T-143
REV. 2

SPRAGUE®

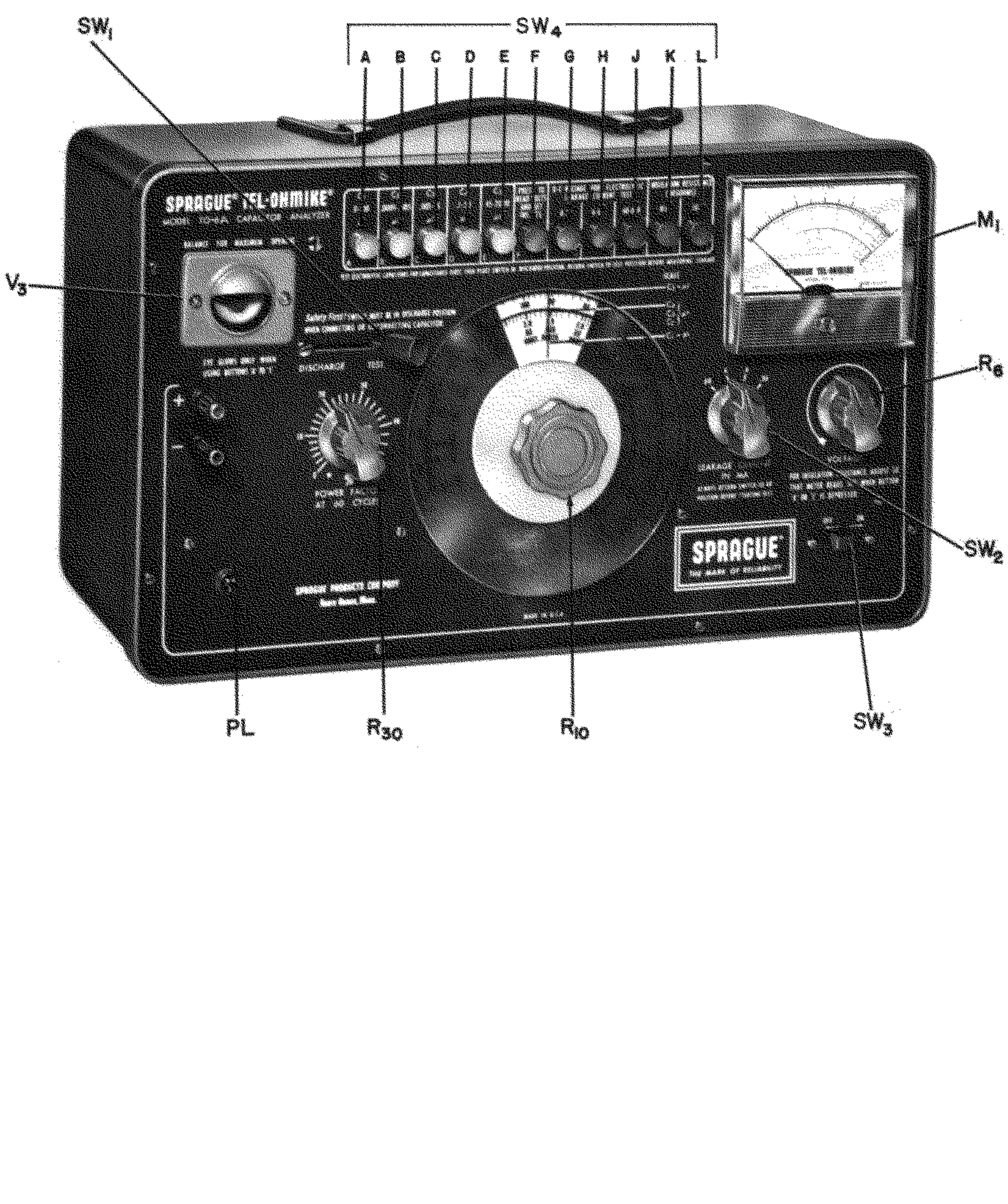
OPERATING MANUAL

MODEL TO-6A
TEL-OHMIKE®

CAPACITOR ANALYZER

SPRAGUE PRODUCTS COMPANY
DISTRIBUTORS' DIVISION OF SPRAGUE ELECTRIC COMPANY
North Adams, Mass.

PRICE: 50 CENTS



Operating Manual
MODEL TO-6A
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1. General Description

1.1 Purpose and Usefulness. Designed specifically to meet the need of television, radio and industrial electronics technicians for a compact, reliable, and simple-to-use instrument for testing capacitors, the Sprague Model TO-6A Tel-Ohmike represents the culmination of years of experience in this field. It incorporates in one instrument an accurate multi-range capacitance and power factor bridge, an insulation resistance checker for paper, plastic-film, mica, and ceramic capacitors, and a leakage current test circuit for electrolytic capacitors. Pushbuttons are provided for instant range selection and a magic-eye tube simplifies bridge balancing for capacitance measurements. A large meter gives direct pointer readings of insulation resistance and leakage current and shows the exact voltage applied to electrolytic capacitors during the leakage test.

1.2 Six especially valuable features of the Model TO-6A Tel-Ohmike are: (1) the I-R (insulation resistance) range of 500 MΩ-50 KMΩ, (2) a special I-R range of 100 MΩ-10 KMΩ (with a 25 volt circuit for low-voltage capacitors), (3) the special low-capacitance bridge circuit for testing low-value ceramic, mica, plastic-film, and air dielectric capacitors from 1-100 pF with improved accuracy, (4) the meter protection which prevents "burn-outs" should the meter be overloaded, (5) the Safety switch for easier discharge of capacitors after test, and (6) the "eye" amplifier to provide greater reading accuracy.

1.3 Capacitance. In addition to the special low range mentioned above, 4 other capacitance ranges are provided for measurements up to 2000 μF. With a TO-6A Tel-Ohmike you are prepared to test every type of capacitor from tiny ceramics or micas to paper and film capacitors of all types, as well as electrolytics—tantalum or aluminum—wet or dry—low voltage or high voltage—small capacitance or large capacitance—from small filter types to large motor-start or photoflash types.

1.3.1 Power Factor. The power factor of all electrolytic capacitors is indicated directly in percent on a single scale.

1.4 Leakage Current. A self-contained continuously adjustable d-c power supply permits measurement of electrolytic capacitor leakage current at exact rated voltage.

1.5 Insulation Resistance. Most paper, plastic-film, ceramic, mica, and air dielectric capacitors have their I-R measured by a circuit which applies 150 volts to the capacitor, and the I-R is indicated directly on the meter dial from 500 MΩ to KMΩ. For testing non-electrolytic capacitors rated at less than 150 volts, an additional range of 100 MΩ to 10 KMΩ is provided in conjunction with a circuit which applies only 30 volts to the capacitor under test.

1.6 Line Voltage and Frequency. The Model TO-6A Tel-Ohmike is available in four types. The standard TO-6A is intended for 115 volt, 50-60 Hz a-c lines. The TO-6ARM is similar except that it is intended for mounting in standard 19" relay racks. Also available is the Model TO-6AS for use on 115/230 volt, 50 Hz mains. Before using a Model TO-6AS, check to see whether the link on the internal terminal plate is in the proper position for the line voltage on which the instrument will be used. A rack-mounting version, the TO-6ASRM, is also available.

1.6.1 Not For Use on Direct Current. Under no circumstances should a Tel-Ohmike be plugged into a d-c outlet. Always use an inverter power supply (either rotary or 60-Hz vibrator type) to supply the required 35 watts of a-c.

1.7 Physical Appearance. The gray hammertone finish steel case, with leather carrying handle, and the dark gray panel with white markings make the Model TO-6A an instrument to attact favorable attention and command respect on every service bench. The striking contrast between the dial and the background makes for easy and error-free readings. The overall size of the standard Tel-Ohmike is $8\frac{7}{8}''$ high by $14\frac{5}{8}''$ wide by $6\frac{1}{8}''$ deep.

1.8 Weight. The net weight of both the TO-6A and the TO-6AS is 13 pounds.

1.9 Electron Tubes. The electron tube complement of each Tel-Ohmike consists of 1 each: 6C4, 6AB4, 6BL7GTA, and 6E5.

2. Capacitance and Power Factor

2.1 Measurements of capacitance from 1 pF to 2000 μF 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 bridge circuit for the C_4 range and Figure 3 is the simplified 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. These potentiometers are especially selected to assure accurate matching of the calibrated scales over their full length. The standard capa-

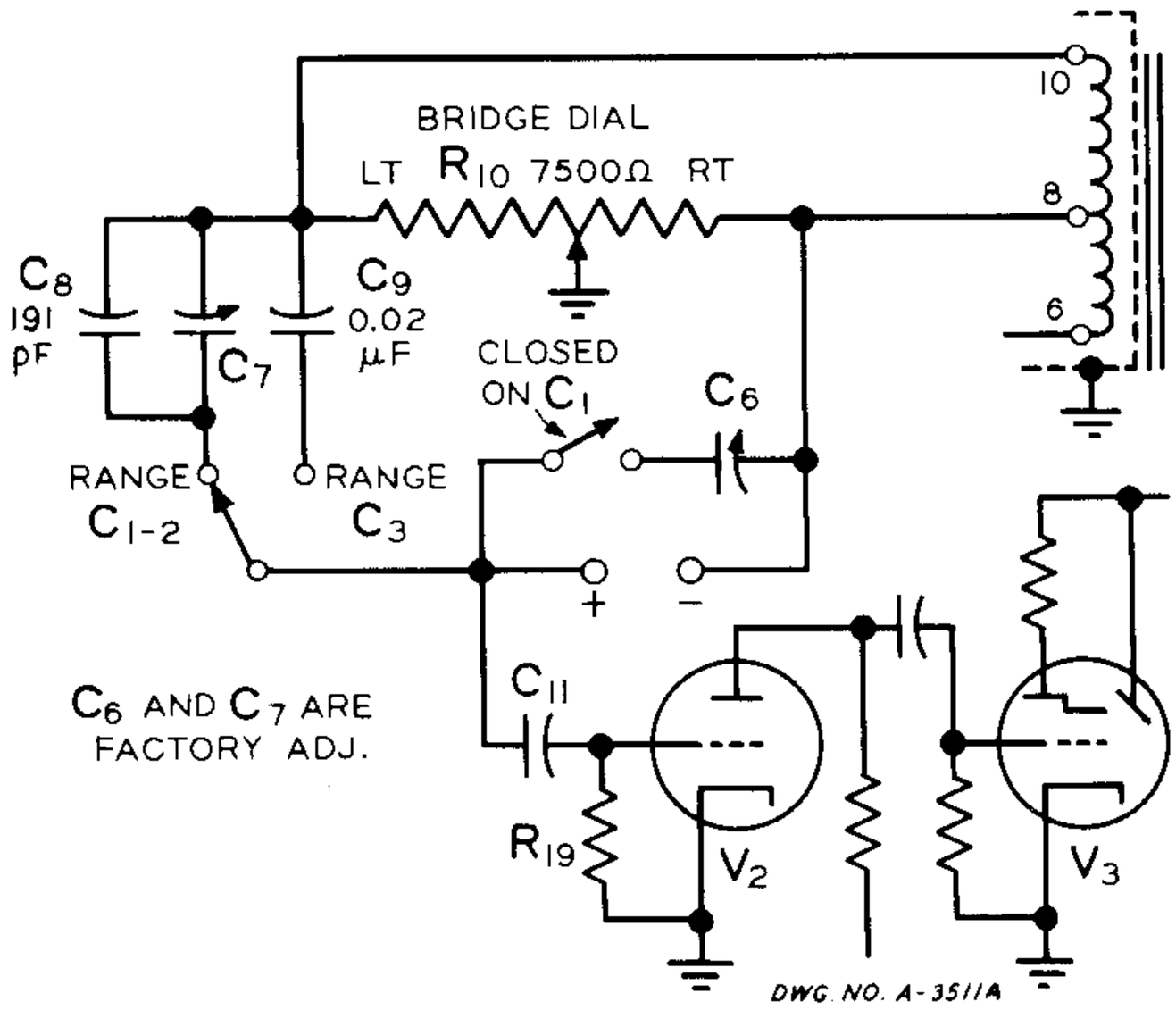


FIGURE 1

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

citors for the C_1 and C_2 ranges are silvered mica-capacitors paralleled by silvered ceramic trimmer capacitors which are factory adjusted to compensate for variations in the inherent wiring capacitance. The standard on the C_4 and C_5 range is a matched pair of molded DiFilm® paper tubulars. The bridge balance or null detector is a high sensitivity "magic-eye" 6E5 tube amplifier combination.

2.1.1 ACCURACY TABLE

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

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

2.2 Operating Procedure.

(1) Depress the proper pushbutton as shown below:

Capacitance	Button	Read on Scale
1-100pF	A	C_1
.0001–.005 μF	B	C_2
.001–.5 μF	C	C_3
.1–50 μF	D	C_4
45–2000 μF	E	C_5

Note: 1 pF = 1μμF, or 0.000001μF.

(2) Set the a-c line switch in the lower right hand corner of the panel in the "ON" position. Set the safety switch in the "TEST" position.

(3) Connect the capacitor under test to the + and − binding posts at the left of the panel. Small ceramic, mica, and paper tubulars should be connected directly across the terminals without using external test leads; otherwise accuracy will be impaired. Observe polarity markings when connecting electrolytics.

(4a) Slowly rotate the main bridge dial in a clockwise direction from left to right until a shadow appears in the eye tube at the upper left. Carefully adjust the control for maximum eye opening. Read the indicated capacitance directly from the proper dial scale.

(4b) For electrolytic capacitors, balance the bridge as in (4a). Then adjust the power factor knob for maximum eye opening. Now readjust the main dial, then the power factor knob, etc. until maximum eye opening is definitely obtained. When maximum shadow angle is reached, read the capacitance from the main dial scale and the power factor from the power factor scale. When using the TO-6A on line frequencies of 50 Hz, multiply the indicated power factor rating by 0.84.

(4c) When it is necessary to measure capacitors without removing them from a chassis, always unsolder one lead from the circuit. Take care not to damage small micas and ceramics with too much heat. To improve the accuracy of measurements on capacitors of less than about 1000 pF under these conditions, measure the capacitance of the test leads arranged as they would

be when connected except for connecting the test clips. Record the reading. Now connect the clips directly across the capacitor and rebalance the bridge. Deduct the test lead capacitance from this reading to get the capacitance of the unit under test.

(4d) Capacitors which can be balanced only at the right hand (counter-clockwise) end of the scales on all ranges are open and should be discarded. Capacitors balancing only on the high (clockwise) end of the scales are short-circuited and should be discarded. Capacitors with "intermittents" will cause a marked flickering of the magic eye indicator and should be replaced.

(4e) The Model TO-6A Tel-Ohmike should be grounded through the power plug at all times, particularly when measuring small values of capacitance. If a grounded three-wire outlet is not available, a suitable adapter may be used with the green wire connected to ground.

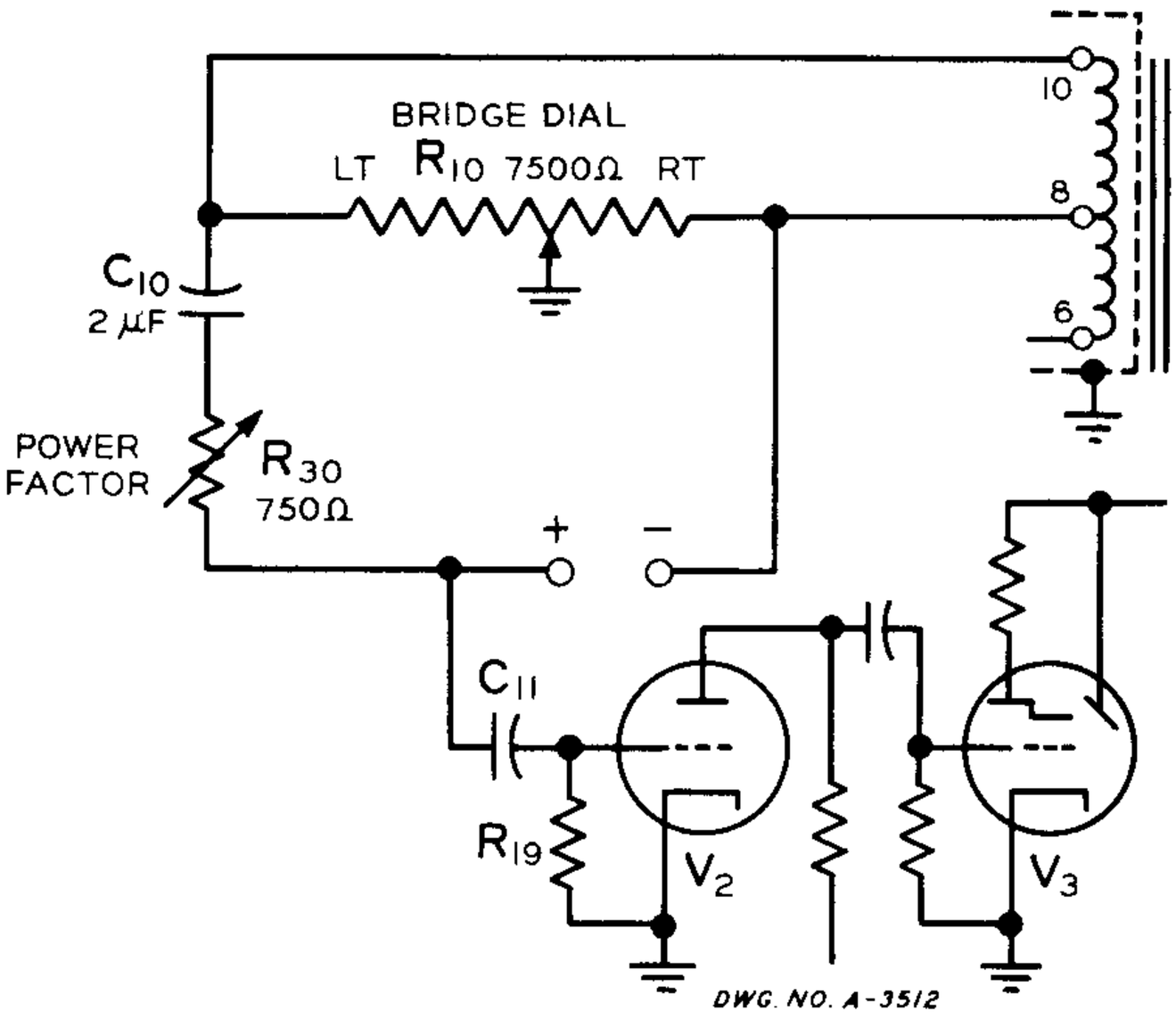


FIGURE 2

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

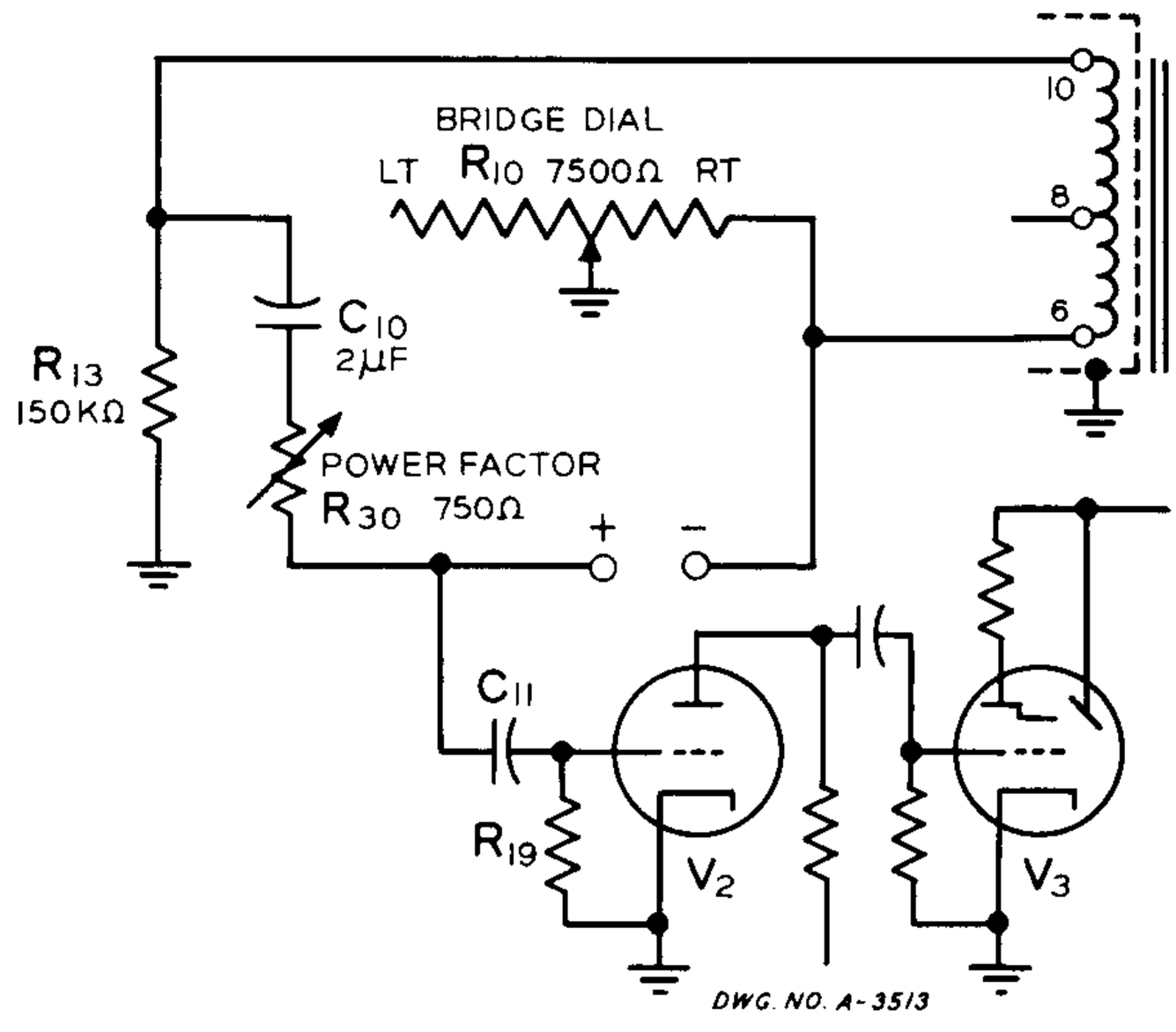


FIGURE 3

Here is how the measurement range of the Wien Bridge is extended for high capacitance electrolytics.

2.3 Capacitance Tolerance.

2.3.1 D-C Dry Electrolytics. In general, capacitors less than 75 percent of their nominal value should be replaced. In bypass capacitors there is, from the application standpoint, usually no upper limit on the capacitance above nominal. This is also true of most filter capacitors except for the "reservoir" or input capacitors in power supplies. Here the upper capacitance limit depends on the permissible current thru the rectifier. New dry electrolytics for TV-radio applications usually meet the following limits:

Rated Voltage	Percent Capacitance Tolerance	
	Single Section	Multi-Section
3 thru 100	−10, +100	−10, +150
101 thru 300	−10, + 75	−10, +100
301 thru 450	−10, + 50	−10, +50

2.3.2 Paper or Film Capacitors. Standard industry tolerance for paper or film tubulars when not otherwise specified or color-coded is usually ±20%.

From the circuit application standpoint, the capacitance tolerances on coupling capacitors are usually more critical than those on bypass and filter capacitors. In radio receivers, units within the tolerances above are generally satisfactory in both types of use. In television sets, it is best to check the manufacturers service data since very tight tolerances are necessary in some specialized circuit locations.

2.3.3 Mica Capacitors. Non-color-coded or marked micas are usually ±20% units. Color-coded capacitors should fall within their marked tolerance.

2.3.4 Ceramic Capacitors. Temperature-compensating capacitors and other units using dielectric bodies with low dielectric constants are usually ±20% tolerance units, unless otherwise color-coded or marked. High dielectric constant units may be of the ±20% type or else of the MRC (minimum rated capacitance) or GMV (guaranteed minimum value) type. These capacitors are usually used for bypass and coupling applications and their actual capacitance varies markedly with the ambient temperature at which they are measured. The rated minimum value is applicable only at 25°C (77°F) and the actual value may be double the MRC rating. Above room temperature, capacitance may increase and then decrease, or decrease and then increase, according to the dielectric material used.

2.3.5 A-C Motor-Starting Electrolytics. Capacitors more than 15% below the minimum marked capacitance should be replaced as the motor-starting torque will be seriously reduced.

2.4 Power Factor

2.4.1 D-C Dry Electrolytics. The 60 Hz power factor of new capacitors will usually fall below the maximum value given below. Capacitors rated at 150 volts or higher should usually be replaced if the measured value is twice that given. Low voltage sections of multiple-section

capacitors will generally have power factor higher than that listed, sometimes by as much as 100%.

WVDC	Max. New P-F
4 thru 9	23
10 thru 24	17
25 thru 74	13
75 thru 450	10

NOTE: Power factor for 3V capacitors and capacitors with a capacitance times voltage product greater than 100,000 will be as specified by the capacitor manufacturer.

2.4.2 A-C Motor Starting Electrolytics. Capacitors with a power factor of more than 15% should be replaced.

3. Insulation Resistance

3.1 The insulation resistance test is made only on electrostatic capacitors such as paper, mica, ceramic, etc. (Electrolytic capacitors are tested for leakage current as in section 4). The test circuit is shown in Figure 4. Passage of current thru the capacitor or other circuit element under test causes an increase in the negative bias on the grid of tube V_4 and a consequent decrease in plate current. The plate current meter is calibrated directly in megohms.

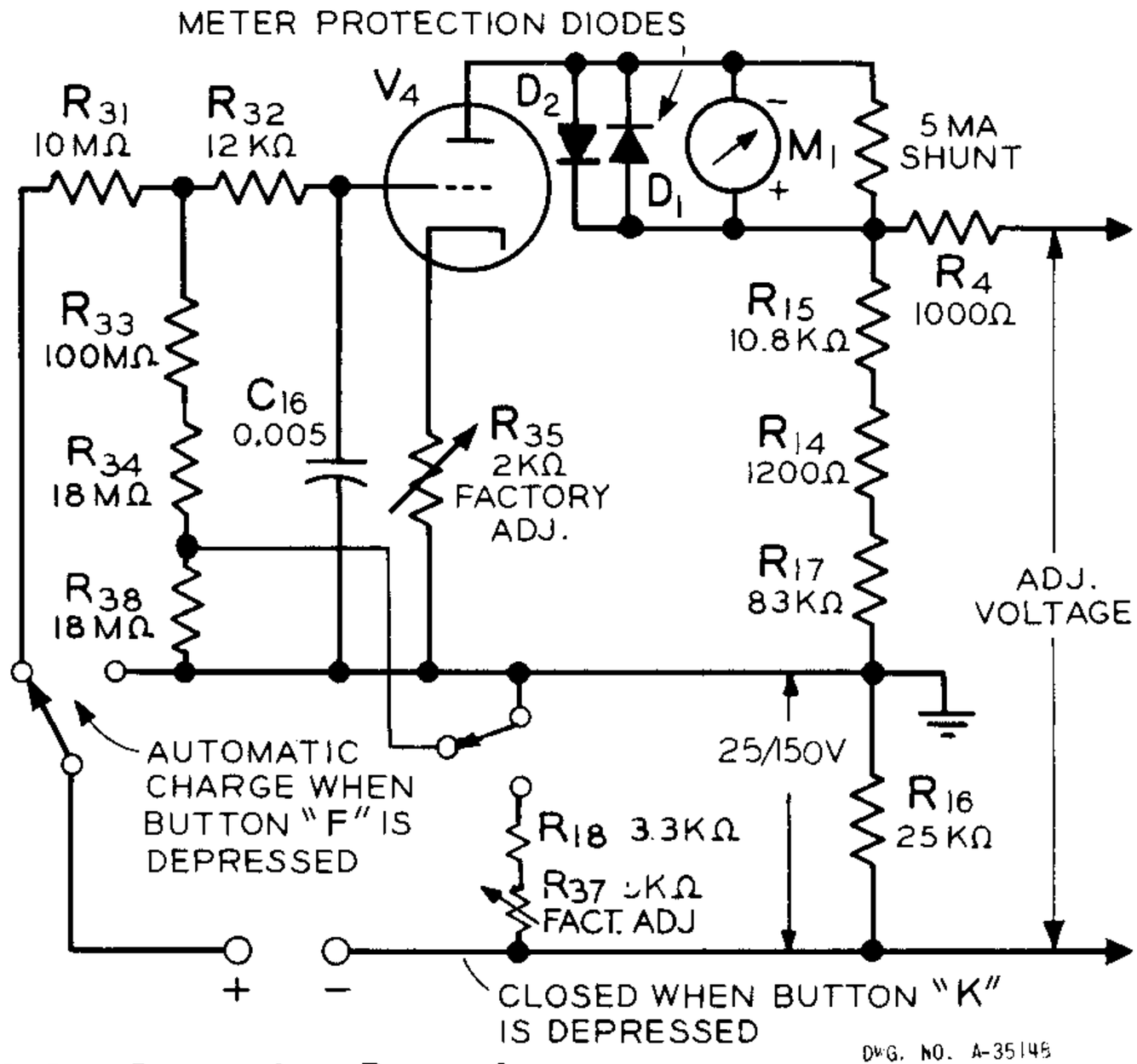


FIGURE 4

This is the insulation resistance measurement circuit with the "Automatic Charge" feature.

3.2 Operating Procedure.

(1) Depress Pushbutton K for capacitors with a d-c voltage rating between 50 and 200 volts. Depress Pushbutton L for units rated at 200 volts and higher. For capacitors rated less than 50 volts, see Paragraph 3.5.

(2) Set the a-c line switch in the lower right hand corner of the panel to "ON". Have the safety switch in the "TEST" position. Allow 1 minute warmup time.

(3) Connect the capacitor under test to the + and — binding posts. Depress Pushbutton F and adjust the Voltage control so that the meter reads "SET"; then release the button.

(4) Allow the capacitor to remain connected to the TO-6A until meter pointer no longer moves downward. The scale reading at which the pointer comes to rest indicates the Insulation

Resistance of the capacitor under test. The time required for the pointer to come to rest is proportional to the capacitance of the capacitor being tested. Wide fluctuations of the pointer indicate an intermittent capacitor which should be discarded. When using Pushbutton K, read the I-R on the lower red scale. Use the upper red scale when using Pushbutton L.

(5) IMPORTANT—Place the Safety Switch in the DISCHARGE position to discharge the capacitor under test before removing it from the binding posts.

3.3 Test Limits.

3.3.1 Mica Capacitors. Standard molded micas will have an I-R when new of more than 3 KMΩ while low-loss case and silvered micas will have an I-R when new of at least 6 KMΩ.

3.3.2 Ceramic Capacitors. Most ceramic capacitors rated at .02 μF or less when new will have a minimum insulation resistance of 7500 MΩ.

3.3.3 Paper Capacitors. The minimum insulation resistance times capacitance product for paper tubular capacitors is 1000 megohm-microfarads when new except that capacitors are in no case required to have an insulation resistance of more than 5000 megohms. Molded tubulars will usually exceed these minimum limits by a wide margin.

3.3.4 Film Capacitors. The minimum insulation resistance times capacitance product for popular film capacitors is 10,000 megohm-microfarads but need not be more than 25,000 megohms.

3.3.5 Insulation resistance measurements are very much affected by temperature. The insulation resistance at 50 C may be between 15% and 50% of the 25 C insulation resistance, depending on the particular dielectric material used.

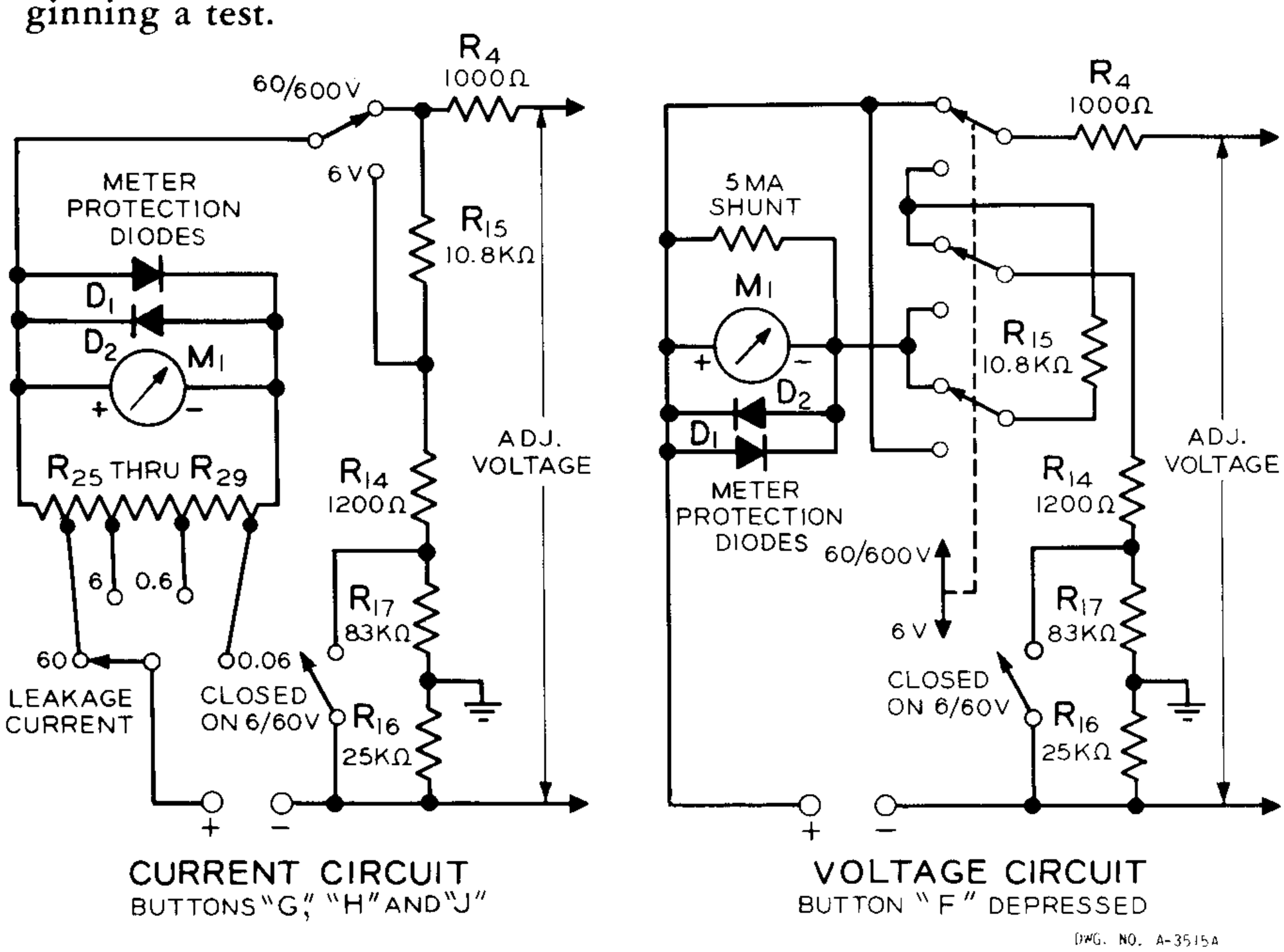
3.3.6 All values given above are for general information only and will change somewhat with different manufacturers, dielectric material, and physical size of the capacitor being tested.

3.4 The insulation resistance circuit may also be used in checking motor windings, high value resistors in photocell and nuclear instrument circuits, leakage between posts on terminal strips, etc.

3.5 The insulation resistance of low-voltage ceramic capacitors (under 50 volts) may best be determined by measuring the leakage current at rated voltage as outlined in paragraph 4.2. The actual value of I-R may then be computed from Ohm's Law, $R = \frac{E}{I}$. E is the rated d-c voltage of the capacitor, I is the measured leakage current in microamperes, and R is the insulation resistance in megohms. For example: a typical 3 volt, 1 μF ceramic capacitor has a leakage current of 5 μA, giving an I-R of 0.6 MΩ (IR $= \frac{3}{5} = 0.6$). A typical 3 volt, 0.1 μF ceramic capacitor has a leakage current of 1.5 μA (I-R $= \frac{3}{1.5}$ or 2 MΩ). If the leakage current is less than 1 μA (the first division on the 0-60 μA scale) then the I-R megohms is greater than the voltage, i.e. 0.6 μA leakage current at 3 volts gives I-R $= \frac{3}{0.6} = 5$ MΩ.

4. Leakage Current of Electrolytic Capacitors

4.1 The test circuits shown in Figures 5 and 6 permit measurement of leakage current of electrolytic capacitors. The self-contained power supply provides any desired test voltage up to 600 volts d-c. To facilitate accurate adjustment of the lower voltages, low voltage ranges of 0-6 and 6-60 volts are provided in addition to the 600 volt max. circuit. The meter reads the actual voltage applied to the capacitor terminals since the limiting resistor (which limits the current thru short-circuited capacitors to 60 mA) is in the cathode circuit of the grid-controlled rectifier tube. The Leakage Current meter has four ranges: 0-.06 mA, 0-.6 mA, 0-6 mA, and 0-60 mA. Even though the meter is protected against burn-outs, the Leakage Current switch should be placed in the 60 position before beginning a test.



FIGURES 5 AND 6 Current and Voltage Test Circuits.

4.2 Operating Procedure.

(1) Turn voltage control to the counter-clockwise position.

(2) Set the a-c line switch to ON. Allow 1 minute warm-up time.

(3) Place the safety switch in the "DISCHARGE" position.

(4) Connect capacitor to be tested across the + and − binding posts, observing proper polarity.

(5) Depress Pushbutton G, H, or J, according to the voltage rating of the capacitor being tested.

(6) Place the safety switch in the "TEST" position.

(7) Depress Pushbutton F, and adjust the voltage control until the meter reads the d-c voltage rating of the capacitor under test. The scale is direct reading when using Pushbutton G (0-6 volts). Multiply the meter reading by 10 when using Pushbutton H (6-60 volts). Multiply the meter reading by 100 when using Pushbutton J (60-600 volts).

(8) Release Pushbutton F and compute the leakage current by multiplying the reading on the 0-6 scale by 10. If the reading is less than .6, turn the Leakage Current switch to the 6 position. The meter is now direct reading. If the reading is less than .6, turn the switch to the .6 position and divide the reading by 10. If the reading is still less than .6, turn the switch to the .06 position and divide the reading by 100. *Note. The .6 position on the scale is in line with the lowest division mark on the upper red scale.*

(9) Release whichever red button is in use and place the Safety switch in the "DISCHARGE" position before removing the capacitor from the binding posts.

4.3 It will be noted that the voltage reading (with button H depressed) will tend to increase after a short time as the leakage current begins to decrease to a stable value. The voltage control should be retarded accordingly to prevent more than rated voltage from being applied to the capacitor. The measurement of leakage current should be made only after a stable value is reached. Capacitors which have been out of use for periods of a year or more may take as long as 30 minutes to reach a stable value of leakage current. Such capacitors usually have a high current initially and the voltage control should be retarded so that the leakage current is less than 10 milliamperes in order to prevent overheating of the capacitors internally. The voltage should be adjusted upwards until rated voltage is reached as the leakage current decreases. When rated voltage is finally reached, proceed as detailed above. If there is appreciable fluctuation in the leakage current indication, the capacitor is probably intermittent and should be discarded.

4.4 Test Limits. New radio-TV type electrolytics should have a maximum leakage current as shown in the following table:

	D-C WORKING VOLTAGE										
μF	6V	15V	25V	50V	100V	150V	250V	300V	350V	400V	450V
1	5.0μA	5.0μA	5.0μA	5 0μA	5.0μA	7.5μA	12.5μA	15.0μA	17.5μA	20.0μA	22.5μA
3	5.0	5.0	5.0	7.5	15.0	22.5	37.5	45.0	194	208	220
5	5.0	5.0	6.25	12.5	25.0	37.5	212	232	251	268	285
10	5.0	7.5	12.5	25.0	50.0	232	300	329	355	380	403
30	9.0	22.5	37.5	233	329	403	520	570	615	658	697
50	15.0	37.5	212	300	425	520	671	735	794	849	900
70	21.0	195	251	355	503	615	794	870	939	1.00mA	1.06mA
100	30.0	232	300	425	600	735	950	1.04mA	1.12mA	1.20	1.27
200	208	328	425	600	849	1.04mA	1.34mA	1.47	1.59	1.70	1.80
300	255	403	520	735	1.04mA	1.27	1.64	1.80	1.94	2.08	2.20
500	329	520	671	950	1.34	1.64	2.12	2.32	2.51	2.68	2.84
700	389	615	794	1.12mA	1.59	1.94	2.51	2.75	2.97	—	—
1000	465	735	950	1.34	1.90	2.32	3.00	—	—	—	—
1500	570	900	1.16mA	1.64	2.32	2.84	—	—	—	—	—
2000	657	1.04mA	1.34	1.90	2.68	—	—	—	—	—	—
3000	806	1.27	1.64	2.32	—	—	—	—	—	—	—
4000	930	1.47	1.90	2.68	—	—	—	—	—	—	—
5000	1.04mA	1.64	2.12	3.00	—	—	—	—	—	—	—
10000	1.47	2.32	3.00	—	—	—	—	—	—	—	—
15000	1.80	2.84	—	—	—	—	—	—	—	—	—
25000	2.32	—	—	—	—	—	—	—	—	—	—
35000	2.75	—	—	—	—	—	—	—	—	—	—

Maximum leakage currents not shown in above table may be derived from the following formula:

For CV products of 1000 or less — $I = 0.05CV$ or $5\mu A$, whichever is greater

For CV products greater than 1000 — $I = 6\sqrt{CV}$

where C is the nominal capacitance in μF
V is the rated d-c working voltage in V
I is the maximum leakage current in μA.

Readings should be taken 5 minutes after capacitors are placed on rated d-c working voltage. These limits may be used as a guide in judging whether capacitors should be replaced, making due allowance for the usual increase in leakage current with age and with any high ambient temperature at which measurements are made.

5. Miscellaneous Hints

5.1 The eye tube glows only when the bridge portions of the Tel-Ohmike are used (black buttons A, B, C, D, and E). It does *not* glow when measuring insulation resistance or leakage current.

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

5.3 For maximum accuracy of reading when there is a choice of bridge scales, always use the measurement range which will give a scale reading nearest the center of the scale arc.

5.4 The maximum accuracy of readings on electric indicating instruments (meters) is over the upper portion of the scale arc.

5.5 When making leakage current or I-R tests on a number of capacitors that have the same rating, the Safety switch may be used to avoid the need of returning the Voltage control to O each time. In such cases, place the Safety switch in the "DISCHARGE" position when connecting or disconnecting the capacitors to the binding posts. Return the Safety switch to the "TEST" position to read leakage current or I-R.

5.6 Return your Tel-Ohmike Registration Card within 5 days of the date of purchase in order to obtain the benefits of the Sprague warranty.

5.7 Always give *model* and *serial number* of your Tel-Ohmike, when corresponding concerning your instrument. You will find the serial number on the rear of the chassis below the line cord.

5.8 If it should ever be necessary to return your TO-6A for service or recalibration, *write for detailed shipping instructions* to your nearest authorized service depot. *You will save time and money by this procedure!* Always attach tag giving details of how instrument is malfunctioning.

LIST OF MAINTENANCE PARTS

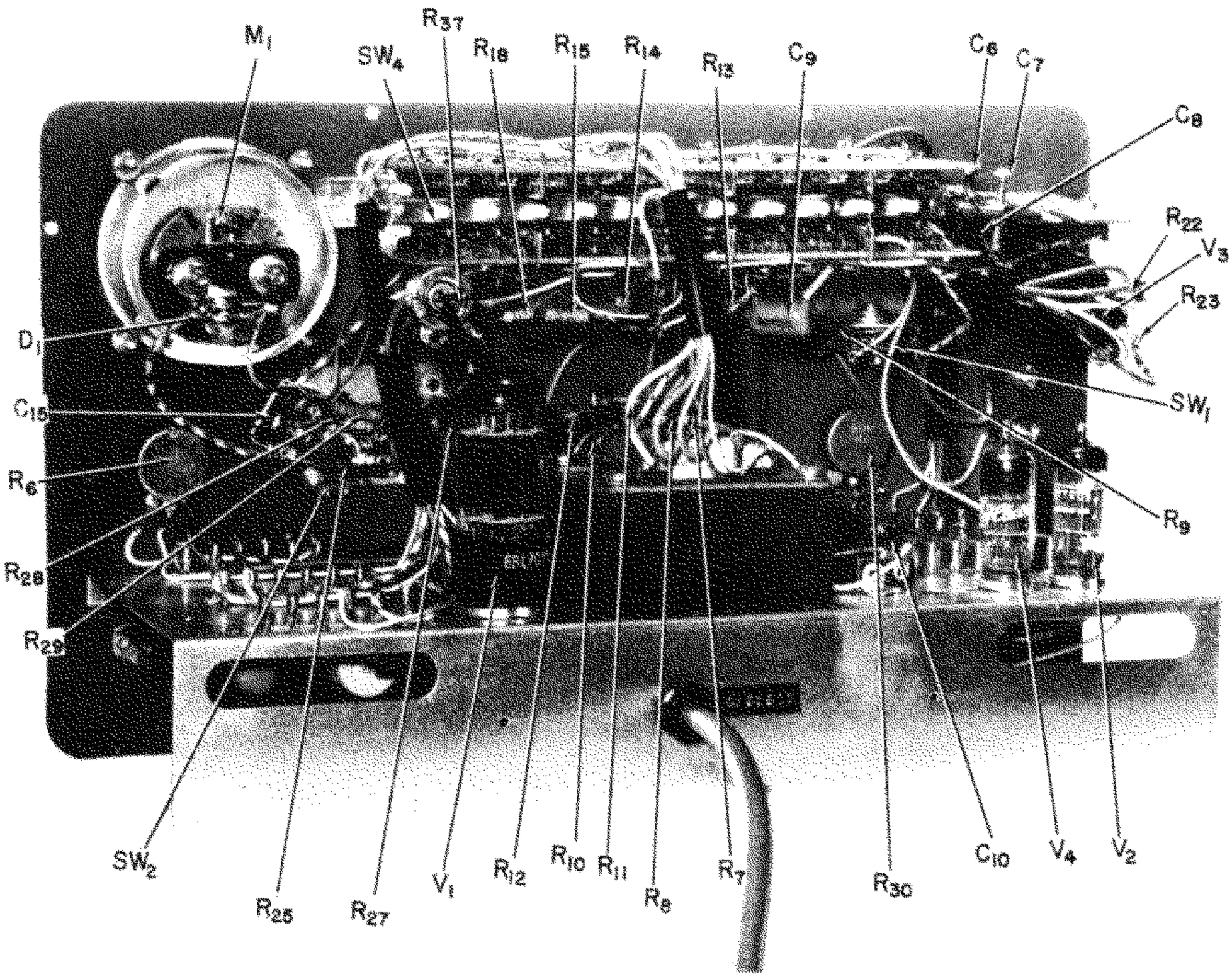
Circuit Symbol	Replacement Part No.	Description
R_1, R_2	2-113	Resistor, fixed, composition, 470 KΩ ±10%, ½ watt.
R_3	2-109	Resistor, fixed, composition, 330 KΩ ±10%, ½ watt.
R_4	2-698	Resistor, fixed, wirewound, 1 KΩ ±5%, 5 watts. Sprague 452E1025.
R_5	2-1090	Resistor, fixed, composition, 270 KΩ ±10%, 1 watt.
R_6	2-1003	Resistor, continuously adjustable, composition, 500KΩ ±20%, linear taper, ½ watt.
R_7	2-101	Resistor, fixed, composition, 150 KΩ ±10%, ½ watt.
R_8	2-115	Resistor, fixed, composition, 560 KΩ ±10%, ½ watt.
R_9	2-678	Resistor, fixed, wirewound, 150 Ω ±5%, 5 watts, Sprague 452E1515.
R_{10}	2-1020E	Resistor, continuously adjustable, wirewound, 7500 Ω ±10%, linear taper, 4 watts, 300° mechanical rotation, 280° electrical rotation. Selected for agreement with calibrated dial. May have make-up resistors R_{11} and R_{12}.
R_{11}, R_{12}	2-1056	Resistor, continuously adjustable, 100 Ω±20%, 1/2 watt, screwdriver adjustment.
R_{13}	2-101A	Resistor, fixed, deposited carbon, 150 KΩ ±1%, ½ watt,
R_{14}	2-51A	Resistor, fixed, composition, 1200 Ω ±2%, ½ watt. May have a resistor in series or parallel to bring to value.
R_{15}	2-1091	Resistor, fixed, composition, 10,800 Ω ±2%, 1 watt. May have a resistor in series or parallel to bring to value.
R_{16}	2-331	Resistor, fixed, composition, 25 KΩ ±2%, 2 watts, consists of two 1 watt resistors in series.
R_{17}	2-601	Resistor, fixed, composition, 83 KΩ ±2%, 4 watts, consists of two 2 watt resistors in parallel.
R_{18}	2-61	Resistor, fixed, composition, 3.3 kΩ ±10%, ½ watt.
R_{19}	2-121	Resistor, fixed, composition, 1 MΩ ±10%, ½ watt.

LIST OF MAINTENANCE PARTS—Continued

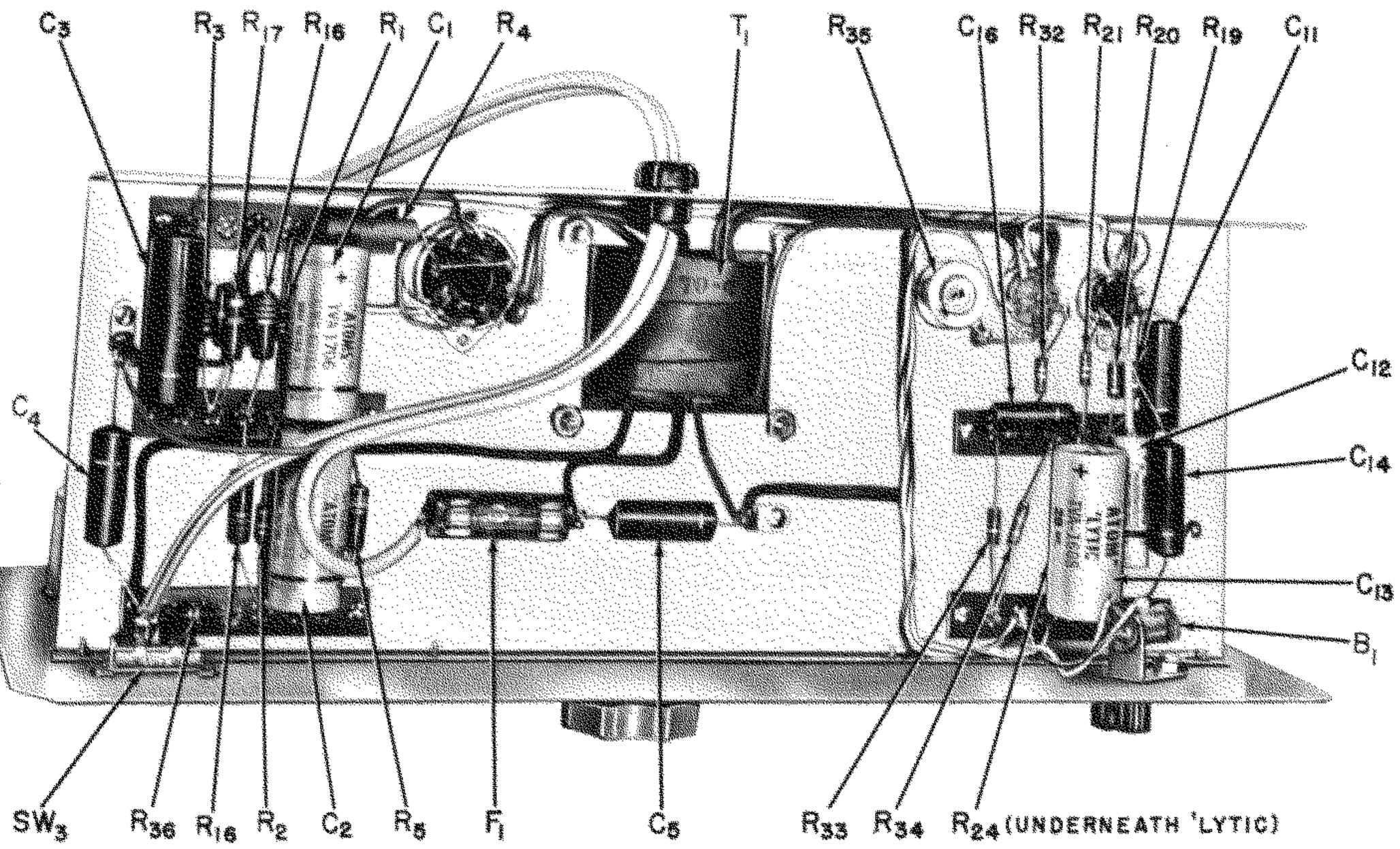
Circuit Symbol	Replacement Part No.	Description
R_{20}	2-51	Resistor, fixed, composition, 1200 Ω ±10%, ½ watt.
R_{21}	2-105	Resistor, fixed, composition, 220 KΩ ±10%, ½ watt.
R_{22}, R_{23}	2-121	Resistor, fixed, composition, 1 MΩ ±10%, ½ watt.
R_{24}	2-57	Resistor, fixed, composition, 2200 Ω ±10%, ½ watt.
R_{25}	2-1093	Resistor, fixed, wirewound, 9.37 Ω ±2%, 1 watt.
R_{26}	2-1094	Resistor, fixed, wirewound, 84.37 Ω ±2%, 1 watt.
R_{27}	2-1095	Resistor, continuously adjustable, 30 Ω ±20%, 1½ watt, screwdriver adjustment.
R_{28}	2-1096	Resistor, fixed, deposited carbon, 825 Ω ±1%, 1 watt.
R_{29}	2-1097	Resistor, fixed, deposited carbon, 8450 Ω ±1%, ½ watt.
R_{30}	2-1013	Resistor, continuously adjustable, wirewound, 750 Ω ±10%, 2 watts, linear taper, 300° mechanical rotation, 280° electrical rotation.
R_{31}	2-145	Resistor, fixed, composition, 10 MΩ ±10%, ½ watt.
R_{32}	2-75	Resistor, fixed, composition, 12 KΩ ±10%, ½ watt.
R_{33}	2-1220	Resistor, fixed, composition, 100 MΩ ±10%, ½ watt.
R_{34}	2-151	Resistor, fixed, composition, 18 MΩ ±10%, ½ watt.
R_{35}	2-1063	Resistor, continuously adjustable, 2 KΩ ±20%, 1.5 watt, screwdriver adjustment.
R_{36}	2-89	Resistor, fixed, composition, 47 KΩ ±10%, ½ watt.
R_{37}	2-1072	Resistor, continuously adjustable, 5kΩ ±20%, 1.5 watt, screwdriver adjustment.
R_{38}	2-151	Resistor, fixed, composition, 18MΩ ±10%, ½ watt.
C_1, C_2	1-660A	Capacitor, fixed, polarized dry electrolytic, 12μF 450 vdc insulating jacket. Sprague TVA-1706.
C_3	1-384	Capacitor, fixed, polyester film .1 μF ±10%, 600 vdc. Sprague WF6-P10.
C_4, C_5	1-382	Capacitor, fixed, polyester film .02 μF ±10%, 600 vdc. Sprague WF6-S20.
C_6, C_7	1-1001	Capacitor, adjustable dual trimmer, silver ceramic, 4-30 pF.

LIST OF MAINTENANCE PARTS—Continued

Circuit Symbol	Replacement Part No.	Description
C_8	1-865A	Capacitor, fixed, silver-mica, 190 pF ±5%, 500 vdc. Consists of 91pF in parallel with 100pF.
C_9	1-202A	Capacitor, fixed, polyester film, .02 picked to ±1%, 600 vdc. Sprague WF6-S20.
C_{10}	1-208B	Capacitor, fixed, polyester film 2 μF ±1%, 200 vdc. Consists of two or three matched parallel capacitors. Sprague WF2-M1.
C_{11}	1-382	Capacitor, fixed, polyester film .02 μF ±10%, 600 vdc. Sprague WF6-S20.
C_{12}	1-676	Capacitor, fixed, dry electrolytic, 5 μF, 25 vdc. Sprague Type TVA-1203.
C_{13}	1-680	Capacitor, fixed, dry electrolytic, 20 μF, 350 vdc. Sprague Type TVA-1608.
C_{14}	1-382	Capacitor, fixed, polyester film .02 μF ±10%, 600 vdc. Sprague WF6-S20.
C_{15}	1-925	Capacitor, fixed, dry electrolytic, 50 μF, 3 vdc. Sprague Type TVA-1085.
C_{16}	1-229	Capacitor, fixed, polyester film .0047 μF ±20%, 400 vdc. Sprague 192P47294.
D_1, D_2	5-100	Meter protection diode. 1N4001.
F_1	7-501	Fuse, cartridge, 1 amp., Type 3AG.
M_1	7-27, 7-27D or 7-27H	Microammeter, 0-50 microamperes, ±2%, special scale.
V_1	5-6BL7GTA	Tube, electron, 6BL7GTA.
V_2	5-6AB4	Tube, electron, 6AB4.
V_3	5-6E5	Tube, electron, 6E5.
V_4	5-6C4	Tube, electron, 6C4.
SW_1	11-200	Switch, lever.
SW_2	11-199	Switch, rotary, 4 position.
S_3	11-76R	Switch, slide, SPST.
S_4	11-58A	Switch, 11 push-button.
T_1	3-140 or	Transformer, filament, power and bridge for TO-6A.
	3-140S	Transformer, filament, power and bridge for TO-6AS.
B_1	5-52	Pilot Lamp, No. NE-2.



VIEW FROM REAR



BOTTOM VIEW OF CHASSIS

SPRAGUE
THE MARK OF RELIABILITY

TO-6A TEL-OHMIKE® CAPACITOR ANALYZER