expressed by the formula:

$$\frac{R_a}{R_b} = \frac{R_u}{R_n}$$

Evaluating for R_u, the formula becomes:

$$R_u = \frac{R_a R_n}{R_b}$$

When resistance arms R_x and R_z and resistor R_y are calibrated on the respective external dials by an operator to obtain a null indication, the value of unknown resistor R_u may be read directly from the LRC dial.

c. Capacitance Bridge Circuit (fig. 21). When measuring capacitors, the test set controls are manipulated as explained in paragraph 23. When the controls are adjusted, the network circuitry becomes a modified De Santy capacitance bridge of the unequal ratio arm type and uses standard capacitor C2 for measurement. The impedances for the two capacitance arms can be shown to be:

$$Z_u = R_u - jX_u \text{ and } Z_b = R_b - jX_{c_b}$$

where: Z_u is impedance of the U ratio arm (fig. 21).
Z_b is impedance of the B ratio arm.
X_u is reactance of the U ratio arm.
X_{c_b} is reactance of the B ratio arm.

When a null exists in the detection circuits, the impedance arm ratios become:

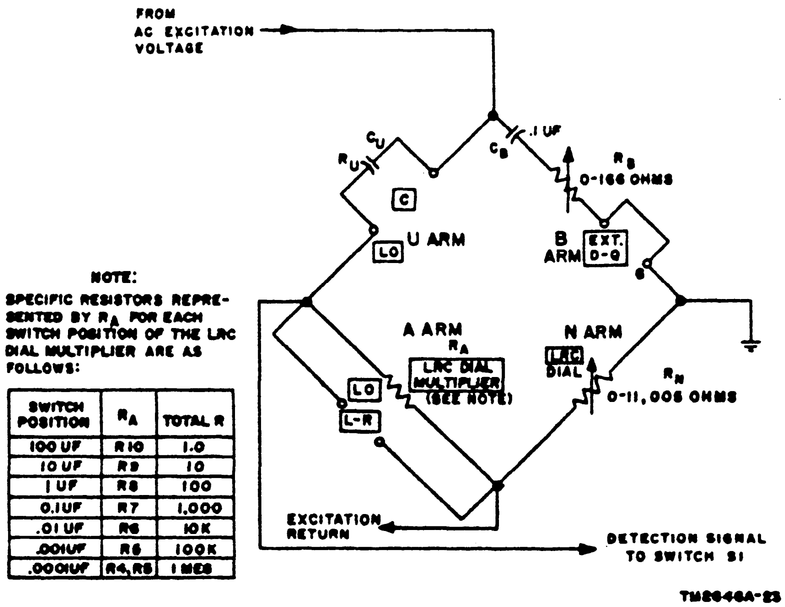
$$\frac{Z_u}{Z_b} = \frac{R_a}{R_n} \quad \text{or } Z_u = \frac{R_a Z_b}{R_n}$$

Evaluating for the reactive parts of the represented impedances, the ratios are:

$$X_u = \frac{R_a X_b}{R_n} \quad \text{or} \quad \frac{1}{\omega C_u} = \frac{R\left(\frac{1}{\omega C_b}\right)}{R_n}$$

Solving for C_u, the ratio becomes:

$$C_u = \frac{R_n C_b}{R_a}$$



SWITCH POSITION	R_A	TOTAL R
100 UF	R10	1.0
10 UF	R9	10
1 UF	R8	100
0.1UF	R7	1,000
.01 UF	R6	10K
.001UF	R6	100K
.0001UF	R4,R5	1 MEG

Figure 21. Modified De Santy capacitance bridge circuit, simplified schematic diagram.

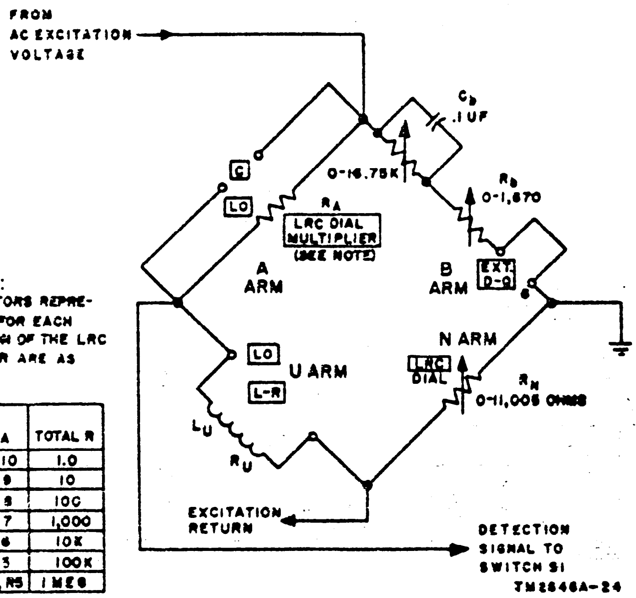
As the bridge arms R_a and R_n are calibrated and because the capacitance C_b (C2) is a standard fixed value, the measurement of the unknown capacitor may be read directly.

d. Maxwell Inductance Bridge Circuit (fig. 22). For measurement of inductors having a storage factor (Q) less than 10.5, the circuit selector switch is set at L and D–Q x 1 position and the rest of the controls are adjusted as explained in paragraph 26. The basic Maxwell bridge resulting compares the unknown inductance (L_u) with standard capacitor C2 (C_b). When a null exists in the detection circuits, the basic equation for the Maxwell bridge is:

$$L_u = R_a R_n C_b$$

and is comparatively independent of frequency. Further, as the bridge ratio arms A and N are set by the operator, and because capacitor C2 is a standard fixed value, the measurement of the unknown inductor is made by taking the readings and making the calculations indicated in paragraph 26*j*, example 1.

e. Hay Inductance Bridge Circuit (fig. 23). For measurement of inductors having a storage factor (Q) between 9.5 and 1,000, the circuit selector switch is set in the L and Q x 100 position and the rest of the bridge controls are adjusted as explained in para-



NOTE:
SPECIFIC RESISTORS REPRESENTED BY R_A FOR EACH SWITCH POSITION OF THE LRC DIAL MULTIPLIER ARE AS FOLLOWS:

SWITCH POSITION	R_A	TOTAL R
0.1 MH	R10	1.0
1 MH	R9	10
10 MH	R8	100
100 MH	R7	1,000
1 H	R6	10K
10 H	R5	100K
100 H	R4, R5	1 MEG

TM2846A-24

Figure 22. Maxwell inductance bridge circuit, simplified schematic diagram.

graph 26. The resulting Hay inductance bridge compares unknown inductance L_u with standard capacitor C2 (C_b). Unlike the Maxwell bridge (*d* above), the Hay bridge depends on frequency, particularly when the inductance has a relatively low Q (a Q of 10 or less). For this reason the Hay bridge is not used to measure inductance having a Q below 10. As the Q of the inductance increases, the considered losses due to frequency become more negligible. For storage factors of approximately 10, or greater, as measured with the Hay bridge circuit, the equation for the Hay bridge circuit is:

$$L_u = R_a R_n C_b$$

Since the bridge arms R_a and R_n are set by the operator, and because standard capacitor C2 has a fixed value, the readings for unknown inductor L_u may be taken and the calculations made (par. 26*j*, example 1).

62. Detection Signal Amplifier Circuit

(fig. 24)

a. The ac detection signal from the bridge circuit is capacitively coupled to the amplifier circuit when DETECTOR switch S1 is in the INTERNAL position by coupling capacitor C28. AMP.

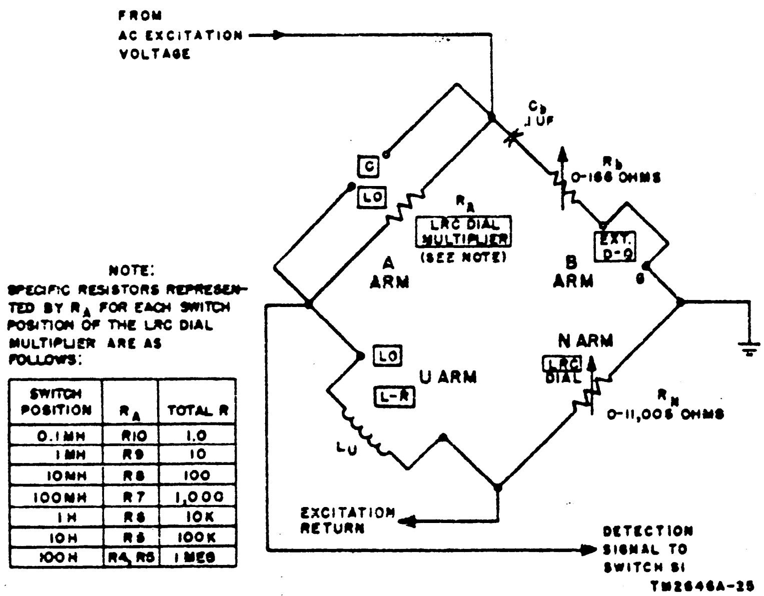


Figure 23. Hay inductance bridge circuit, simplified schematic diagram.

GAIN control R65 serves as both the signal level adjustment and the grid return for first stage amplifier V3A.

b. Amplifier V3A uses cathode bias through cathode-biasing resistor R39 and bypass capacitor C26, section A. Resistor R38 is the plate load for the first stage, and capacitor C23 couples the output signal to the grid of second stage amplifier V3B. Cathode-biasing resistor R40 and bypass capacitor C26, section B provide bias for second stage amplifier V3B. Resistor R41 is the grid return and resistor R42 as the plate load for second stage amplifier V3B.

c. Filtering of the output of second stage amplifier V3B is provided by part of oscillator-filter assembly Z3. When the AMP. RESPONSE switch is in the PEAK position, the filter is coupled between the output plate load and grid circuits of second stage amplifier V3B. This filter provides a high gain at the oscillator excitation frequency of 1,000 cycles, and a high relative attenuation to signals above and below that frequency. The response curve for the filter at various frequencies is shown in figure 25.

d. Resistor R52 and capacitor C25 form a decoupling network. The amplified detection signal passes from the plate of second stage amplifier V3B directly to the null detector located in the detection circuits.

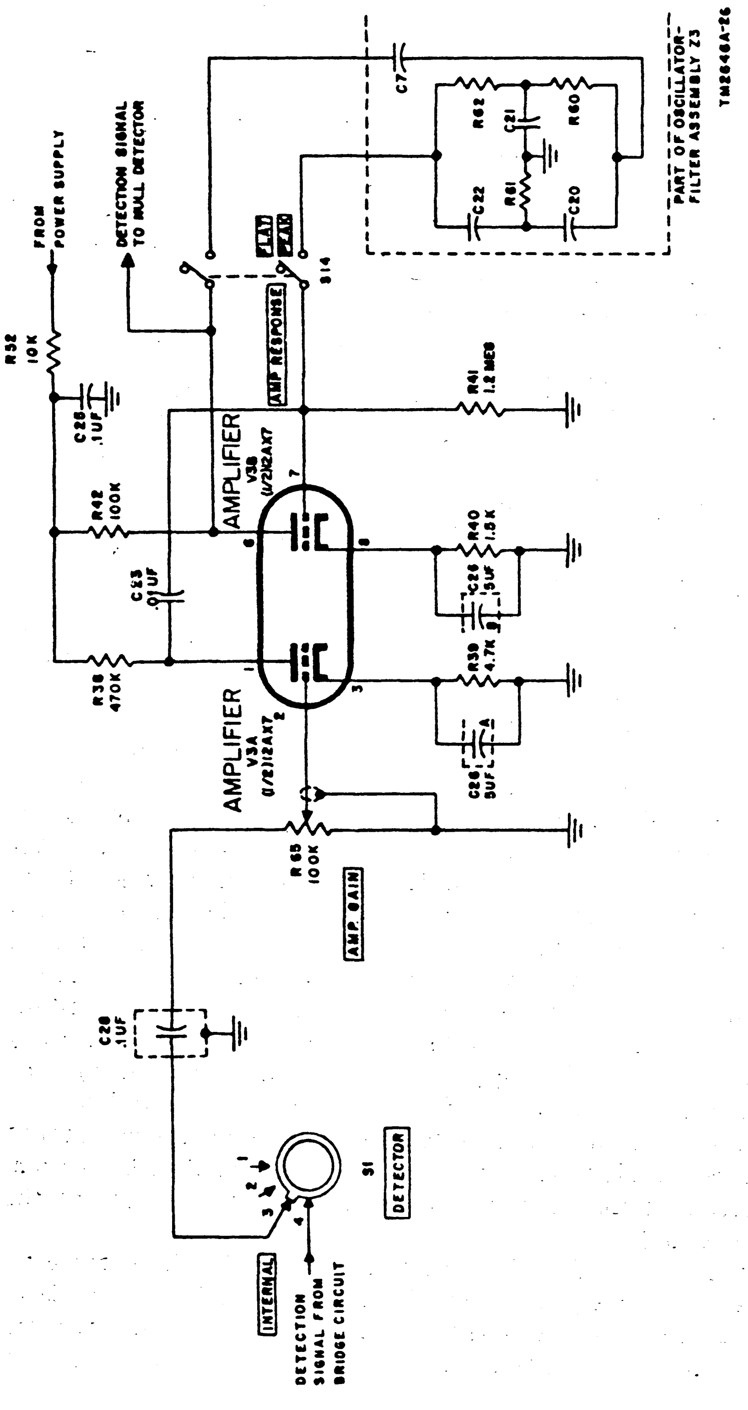


Figure 24. Amplifier circuit, simplified schematic diagram.

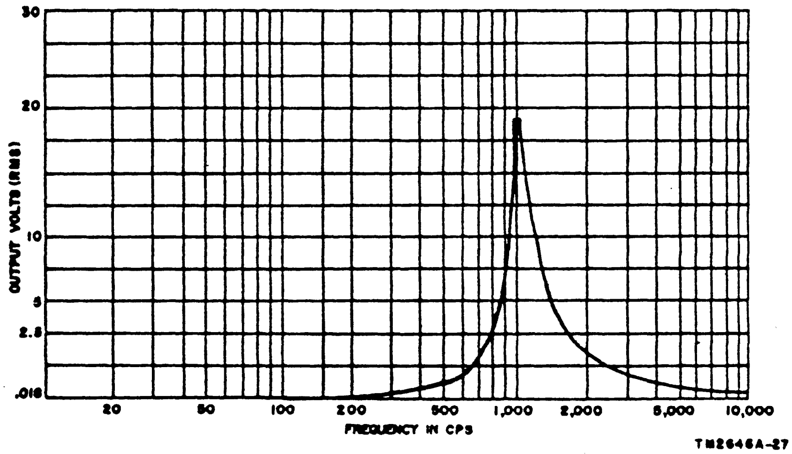


Figure 25. Amplifier circuit filter, response curve.

63. Detection Circuits

a. The detection signals to the detection circuits are controlled by DETECTOR switch S1 (fig. 37) and are directly coupled to the detector except for the INTERNAL position (par. 61), which controls the input to the amplifier circuit. When the DETECTOR switch is in the INTERNAL position, the detector signal from the amplifier circuit is coupled, through capacitor C9 to the grid (pin 3) of null detector V2 (B, fig. 26). The plate (pin 4) of tube V2 is connected directly to the B+ power supply and the deflector plate (pin 2) is connected to B+ through plate voltage-dropping resistor R43. Resistor R44 is the grid-leak resistor. The PHONES jacks are connected across the grid of null detector V2 to ground, and are provided for audio null detection purposes.

b. When DETECTOR switch S1 is in the EXTERNAL position, the detection signal from the bridge circuit is channeled directly to the EXT. DET. binding posts on the front panel (A, fig. 26) through contacts 4 and 2 of S1. Provision is thus available for connecting other detection devices, such as oscilloscopes, output voltmeters, etc. However when S1 is in the EXTERNAL position, the detection signal amplifier (par. 61) is switched out of the circuit (fig. 37).

c. When in the METER position, the DETECTOR switch connects the detection signal directly to galvanometer M1 (A, fig. 26). The galvanometer is a conventional D'Arsonval type meter, with 7.5 microamperes sensitivity in either direction from center 0 position. Resistor R1 is the damping resistor and resistor R2 is the shunt for the galvanometer. When operated, push-to-operate METER SHUNT switch S13 connects the detector signal directly to the galvanometer. This increases the sensitivity of the galvanometer for fine adjustments.

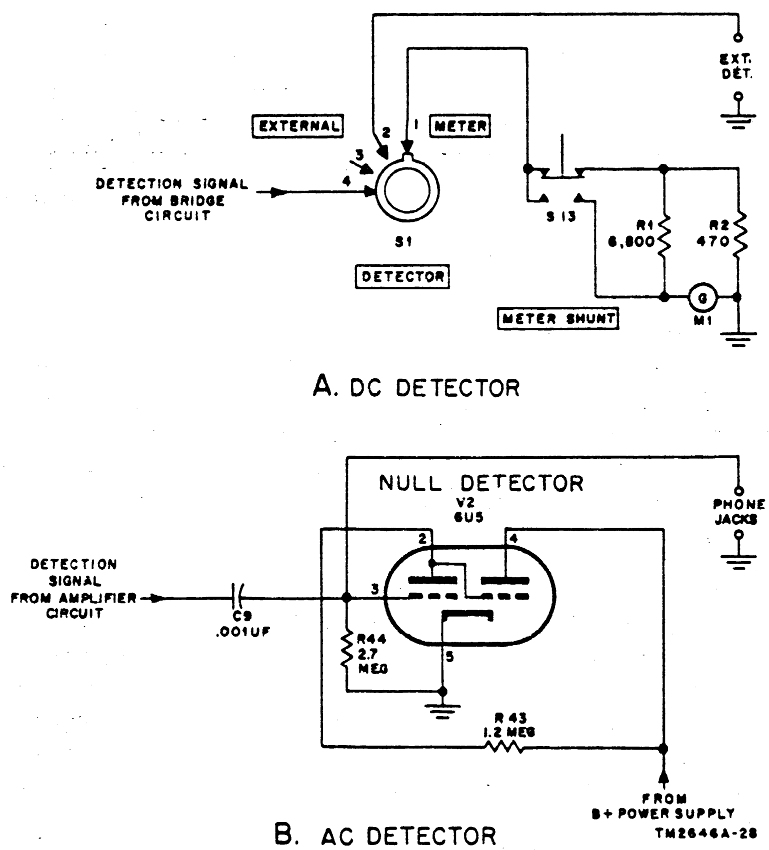


Figure 26. Detection circuits, simplified schematic diagram.

CHAPTER 6

FIELD MAINTENANCE

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

Section I. TROUBLE SHOOTING AT FIELD MAINTENANCE LEVEL

Warning: Certain points located throughout the chassis of the test set operate at voltages above 310 volts (fig. 28 and 29). Do not touch these points while power is applied to the test set.

64. Trouble-shooting Procedures

a. General. The first step in servicing a defective bridge is to sectionalize the fault. Sectionalization means tracing the fault to the circuit responsible for the abnormal operation of the test set. 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 transformers, leaky capacitors, or broken wires, often can be located by sight, smell, and hearing (par. 53). The majority of faults, however, must be localized by checking voltages and resistances (fig. 28 and 29).

b. Component Sectionalization and Localization. Listed below are a group of tests arranged to simplify and reduce unnecessary work and to aid in tracing a trouble to a specific part. Follow the procedures carefully in the sequence given.

(1) *Visual inspection.* Visual inspection (par. 53) 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. 68) 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. All symptoms must be interpreted in relation to one another. To perform an operational test on the bridge use the equipment performance check list (par. 56).

(4) *Trouble-shooting chart.* The trouble symptoms listed in this chart (par. 69) 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. Check wiring for loose connections and carefully apply a small amount of pressure to wires and components with an insulated tool. This will show where a faulty connection or component is located.

65. Trouble-shooting Data

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

Fig. or par. No.	Title
Fig. 17	Power supply, simplified schematic diagram.
Fig. 18	Oscillator-amplifier circuit, simplified schematic diagram.
Fig. 19	Bridge network circuit, simplified schematic diagram.
Fig. 24	Amplifier circuit, simplified schematic diagram.
Fig. 26	Detection circuits, simplified schematic diagram.
Fig. 27	Test set, voltage distribution.
Fig. 28	Test set, tube socket voltage and resistance diagram.
Fig. 29	Test set, terminal board voltage and resistance diagram.
Fig. 30	Capacitance-Inductance-Resistance Test Set AN/URM-90, top view of chassis, location of parts.
Fig. 31	Capacitance-Inductance-Resistance Test Set AN/URM-90, bottom view of chassis, location of parts.
Fig. 32	Capacitance-Inductance-Resistance Test Set AN/URM-90, right side view of chassis, location of parts.

Fig. or par. No.	Title
Fig. 33	Terminal board assembly E2, bottom view, showing location of resistors.
Fig. 35	MIL STD capacitor color codes.
Fig. 36	MIL STD resistor color codes.
Fig. 37	Test set, schematic diagram.
Fig. 38	Test set, wiring diagram.
Par. 53	Trouble shooting by visual inspection.
Par. 54	Trouble shooting and replacing faulty tubes.
Par. 56	Equipment performance check list.
Par. 64	Trouble-shooting procedures.
Par. 68	Checking filament and B+ circuits for shorts.
Par. 69	Trouble-shooting chart.
Par. 70	Dc resistances of transformers.

66. Test Equipment Required for Trouble Shooting

The test equipment required for trouble shooting the test set is listed in the table below. Technical manuals associated with each item also are listed.

Test equipment	Technical manual
Electron Tube Test Set TV-2/U	TM 11-2661
Multimeter TS-352/U	TM 11-5527
Resistance Bridge ZM-4A/U	TM 11-2019
Frequency Meter FR-67/U	TM 11-2698

67. General Precautions

Observe the following precautions carefully when servicing the test set:

a. Be careful when servicing the bridge when removed from its case; dangerous voltages are exposed.

b. If the test set has been operating for some time, prevent burns on the hand or fingers by using a cloth when removing the hot metal tube shields and a tube puller to remove the tubes.

c. When moving the test set during servicing operations, check to be sure the galvanometer needle is secured by moving the galvanometer needle clamp to the CLAMP position.

d. Do not overtighten screws when assembling mechanical couplings.

e. When changing a component that is secured with screws, be sure to replace the lock washers.

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 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) Be careful when using a soldering iron near decade resistors R4 through R20 and R27 through R35 (fig. 32). These decade resistors are precision parts and exposure to excessive heat may materially change their resistance, thus affecting the over-all accuracy of the bridge.

(4) Do not attempt to replace the individual decade resistors. Replace the entire decade unit when tests indicate faulty individual decade resistor.

(5) Do not allow drops of solder to fall into parts of the chassis. They may cause short circuits.

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

(7) The bridge contains a number of precision electrical components, 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 bridge operation or instability.

68. Checking Filament and B+ Circuits for Shorts

a. General. Short circuits in either the B+ or filament circuits of the bridge may disable the unit. If the bridge is operated with a short circuit, the increased current that results may permanently damage the tubes and other circuit components. Figure 27 shows schematically the components of the B+ circuit.

b. Short Circuit Indications. Short circuits may be suspected because of any one of the following symptoms:

(1) Abnormally short tube life.

(2) Evidences of discoloration caused by overheating.

(3) Burned-out fuse F1.

(4) Melted or charred insulation on bridge wiring.

(5) Improper bridge operation, particularly when making capacitance and inductance measurements.

c. Short Circuit Checks. To check for short circuits without causing additional damage to the bridge, proceed as follows:

(1) Disconnect all power to the bridge.

(2) Remove the bridge chassis from the case (par. 51*b*(2)).

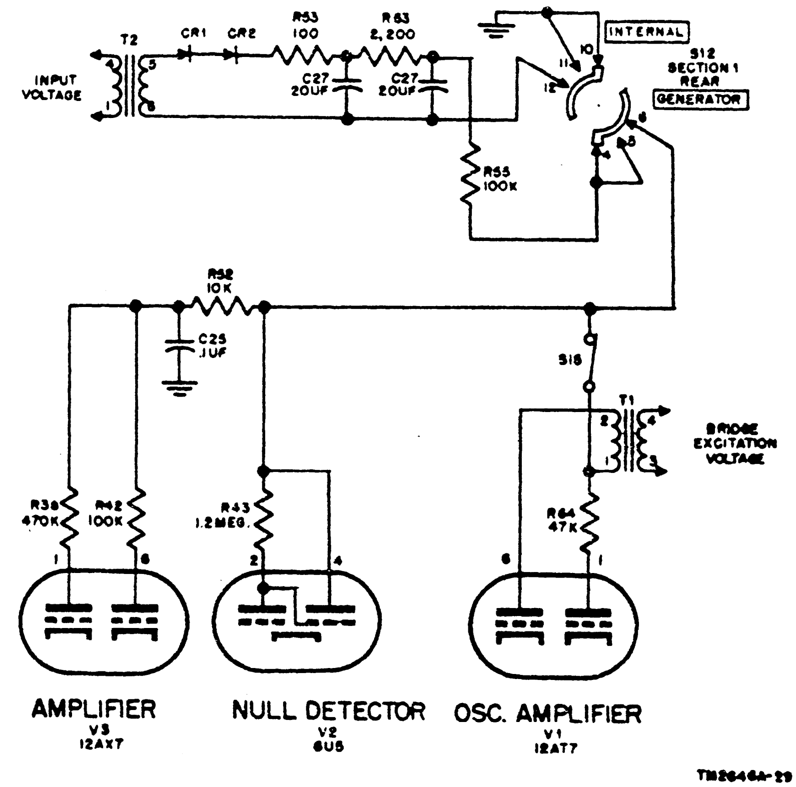
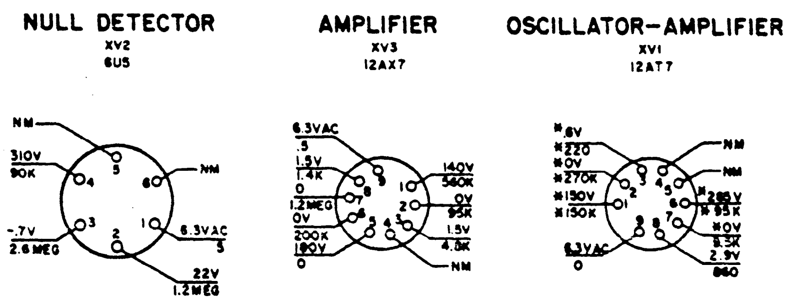


Figure 27. Test set, B+ voltage distribution.



NOTES: 1. LINE VOLTAGE 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS, EXCEPT WHERE OTHERWISE SPECIFIED.
3. NM MEANS NOT TO BE MEASURED.
4. MAKE ALL MEASUREMENTS WITH 20,000 OHM-PER-VOLT METER.
5. GENERATOR SWITCH IN INTERNAL POSITION.
6. ALL MEASUREMENTS ARE MADE FROM TUBE SOCKET PIN TO CHASSIS GROUND. VOLTAGE READINGS ARE SHOWN ABOVE THE LINE AND RESISTANCE READINGS BELOW THE LINE.
7. OSC. GAIN SWITCH IN OFF POSITION EXCEPT FOR MEASUREMENTS WITH ASTERISK (*). THESE MEASUREMENTS MADE WITH OSC. GAIN SWITCH IN HI POSITION.

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Figure 28. Test set, tube socket voltage and resistance diagram.

(3) Use Multimeter TS-352/U and perform resistance to ground checks as indicated in figures 29 and 30. All resistance readings should be within ±10 per cent of the indicated value. The B+ schematic diagram is shown in figure 27 and the filament schematic is shown in figure 37.

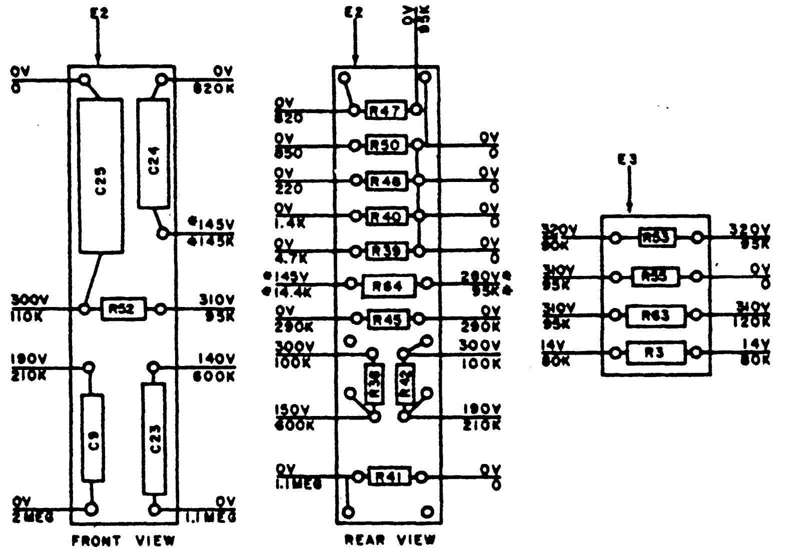
d. Isolating Short Circuits. The following chart may be used in conjunction with the check readings performed as instructed in *c*(3) above to isolate the probable causes of abnormal resistance readings:

Points of measurement[a]	Normal indication (±10%)	Isolation
Between pin 6 of tube socket X7 (V3) and ground.	Resistance reading of 200,000 ohms.	Reading of approximately 100,000 ohms may indicate one of the following conditions: (1) Shorted capacitor C25. (2) One section of capacitor C27 shorted.
Between pins 5 and 6 of transformer T2.	Resistance reading of 414 ohms.	Low resistance reading will indicate high-voltage winding of transformer T2 shorted.
Between pin 9 of tube socket X6 (VI and ground.	Resistance reading of .5 ohm.	Zero resistance reading may indicate one of the following conditions: (1) Shorted filament winding of transformer T2. (1) Short across filament of V1, V2, or V3.

[a]All readings shall be made with the GENERATOR switch in the INTERNAL position.

69. Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the test set. It lists the symptoms the repairman observes, either visual or audible, 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 the circuit (fig. 28 and 29), ordinarily should be sufficient to isolate the defective part.



NOTES:

1. LINE VOLTAGE IS 115 VOLTS.
2. ALL RESISTANCES ARE IN OHMS.
3. VOLTAGES MEASURED WITH 20,000 OHMS-PER-VOLT METER.
4. GENERATOR SWITCH IN INTERNAL POSITION.
5. OSC. GAIN CONTROL IN OFF POSITION EXCEPT WHERE INDICATED WITH ASTERISK (*). THESE MEASUREMENTS ARE MADE WITH SWITCH IN HI POSITION.
6. VOLTAGE READINGS ABOVE LINE, AND RESISTANCE TO GROUND BELOW LINE.

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Figure 29. Test set, terminal board voltage and resistance diagram.

Symptom	Probable cause	Correction
1. Pilot lamp I 1 does not light when POWER switch is moved to ON.	*a.* Burned-out fuse F1. *b.* Defective POWER switch S16. *c.* Burned-out pilot lamp I 1.	*a.* Replace defective fuse (par. 58). *b.* Replace defective switch (par. 81). *c.* Replace pilot lamp (par. 57).
2. Electron ray tube V2 does not light when GENERATOR switch S12 is turned to EXTERNAL or INTERNAL position.	*a.* Defective transformer T1. *b.* Defective or dirty GENERATOR switch S12. *c.* Defective electron ray tube V2.	*a.* Replace transformer (par. 86). *b.* Clean or replace switch (par. 83). *c.* Replace electron ray tube (par. 54).
3. Rotation of OSC. GAIN control does not affect shadow width on electron ray tube V2.	*a.* Defective OSC. GAIN control (R66 and S15).	*a.* Replace control (par. 75).

Symptom	Probable cause	Correction
4. Erratic or inoperative galvanometer operation.	*a.* Defective galvanometer M1.	*a.* Replace galvanometer (par. 74).
	b. Defective transformer T2.	*b.* Replace transformer T2 (par. 86).
	c. Defective or dirty DETECTOR switch S1.	*c.* Clean or replace switch S1 (par. 84).
	d. Defective METER SHUNT switch S13.	*d.* Replace switch S13 (par. 78).
	e. Defective resistor R1 or R2.	*e.* Replace defective resistor R1 or R2 (par. 78).
5. No audible tone signal in headset when detecting aurally.	*a.* Defective oscillator-filter Z3.	*a.* Replace oscillator-filter Z3 (par. 77).
	b. Defective electron ray tube V1.	*b.* Replace tube V1 (par. 54).
	c. Defective PHONES jack J2 or J3.	*c.* Replace defective jack J2 or J3 (par. 88).
	d. Defective or dirty DETECTOR switch S1.	*d.* Clean or replace switch S1 (par. 84).
6. Bridge operates satisfactorily, except when using external generator.	*a.* Defective or dirty GENERATOR switch S12.	*a.* Clean or replace switch S12 (par. 83).
7. Bridge operation erratic and inaccurate on all ranges when LRC dial is adjusted.	*a.* Defective or dirty variable resistor R36.	*a.* Clean or replace variable resistor R36.
	b. EXT. D-Q binding posts not shorted.	*b.* Insert shorting bar between binding posts.
	c. Dirty or defective switch S4 or S8.	*c.* Clean or replace switches.
8. Bridge operation erratic or inaccurate only on certain ranges of the LRC DIAL MULTIPLIER and circuit selector switch.	*a.* Defective decade resistors R11 through R20, or R27 through R35 (one or more).	*a.* Replace defective switch assembly.
	b. Dirty or defective switch S4 or S8.	*b.* Clean if found dirty. Replace defective switch.
	c. Defective resistor R22 or R23.	*c.* Replace defective resistor.
9. Operation of METER SHUNT switch does not increase galvanometer sensitivity.	*a.* Defective METER SHUNT switch S13.	*a.* Replace switch S13 (par. 78).
	b. Defective resistor R1 or R2.	*b.* Replace defective resistor.

Symptom	Probable cause	Correction
10. Bridge inoperative for dc resistance measurements.	*a.* Burned-out fuse F1.	*a.* Replace defective fuse (par. 58).
	b. Defective POWER switch S16.	*b.* Replace switch S16 (par. 81).
	c. Defective transformer T2.	*c.* Replace transformer (par. 86).
	d. Defective GENERATOR switch S12.	*d.* Replace switch S12 (par. 83).
	e. Faulty wiring if galvanometer will not center at 0.	*e.* Check wiring for short circuits. Check exposed wiring for shorts to metal cabinet (par. 68).
	f. EXT. D-Q binding posts not shorted.	*f.* Insert shorting bar between EXT. D-Q binding posts.
	g. Defective or dirty switch S5 or S6.	*g.* Clean contacts or replace affected switch.
	h. Open or defective variable resistor R36.	*h.* Adjust or replace variable resistor R36.
	i. Defective DETECTOR switch S1.	*i.* Replace or repair switch S1 (par. 84).
	j. Defective galvanometer M1.	*j.* Replace galvanometer M1 (par. 74).
11. Bridge inoperative for capacitance or inductance measurements (ac measurements).	*a* Defective tube V1, V2, V3.	*a.* Check tubes, replace defective tube or tubes (par. 54).
	b. Open in AMP. GAIN control R65. (Control grid of tube V1 to ground should measure 100K when AMP. GAIN control is in H1 position.)	*b.* Replace AMP. GAIN control R65 (par. 82).
	c. Shorted section (A, B, or C) capacitor C26.	*c.* Replace capacitor C26 (par. 73).
	d. Faulty oscillator-filter assembly Z3.	*d.* Replace oscillator-filter assembly Z3 (par. 77).
	e. Defective transformer T1.	*e.* Replace transformer T1 (par. 86).
	f. Shorted or defective capacitor C2.	*f.* Replace capacitor C2 (par. 72).
	g. Burned-out fuse F1.	*g.* Replace defective fuse F1 (par. 58).

Symptom	Probable cause	Correction
	h. Defective POWER switch S16.	*h.* Replace switch S16 (par. 81).
	i. Defective transformer T2.	*i.* Replace transformer T2 (par. 86).
	j. Defective GENERATOR switch S12.	*j.* Replace or repair switch (par. 83).
	k. EXT. D-Q binding posts not shorted.	*k.* Insert shorting bar between binding posts.
	l. Defective or dirty switch S5 or S6.	*l.* Clean or replace affected switch.
	m. Open or defective variable resistor R21.	*m.* Replace or repair resistor R21.
	n. Open or defective variable resistor R36.	*n.* Replace faulty variable resistor R36.
	o. Defective DETECTOR switch S1.	*o.* Replace or repair switch S1 (par. 84).

70. Dc Resistances of Transformers

The dc resistances of transformers T1 and T2 in the test set are listed below:

Transformer	Terminals	Ohms
T1	1–2	2,512
	3–4	222
T2	1–4	19.5
	5–6	413.5
	7–8	.257
	9–10	3.5

Section II. REPAIRS

71. Replacement of Parts

Note. Sometimes dissimilar components on the bridge are provided with common mountings. For example, the resistor and switch assembly consists of switch S5, part of switch S6, and decade resistors R4 through R10.

a. Before replacing any component part of the bridge not explained in paragraphs 72 through 91, refer to paragraph 67.

b. Before replacing or repairing any parts, such as capacitors, variable resistors, terminal boards, or switches, refer to paragraph 67*f*(1). The bridge contains a number of bus wire type interconnections; therefore, before removing any bus wire connection, carefully note the exact routing and all connecting techniques used. Improper replacement of these wires may affect the design characteristics of the bridge. Use the wiring diagram (fig. 38) as a guide in connecting wires between terminals; use the old lead, if possible, as a guide in forming the new lead.

c. Carefully note the dial and pointer settings of each switch and variable resistor relative to the actual physical position of the component wiper or contact prior to disassembly. Use these notes to insure correct reassembly.

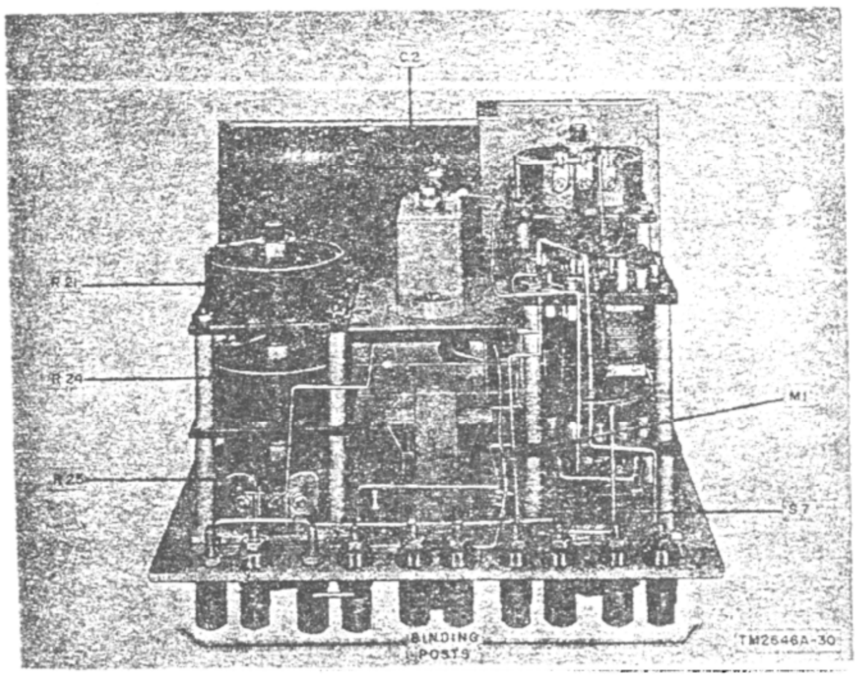


Figure 30. ***Capacitance-Inductance-Resistance Test Set AN/URM-90, top view of chassis, location of parts.***

d. To remove the bridge chassis from the case, refer to paragraph 51*b*(2). For servicing, the chassis should be placed on a work bench so that the part of chassis to be serviced is closest to the repair personnel.

Warning: Discharge capacitor C2 (fig. 30) by shorting the capacitor terminals before making any repairs to the set.

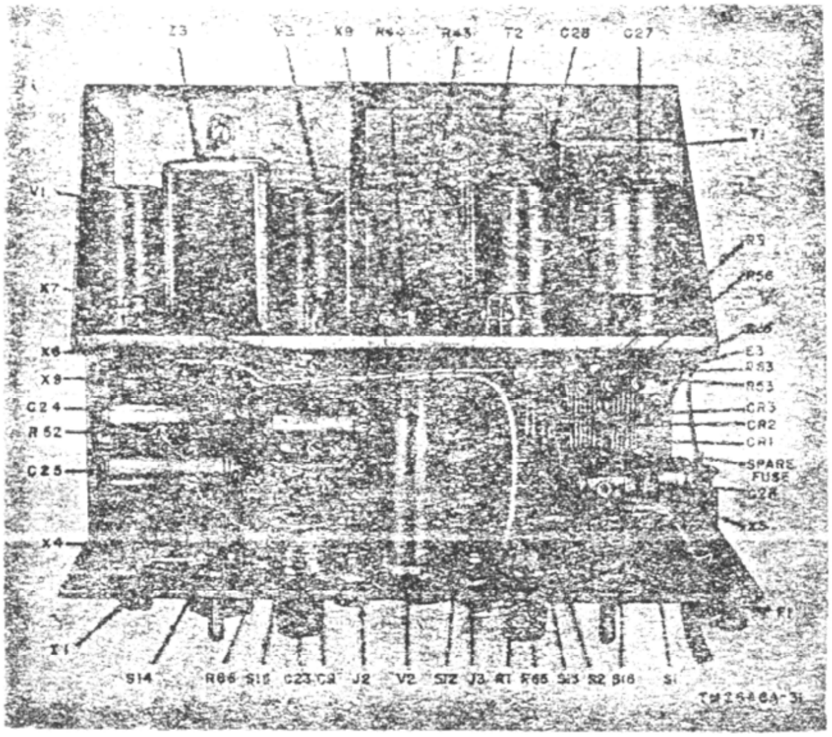


Figure 31. Capacitance-Inductance-Resistance Test Set AN/URM–90, bottom view of chassis, location of parts.

72. Replacing Capacitor C2
(fig. 30)

a. Removing Capacitor C2.

(1) Remove the bridge chassis from the case (par. 51*b* (2)).

(2) Remove the two hexagonal nuts that attach the bus wire terminals to the capacitor studs. Tag and remove the bus wire connections (par. 67*f*).

(3) Remove the two binder head screws and washers attaching the capacitor to the mounting board.

b. Reassembling Capacitor C2.

(1) Mount the capacitor on the mounting board with the binder head screws and washers.

(2) Replace the bus wire terminals on the proper capacitor studs.

(3) Secure the bus wire terminals by replacing the two hexagonal nuts on the capacitor studs.

(4) Replace the bridge chassis in the carrying case (par. 51*b* (11)).

73. Replacing Capacitors C26 and C27
(fig. 31)

a. Removing Capacitors C26 and C27.

(1) Remove the bridge chassis from the carrying case (par. 51*b*(2)).

(2) Unsolder the leads from the bottom of the faulty capacitor. Refer to paragraph 67*f* before unsoldering any of the leads.

(3) Note the index marks on the bottom of the faulty capacitor, and mark the location of these index marks on the mounting plate so that the new capacitor can be positioned exactly as the faulty capacitor.

(4) Loosen the retaining screw on the capacitor mounting bracket. Carefully slide the faulty capacitor out of the mounting bracket.

b. Reassembling Capacitors C26 and C27.

(1) Check the index markings on the bottom of the new capacitor.

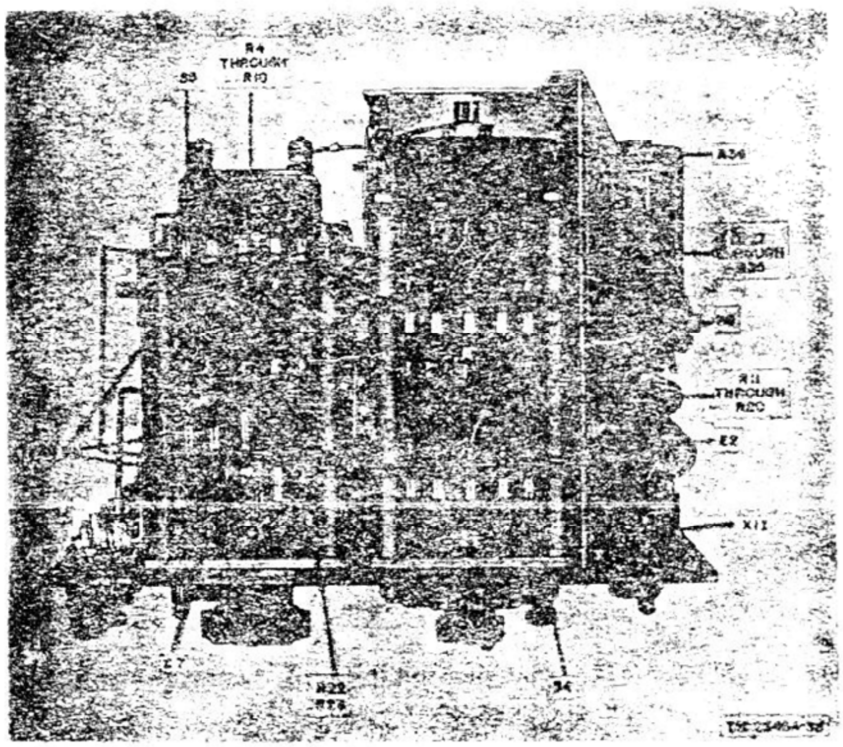


Figure 32. Capacitance-Inductance-Resistance Test Set AN/URM-90, right side view of chassis, location of parts

(2) Slide the new capacitor into the capacitor mounting bracket. Turn the new capacitor so that it is positioned exactly as the faulty capacitor was positioned.

(3) Tighten the retaining screw on the capacitor mounting bracket.

(4) Connect the leads to the terminals on the bottom of the new capacitor (fig. 38). Do not bend or twist the terminals on the capacitor.

(5) Solder the connections on the bottom of the new capacitor.

(6) Replace the bridge chassis in the carrying case (par. 51*b*(11)).

74. Replacing Galvanometer M1

a. Removing Galvanometer M1.

(1) Remove the bridge chassis from the carrying case (par. 51*b*(2)).

(2) Unscrew the two fillister head screws that secure the galvanc ıeter into the front panel (fig. 4).

(3) Carefully slide the galvanometer out of the front panel.

(4) Unscrew the flat head machine screws that were hidden by the galvanometer movement.

(5) Remove the magnet retaining bar from the chassis (fig. 30).

(6) Remove the permanent magnet from the chassis.

(7) Unsolder and remove the leads connected to the galvanometer and remove the insulating terminal board from the rear of the panel. Refer to paragraph 67*f* before disconnecting any leads.

b. Reassembling Galvanometer M1.

(1) Align the two tapped holes in the insulator-terminal board with the upper galvanometer mounting holes in the panel and slide the studs into the holes in the panel (fig. 4 and 30).

(2) Connect and solder the leads to the terminals on the insulator-terminal board.

(3) Position the magnet against the insulator-terminal board with the open end of the magnet toward the top of the panel.

(4) Position the magnet retaining bar against the back of the magnet. Align the tapped holes in the bar with the lower mounting holes in the front panel.

(5) Replace the flat head screws. Do not tighten beyond the point necessary to retain the mounted parts.

(6) Temporarily insert the meter movement in the hole in the panel to check meter clearance.

(7) Remove the meter movement and loosen the flat headed screws. Align the open end of the magnet so that the meter movement is positioned exactly in the center of the opening and the end of the magnet is flush with the top of the meter movement.

(8) Replace the meter movement in the front panel.

(9) Replace and tighten the fillister head screws that retain the meter movement.

(10) Replace the bridge chassis in the carrying case (par. 51*b*(11)).

75. Replacing OSC. GAIN Control (R66 and S15) (fig. 31)

a. Removing OSC. GAIN Control.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

(2) Unsolder the leads from the back of the switch. Refer to paragraph 67*f* before disconnecting any leads.

(3) Loosen the retaining screw on the side of the knob and remove the control knob.

(4) Remove the hexagonal mounting nut that attaches the control to the front panel with a wrench of the proper size. Be careful not to scratch the front panel.

(5) Slide the control from the rear of the front panel

b. Reassembling OSC. GAIN Control. Install the new OSC. GAIN control on the bridge by reversing the disassembly procedure in *a* above. Replace the chassis in the carrying case (par. 51*b*(11)).

76. Replacing Resistors R38 Through R42, R45, R47, R48, R50, and R64 on Terminal Board E2

a. Removing Resistors.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

(2) Remove the two retaining screws and washers that attach terminal board E2 to the bridge chassis (fig. 32).

(3) Unsolder all lead wires necessary (par. 67*f*) to reach the underside of the terminal board.

(4) Replace the resistors as necessary (fig. 33).

Note. To replace terminal board E2, unsolder all resistors (from the bottom) and capacitors (from the top, fig. 32) and resolder these components on the replacement board.

b. Reassembling Terminal Board.

(1) Resolder all resistor lead wires to the terminal board (fig. 33).

(2) Position the terminal board on the standoff mounting spacers.

(3) Replace the two screws and washers that attach the terminal board.

(4) Replace the bridge chassis in the carrying case (par. 51*b*(11)).

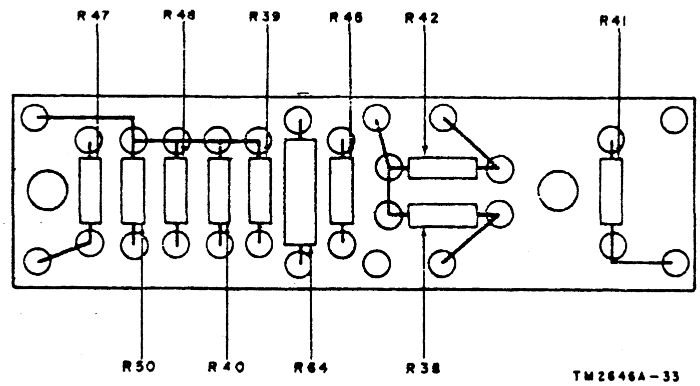


Figure 33. Terminal board assembly E2, bottom view, showing location of resistors.

77. Replacing Oscillator-filter Control Assembly Z3

(fig. 16 and 31)

Note. Do not attempt any repair operations or replacement of resistors or capacitors within sealed oscillator-filter assembly Z3 (fig. 31). If in doubt as to the condition of the internal components, replace the entire assembly.

a. Removing Oscillator-filter Assembly Z3.

(1) Remove the bridge chassis from the carrying case (par. 51*b*(2)).

(2) Unscrew the retaining screw from the bracket on the top of the filter control assembly (fig. 16).

(3) Pull the filter control assembly out of the socket. Be careful not to twist the assembly so the socket is damaged.

b. Installing Oscillator-filter Assembly Z3.

(1) Slide the new filter assembly into the socket. Be sure it is positioned correctly.

(2) Replace the retaining screw in the bracket on the top of the filter assembly.

(3) Replace the bridge chassis in the carrying case (par. 51*b*(11)).

78. Replacing METER SHUNT Switch S13

(fig. 31)

a. Removing METER SHUNT Switch S13.

(1) Remove the bridge chassis from the carrying case (par. 51*b*(2)).

(2) Unscrew the retaining nut on the front panel and slide the METER SHUNT switch out of the front panel.

(3) Unsolder the leads connected to the switch. Refer to paragraph 67*f* before disconnecting any leads.

(4) Unsolder the resistors (R1 and R2) connected to the switch. Save the resistors so they can be used on the new switch.

b. Installing METER SHUNT Switch S13.

(1) Connect the resistors to the new switch. Be sure the resistors are connected to the correct terminals. (fig. 38).

(2) Connect the leads to the switch and solder the connection. Be sure the leads are connected to the correct terminals.

(3) Slide the switch into the front panel, and replace the retaining nut.

(4) Dress the leads connected to the switch into their original positions.

(5) Replace the bridge chassis in the carrying case (par. 51*b* (11)).

79. Replacing Terminal Board E3

(fig. 31)

a. Removing Terminal Board E3.

(1) Remove the bridge chassis from the carrying case (par. 51*b* (2)).

(2) Unsolder the leads connected to the terminals (par. 67*f*).

(3) Remove the two retaining screws located on the opposite side of the mounting plate, behind capacitor C27.

Note. The resistors mounted on the terminal board can be replaced without removing the terminal board.

b. Installing Terminal Board E3. Replace the terminal board by reversing the instruction in *a* above.

80. Replacing Rectifiers CR1, CR2, and CR3

(fig. 31)

a. Removing Rectifiers.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

(2) Unsolder rectifier wiring (par. 67*f*).

(3) Remove the two screws, nuts, and washers that attach the brackets at either end of the assembled rectifiers.

(4) Disassemble the desired rectifier by removing the mounting screw, nut, and washer that attach the rectifiers to the brackets.

b. Installing Rectifiers. To reassemble and replace the rectifiers, reverse the disassembly procedure given in *a* above.

81. Replacing POWER Switch S14 and AMP. RESPONSE Switch S16

(fig. 31)

a. Removing Switches S14 and S16.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

(2) Unsolder the switch wiring (par. 67*f*).

(3) Remove the retaining nuts at the front panel; be careful not to mar the finish of the panel.

(4) Extract the switches from the rear of the panel.

b. Installing Switches. To install the switches, reverse the disassembly procedure given in *a* above.

82. Replacing AMP. GAIN Control R65

(fig. 31)

a. Removing AMP. GAIN Control.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

(2) Unsolder the lead wires to the control (par. 67*f*).

(3) Loosen the retaining screw on the side of the control knob and remove the knob.

(4) Remove the retaining nut at the front panel; be careful not to mar the finish of the panel.

(5) Extract the control from the rear of the panel.

b. Installing AMP. GAIN Control. To replace R65, reverse the disassembly procedure given in *a* above.

83. Replacing GENERATOR Switch S12

(fig. 31)

a. Removing GENERATOR Switch S12.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

(2) Remove the entire rectifier assembly (par. 80).

(3) Remove electron ray tube V2.

(4) Loosen the two set screws on the side of the control knob with a No. 8 Allen wrench. Remove the knob.

(5) Remove the retaining nut at the front panel. Be careful not to mar the finish of the panel.

(6) Carefully slide the switch from the rear of the panel. Be careful not to place any undue strain on the lead wires connected to the switch.

(7) Unsolder the lead wires to the switch (par. 67*f*).

b. Reassembling GENERATOR Switch S12.

(1) Resolder the lead wires to the switch.

(2) Replace the switch in its mounting position on the rear of the front panel.

(3) Replace the retaining nut at the front panel. Be careful not to mar the finish of the panel.

(4) Place the control knob on the switch shaft. Tighten one of the set screws on the side of the knob with the No. 8 Allen wrench.

(5) Rotate the switch to the extreme counterclockwise position.

(6) Check the position of the knob pointer. It should be positioned opposite the DC HI marking on the front panel. If necessary, loosen the knob set screw and index the pointer.

(7) Tighten the two set screws on the side of the knob by using the No. 8 Allen wrench.

(8) Replace the electron ray tube in its socket.

(9) Reassemble the rectifier assembly (par. 86*b*).

(10) Replace the bridge chassis in the carrying case (par. 51*b*(11)).

84. Replacing DETECTOR Switch S1

(fig. 31)

a. Removing Switch S1.

(1) Remove the bridge chassis from the case (par. 31*b*(2)).

(2) Loosen the two set screws on the side of the control knob with the No. 8 Allen wrench and remove the knob.

(3) Remove the entire rectifier assembly (par. 80).

(4) Unsolder all switch wiring and the wiring to capacitor C28.

(5) Remove the switch retaining nut at the front panel; be careful not to mar the finish of the panel.

(6) Extract the switch from the rear of the panel.

(7) Remove capacitor C28 from the switch (par. 85).

b. Installing Switch S1.

(1) Reconnect capacitor C28 to the switch (par. 85).

(2) Replace the switch in its mounting position at the rear of the front panel.

(3) Replace and tighten the switch retaining nut at the front panel; be careful not to mar the finish of the panel.

(4) Resolder the lead wires to the switch and to capacitor C28.

(5) Replace the rectifier assembly (par. 80).

(6) Place the control knob on the switch shaft. Tighten one of the set screws on the side of the knob with the No. 8 Allen wrench.

(7) Rotate the switch to the extreme counterclockwise position.

(8) Check the position of the knob pointer. It should be positioned opposite the METER marking on the front panel. If necessary, loosen the knob set screw and index the pointer.

(9) Tighten the two set screws on the side of the knob with the No. 8 Allen wrench.

85. Replacing Capacitor C28

(fig. 31)

a. Removing Capacitor C28.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

(2) Remove DETECTOR switch S1 (par. 84).

(3) Remove the retaining nut and washer attaching the capacitor bracket to the switch.

b. Installing Capacitor C28. To install capacitor C28 in the bridge, reverse the procedure in *a* above.

86. Replacing Transformers T1 and T2

(fig. 31)

a. Removing Transformers T1 and T2.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

(2) Unsolder the transformer lead wires (par. 67).

(3) Remove the four nuts and lock washers that attach each transformer to the chassis.

(4) Carefully remove each transformer by pulling it straight up from the chassis.

b. Installing Transformers T1 and T2. To install the transformers, reverse the disassembly procedure given in *a* above.

87. Replacing Binding Posts

(fig. 30)

a. Removing Binding Posts.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

Note. Before replacing any or all binding posts, carefully note the color and type of binding post attached at each of the identification markings. Also note the exact location and arrangement of all grounding lugs and terminals installed with the binding posts.

(2) Unsolder the wiring to the binding posts (par. 67*f*).

(3) Remove the mounting nuts and lock washers from the binding posts. To keep the binding posts from turning when loosening the retaining nuts, insert a punch or similar object into the vertical holes located in the front panel side of the binding posts.

(4) Remove the identification plates after all binding posts have been removed.

b. Installing Binding Posts. To install a binding post, reverse the disassembly procedure given in *a* above.

88. Replacing PHONES Jacks J2 and J3

(fig. 31)

a. Removing Phone Jacks.

(1) Remove the bridge chassis from the case (par. 51*b*(2)).

(2) Unsolder the lead wires to the jacks.

(3) Remove the mounting nuts that secure the phone jacks to the front panel. Jack J2 has two insulating washers that prevent the jack from grounding to the panel. Remove and save these washers.

b. Installing Phone Jacks.

(1) Replace the jacks in their respective mounting holes in the front panel. Jack J2 has an insulating washer on each side of the panel to prevent the jack from grounding. Replace these washers. Jack J3 is grounded, and has no insulating washers.

(2) Replace and tighten the mounting nuts at the rear of the panel.

(3) Connect the lead wires to the jacks.

Section III. CALIBRATION

Note. Capacitance-Inductance-Resistance Test Set AN/URM-90 is calibrated during manufacture. After calibration, the controls are locked in place and recalibration is not required unless parts replacement has been necessary, or it has been definitely established that adjustments must be made. If it is impossible to obtain the recommended reading for variable resistor R25, R24, or R21, by the following adjustments, replace the affected resistor.

89. Calibrating Variable Resistor R25

To check the calibration of variable resistor R25, proceed as follows:

a. Operate the POWER switch to the OFF position.

b. Set the circuit selector switch to L and D-Q x 1 position.

c. Turn the Q and D-Q dial to 6.3 on the black scale.

d. Measure the resistance from any G (ground) binding post and the C (high) binding post with Laboratory Standard AN/URM-2. Resistance should be 10,030 ±100 ohms.

e. If adjustment is required, remove the bridge chassis from the case (par. 53*c*) and proceed as follows:

(1) Loosen the two set screws in the collar of the contact and collar assembly for R25 with the No. 10 Allen wrench.

(2) Rotate the contact arm along the resistance winding until the calibration is correct.

(3) Tighten the two set screws in the contact and collar assembly at the correct calibration point with the No. 10 Allen wrench.

90. Calibrating Variable Resistor R24

To check the calibration of variable resistor R24, proceed as follows:

a. Check to be sure the POWER switch is in OFF position.

b. Set the circuit selector switch to the L and Q x 100 position.

c. Turn the Q and D-Q dial to 6.3 on black scale.

d. Measure the resistance from the center terminal of variable resistor R24 (fig. 30) to the wiper arm of switch S6 (fig. 32) that is immediately behind the front panel. Use a Laboratory Standard AN/URM-2. Resistance must be 68 ±1 ohms.

e. If adjustment is required, remove the bridge chassis from the case (par. 51*b*(2)), and proceed as follows:

(1) Loosen the two set screws in the collar of the contact and collar assembly for R24 with a No. 10 Allen wrench.

(2) Rotate the contact arm along the resistance winding until the calibration is correct.

(3) Tighten the two set screws in the contact and collar assembly at the correct calibration point with a No. 10 Allen wrench.

f. Turn the circuit selector switch to C and D–Q x .01 position.

g. Repeat the resistance measurement described in *d.* above. Resistance must be 100.3 ±1 ohms.

91. Calibrating Variable Resistor R21

To check the calibration of variable resistor R21, proceed as follows:

a. Check to see that the POWER switch is in the OFF position.

b. Set the circuit selector switch to the C and D–Q x 0.1 position.

c. Turn the Q and D–Q dial to 6.3 on the black scale.

d. Measure between the center terminals of R24 and R21 (fig. 30) with a Laboratory Standard AN/URM-2. Resistance must be 1003 ±10 ohms.

e. If adjustment is required, remove the bridge chassis from the case (par. 51*b*(2)), and proceed as follows:

(1) Loosen the two set screws in the collar of the contact and collar assembly for R21 with a No. 10 Allen wrench.

(2) Rotate the contact arm along the resistance winding until the calibration is correct.

(3) Tighten the two set screws in the contact and collar assembly at the correct calibration point with a No. 10 Allen wrench.

Section IV. FINAL TESTING

92. General

This section is to be used as a reference in determining the quality of a repaired Capacitance-Inductance-Resistance Test Set AN/URM-90. The minimum test requirements outlined in paragraphs 94 through 98 should be performed by maintenance personnel with the proper test equipment (par. 93) and the necessary skills. Repaired equipment meeting these requirements should furnish uniformly satisfactory operation.

93. Test Equipment Required for Final Testing

The following test equipment is required for final testing the test set:

Test equipment	Technical manual
Multimeter TS–352/U	TM 11–5527
Resistance Bridge ZM–4 A/U	TM 11–2019
Frequency Meter FR–67/U	TM 11–2698
Laboratory Standard AN/URM–2	
Voltmeter ME–30A/U	

94. Testing 1,000 Cps Oscillator Frequency

a. Turn the circuit selector switch to L and D–Q x 1 position.

b. Set the LRC DIAL MULTIPLIER to the 100h position on the L scale.

c. Turn the Q and D–Q dial to 10 on the black scale.

d. Adjust the LRC dial to 10.00.

e. Turn the DETECTOR switch to the INTERNAL position.

f. Turn the GENERATOR switch to the INTERNAL position.

g. Connect the test cable of Frequency Meter FR–67/U between the L and R (high) binding posts and the C (high) binding post (fig. 5).

h. Move the POWER switch to the ON position. Allow at least 5 minutes for warm-up before proceeding with the measurement.

i. Measure the oscillator frequency with the FR–67/U, which should indicate 1,000 $\pm$10 cps.

j. Move the POWER switch to the OFF position and disconnect the frequency meter.

95. Testing Oscillator Output Voltage

a. Adjust the bridge controls as described in paragraph 94*a* through *f*.

b. Connect the red and black test leads to Voltmeter ME–30A/U (fig. 34) as follows:

(1) Connect the INPUT (high) binding post of Voltmeter ME–30A/U to the C (high) binding post (fig. 5) of the bridge.

(2) Connect the INPUT G binding post of the voltmeter to the L and R (high) binding posts of the bridge.

c. Turn the ME–30A/U meter range switch (fig. 34) to 30. Move the ON-OFF switch on the ME–30A/U to ON. The pilot lamp should light.

d. Move the bridge POWER switch to ON. Allow at least 5 minutes for the equipment to warm up.

e. After the 5-minute warm-up period, the ME–30A/U should indicate a minimum of 12 volts. Reading should be made on the lower meter scale; use 10 as the multiplication factor.

f. Upon completion of the test, move both the ON-OFF switch of the ME–30A/U and bridge POWER switch to their OFF positions. Disconnect the test leads.

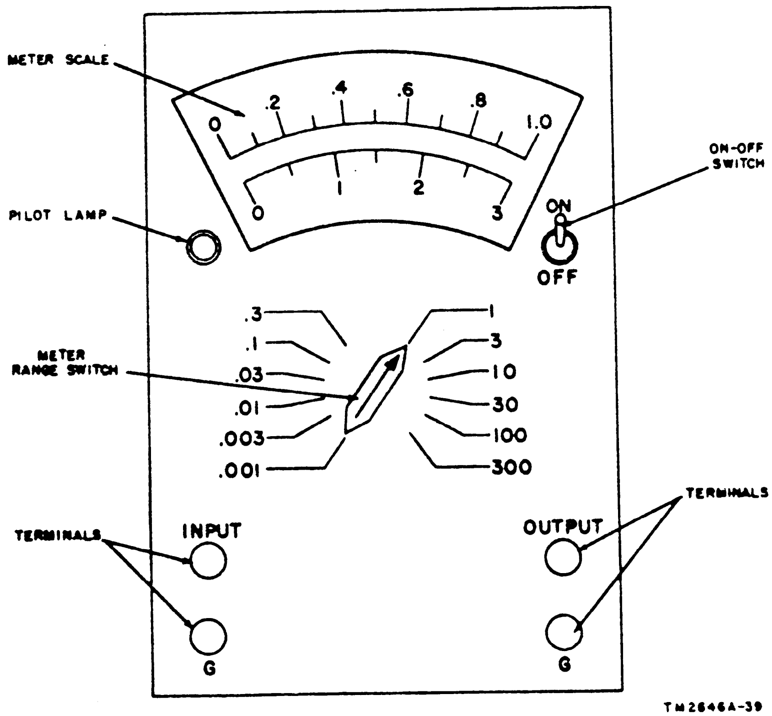


Figure 34. Voltmeter ME–30A/U, front panel view showing controls.

96. Testing High-voltage Dc Bridge Excitation

a. Remove the bridge chassis from the case (par. 51*b*(2)).

b. Turn the circuit selector switch to R and R x 10 position.

c. Turn the LRC DIAL MULTIPLIER to the 100kΩ position on the R scale.

d. Turn the DETECTOR switch to the EXTERNAL position.

e. Turn the GENERATOR switch to the DC HI position.

f. Turn the LRC dial to 10.00

g. Connect the test leads from Multimeter TS–352/U to the L and R (high) and C (high) binding posts (fig. 5). Adjust the TS–352/U to measure currents of 50 milliamper

Caution: Observe the TS–352/U carefully for a reversed polarity indication, when the bridge POWER switch is turned to ON.

h. Connect a second Multimeter TS–352/U or equivalent across resistor R56 (fig. 31). Set the TS–352/U to read a minimum of 500 volts dc.

i. Watch the meter scale to insure correct polarity of connections and move the bridge POWER switch to ON. Allow 5 minutes warm-up time.

j. Note the reading of the first meter (*g* above). The reading should be a minimum of 10 milliamperes.

k. Note the reading of the second meter connected as described in *h* above. Reading should be a minimum of 200 volts dc.

l. After measurements have been taken, move the bridge POWER switch to OFF. Disconnect both Multimeters TS–352/U from the bridge.

m. Replace the bridge chassis in the case (par. 51*b* (11)).

97. Testing Low-voltage Dc Bridge Excitation

a. Remove the bridge chassis from the case (par. 51*b*(2)).

b. Turn the circuit selector switch to the R and R x 10 position.

c. Turn the LRC DIAL MULTIPLIER to the 100kΩ position on the R scale.

d. Turn the DETECTOR switch to the EXTERNAL position.

e. Turn the GENERATOR switch to the DC LO position.

f. Turn the LRC dial to 10.00.

g. Connect Multimeter TS–352/U or equivalent test leads to the L and R (high) and C (high) binding posts. Adjust the TS–352/U to measure currents of 500 milliamperes.

Caution: Observe the TS–352/U carefully for reversed polarity indication when the bridge POWER switch is turned ON.

h. Connect a second Multimeter TS–352/U or equivalent across resistor R3 (fig. 31). Set the TS–352/U to read a minimum of 50 volts dc.

i. Watch the meter scale to insure correct polarity of connection and move the bridge POWER switch on the test set to ON. Allow 5 minutes warm-up time.

j. Note the reading of the first meter (*g* above). The reading should be a minimum of 250 milliamperes.

k. Note the reading of the second meter connected as described in *h* above. Reading should be a minimum of 10 volts dc.

l. After measurements have been taken, move the bridge POWER switch to OFF. Disconnect both Multimeters TS–352/U from the bridge.

m. Replace the bridge chassis in the case (par. 52*b*(11)).

98. Testing Bridge Accuracy

a. Testing the accuracy of the bridge requires the use of certain standard resistors, capacitors, and inductors (*c* below). The standard capacitors and inductors are included in Laboratory Standard AN/URM-2, which must be used in conjunction with these tests. The standard resistor is Resistance Bridge ZM-4A/U.

b. Test the test set for accuracy by connecting the calibration standards (*c* below) to the test set and obtaining a bridge balance through the applicable operating procedure (par. 18, 23, or 26). When testing for capacitance and inductance accuracy, operate the GENERATOR and DETECTOR switches to their INTERNAL positions. Each test reading lists two balance readings for the LRC dial. Check each balance position. Refer to paragraph 17 for starting procedure and paragraph 44 for stopping procedure.

c. The following chart lists the calibration standards used to test the accuracy of the bridge at various settings of the circuit selector switch and LRC DIAL MULTIPLIER.

Calibration standard	Switch position		Normal balance positions of LRC dial			Allowable error in percentage
	Circuit selector	LRC DIAL MULTIPLIER	Outer dial ring	Middle dial ring	Inner dial ring	
.1 ohm	R x 1	0.1	1.	0	0	±.35
			0.	9	10	
10. ohms	R x 1	1	10.	0	0	±.15
			9.	9	10	
100. ohms	R x 10	1	10.	0	0	±.15
			9.	9	10	
1,000. ohms	R x 10	10	10.	0	0	±.15
			9.	9	10	
10,000. ohms	R x 10	100	10.	0	0	±.15
			9.	9	10	
100,000. ohms	R x 10	1k	10.	0	0	±.15
			9.	9	10	
100,000. ohms	R x 1	10k	10.	0	0	±.15
			9.	9	10	
100,000. ohms	R x 1	100k	1.	0	0	±.15
			0.	9	10	
1,000. uuf	D-Q x .1	.01 uf	1.	0	0	±.5
			0.	9	10	
100. mh	D-Q x 1	10 mh	10.	0	0	±.1
			9.	9	10	

INDEX

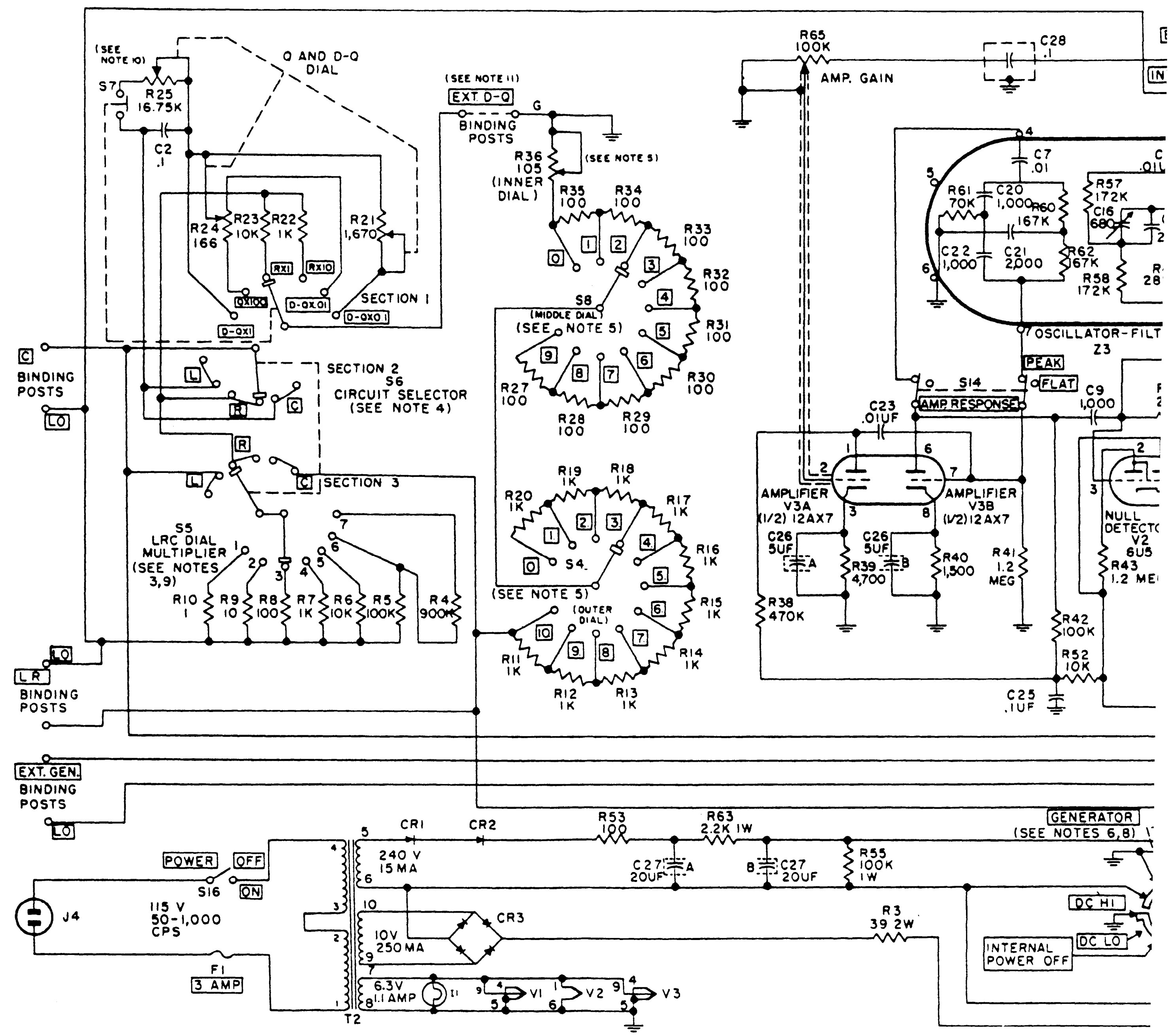
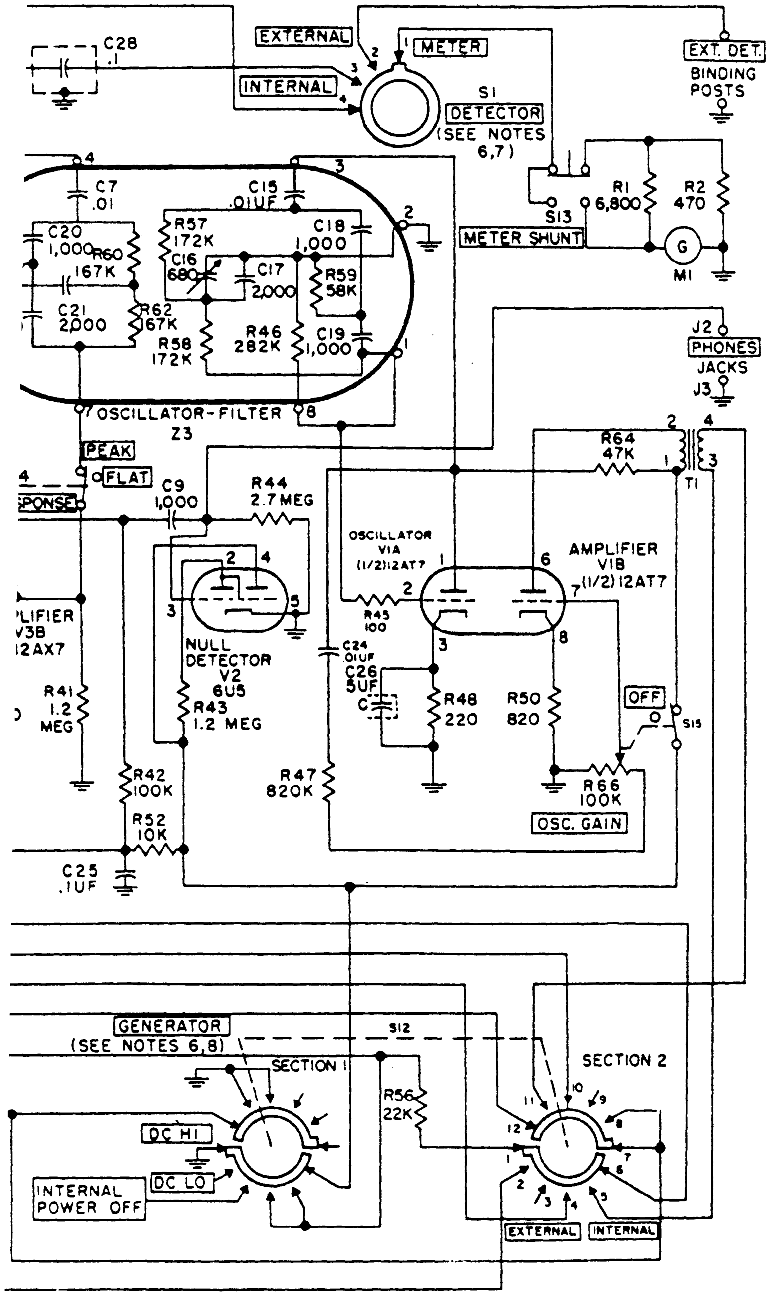


Figure 37. Test set, sche



NOTES:

1 UNLESS OTHERWISE SHOWN, RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UUF.

2 [box] INDICATES EQUIPMENT MARKING.

3 SWITCH S5 IS VIEWED FROM REAR.

4 SECTION 1 OF SWITCH S6 IS CLOSEST TO CONTROL KNOB.

5 SWITCHES S4 AND S8, AND VARIABLE RESISTOR R36 COMPRISE THE LRC DIAL.

6 DETECTOR SWITCH S1 AND GENERATOR SWITCH S12 ARE VIEWED FROM REAR. SECTION 1 OF SWITCH S12 IS CLOSEST CONTROL KNOB.

7 DETECTOR SWITCH IS SHOWN IN METER POSITION.

8 GENERATOR SWITCH IS SHOWN IN DC HI POSITION.

9 CONTACTS MADE IN EACH POSITION OF SWITCH S5 ARE AS FOLLOWS.

SWITCH POSITION			CONTACT
L	R	C	
0.1mh	0.1Ω	100uf	1
1mh	1Ω	10uf	2
10mh	10Ω	1uf	3
100mh	100Ω	0.1uf	4
1h	1kΩ	.01uf	5
10h	10kΩ	.001uf	6
100h	100Ω	.0001uf	7

10. SWITCH S7 CLOSES WHEN S6 IS IN THE L AND D-QX1 POSITION.

11. DASHED LINE INDICATES JUMPER PLACED BETWEEN EXT. D-Q BINDING POSTS, WHEN EXTERNAL DECADE RESISTOR IS NOT CONNECTED.

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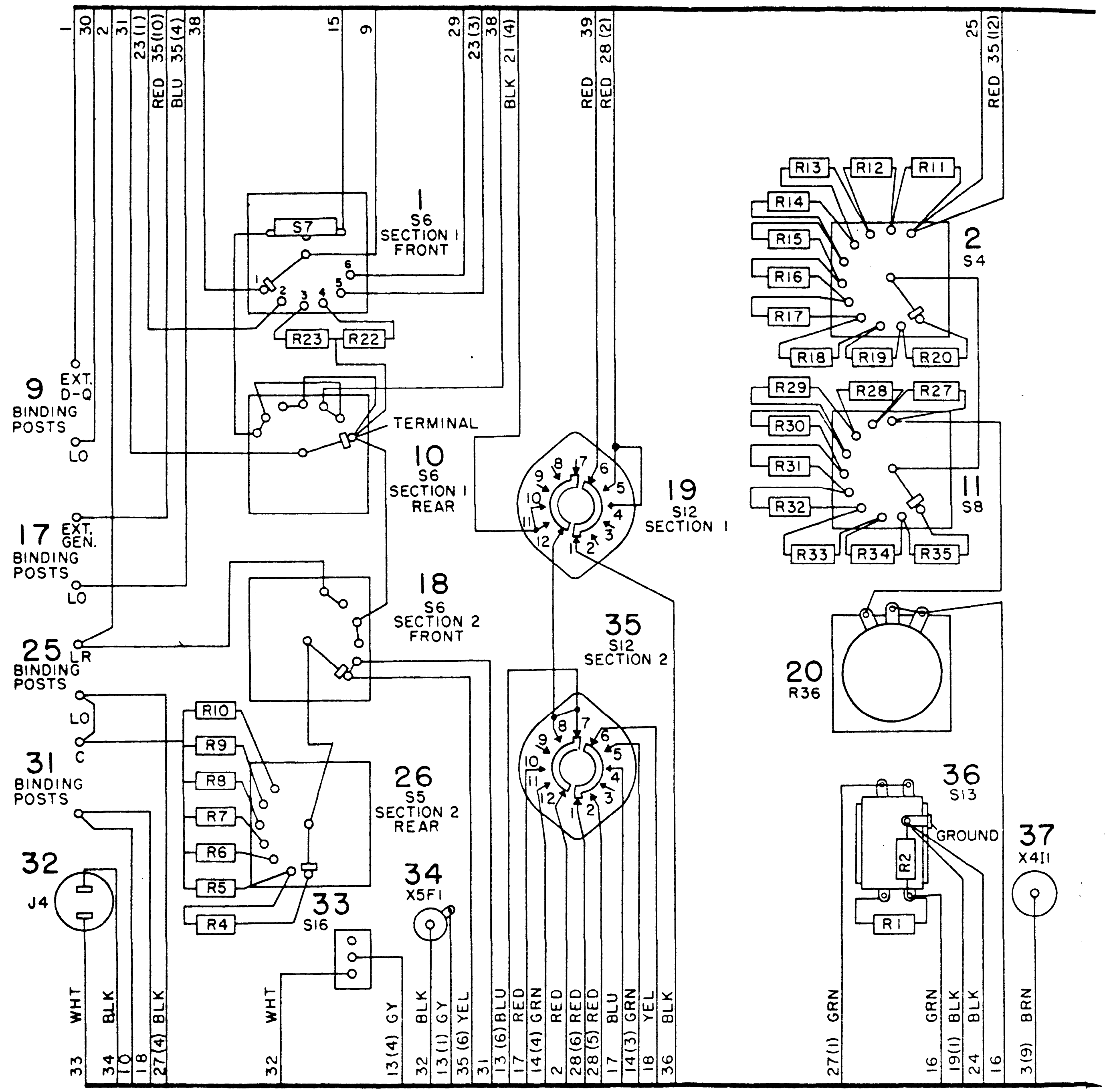
ure 37. Test set, schematic diagram.


1
S6
SECTION 1
FRONT
S7
R23
R22
TERMINAL
10
S6
SECTION 1
REAR
9
EXT.
D-Q
BINDING
POSTS
LO
17
EXT.
GEN.
BINDING
POSTS
LO
18
S6
SECTION 2
FRONT
25
LR
BINDING
POSTS
LO
C
31
BINDING
POSTS
26
S5
SECTION 2
REAR
R10
R9
R8
R7
R6
R5
R4
32
J4
33
S16
34
X5F1
19
S12
SECTION 1
35
S12
SECTION 2
2
S4
R13
R12
R11
R14
R15
R16
R17
R18
R19
R20
11
S8
R29
R28
R27
R30
R31
R32
R33
R34
R35
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BLU
RED
GRN
BRN

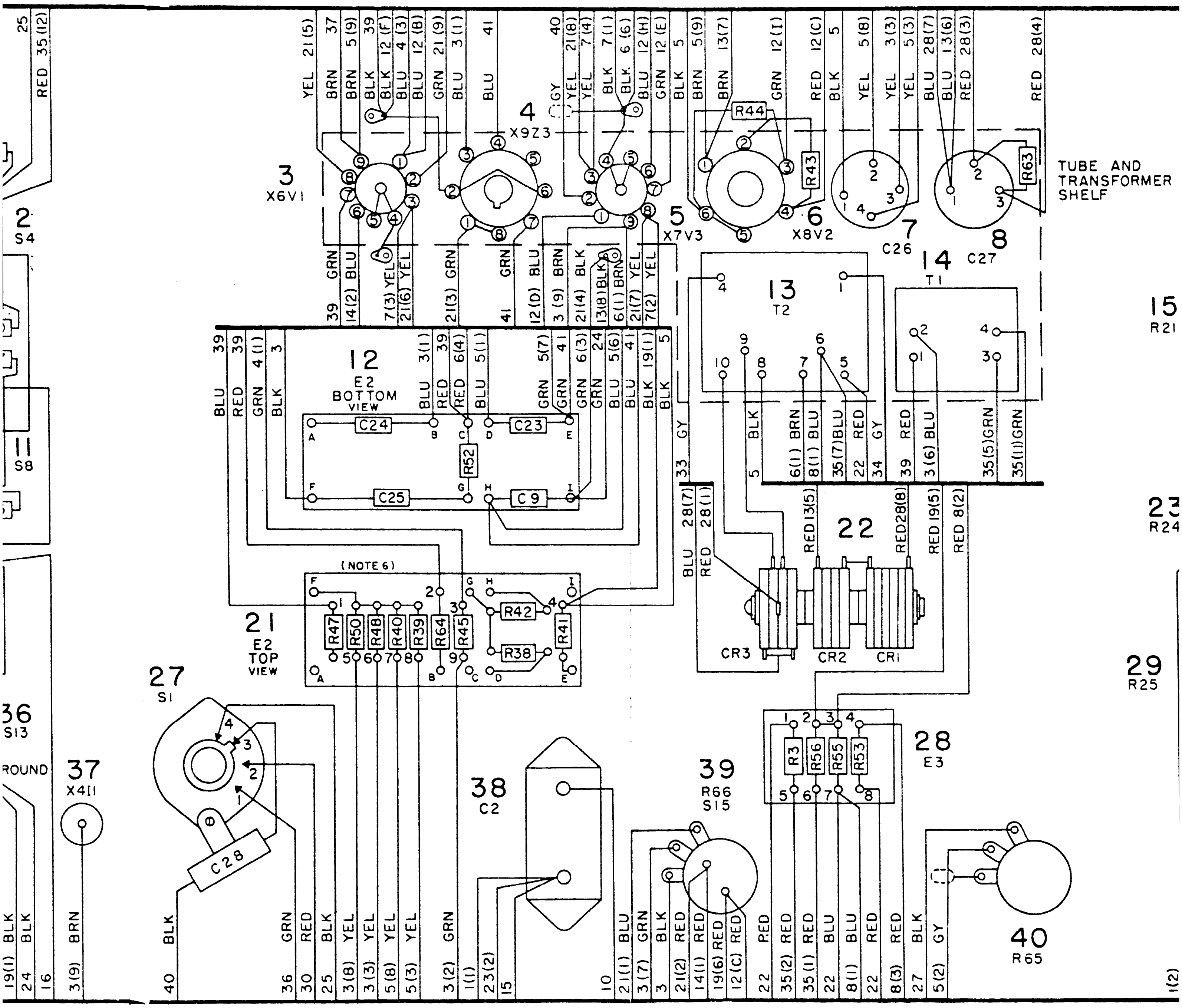
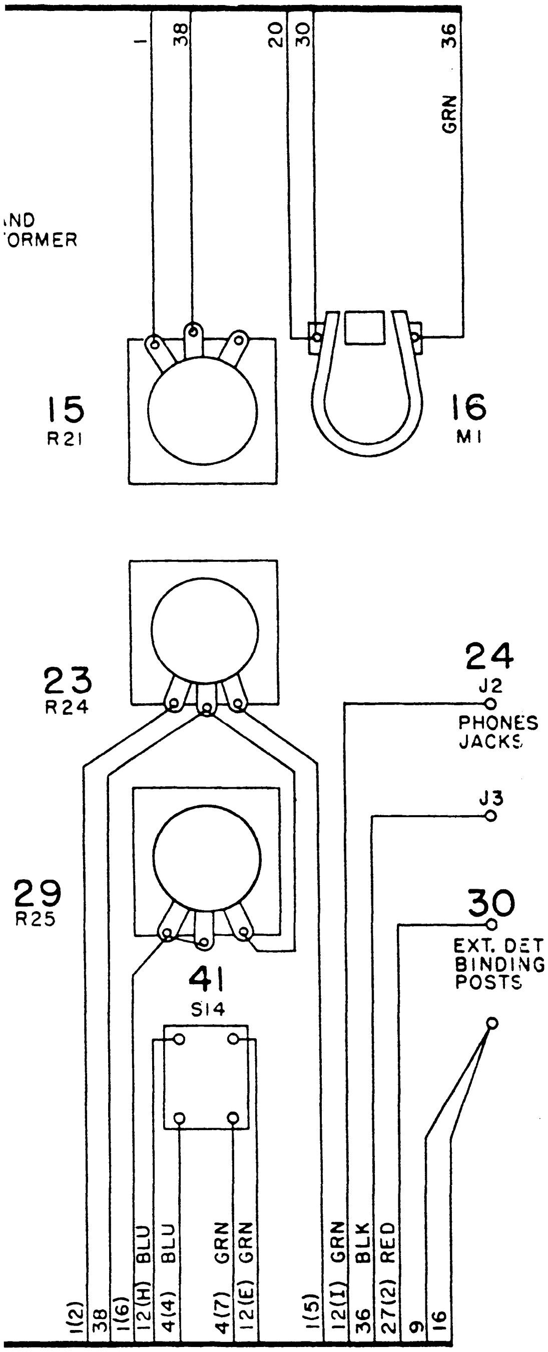


Figure 38. Test set, wiring diagram.



NOTES:

1. ALL TERMINAL NUMBERS EXCEPT THOSE OF T1 AND T2 ARE ASSIGNED ARBITRARILY FOR REFERENCE ONLY AND DO NOT APPEAR ON THE EQUIPMENT.
2. NUMBERS IN ( ) INDICATES TERMINAL TO WHICH THE LEAD IS CONNECTED.
3. —⊂⁻⁻⁻⊃— DENOTES SHIELDED CONNECTION AND IS NUMBERED THE SAME AS ADJACENT STATION.
4. ⊙⊃ DENOTES GROUND TERMINAL.
5. ALL COLOR CODED WIRES ARE 22 GAGE SOLID WIRE. ALL OTHER WIRES ARE 14 GAGE BARE TINNED BUSS WIRE.
6. THE LETTERED TERMINALS (A THRU I) ON TERMINAL BOARD E2 (STATIONS 21 AND 12) EXTEND THRU TERMINAL BOARD AND BEAR THE SAME IDENTIFICATION LETTER ON BOTH SIDES OF THE BOARD.

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