UNIVERSAL A. C. BRIDGE

TYPE TMV-132A

INTRODUCTION

These instructions cover the operation, maintenance, and servicing of the Type TMV-132A Universal A.C. Bridge, a self-contained, portable, a-c operated instrument. This Universal Bridge consists of a variable-ratio-arm Wheatstone Bridge having three standards each of inductance, capacity and resistance. A vacuum tube 1,000-cycle oscillator and a two-stage amplifier, together with their power supply, make up the major part of the equipment. The only additional equipment required is a "null" indicator for which the usual high impedance headphones suffice. Power is obtained from a 110- to 120-volt, 25- to 60-cycle supply.

Referring to Figure 1, two terminal posts in the upper left-hand corner, marked "X," are the points to which the component to be measured is connected. Beneath are the two phasing controls, used for balancing out the resistance component always present in inductors or capacitors. The upper control graduated from 1 to 100 is for coarse adjustment. The lower control, graduated from 1 to 10, is used when fine adjustment is required. The control, "Capacity Balance for Resistance, 100M-1 Meg.," in the lower right-hand corner is a phasing control necessary for obtaining balance in this range. Above this phasing control is the "Range" selector switch, which determines the type and range of measurement, i. e., whether it is resistance, capacity or inductance, and in conjunction with the "Low-High" switch, the bracket of measurement is indicated. The main dial, (calibrated from 1 to 10) located in the center of the panel, is used for obtaining balance on all measurements. The switch marked "R in X Arm" and "R in Std. Arm" shifts the "phase" controls from the "X" arm to the "Std.". arm of the bridge.

OPERATION

With the phones plugged in and with no external connections to the "X" terminals, make the 110-volt connection to the line and turn the "110-Volt A.C." switch "ON." After a short interval, during which the tubes are warming up, a 1,000-cycle tone will be heard in the phones. The bridge is now ready for operation.

Caution: Do not connect the case or any part of this instrument to ground. The unknown unit being measured must not be grounded. This is necessary for the protection, operation and accuracy of this bridge.

The unit to be measured may now be connected to the binding posts marked "X" with its low terminal connected to the "X" terminal to the left. By low terminal it is meant that terminal nearest ground potential. The bridge may now be balanced (see specific instruction under Resistance, Capacity and Inductance measurements). Remember that the balance is indicated by minimum ***1,000-cycle*** tone in the headphones. When this condition exists, the second harmonic, 2,000 cycles, often becomes quite loud in the phones. This, however, does not indicate an unbalance. The ***1,000-cycle*** tone is always the tone to adjust to a minimum.

If it is found impossible to obtain a null point on the bridge, the unit under test is either defective or outside the range of the bridge. Note, however, that it is impossible to measure with the bridge the resistance of an inductor. This does not indicate a faulty inductor or bridge, but is simply a characteristic of this type bridge circuit.

RESISTANCE MEASUREMENTS

Connect the resistance to be measured to the binding posts marked "X." The low side of the resistor should be connected to the terminal to the left. The two phasing controls should be set so that each is at its counterclockwise position, since they are not used in resistance measurements. More conveniently, they may be cut out of the circuit by throwing the phasing toggle switch to the down, "R in Std. Arm" position. Now select the lowest resistance scale. This is done by throwing the range toggle switch to "Low" and by turning the Range Switch to the first resistance position (1-10 ohm). Now turn the large centrally located knob so that the pointer moves over the main scale from 1 to 10. If the resistance we have selected to measure lies anywhere between 1 and 10 ohms, a null point (balance) will occur and moving the pointer in either direction will ***increase*** the signal in the phones. If the null point is exactly at 5 on the scale, the resistance of the unknown is 5 ohms. If it occurs between 5 and 6 and exactly on the first small division to the right of 5, the resistance is 5.1 ohms. If no null point is found on this scale, throw the toggle switch to "High." The main scale now reads from 10 to 100 ohms. If still no null point is found, set the toggle switch on "Low" again and move the Range Switch one position to the right, so that just under ohms we read 100-1M. Since M represents 1,000, the scale now reads 100 to 1,000 ohms. In a

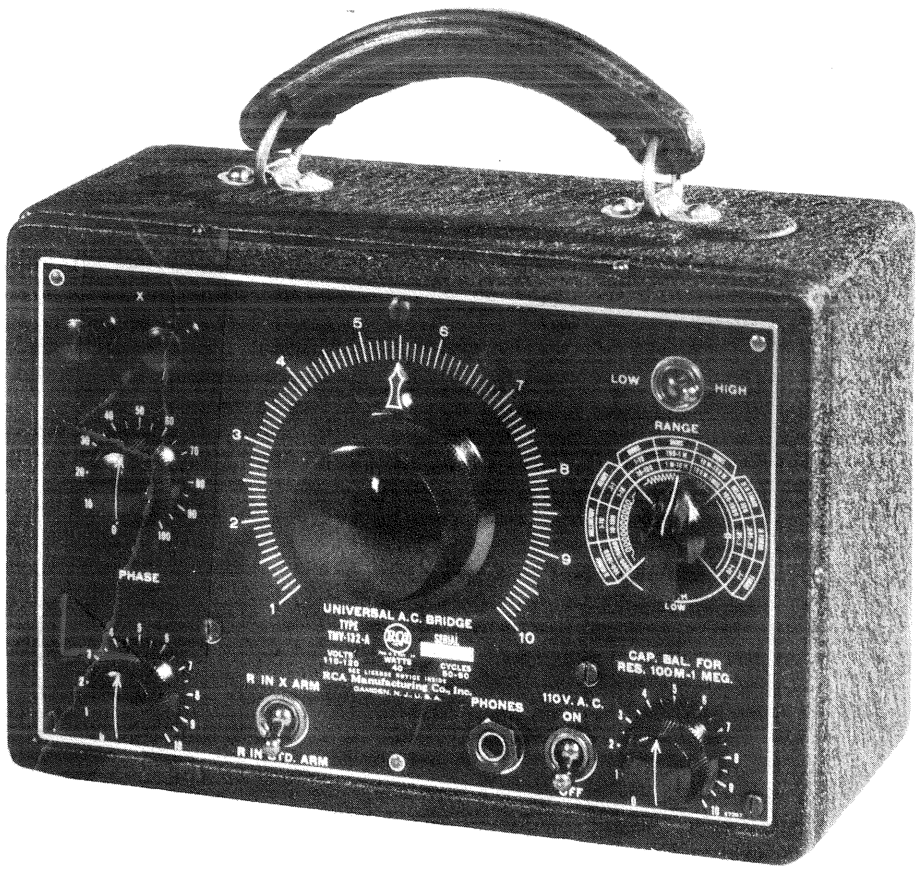

Figure 1. Universal A. C. Bridge

like manner, by throwing the toggle switch to "High" the main scale becomes 1M to 10M; that is 1,000 to 10,000 ohms. On this latter scale, a null point at 5 means that the unknown resistance is 5,000 ohms. If it is known before-hand that the resistance is somewhere between 1,000 and 10,000 ohms, then the range switch and "Low-High" switch are set to select this range and the resistance reading obtained from the main scale after locating the null point. With this control set at approximately mid scale obtain an initial resistance balance. Then vary the capacitor for a null point. A slight readjustment of the resistance balance may be necessary for the minimum null point.

CAPACITY MEASUREMENTS

Set the bar pointer knob so that it is pointing to MMFarads, which is an abbreviation for the familiar micro-micro-farads. Set the toggle switch to "Low" so that the range we are using is "below 100." Now move the pointer over the main scale and at somewhere near 30 (scale division 3) a null point will be found. This is the balance point with no capacity across the "X" terminals. For convenience, we will refer to this reading as the capacity constant "K." Now if a small capacity is connected across the "X" terminals, say 20 MMFarads, a new null point will be found at the capacity constant reading plus 20. Therefore when making measurements with the range switch in the lowest capacity position, the null point is found, the scale is read and then "K" is subtracted from this reading. For illustration, if "K" is 28 MMFarads, and with the unknown connected, the reading is 90, then the value of this unknown is 90-28 or 62 MMFarads.

At this point the two variable resistor phasing controls should be considered. For the very small capacitors treated above, their setting does not affect the null point appreciably. The reason for the inclusion of these controls in this bridge is that all capacitors and inductances have some resistance. The amount of this resistance is an indication of power loss. Ordinarily we are not interested in exact power loss, but in order to secure a null point the effect of this resistance must be balanced out.

To continue with capacity measurements, leaving the range switch (pointer) at MMFarad, throw the toggle switch to "High." The scale is now from 100 to 1,000 MMFarad. In this range, the phasing controls have more effect on the null point. Set the phasing controls at their minimum positions and with the main control secure a tentative null reading. Then increase the upper (coarse) control to see if the signal increases or decreases. If the signal decreases, adjust the phasing control for a minimum signal. Then readjust the main control for minimum. The true null point is obtained by successive adjustments as outlined above.

If increasing the phasing control causes an increase in signal instead of a decrease, then the toggle switch to the right of the lower control should be thrown to the opposite position and successive adjustments made until the null point is obtained. In this capacity range (100 to 1,000 MMFds.) the lower (fine) phasing control will have little effect. In this range also the capacity constant "K" is subtracted from the null point reading. If the null is at 500 MMFd. and "K" is 30, then the true capacity is 500 minus 30 equals 470 MMFd. For all higher capacity ranges, this correction need not be made as it will be a negligible portion of the capacity.

INDUCTANCE MEASUREMENTS

Connect the inductance to be measured to the "X" terminals and with its low side connected to the left terminal, a preliminary null point is obtained on the main scale. Then the phasing controls should be adjusted to reduce the signal in the phones to a new low point. Successive adjustments of the main control and phasing controls should be made until the lowest signal can be obtained. The inductance is read directly from the main scale. For illustration, suppose the Range Switch is set to "millihenry," the range toggle switch is on "Low" and the main scale reads 6, then the inductance is 6 millihenries. The setting of the phasing controls is not taken into consideration at all. The two phasing controls are in series and in measuring inductance it will usually be necessary to find the resistance component balance roughly on the "coarse" control and then adjust the "fine" control for the final balance. Facility in successively manipulating the phase control and ratio comes readily with practice. On the lowest inductance scales, the resistance balance is quite critical and some care will be required to secure the correct null point. This same care is necessary with a laboratory bridge as well.

RANGE AND APPLICATIONS

Capacity

The capacity range of this instrument is from 10 MMFarads to 10 MFarads, a range of 1,000,000 to 1. Capacity between leads, capacity from wiring to ground, the minimum and maximum of tuning condensers can be found readily, as well as the higher values of capacity of by-pass capacitors, etc. Electrolytic condensers may be measured up to values of 10 microfarads. For accurate measurements, the electrolytic condenser should be formed from three to five minutes by the application of rated voltage of the proper polarity.

Inductance

The inductance range is from 100 Microhenries to 10 Henries, a range of 100,000 to 1. In general, the inductance of the windings of the audio transformer cannot be measured, due to their high values. However, this type of measurement is not generally made by bridge measurements. Due to the iron cores, the inductance is not constant and a satisfactory balance cannot usually be obtained.

Resistance

The resistance range is from 1 ohm to 1 megohm. Above 100,000 ohms, the capacity to ground of the bridge arms must be balanced out to obtain a sharp null point. The control directly below the range switch is for this purpose and functions in that range only.

The greater part of the values of resistance, inductance and capacity used in communication engineering can be measured very satisfactorily. Testing, servicing and development is practically impossible unless the quantities used are known.

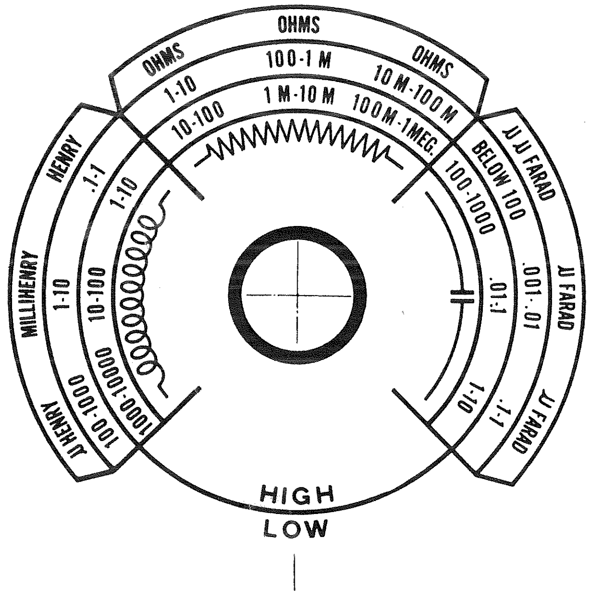

Figure 2. Range Scale

Circuit Description

Bridge Elements

A simplified a-c Wheatstone Bridge is shown in Figure 3 to illustrate the principles of measurement involved, whereby, the value of an unknown resistance, capacitance, or inductance may be measured by comparison with a known standard resistance, capacitance, or inductance. This diagram shows an impedance network into which an unknown "X" may be connected in series with a known "Standard," a variable ratio arm "A," and a fixed arm "B." An a-c voltage of 1,000 cycles is connected across the bridge elements between points C and D. An indicating device (headphones) is connected between points E and F to detect balance. Such a balance is indicated when a minimum signal is heard in the headphones, thus indicating that the ratio of arm "A" to arm "B" is identical to the ratio of the unknown "X" to the "Standard." By calibrating arm "A," the value of the unknown may be read direct. By properly choosing the values of the standards, the various ranges may be made multiples of the basic range of 1 to 10.

In the schematic circuit of the TMV-132-A Bridge shown by Figure 4, the 1,000-cycle energy is delivered to the bridge elements through the transformer (T-1) which is balanced capacitively to ground. This transformer isolates the bridge elements from the auxiliary equipment; that is, the power supply and oscillator, and insures the desired capacity-to-ground of the "known" and "standard" arms of the bridge.

The differential voltage, which indicates unbalance, is fed from the bridge elements through condenser (C-4) to the pentode-grid of the RCA-6F7 Radiotron. This unbalance-voltage is amplified in both sections of the tube and then made audible by headphones connected to the secondary of the output transformer (T-3), the primary of which is connected in the plate circuit of the triode section.

Three standards each of inductance, capacitance, and resistance contained in the bridge elements are so arranged as to be selected by the Range switch (S-1). Two ranges for each standard are obtained by means of the High-Low switch (S-4).

Arm "A" is the Main Linear Control (R-6) calibrated over a range of from 1,000 to 10,000 ohms. Arm "B" is 10,000 ohms (R-8) for the "low" position of the High-Low switch, and 1,000 ohms (R-7) for the "high" position of the High-Low switch. This arrangement, for a given standard, gives ratios of 0.1-to-1 for the "low" position and 1-to-10 for the "high" position. An overall range for one standard is, therefore, 1-to-100. By this arrangement, the ratio of the bridge arm is never greater than 10, thus preserving sensitivity.

For inductance and resistance measurements, the "X" arm is the unknown element being measured, and "standard" is the internal standard selectable by the Range switch (S-1). Then, the ratio of the unknown resistance or inductance is to the standard resistance or inductance as arm "A" is to arm "B." The two phasing controls, (R-5) and (R-4) can be placed in either the "X" arm or "standard" arm by means of the "R in X Arm—R in Std. Arm" switch (S-3). The two rear sections of the Range switch act as a double pole-double throw switch to reverse arms "X" and "standard" ***for capacity measureuents,*** since the reactance of a condenser decreases as its value increases. This permits use of the same linear scale for all measurements.

Oscillator

The oscillator which supplies the 1,000-cycle energy to the bridge elements consists of an RCA-76 and transformer (T-2). The grid winding of the transformer is tuned to 1,000 cycles by condensers (C-7) and (C-16). Self bias is obtained by the grid leak-condenser combination (R-13) and (C-5). A separate winding is provided to feed the energy to the bridge elements through transformer (T-1).

Amplifier

An RCA-6F7 Triode-Pentode Radiotron is used as a two-stage amplifier to provide adequate 1,000-cycle energy to the headphones for detecting balance. The signal from the bridge elements is amplified in the pentode section and then fed to the triode section through condenser (C-12) The plate impedance of the pentode section is tuned to 1,000 cycles by (L-4) and (C-13), which permits maximum signal voltage to appear on the triode grid. This arrangement provides high sensitivity, giving a sharp balance. The energy is then transferred to the headphones through transformer (T-3).

Power Supply

The rectifier, an RCA-25Z5 Radiotron, comprises two separate diodes of the heater-cathode type. It is employed in a voltage-doubler circuit and acts as a full-wave rectifier with one-half of the tube passing current to the load on each half of the a-c input

Electrical Specifications

Power Supply Rating	Voltage	110-120 Volts A.C.
	Frequency	25-60 Cycles
	Wattage Consumption	40 Watts
	Fuse Protection	2 Amps.
Applications and Ranges	Capacity	10 Mmfd. to 10 Mfd.
	Resistance	1 Ohm to 1 Megohm
	Inductance	100 Microhenries to 10 Henries
Radiotrons Used and Functions	1 RCA-76	Oscillator
	1 RCA-6F7	Triode-Pentode Amplifier
	1 RCA-25Z5	Rectifier-Doubler

Mechanical Specifications

Overall Dimensions	Height	6½ inches
	Width	9¾ inches
	Depth	4½ inches
Weight (Net)		6 pounds
Weight (Shipping)		9½ pounds

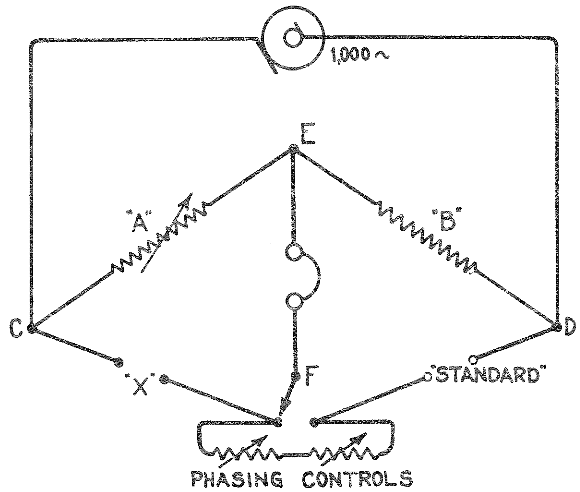

Figure 3. Simplified Wheatstone Bridge

cycle. During the period that one half of the Radiotron is rectifying, the condenser across the other half is discharging through the conducting diode and the load. The voltage across the load is the sum of the d-c output voltage of the conducting diode and the discharge voltage of the condenser. C-8 and C-9 are the condensers which are alternately charging and discharging. C-10 and R-11 constitute a resistance-capacity filter. R-11 and R-12 form a bleeder circuit. The filaments of the three tubes and the dropping resistor (R-9) are in series across the line.

MAINTENANCE

The various diagrams given in this booklet contain such information as will be needed to isolate causes for defective operation when such develops. The values of the various resistors, capacitors, and inductances are indicated adjacent to the symbols signifying these parts on the diagrams. Identification titles such as R-3, L-2, and C-1, etc., are provided for reference between the illustrations and the Replacement Parts List. These identifications are in a sequence which begins at the left of the diagram and increases numerically from left to right, thus facilitating the location of such parts on the schematic diagram.

The coils, reactors, and transformer windings are rated in terms of their d-c resistance. This method of rating provides ready means for checking continuity of circuits. Suspected faulty circuits or parts may be checked and their resistances compared with the value given on the schematic diagram.

Failure of operation may result from:

(1) Power supply being "off."
(2) Open fuses within the instrument.
(3) Defective tubes.
(4) Open or disconnected headphones.
(5) Defects within the instrument itself.

CAUTION—Disconnect power supply before removing case.

Care in removing the case will prevent damage to the internal parts. After the four screws around the edge of the front panel are removed, the panel should be tilted forward and the case slipped off, simultaneously pushing in the power cord.

Radiotrons

Under ordinary usage within the ratings specified for voltage supply, tube life should be consistent with that obtained in other applications. Inability to obtain balance, loss of sensitivity, or total failure of operation, may be indicative of tube trouble.

If tube trouble is suspected, the tubes should be removed from the instrument and tested in a reliable tube-testing device. Replacing a questionable tube with one known to be good is another sure and definite means of tracing tube trouble.

Fuse Replacements

Both sides of the a-c line are protected by small 2-ampere cartridge fuses. These fuses are located on a fuse board mounted beneath the chassis on the left apron, when viewed from the bottom-rear. These fuses are intended for protection of the entire power system of this instrument and, therefore, should not be replaced with ones having a higher rating, nor be shorted out. Fuse failures should be carefully investigated before making replacements, since fuses of good quality fail only under conditions of overload. The cause may originate from a surge in the power-supply line, but more likely the cause may be centered in the apparatus protected, such as shorted rectifier elements, etc. Poor contact of the fuse clips may result in an open fuse due to the heat developed. These contacts should, therefore, be kept clean and in secure contact with the fuses.

Radiotron Socket Voltages

Operating conditions of the basic circuits of this instrument may be determined by measuring the voltages applied to the tube elements. Figure 6 shows the voltage values from the socket contacts to ground and appearing across the heater contacts (H-H). Each value as specified should hold within ± 20% when this instrument is normally operative with all tubes intact and rated voltage applied. Variations in excess of this limit will usually be indicative of trouble.

The voltages given on this diagram are actual measured voltages, and are the results obtained after the loading of the circuit, by the voltmeter, has taken place.

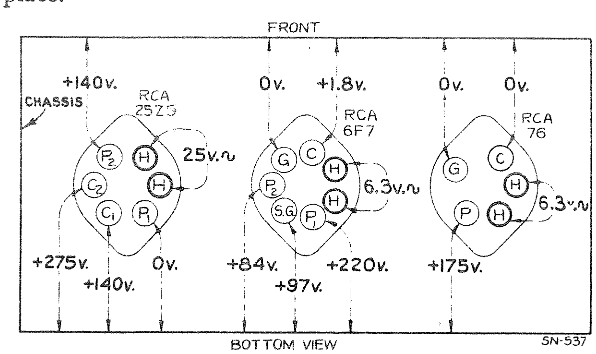

Figure 6. Socket Voltages

To fulfill the conditions under which the d-c voltages were measured requires a 1,000-ohm-per-volt d-c voltmeter having ranges of 10, 250, and 750 volts. Voltages below 10 volts should be measured on the 10-volt scale; between 10 and 250, on the 250-volt scale; and above 250 on the 750-volt scale. To accu-

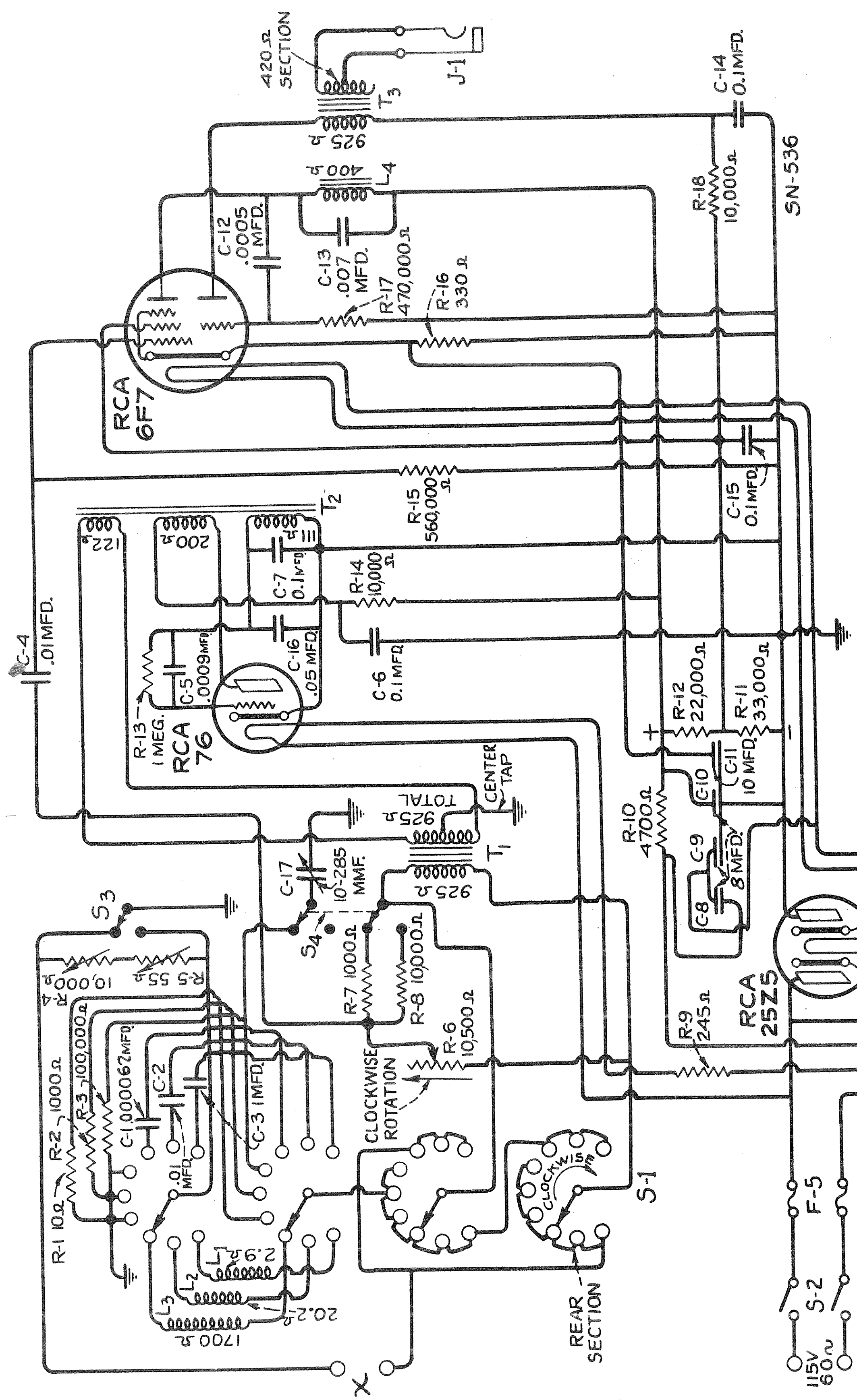

Figure 4. Schematic Circuit Diagram

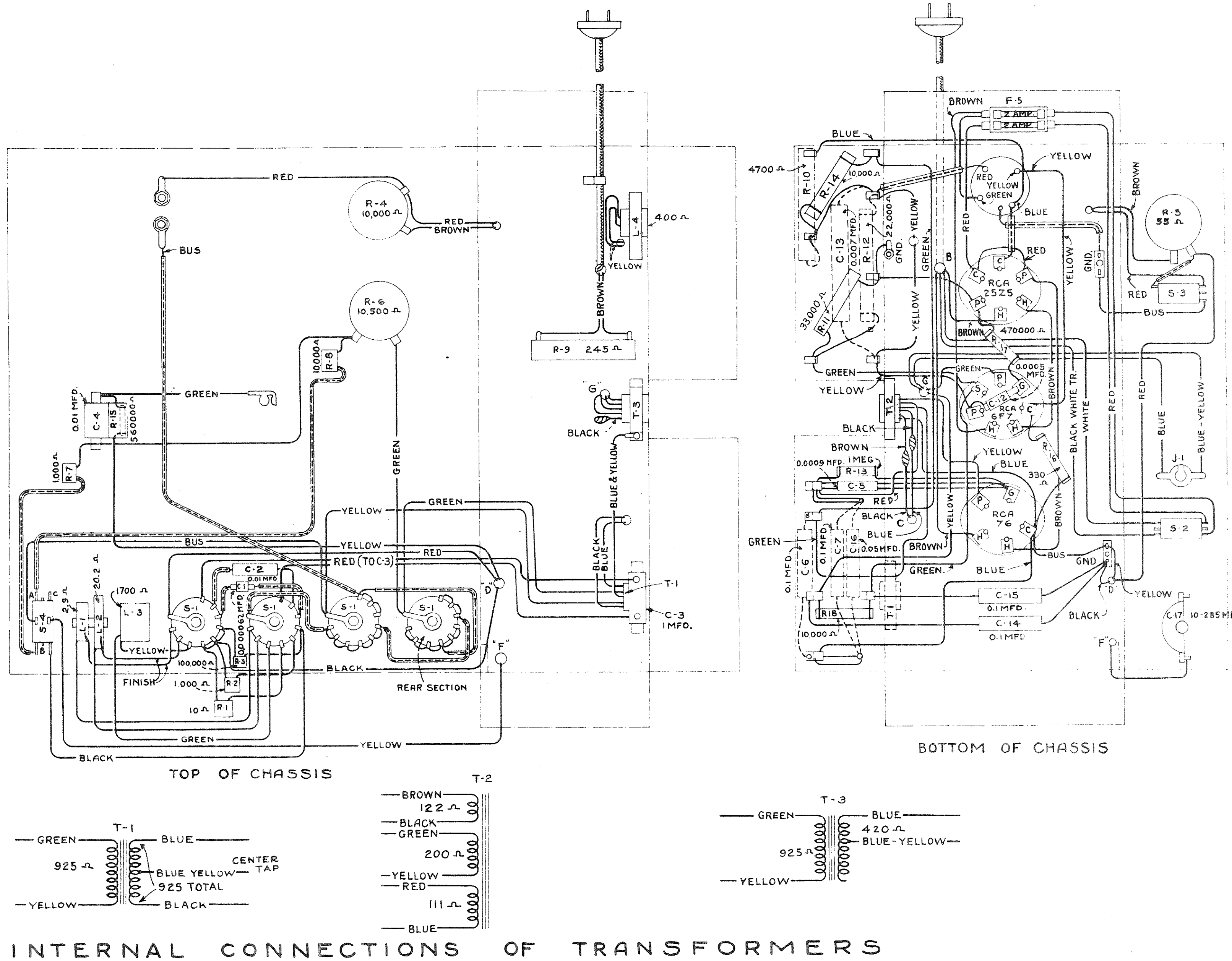

Figure 5. Connection Wiring Diagram

rately measure the heater voltage requires a 1,000-ohm-per-volt a-c voltmeter having ranges of 10 and 50 volts. Voltages below 10 volts should be measured on the 10-volt scale; and from 10 to 50, on the 50-volt scale.

For meters of the 1,000-ohm-per-volt type, but ranges other than above, use the nearest ranges to those specified. If the range is higher the voltage may be higher, if the range is lower the voltage may be lower; either condition depending on the percentage of circuit current drawn by the meter.

Noisy Operation of Controls

The Main control (R-6), and both Phasing controls (R-4) and (R-5) are sliding arm type variable resistors. Noisy operation, evidenced by a grating noise in the headphones when either of these three controls are manipulated will occur when dust or corrosion, collects or forms on the sliding contact arm, or on that portion of the resistance wire over which the sliding arm rides. These controls are properly lubricated during manufacture to guard against noise and insure correct operation; however, after lengthy use all types of contacts require some attention. This condition may be corrected by turning the controls a few times. The application of a small amount of lubricant (petroleum jelly) to the resistance wire and contact arm will aid in obtaining quiet operation by preventing corrosion. The lower Phasing control contact arm makes contact by a pressure spring. To correct noisy operation caused by a dirty contact at this point, pry off the back cover and slip a visiting card between the spring and center shaft contact. Moving the visiting card back and forth a few times will restore the contacts to their correct operating condition.

Resetting Main Control Pointer

If for any reason the Main control dial is removed or its position altered from its initial setting on the shaft of R-6, accurate adjustment will be required. An accurate 1,000-ohm resistor, such as RCA Victor Stock No. 11795, should be placed across the "X" binding post. Place the instrument in operation with the Range selector set to "1M-10M" position and High-Low switch to "high" position. Rotate the Main control shaft until balance is obtained. Place the knob on the shaft with its pointer set to 1. Tighten the set screw. The balance point will be at 1 indicating 1,000 ohms.

A substitute method may be used if an accurate means of measuring 1,000 ohms is available. With the instrument removed from the case, disconnect the green lead connecting from the Main control to the Range switch. Connect the resistance measuring device across the two terminals of the Main control and accurately set the sliding arm until a value of 1,000 ohms is obtained. Set the pointer of the Main control to 1. Tighten the set screw and restore the green lead to its original condition.

REPLACEMENT PARTS

Insist on genuine factory tested parts, which are readily identified and may be purchased from any authorized dealers

Stock No.	DESCRIPTION	List Price
11792	Capacitor—Variable capacity—for capacity balance—(C17)	$0.98
11782	Capacitor Pack—Comprising three sections of 8 Mfd., and one section of 10 Mfd. —(C8, C9, C10, C11)	3.25
11798	Capacitor—.000062 Mfd.—(C1)	.28
11800	Capacitor—.0005 Mfd.—(C12)	.20
4245	Capacitor—.0009 Mfd.—(C5)	.26
5148	Capacitor—.007 Mfd.—(C13)	.20
15779	Capacitor—.01 Mfd.—Faradon model "T" —(C4)	1.30
11799	Capacitor—.01 Mfd.—(C2)	.20
4836	Capacitor—.05 Mfd.—(C16)	.30
4841	Capacitor—0.1 Mfd.—(C6, C7, C14, C15)	.22
11790	Capacitor—1.0 Mfd.—(C3)	2.40
4693	Clamp—Electrolytic capacitor mounting clamp—for Stock No. 11782	.15
11788	Coil—(L2)	.38
11789	Coil—(L1)	.38
11773	Choke—Choke coil—located in plate circuit of 6F7 Radiotron—(L4)	1.16
11776	Escutcheon—Front panel escutcheon	2.25
3883	Fuse—2.0 ampere fuse—Package of 5	.40
11780	Jack—Phone jack—(J1)	.80
3984	Knob—Phase adjusting or capacitor balance knob	.30
7960	Knob—Range switch knob	.20
11784	Knob—for Stock No. 11783	.46
11787	Reactor—(L3)	2.00
11772	Rheostat—Phase adjusting rheostat—for coarse adjustment—(R4)	4.55
11777	Rheostat—Phase adjusting rheostat—for fine adjustment—(R5)	1.12
11783	Rheostat—(R6)	4.50
11794	Resistor—10 ohms—wire wound—(R1)	1.68
11785	Resistor—245 ohms—wire wound—(R9)	2.10

Stock No.	DESCRIPTION	List Price
8063	Resistor—330 ohms—carbon type—½ watt—(R16)—Package of 5	1.00
11795	Resistor—1000 ohms—wire wound—(R2, R7)	1.78
11768	Resistor—4700 ohms—carbon type—2 watts—(R10)	.25
3078	Resistor—10,000 ohms—carbon type—½ watt—(R14, R18)—Package of 5	1.00
11796	Resistor—10,000 ohms—wire wound—(R8)	2.52
11332	Resistor—22,000 ohms—carbon type—1 watt—(R12)—Package of 5	1.10
8072	Resistor—33,000 ohms—carbon type—½ watt—(R11)—Package of 5	1.00
11797	Resistor—100,000 ohms—wire wound—(R3)	3.52
5202	Resistor—470,000 ohms—carbon type—½ watt—(R17)—Package of 5	1.00
5035	Resistor—560,000 ohms—carbon type—¼ watt—(R15)—Package of 5	1.00
3033	Resistor—1 megohm—carbon type—¼ watt—(R13)—Package of 5	1.00
4814	Socket—5-contact Radiotron 76 socket	.15
4786	Socket—6-contact Radiotron 25Z5 socket	.15
4787	Socket—7-contact Radiotron 6F7 socket	.15
11778	Switch—Standard resistance change over toggle switch—(S3)	.88
11779	Switch—Double pole single throw toggle power switch—(S2)	1.25
11781	Switch—Range switch—(S1)	2.45
11786	Switch—Double pole—double throw toggle switch—(S4)	1.05
11774	Transformer—Input transformer—(T1)	5.15
11775	Transformer—Oscillator transformer—(T2)	1.05
11791	Transformer—Output Transformer—(T3)	5.15