SPRAGUE®

OPERATING MANUAL

MODEL TCA-1
TRANSFARAD*
CAPACITOR ANALYZER

★ TRADEMARK

SPRAGUE PRODUCTS COMPANY

North Adams, Mass.

Operating Manual
MODEL TCA-1
TRANSFARAD CAPACITOR ANALYZER

1. General Description

1.1 Purpose and Usefulness. The TCA-1 was designed specifically to enable design engineers, inspection departments and service engineers to test all types of capacitors (electrolytic, film, and ceramic) used in transistor circuits without harm to the capacitor regardless of voltage rating. It incorporates in one compact instrument a multi-range capacitance and power factor bridge, an insulation resistance checker for film, paper, mica and ceramic capacitors, and a leakage current test circuit for electrolytic (including all types of tantalum) capacitors. All functions are selected by a single knob, and a magic eye indicator simplifies bridge balancing for capacitance and power factor measurements. The large meter gives direct readings of insulation resistance and leakage current, and shows the exact voltage applied to electrolytic capacitors during the leakage test.

1.2 The especially valuable features incorporated into the TCA-1 are:

a. The low a-c voltage applied to the bridge circuit during the capacitance and power factor measurements is 0.5 volts. The actual a-c voltage across the capacitor is therefore less than 0.5 volts depending upon the magnitude of the capacitance being measured;

b. The special low capacitance circuit for measuring low values of ceramic and mica capacitors (from 1 mmf to 100 mmf) with improved accuracy;

c. The insulation resistance test with a range up to 20,000 megohms with only 25 volts applied to the test circuit;

d. Provision for measuring the insulation resistance of even 3 volt ceramic capacitors without over-stressing the insulation;

e. The high gain meter amplifier which provides a full scale sensitivity of 0.6 μA for measuring the leakage current of low voltage electrolytic and ceramic capacitors;

f. The etched circuit and encapsulation techniques which make possible the high-gain and long-time stability of the meter amplifier;

g. The voltage regulator (magnetic and electronic) which contributes in a large measure to the stability and accuracy of the instrument even though the line voltage varies from 105 to 125 volts;

h. The high-gain null detector amplifier with a gain control thus enabling the user to select the best combination of detector sensitivity and ease of operation for his particular application;

i. Automatic discharge of the capacitor under test;

j. Shielding of small capacitors under test to prevent errors due to stray pick-up;

k. Overload protection of the meter;

l. Easily followed operating procedures shown on the pull-out slide at the base of the instrument.

1.3 Capacitance. In addition to the special low range mentioned above, four other capacitance ranges are provided for measurements up to 2000 mf. With the TCA-1 you can safely and easily test (for all characteristics) all types of capacitors used in transistor circuits (aluminum and tantalum electrolytics, film capacitors, and ceramic capacitors, including the 1 and 3 volt types) of computers and other types of industrial electronic equipment as well as in ultra-miniature radio sets and hearing aids.

1.3.1 Power Factor. The power factor of all electrolytics is indicated directly on the panel.

1.4 Leakage Current. A self-contained, regulated, continuously adjustable d-c power supply permits measurement of the leakage current of all transistor-type electrolytic capacitors at exact rated voltage.

1.5 Insulation Resistance. The electronic measurement circuit reads IR directly from 50 to 20,000 megohms, covering the wide range necessary for testing ceramic, mica, air, paper, film, or paper-film capacitors, as well as cables and other insulating material used in electronic equipment.

1.6 Line Voltage and Frequency. The Model TCA-1 Transfarad is designed for use on 105-125 volt, 60 cycle lines ONLY. It will NOT operate on 25 or 50 cycle lines of any voltage. A step-down transformer rated for at least 50 watts is necessary for operation on 230 volt, 60 cycle lines.

1.6.1 The TCA-1 is supplied with a 3-wire line cord to automatically ground the case when the plug is inserted into a 3-prong power receptacle. In the case of 2-prong receptacles, an adaptor, available from all electronic distributors, should be used with the ground wire connected to the screw on the receptacle plate.

1.7 Not For Use On Direct Current. Under NO circumstances should TCA-1 be plugged into a d-c outlet. Always use an inverter power supply (either transistor or other type) that will supply exactly 60 cycles. The supply must be capable of supplying at least 50 watts at 105–125 volts.

1.8 Physical Appearance. The blue-gray hammertone finish steel case, with leather carrying handle, and the light gray panel with red and black markings, along with the charcoal dial (white lettering) and plastic indicator make the Model TCA-1 an instrument that will command respect wherever it is used. The overall size of the Transfarad is 8⅞ in. high x 14⅝ in. wide x 9 in. deep.

1.9 Weight. The net weight of the TCA-1 is 27 lbs.

1.10 Electron Tubes. The electron tube complement of each Transfarad consists of two each 12AT7 and OB2, and one each 6AU6, 6CG7, 6X4, 1629, OA2 and No. 51 lamp.

1.11 Components. The components used in the TCA-1 were chosen for suitability and dependability. Sprague molded Difilm® capacitors, Koolohm® resistors, and Filmistor® molded carbon-film resistors are used wherever appropriate. Ceramic trimmer and stabilized silver mica capacitors are used as low-capacitance standards. The meter amplifier is mounted on an etched board and then completely encapsulated to exclude moisture and insure long-time stability. Switches were especially chosen for the moisture resistance of the dielectric used. The transformers are impregnated with a special moisture-proofing compound. Metal parts are suitably painted or plated as required to resist corrosion.

2. Capacitance and Power Factor

2.1 Measurements of capacitance from 1 mmf to 2000 mf are made on a 5-range line frequency capacitance bridge. Figure 1 shows a simplified circuit diagram of the bridge employed for the C_1, C_2 and C_3 ranges. Figure 2 shows the basic circuit for the C_4 range, and Figure 3 is the circuit for the C_5 range. Since the bridge is balanced on all ranges by continuously varying the ratio arm, a highly accurate, linear-taper wirewound variable resistor is used for the main bridge element, R_{46}. These resistors are especially selected to assure proper accuracy of the calibrated dial. In addition, trimming resistors are provided at each end of the control (not shown on the basic circuits). The standard capacitors for the C_1 and C_2 ranges are stabilized silver-mica capacitors paralleled by silver-ceramic trimmers which are factory adjusted to compensate for variations in wiring capacitance. The C_3 and C_4 standards are matched pairs of Sprague DIFILM® molded tubular capacitors. R_{42} in the basic circuit is the sensitivity control for the amplifier which, along with the "magic-eye", tube constitutes the bridge balance indicator.

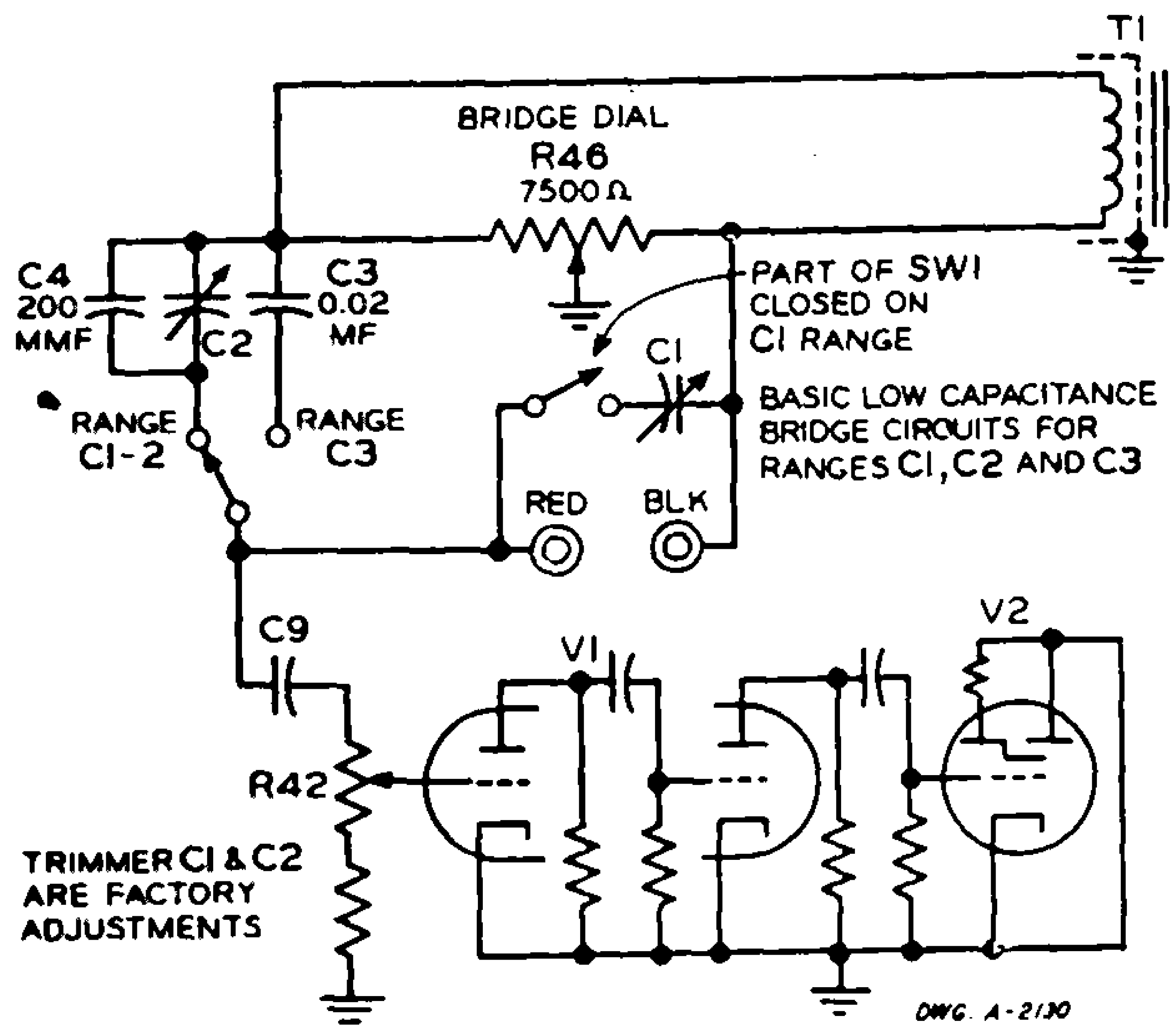


FIGURE 1

Basic Low Capacitance Bridge Circuit for Ranges C_1, C_2, and C_3.

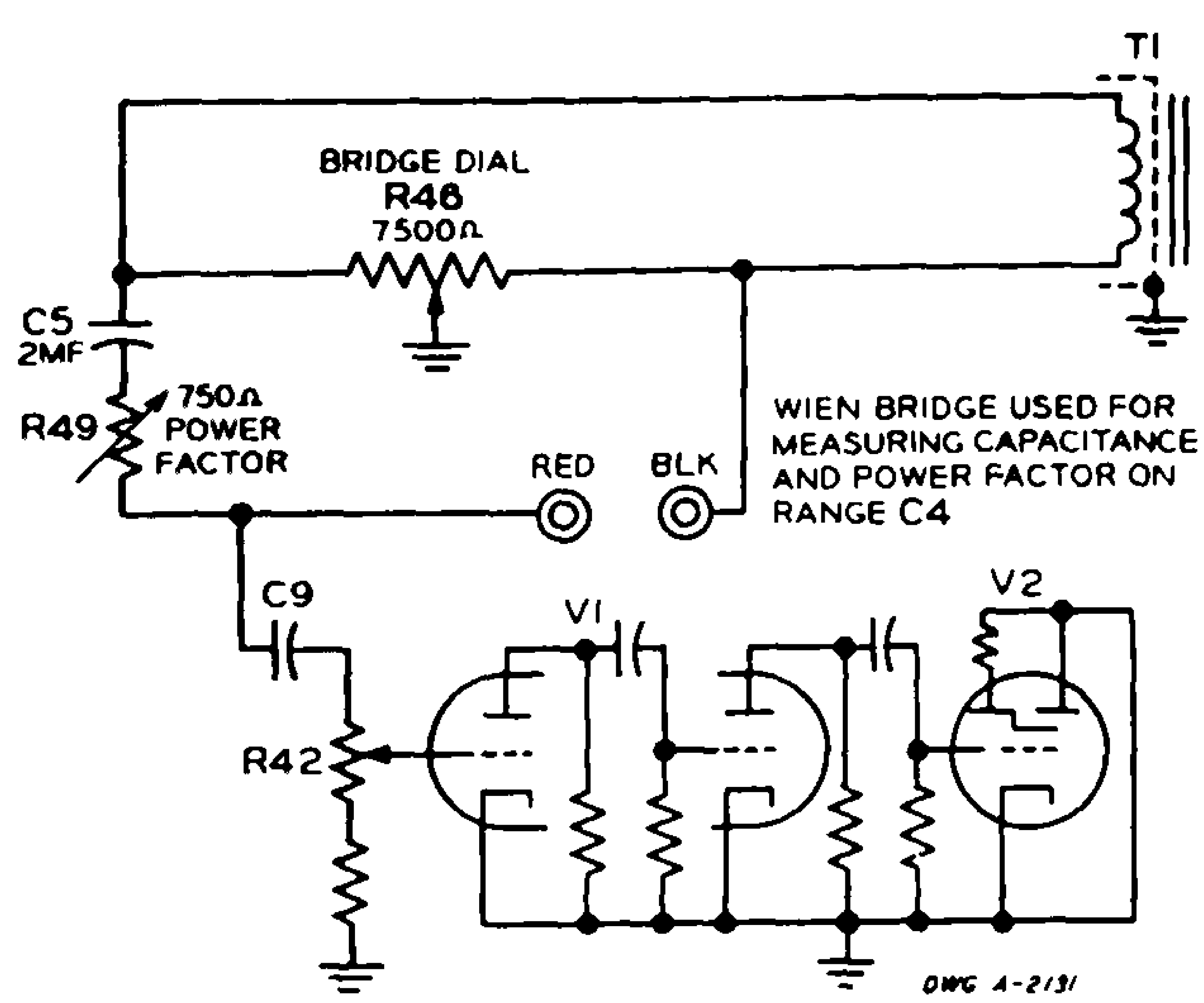


FIGURE 2

This Wien Bridge is used for measuring capacitance and power factor on Range C_4.

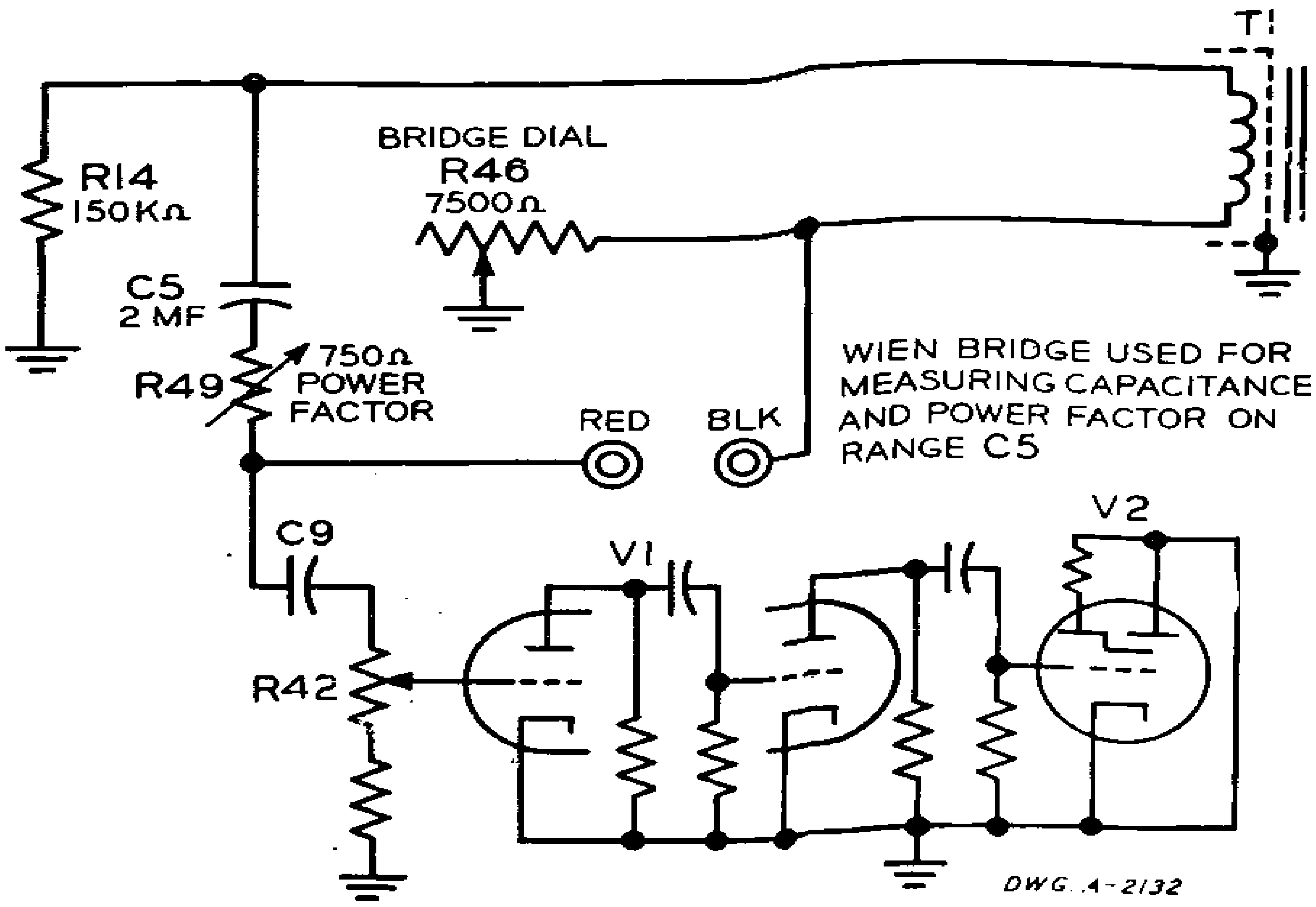


FIGURE 3

This Wien Bridge is used for measuring capacitance and power factor on Range C_5.

2.1.1 ACCURACY TABLE

Range	*Accuracy*
C_1	±2% ±1 mmf over entire range

Range	±3%	±5%	±5%
		Reading Accuracy Determining Factor	
C_2	.00015-.001 mf		.001-.005 mf
C_3	.005-.1 mf	.001-.005 mf	.1-.5 mf
C_4	.5-10.0 mf	.1-.5 mf	10-50 mf
C_5	50-200 mf	45-50 mf	200-2,000 mf

2.2 Operating Procedure.

(1) Set the SELECTOR switch to the position shown below:

Capacitance	*Position*	*Read on Scale*
1-100 mmf	C_1	C_1
.0001-.005 mf	C_2	C_2
.001-.5 mf	C_3	C_3
.1-50 mf	C_4	C_4
45-2000 mf	C_5	C_5

Note: 1,000,000 mmf = 1 mf

(2) Set the a-c line switch in the ON position.

(3) Connect the capacitor to be tested to the binding posts at the left side of the panel. Wherever practical the capacitor should be connected directly to the terminals in order to avoid error due to stray "pick-up". If the capacitance being measured is less than .1 mf, the shield furnished should be used. It is grounded automatically when the studs are pushed into the receptacles adjacent to the binding posts. Polarity MUST be observed when testing electrolytic capacitors.

(4a) Set EYE SENSITIVITY knob at 5 initially. Rotate the main bridge dial slowly until a shadow appears in the "eye" tube (upper left of panel). Carefully adjust the dial for maximum shadow angle on the "eye". If the "eye" sensitivity is too great (the bridge balance is too critical), retard the EYE SENSITIVITY to 3 or 4, while if the "null" is broad, the knob should be advanced to 7 or 8 to permit accurate readings. Should the "balance" be obtained off the scale on the low capacitance end of the dial, the capacitor is either "open" or its capacitance is less than anticipated. To determine which is the case, rotate the SELECTOR to the next lower position and again rotate the dial to obtain a balance. Conversely, if the balance is obtained at the high capacitance end of the dial, the capacitor is shorted or has more capacitance than expected. In such a case rotate the SELECTOR to a higher range and repeat the test.

(4b) If the capacitor being tested is of the electrolytic type, balance the bridge as in (4a). Then rotate the power factor knob to sharpen the "opening" of eye. Readjust the main dial, and again adjust the power factor knob to obtain the maximum sharp "opening". When maximum shadow angle is reached, read the capacitance from the proper scale on the main dial, and the power factor directly from the scale on the panel.

(4c) Capacitors which cause flickering of the "eye" are "intermittent" and should be replaced.

3. Insulation Resistance

3.1 The insulation resistance test is made only on electrostatic capacitors such as paper, film, or paper-film, mica and ceramic (d-c voltage above 25) capacitors. The measurements of IR for ceramics rated less than 25 volts are outlined in Section 5.1. Electrolytic capacitors are tested for leakage current as in Section 4. The basic Insulation Resistance circuit is shown in Figure 4. The meter and meter amplifier constitute a micro-ammeter with a full scale sensitivity of 0.05 microamperes. In the SET INS. RES. position of the SELECTOR switch, the binding posts are short circuited, and a potential of 25 volts is applied to the meter amplifier through a 500 megohm resistor (R_{15}) to produce a full scale reading. In the READ INS. RES. position of the SELECTOR switch, the short circuit across the binding posts is removed, and the meter is calibrated to read the IR (in megohms) of the capacitor being tested.

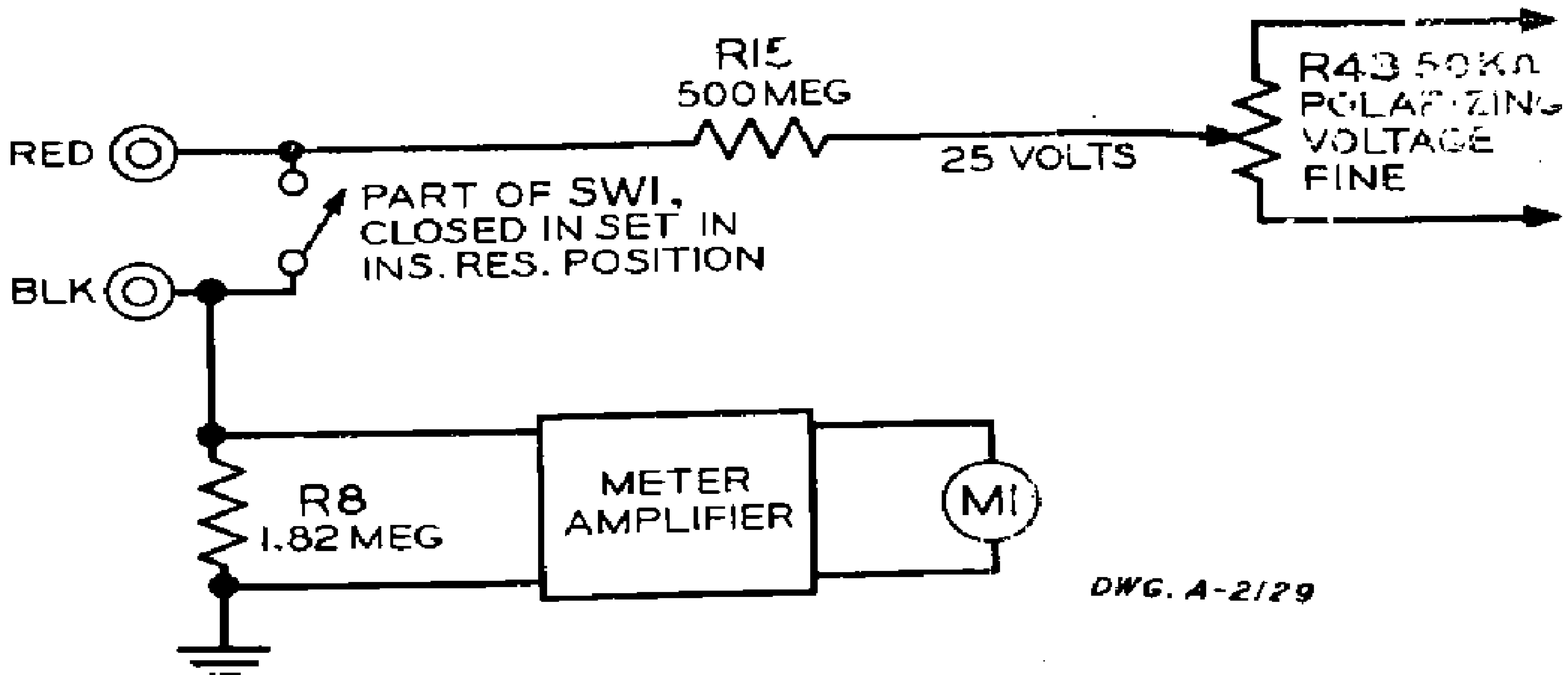


FIGURE 4

This is the basic insulation resistance measurement circuit.

3.2 Operating Procedure.

(1) If the TCA-1 has not been ON for 15 minutes, allow that much time for it to stabilize.

(2) Turn the SELECTOR knob to the ZERO ADJUST position, and rotate the ZERO ADJUST knob (adjacent to the meter) so that the meter reads zero.

(3) Turn the SELECTOR knob to the CALIBRATE position, and turn the NORMAL-SET METER knob to SET METER. Adjust the POLARIZING VOLTAGE FINE knob (under meter) so that the meter reads SET. Return the NORMAL-SET knob to NORMAL, and rotate the ADJUST knob (adjacent to Pilot Light) until the meter again reads SET.

(4) Recheck zero as in (2) above.

(5) Turn the SELECTOR knob to SET INS. RES., and rotate the POLARIZING VOLTAGE FINE knob until the meter reads SET.

(6) Turn the SELECTOR knob to READ INS. RES., and rotate the ZERO ADJUST knob so that the meter reads zero. Recheck (5). Connect the capacitor to the binding posts and read the insulation resistance in megohms on the red scale of the meter. Capacitors rated above .1μF require an appreciable time to become charged. When testing such capacitors, several minutes should be allowed for the meter reading to reach a stable value.

(7) To discharge the capacitor under test, rotate the SELECTOR switch to the SET INS. RES. position. It may then be removed from the posts without danger of shock.

4. Leakage Current of Electrolytic Capacitors

4.1 The basic circuit for the meter amplifier calibration is shown in Figure 5. The amplifier is designed so that an input of .09 volts will produce full scale deflection of the meter. In order to maintain accuracy as tubes age or are replaced, it is necessary to check the gain and correct it if needed. This is accomplished in the calibration circuit.

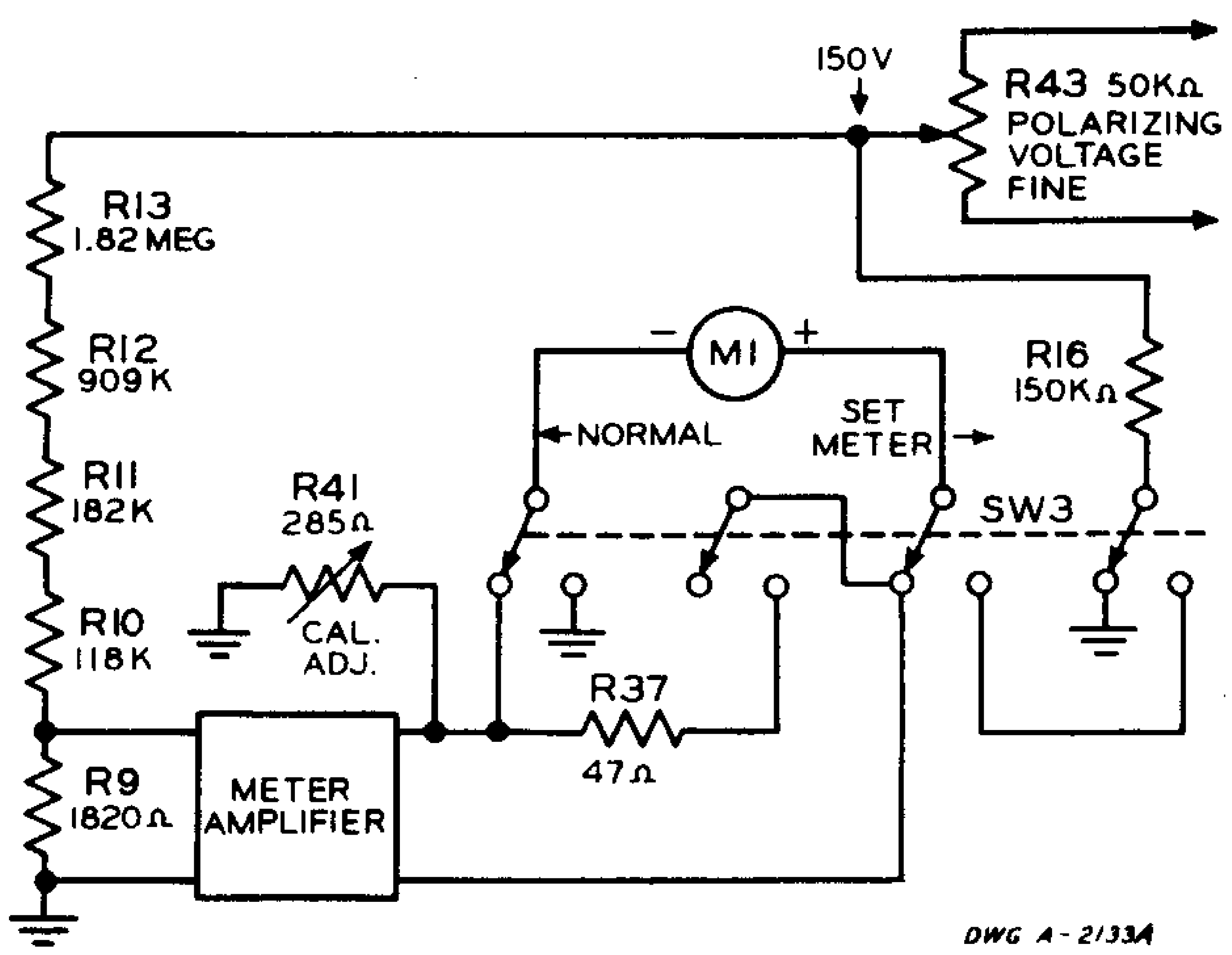


FIGURE 5

This is the basic circuit for the meter amplifier calibration.

4.1.1 In the SET METER position of the NORMAL-SET METER switch, the meter M_1 is in series with R_{16} (a 1% Filmistor) and is used as a basic voltmeter to accurately set the potential applied to the input of the amplifier. In the NORMAL position of the switch, the meter is in the amplifier output circuit, and the gain is adjusted by the ADJUST control (R_{41}) to give full scale meter deflection thereby preventing any errors due to incorrect amplifier gain.

4.2 The basic circuit used to obtain the polarizing voltage for the Leakage Current test is shown in Figure 6. This voltage is continuously variable from 0-150 volts, and is controlled by the "COARSE" switch (4 steps) and the "FINE" control which gives full variation within each step.

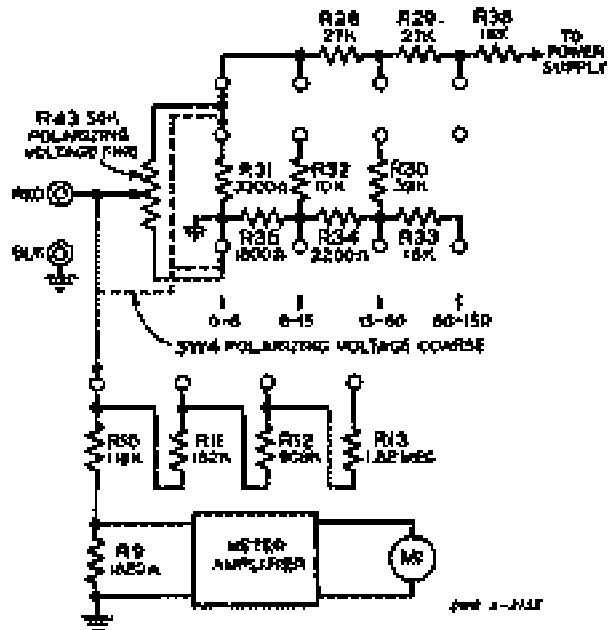


FIGURE 6

This is the basic circuit for measuring the polarizing voltage of electrolytic capacitors.

4.2 The basic circuit for the measurement of leakage current of electrolytic capacitors is shown in Figure 6. The meter amplifier has seven different values of input resistance in order for the meter to read leakage currents ranging from 0.6 to 600 microamperes (full scale values – in seven ranges). The first scale division is .02 µA. Thus .01 µA can be read accurately. The input circuit has a constant voltage drop, on all ranges, of .09 volts. This is particularly important when testing very low voltage capacitors in the 1 or 2 volt range.

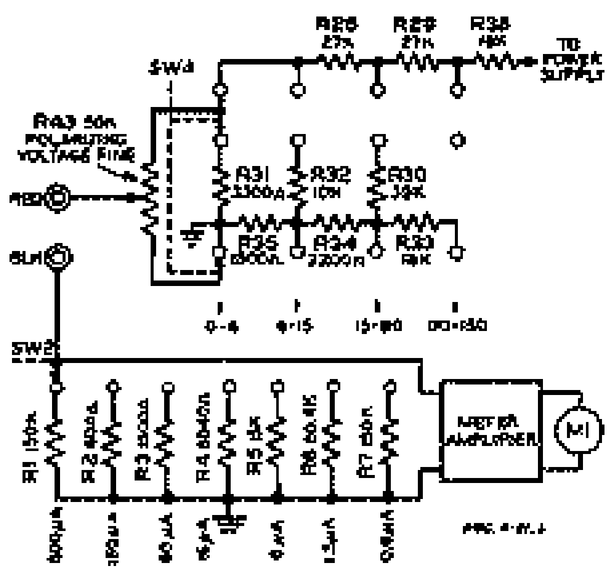


FIGURE 7

This is the basic arrangement for measuring the leakage current of electrolytic capacitors.

4.4 Operating Procedure

(1) Calibrate the TCA-1 as in Section 3.2.

(2) Rotate the SELECTOR knob to POLARIZING VOLTAGE, and adjust the POLARIZING VOLTAGE COARSE and FINE knobs so that the meter reads the rated d-c voltage of the capacitor to be tested.

(3) Determine that the LEAKAGE CURRENT knob is in the 600 position. It should be kept in this position, unless the control is in use, even though the meter is over-load protected.

(4) Connect the capacitor to be tested to the binding posts observing polarity.

(5) Rotate the SELECTOR knob to the LEAKAGE CURRENT position, and note the meter reading. Allow the reading to become stable (it may take as long as 5 minutes) and if it is less than 150 μA, rotate the LEAKAGE CURRENT switch to the 150 μA position, or to a lower current range until the meter reading is on the upper portion of the scale. The leakage current is then read directly from the scale.

(6) If the initial current reading is high, after it stabilizes, rotate the SELECTOR knob back to the POLARIZING VOLTAGE position and readjust the FINE control, if necessary, to bring the meter reading to the exact value of the d-c voltage rating of the capacitor.

(7) Repeat (5) and obtain the final reading.

(8) The leakage current of new transistor-type capacitors is quite small compared with the currents encountered in the case of the higher voltage types. The capacitor manufacturer's specifications or equipment service manual should be consulted for permissible leakage data. In the absence of such information, the average leakage current for new capacitors may be computed from the formula: $I = kCE$ where I is in μA, C in mf, E in volts, and k is a constant for a given capacitor (it is different for the various types of capacitors and, in general, increases with temperature). The following values of k will serve as a guide (all values are for 25C):

	k
Tantalum foil (plain)	.02
Tantalum foil (etched)	.01
Tantalum sintered anode	.003
Tantalum solid electrolyte	.02

(9) The leakage of new subminiature aluminum capacitors may be expected to be as shown below:

3VDC	1 μA
12VDC	2 μA
25VDC	3 μA
150VDC	15 μA

(10) Capacitors with obviously excessive leakage or those whose leakage does not reach a stable value should be replaced.

(11) To discharge the capacitor under test, rotate the SELECTOR switch to the SET INS. RES. position. It may then be removed from the post without danger of shock.

5. Insulation Resistance of Low Voltage Ceramic Capacitors

5.1 The IR of low voltage (under 25VDC) ceramic capacitors may be determined by measuring the leakage current at the rated voltage of the capacitor, as outlined above, and computing the insulation resistance from Ohms' Law, $R = \frac{E}{I}$

6. Miscellaneous Hints

6.1 As noted on the panel, the "eye" glows only when the bridge portions of the TCA-1 are used ($C_1 - C_5$ positions of the SELECTOR switch). It does NOT glow when measurements of insulation resistance or leakage current are being made.

6.2 To avoid parallax error, always read the main dial with your eye directly in front of the indicator line. Reading from an angle will introduce errors.

6.3 For maximum accuracy of capacitance readings, when there is a choice of bridge scales use the range which will give a balance near the center of the scale.

6.4 For best accuracy when reading voltage or current on the meter, when there is a choice, use the range that gives a reading on the upper portion of the scale.

6.5 Return your TCA-1 Registration Card within five (5) days of the date of purchase in order to obtain the benefits of the Sprague warranty.

6.6 Always give model and serial number of your Transfarad, when corresponding concerning your instrument. The serial number is on the rear of the chassis below the line cord.

6.7 If it should ever be necessary to return your TCA-1 for recalibration or service, *write for detailed shipping instructions* BEFORE returning the instrument. *You will save time and money by this procedure.* Always attach a tag giving details of how the instrument is malfunctioning.

LIST OF MAINTENANCE PARTS FOR TCA-1

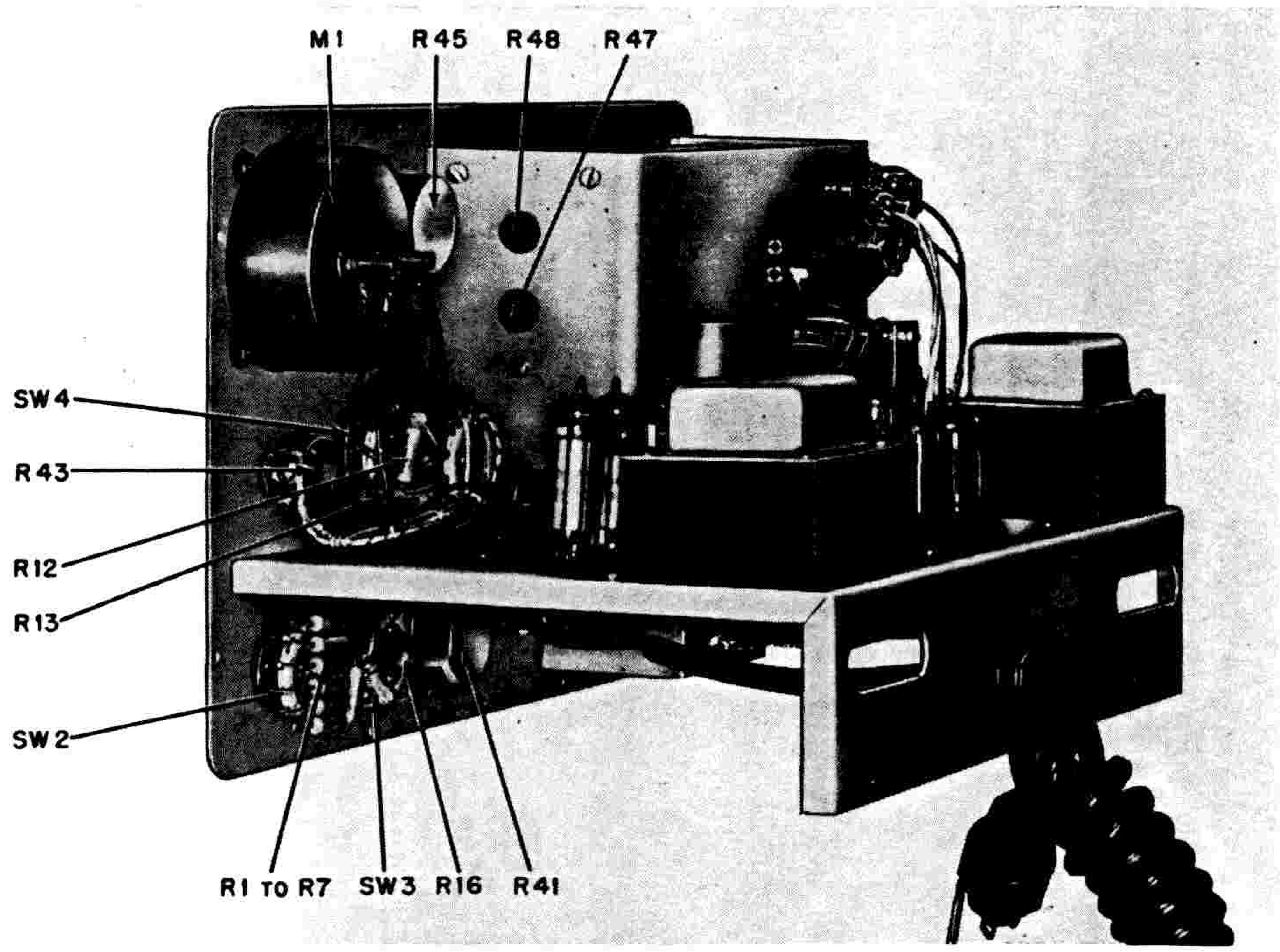
Circuit Symbol	Replacement Part No.	Description
C_1, C_2	1-1000	Capacitor, adjustable dual trimmer, silver ceramic, 4-30 mmf.
C_3	1-202A	Capacitor, fixed, molded Difilm, .02 mf., picked to ±1%, 600 vdc. Sprague No. 6TM-S2.
C_4	1-865	Capacitor, fixed, silver-mica, 200 mmf ±5%, 500 vdc Sprague No. MS-32
C_5	1-208A	Capacitor, fixed, Difilm, 2 mf., ±1%, 400 vdc. Consists of two or three matched parallel capacitors.
C_6, C_7	1-382	Capacitor, fixed, .02 mf., ±10% 600 vdc. Sprague No. 6TM-S2
C_9, C_{10}, C_{11}	1-383	Capacitor, fixed, .033 mf., ±10%, 600 vdc. Sprague No. 6TM-S33
C_{12}, C_{13}	1-525	Capacitor, fixed, dry electrolytic, 100 mf, 3 vdc. Sprague Type TVL.
C_{14}	1-525	Capacitor, fixed, dry electrolytic, 20 mf, 250 vdc. Sprague Type TVL.
C_{15}	1-1110	Capacitor, fixed, Clorinol, 1 mf., 660 vac. Sprague No. 200P225
C_{16}, C_{17}	1-524	Capacitor, fixed, dry electrolytic, Sprague No. TVL2762 with insulating cover 40 + 20 mf @ 450 vdc.
F_1	7-501	Fuse, cartridge, 1 Amp., Type 3AG
Meter Amp.	15-40WP	Direct current meter amplifier unit.
M_1	7-15	Milliammeter, 0-1 ma, d-c ±2%, special scale
R_1	2-29A	Resistor, fixed, deposited carbon, 150Ω, ±1%, ½ watt, Sprague No. 407E150R1
R_2	2-982	Resistor, fixed, deposited carbon, 604Ω, ±1%, ½ watt, Sprague No. 407E604R1
R_3	2-53A	Resistor, fixed, deposited carbon, 1500Ω, ±1%, ½ watt, Sprague No. 407E15011
R_4	2-983	Resistor, fixed, deposited carbon, 6040Ω, ±1%, ½ watt, Sprague No. 407E60411
R_5	2-77A	Resistor, fixed, deposited carbon, 15,000Ω, ±1%, ½ watt, Sprague No. 407E15021
R_6	2-984	Resistor, fixed, deposited carbon, 60,400Ω ±1%, ½ watt, Sprague No. 407E60421

LIST OF MAINTENANCE PARTS—Continued

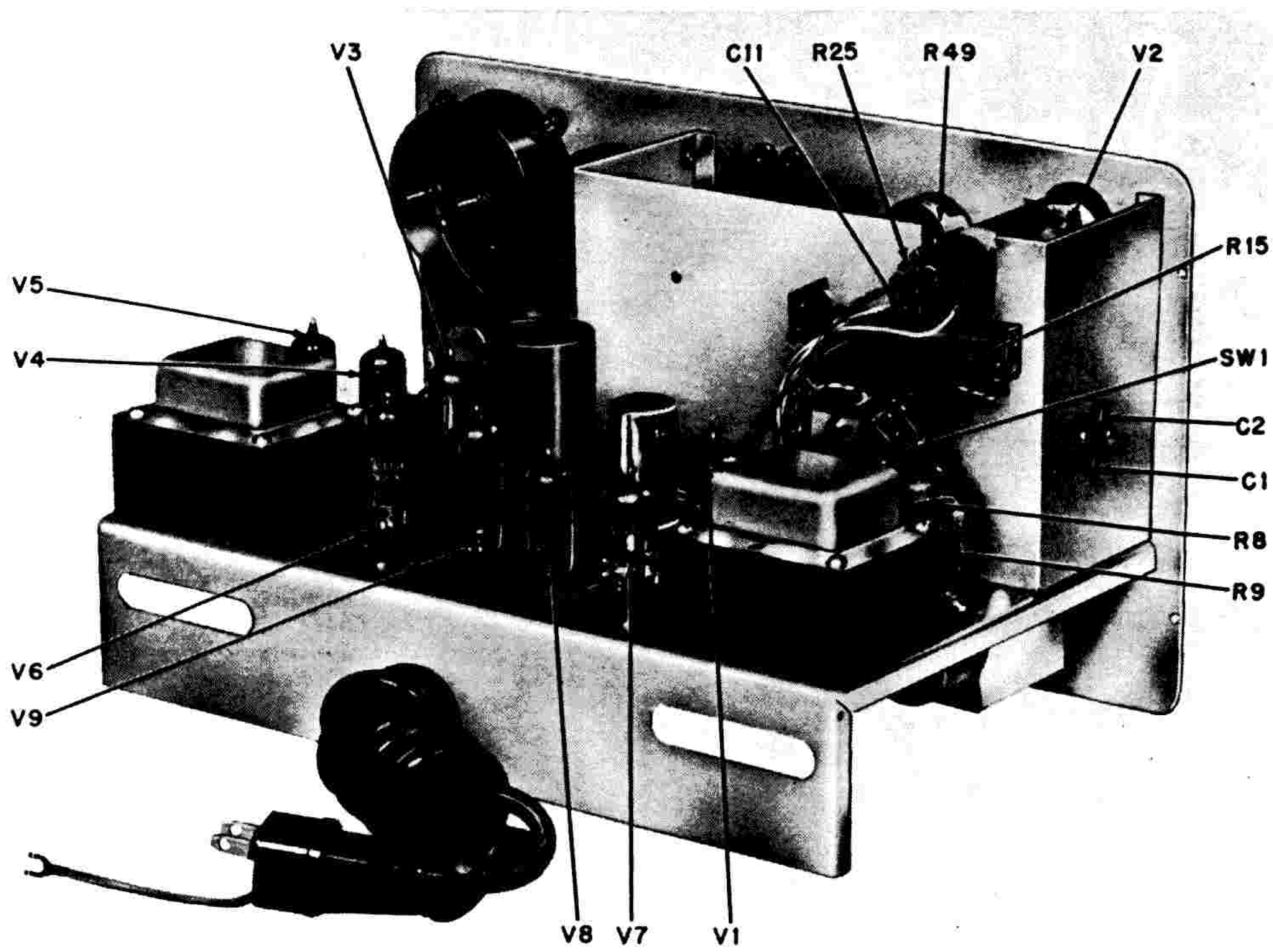
Circuit Symbol	Replacement Part No.	Description
R_7, R_{14}, R_{16}	2-101A	Resistor, fixed, deposited carbon, 150,000Ω, ±1%, ½ watt, Sprague No. 407E15031
R_8, R_{13}	2-985	Resistor, fixed, deposited carbon, 1.82 megohms, ±1%, 1 watt, Sprague No. 408E18241
R_9	2-986	Resistor, fixed, deposited carbon, 1820Ω, ±1%, ½ watt, Sprague No. 407E18211
R_{10}	2-987	Resistor, fixed, deposited carbon, 118,000Ω, ±1%, ½ watt, Sprague No. 407E11831
R_{11}	2-988	Resistor, fixed, deposited carbon, 182,000Ω, ±1%, ½ watt, Sprague No. 407E18231
R_{12}	2-989	Resistor, fixed, deposited carbon, 909,000Ω, ±1%, ½ watt, Sprague No. 407E90931
R_{15}	2-990	Resistor, fixed, molded, 500 megohms, ±5%, 2½ watts, Sprague type 702E
R_{17}, R_{36}	2-109	Resistor, fixed, composition, 330,000Ω, ±10%, ½ watt
R_{18}	2-91	Resistor, fixed, composition, 56,000Ω, ±10%, ½ watt
R_{19}, R_{22}	2-65	Resistor, fixed, composition, 4700Ω, ±10%, ½ watt
R_{20}, R_{23}, R_{25}, R_{27}	2-113	Resistor, fixed, composition, 470,000Ω, ±10%, ½ watt
R_{21}, R_{24}	2-121	Resistor, fixed, composition, 1 meghom, ±10%, ½ watt
R_{26}, R_{34}	2-57	Resistor, fixed, composition, 2200Ω, ±10%, ½ watt
R_{28}, R_{29}	2-83	Resistor, fixed, composition, 27,000Ω, ±10%, ½ watt
R_{30}	2-87	Resistor, fixed, composition, 39,000Ω, ±10%, ½ watt
R_{31}	2-61	Resistor, fixed, composition, 3300Ω, ±10%, ½ watt
R_{32}	2-73	Resistor, fixed, composition, 10,000Ω, ±10%, ½ watt
R_{33}, R_{38}	2-79	Resistor, fixed, composition, 18,000Ω, ±10%, ½ watt
R_{35}	2-55	Resistor, fixed, composition, 1800Ω, ±10%, ½ watt

LIST OF MAINTENANCE PARTS—Continued

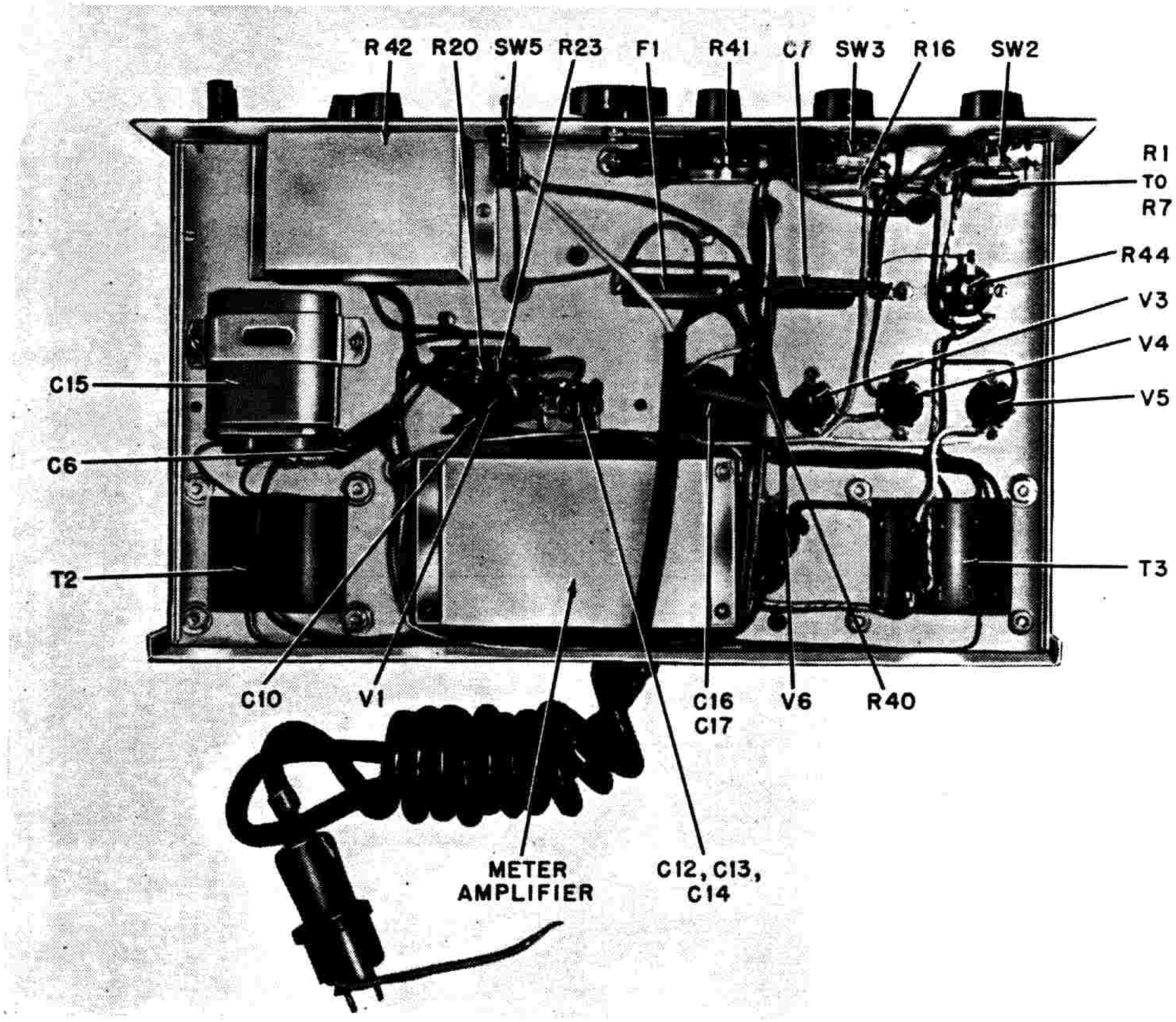
R_{37}	2-17	Resistor, fixed, composition, 47Ω, ±10%, ½ watt
R_{39}	2-548	Resistor, fixed, composition, 1000Ω, ±10%, 1 watt
R_{40}	2-556	Resistor, fixed, composition, 2200Ω, ±10%, 2 watt
R_{41}	2-1031	Resistor, continuously adjustable, wire-wound, 285Ω, ±10%, linear taper, 2 watts, 300° mechanical rotation, 280° electrical rotation
R_{42}	2-1003	Resistor, continuously adjustable, composition, 500,000Ω, ±20%, linear taper, ½ watt
R_{43}	2-1051	Resistor, continuously adjustable, composition, 50,000Ω, ±20%, linear taper, ½ watt
R_{44}	2-1065	Resistor, continuously adjustable, wire-wound, 1000Ω, ±20%, 1½ watts, screwdriver adjustment
R_{45}	2-1015	Resistor, continuously adjustable, wire-wound, 2000Ω, ±20%, linear taper, 2 watts
R_{46}	2-1020C	Resistor, continuously adjustable, wire-wound, 7500Ω, ±10%, linear taper, 3 watts, 300° mechanical rotation, 280° electrical rotation. Selected for agreement with calibrated dial
R_{47}, R_{48}	2-1064	Resistor, continuously adjustable, wire-wound, 100Ω, ±20%, 1½ watts
R_{49}	2-1013	Resistor, continuously adjustable, wire-wound, 750Ω, ±10%, 2 watts, linear taper, 300° mechanical rotation, 280° electrical rotation
SW_1	11-188	Switch, rotary, 11 position
SW_2	11-193	Switch, rotary, 7 position
SW_3	11-192	Switch, rotary, 2 position
SW_4	11-191	Switch, rotary, 4 position
SW_5	11-6	Switch, toggle, SPST
T_1	3-108-1	Transformer, bridge supply
T_2	3-108-2	Choke, regulating type
T_3	3-108-3	Transformer, filament and power, regulating type
V_1, V_7	5-12AT7	Tube, electron, 12AT7
V_2	5-1629	Tube, electron, 1629
V_3	5-OA2	Tube, electron, OA2
V_4, V_5	5-OB2	Tube, electron, OB2
V_6	5-6X4	Tube, electron, 6X4
V_8	5-6AU6	Tube, electron, 6AU6
V_9	5-6CG7	Tube, electron, 6CG7
PL	5-51	Pilot Lamp, No. NE 51



VIEW FROM LEFT REAR

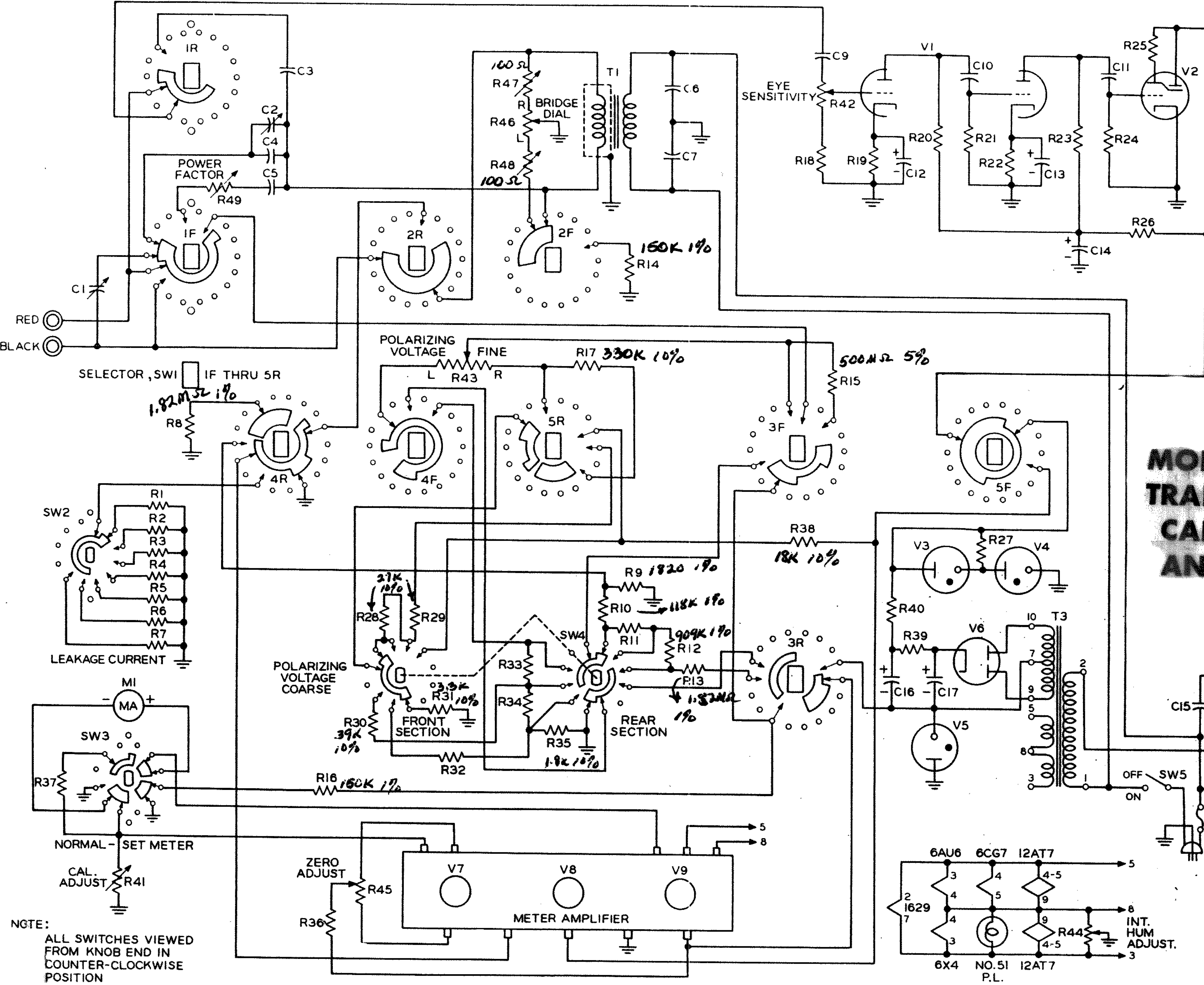


VIEW FROM RIGHT REAR



BOTTOM VIEW OF CHASSIS

MODEL TCA-1 TRANSFARAD CAPACITOR ANALYZER



NOTE:
ALL SWITCHES VIEWED FROM KNOB END IN COUNTER-CLOCKWISE POSITION