ELECTROLYTIC CAPACITOR CHECKER

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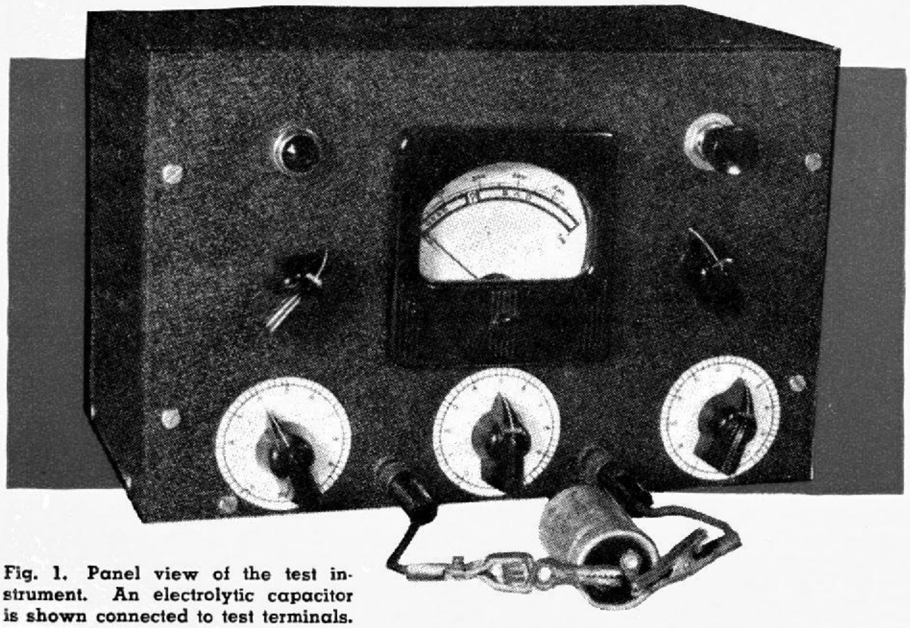


Fig. 1. Panel view of the test instrument. An electrolytic capacitor is shown connected to test terminals.

The construction and operation of an easy to read electrolytic leakage tester. Its scale shows GOOD-?-BAD similar to tube testers.

A RESPECTABLE percentage of capacitor replacements in receiver servicing are electrolytic. Some servicemen report that they replace more electrolytic capacitors annually than wax or mica types combined.

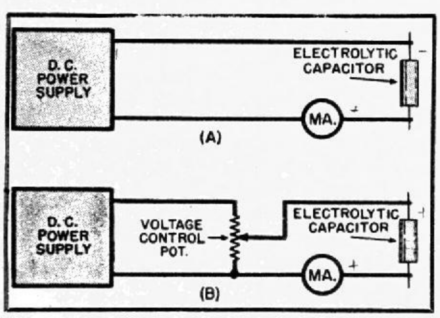
In a receiver, the normal position of electrolytic capacitors is in the power supply filter, but one or more of these units may be found in by-pass positions in the audio amplifier stages as well. In P. A. amplifiers, all of the by-pass and decoupling capacitors are apt to be electrolytic.

In all common by-pass and filter applications, capacitance values generally are not too important. Wide tolerances are permissible. Electrolytic capacitors so used often vary from one-half to twice their labelled capacitance without causing trouble in receivers or amplifiers. Capacitance measurements, whether alone or in combination with other tests, therefore, do little in themselves to satisfy the serviceman quickly as to the condition of an electrolytic capacitor.

On the other hand, a leakage test made at the rated d.c. working voltage of the capacitor is much more useful in radio servicing for revealing quickly the condition of a questionable electrolytic capacitor. But relatively few operators possess equipment for making such leakage tests, and the few *satisfactory* instruments to be found in service shops rarely ever are portable.

A handy electrolytic capacitor condition checker must be capable of indicating *directly* either the actual leakage current in milliamperes or the condition of the capacitor as good or bad. In order to be most useful in servicing, no calculations should be required. Adjustments and manipulations must be kept to the minimum. The capacitor must be tested at its rated d.c. working voltage which must be supplied by the instrument and must be adjustable between 0 and 500 volts.

Fig. 2. Block diagram of basic circuit.



The instrument described in this article is a simple, but highly effective, leakage tester meeting the specifications just given. It supplies its own adjustable d.c. voltage in the range 0-500 and will accommodate all common sizes of capacitors between 2 and 100 μfd. Leakage indications are given on an English scale reading GOOD and BAD like the scale of a tube tester. The working current range is 0 to 17.7 milliamperes.

First, we shall discuss the theory of the leakage test and the basic test circuit, and then will describe the constructional details of the actual instrument.

How Capacitor is Tested

There is nothing complicated about a capacitor leakage test circuit. Nevertheless, it is a useful service tool. What is desired in such a set-up is to impress across the capacitor a d.c. voltage equal to the rated capacitor working voltage and to measure the resulting leakage current. This scheme is illustrated by Fig. 2A.

In order to accommodate the large number of electrolytic capacitors having different working voltages and different maximum permissible leakage currents, the test voltage may be made adjustable by means of a potentiometer in the output circuit of the d.c. power supply, and the range of the milliammeter may be made adjustable by means of a shunt rheostat. This arrangement is shown in Fig. 2B. The dial of the voltage control potentiometer may, if desired, be graduated in volts for direct reading without a voltmeter.

For use in these circuits, Chart 1 lists the maximum permissible leakage currents for various d.c. working voltages and rated capacitances. This table has been based upon recommendations by leading capacitor manufacturers for determining the maximum leakage values. These recommendations have been expressed as follows: Maximum leakage when the d.c. working voltage is between 0 to 99 volts should be .3 milliampere plus .01 milliampere per μfd.; for 100-199 v., .3 ma. plus .02 ma. per μfd.; 200-299 v., .3 ma. plus .03 ma. per μfd.; 300-399 v., .3 ma. plus. .04

ma. µfd.; and 400 v. and higher, .3 ma. plus .05 ma. per µfd.

When making a leakage test it is important to keep the capacitor connected in the measuring circuit and to maintain the test voltage for a few minutes until the leakage current stabilizes. The current is high when the voltage first is applied, in a number of cases, but decreases slowly, finally reaching a steady value. If the voltage alters during this period of current decay, it must be readjusted to the rated working value of the capacitor. For best accuracy, one capacitor manufacturer recommends that before taking the final leakage reading the d.c. working voltage be applied for 5 minutes plus 1 minute for each month the capacitor has been stored prior to the test.

Use of English Scale

Operation of the leakage tester in radio servicing and interpretation of its indications may be simplified by working out a series of special settings for the milliammeter shunt resistance. These selected settings will allow the circuit to be preadjusted so that each of the maximum permissible leakage values (Chart 1) always will be read at the same point on the meter scale. Thus, if an 8-µfd., 450-v. capacitor is being checked, the shunt rheostat is set to such a value that .7 ma. will deflect the pointer to some previously selected position on the scale—and when working, say, with a 20-µfd., 300-v. capacitor, the rheostat will be set so that this time 1.1 ma. will deflect the pointer to the same scale position.

The selected scale point may be labelled with a question mark. That portion of the scale between 0 and ? then may be labelled GOOD, and the portion between ? and full-scale, BAD. The leakage tester then may be read in the same manner as a tube tester.

In order to employ a simple 0-1 d.c. milliammeter as the indicating instrument without sacrificing any of the values given in Chart 1, the question mark must be placed at the .3-ma. point on the scale. The required range of the shunt rheostat then will be 6 to 1110 ohms. Photograph 1 shows the appearance of the special meter scale, and Chart 3 shows the precise manner in which it is marked off.

Complete Circuit

The complete wiring diagram of the electrolytic capacitor checker is given in Fig. 3.

The d.c. test voltage is supplied by two 25Z5 or 25Z6-G tubes arranged in a voltage quadrupler circuit. The quadrupler saves the space that ordinarily would be required by a 500-volt power transformer. The no-load output voltage of this section is 4 times the peak value of the power-line voltage, or approximately 650 volts d.c. for an a.c. line voltage of 115. However, the loading effect of the voltage control potentiometer, R_1, reduces the maximum obtainable d.c. voltage to approximately 500. Adjustment of R_1 makes available a filtered d.c. test voltage which is continuously variable from 0 to 500.

D. C. WORKING VOLTAGE	2 µfd.	4 µfd.	5 µfd.	8 µfd.	10 µfd.	16 µfd.	20 µfd.	30 µfd.	40 µfd.	50 µfd.	100 µfd.
0-99	.32	.34	.35	.38	.40	.46	.50	.60	.70	.80	1.3
100-199	.34	.38	.40	.46	.50	.62	.70	.90	1.1	1.3	2.3
200-299	.36	.42	.45	.54	.60	.78	.90	1.2	1.5	1.8	3.3
300-399	.38	.46	.50	.62	.70	.94	1.1	1.5	1.9	2.3	4.3
400 & HIGHER	.40	.50	.55	.70	.80	1.1	1.3	1.8	2.3	2.8	5.3

Chart 1. Maximum permissible leakage current (in milliamperes) of electrolytic capacitors between 2 and 100 µfd. and a d.c. working voltage of 0 to over 400 v.

The 25,000-ohm series resistor, R_3, limits the maximum current which may be drawn from the power supply to 20 milliamperes. This prevents damage to the tubes and to the voltage control potentiometer by short-circuited capacitors. The 0-1 d.c. milliammeter, *M*, is protected by a Type 4AG Littelfuse which will open at 1½ ma.

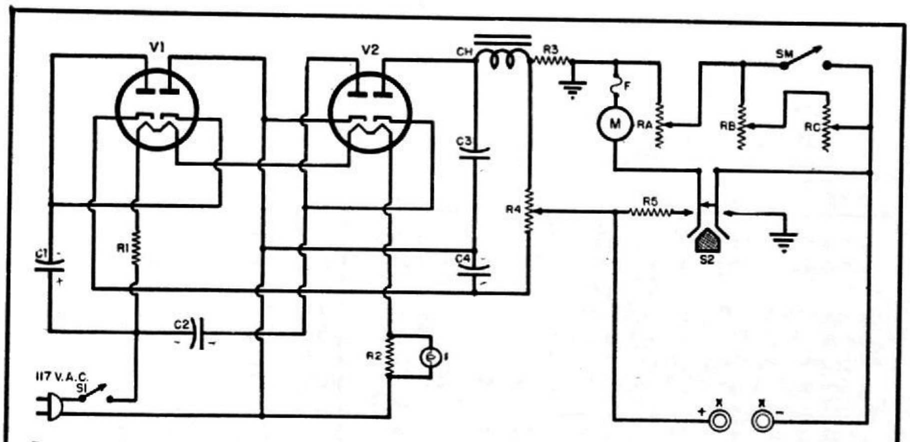
It has been stated already that the meter shunt rheostat must be adjustable from 6 to 1110 ohms. It is entirely possible to obtain this range in a single rheostat, but many of the resistance settings corresponding to the various maximum permissible leakage currents lie too close together to be set reliably on such a rheostat. For that reason, the shunt resistor has been separated into three series-connected rheostats, R_A, R_B, and R_C, having maximum resistance values of 10, 100, and 1000 ohms respectively. Several shunt settings must be made between 6 and 10 ohms on rheostat R_A, and it is essential when these settings are made that R_B and R_C be set exactly to zero. However, true zero setting seldom is obtained with high-resistance rheostats, so a switch, S_M, has been included in the circuit to short-circuit R_B and R_C when R_A alone is being used.

Working with the maximum permissible leakage current values given in Chart 1, a table of settings for the shunt rheostats, R_A, R_B, and R_C, and the switch, S_M, has been worked out and is given in Chart 2. These settings of the shunt rheostats and switch will place at the .3-ma. point on the meter scale the maximum permissible leakage values for corresponding capacitances and working voltages, as given by Chart 1.

The pushbutton switch, S_2, when depressed, connects the milliammeter as a 0-500 d.c. voltmeter across the output of the variable power supply. S_2 is a 2-pole, make-two, break-one, non-locking pushbutton. When reading the test voltage by this scheme, the shunt rheostats (R_A, R_B, and R_C) are cut out of the circuit automatically, while the milliammeter is connected to the test voltage points in series with resistors R_3 and R_4 which act as multipliers. If a test capacitor happens to be connected to terminals *X-X*, it is left in the circuit undisturbed, so that the voltage may be checked under actual load condi-

Chart 2. Instrument settings for leakage test. All resistance (*R*) values are given in ohms. These values are for use with a 0-1 d.c. milliammeter having an internal resistance of 100 ohms. For meters with movement resistances other than 100 ohms, divide the values given by 100/R_m, where R_m is the new meter resistance.

D. C. WORKING VOLTAGE		2 µfd.	4 µfd.	5 µfd.	8 µfd.	10 µfd.	16 µfd.	20 µfd.	30 µfd.	40 µfd.	50 µfd.	100 µfd.
0-99	R_A		0	0	0	0	0	0	0	0	0	0
	R_B		0	0	0	0	0	0	0	75	60	30
	R_C		757	606	377	301	188	150	100	0	0	0
	S_M		open	open	open	open	open	open	open	open	open	open
100-199	R_A	0	0	0	0	0	0	0	0	0	0	0
	R_B	0	0	0	0	0	94	75	50	37	30	15
	R_C	757	377	301	188	150	0	0	0	0	0	0
	S_M	open	open	open	open	open	open	open	open	open	open	open
200-299	R_A	0	0	0	0	0	0	0	0	0	0	10
	R_3	0	0	0	0	0	63	50	33	25	20	0
	R_C	502	251	201	125	100	0	0	0	0	0	0
	S_M	open	open	open	open	open	open	open	open	open	open	closed
300-399	R_A	0	0	0	0	0	0	0	0	0	0	7.5
	R_3	0	0	0	94	75	47	37	25	19	15	0
	R_C	377	188	150	0	0	0	0	0	0	0	0
	S_M	open	open	open	open	open	open	open	open	open	open	closed
400 & HIGHER	R_A	0	0	0	0	0	0	0	0	0	0	6
	R_3	0	0	0	75	60	37	30	20	15	12	0
	R_C	301	150	120	0	0	0	0	0	0	0	0
	S_M	open	open	open	open	open	open	open	open	open	open	closed



R_1—196 ohm, 50 w. res.
R_2—42 ohm, 5 w. res.
R_3—25,000 ohm, 10 w. res.
R_4—10,000 ohm, 50 w. pot., Ohmite Model J
R_5—475,000 ohm, 1 w. (250,000 & 225,000 ohm, connected in series)
R_A, R_B, R_C—See text
C_1, C_2, C_3, C_4—16 μfd., 450 d.c.w.v. elec. cond.
Ch—10-henry, 75 ma. filter choke
F—Fuse, 1½ ma., Littelfuse, Cat. No. 1331
M—0-1 d.c. (meter res. 100 ohm)
S_1—S.p.s.t. sw., on R_4
S_2—Pushbutton sw., 2-pole, make-two break-one, non-locking Mallory 2007
S_M—S.p.s.t. wafer-type sw.
P—Pilot lamp, 6-8 v. .15 amp. Brown Bead
V_1, V_2—25Z5 or 25Z6-G

Fig. 3. Complete schematic diagram of the two-tube electrolytic leakage tester.

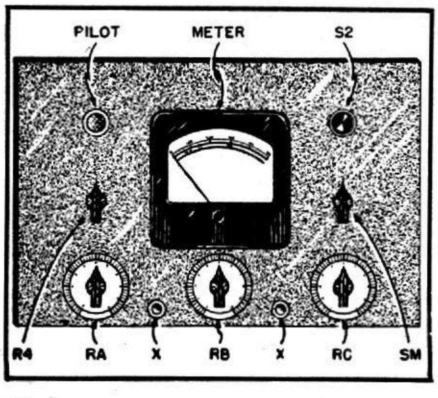
tions. The resistance values of R_3 and R_5 must be selected and checked closely so that these two resistors, acting together as the voltmeter multiplier, will show a total resistance value of 500,000 ohms. The top of the meter scale (See Fig. 1 and Chart 3) is graduated in volts.

The capacitor to be tested is connected to terminals *X-X*, the positive capacitor terminal to the positive instrument terminal. Since only a low value of limiting resistance is connected between the power supply and terminals *X-X*, the operator must exercise full caution to prevent touching the terminals, or the bare clips or prods of test leads connected to the terminals, while the instrument is switched on. The pilot light is a convenient, although not foolproof danger signal. The builder of the instrument should read closely the operating instructions given in the latter part of this article.

Heater voltage for the two tubes and the pilot light is supplied through the 196-ohm, 50-watt resistor, R_1, which may, if desired, be a line-cord resistor such as used in a.c.-d.c. receivers.

Only the necessary essentials have been included in this instrumental circuit. The checker has not been complicated by components and sub-circuits that would add little real advantage to its performance. The simple circuit arrangement and lack of critical combinations makes it possible to build the instrument into close quarters. The carefully worked-out table of settings (Chart 2) makes it possible for any builder to calibrate the few controls himself in the easiest possible manner and without additional complicated test gear.

Fig. 4. Panel layout showing proper position of meter and operating controls.



Electrical Construction

Since the electrolytic capacitor checker is a d.c. instrument, the builder will not be concerned with coupling, hum fields, and similar considerations which complicate the assembly and wiring of a.f. and r.f. test instruments. For this reason, no set rules of arrangement and wiring need be followed. Shielding is not required, and the instrument may be built on a wooden panel and housed in a wooden case if metal is not available.

A heavy, flexible, insulated hookup wire may be used for wiring. Cabling the wire leads will enhance the appearance of the instrument's interior. Leads to and between rheostats R_A, R_B, and R_C and switch S_M must be of heavy conductor—at least No. 14—and must be as short as practicable.

Mechanical Construction

Because of the small size of required parts, the electrolytic capacitor checker may be made compact. The author's version of this instrument, shown in the photograph and in the front panel layout drawing, Fig. 4, is built into a small steel cabinet, 9" long, 6" high, and 5" deep. The steel chassis is 8½" long, 4¾" wide, and 1½" high. The author used a steel cabinet and chassis simply because these parts were on hand. Other builders may favor the carrying case style common to tube testers and set analyzers. Still others may prefer the store-counter type of construction.

Filter choke *Ch*, the fuse block for the meter fuse, and sockets for the tubes are mounted on the chassis. Capacitors C_1 to C_4 and resistors R_1, R_2, R_3, and R_5 are mounted underneath the chassis. Indicating meter *M*, the pilot light bracket, voltage control potentiometer R_4, shunt rheostats R_A, R_B, and R_C, pushbutton S_2, meter switch S_M, and capacitor terminals *X-X* are mounted on the front panel, as shown in the photograph and in Fig. 4.

Terminals *X-X* are the only panel-mounted parts which must be insulated from the panel. For this reason, they are protected by shoulder-type washers made of good-grade bakelite. It is convenient to employ plastic-top binding posts of different colors, such as red and black, for the positive and negative terminals.

The on-off switch, S_1, is mounted on the rear of the voltage control potentiometer, R_4, and is operated by the shaft of this potentiometer, the switch being opened when the potentiometer is in the zero voltage position.

Both the meter card and the scales for rheostats R_A, R_B, and R_C are made by drawing on thin white Bristol board with black India ink. The meter card in the author's instrument has been graduated 0-500 volts, as well as GOOD-?-BAD, in accordance with the calibration scale given in Chart 3. In this instrument, the scales of R_A, R_B, and R_C have been graduated (as may be seen from the photograph) in arbitrary units from 0 to 10, rather than in ohms. Settings of these dials and of switch S_M have been recorded on a chart cemented on the inside of the cabinet lid, all of the arbitrary dial figures having been listed to correspond to the resistance values in Chart 3.

Thus, when setting the instrument, a dial is turned to, say, 9, which means the same as a Chart 2 setting of 1000 ohms.

Calibration and Adjustment

The regular card of the milliammeter must be removed carefully from the instrument and a new one prepared according to Chart 3. This new card may be made from thin, white Bristol board if it is to be mounted by itself on the meter, or may be made of white paper if it is desired to cement it to the regular dial card. The regular card may be used as a template and pattern in preparing the special one.

After mounting the special card in the meter and mounting the meter on the front panel of the checker, resistors R_3 and R_5 are adjusted carefully to the *exact* values given in Fig. 3. For this purpose, employ a Wheatstone bridge or a *good* ohmmeter.

Setting of rheostat R_A every 1 ohm from 0 to 10 ohms, of R_B every 10 ohms from 0 to 100 ohms, and of R_C every 100 ohms from 50 to 1000 ohms also must be determined by means of the

(*Continued on page* 153)

The incoming r.f. signal from the antenna is applied to the grid of the superregenerative stage. Since the tube is operated in a highly regenerative state, there will be very high amplification of the signal *during periods of oscillation.*

Because of the limiting action of the circuit, the video output doesn't depend on the strength of the input r.f. signal.

Although the sensitivity of a superregenerative receiver is very high, its lack of stability, and other disadvantages, prevents wide use in radar applications.

(To be continued)

Capacitor Checker

(Continued from page 40)

bridge or good ohmmeter. These setting are inscribed upon the rheostat scales. If arbitrary dial divisions are employed, locate each resistance setting listed in Chart 2 and make a list of the corresponding dial settings rather than ohmic values.

To check the power supply, voltage control potentiometer, and d.c. voltmeter circuit, (1) with S_1 switched off, insert power plug into line receptacle and (2) while holding pushbutton S_2 depressed, close S_1 and advance R_4 slowly, noting readings on voltmeter scale of meter *M*. If it is desired to compare meter *M* readings with those of a standard d.c. voltmeter, connect latter between positive *X* terminal and junction of *Ch* and R_4. If the milliammeter is of good quality and calibration and if the voltage scale has been drawn carefully and the resistors R_3 and R_4 critically adjusted, the voltage scale of meter *M* will be found to agree closely with a standard d.c. voltmeter.

If desired, the voltage control potentiometer may be provided with a scale or dial graduated directly in volts. This will obviate taking voltage readings with the meter. However, such a scale is not recommended unreservedly, since its readings will not be true for all load conditions.

If rheostats R_A, R_B, and R_C are calibrated meticulously, no further adjustment or calibration of the instrument will be required.

How to Operate the Instrument

The method of using the capacitor checker is always the same, regardless of the type and characteristics of electrolytic units tested. Only the settings of the controls will differ for various capacitances and working voltages. The routine manipulations may be mastered in a short time by the busy serviceman.

The following procedure must be observed in checking the condition of electrolytic capacitors: (1) With line plug inserted into power outlet and S_1 switched off, connect electrolytic capacitor to terminals *X-X, positive capacitor terminal to positive instrument terminal.* (2) Set rheostats R_A, R_B, and R_C and switch S_M to positions given in Chart 2. (3) Switch on S_1 and advance voltage control potentiometer R_4 slowly from zero voltage, a short distance, noting meter *M* reading. (4) At this point, check operating voltage simply by depressing pushbutton S_2 and reading voltage scale of meter *M*. If voltage is not up to rated working value for capacitor under test, release S_2 and advance R_4 slightly higher. Re-check voltage by depressing S_2. As capacitor charges, or as it forms (if it has been shelved for a considerable period), voltage may be observed to fall very slowly. In this case, continue adjustments over period of several minutes until voltage stabilizes at the working value. (5) When voltage is stabilized, release pushbutton

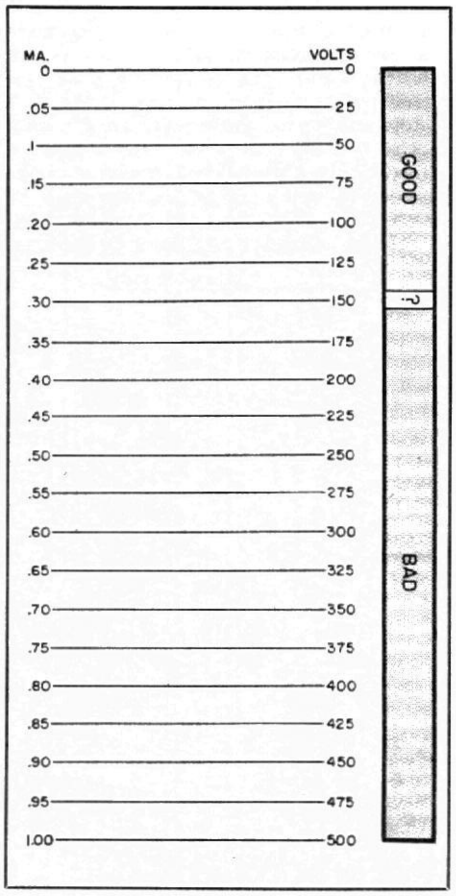


Chart 3. Dial calibrations.

S_2 and read capacitor condition on English portion of meter scale. (6) If meter pointer reaches BAD portion of scale (with S_2 released) before voltage reaches rated working value for capacitor, and does not fall slowly back toward zero, capacitor has excessive leakage and is probably shorted if the pointer climbs to the upper limit of the BAD region. (7) When meter reading (with S_2 released) is at the question mark on the meter scale, capacitor leakage is at the maximum permissible value for the unit being tested.

Always discharge the capacitor after it has been tested, otherwise a severe shock may be received. Keep switch S_1 *off* when an actual test is not being made, and turn it *off* again before disconnecting the capacitor from the instrument. Keep a good pilot lamp in the socket to warn you when the power is on. Never attempt to disconnect the capacitor from the instrument until the pointer of the meter (instrument in the leakage test, not voltage, position) has fallen all the way back to zero, indicating complete discharge of the capacitor. If the pointer seems too slow in falling to zero, the capacitor may be discharged more quickly by short-circuiting its terminals or the X-X instrument terminals to which it is connected. For this purpose, use a short length of insulated wire with the two ends bared, but be sure to touch only the insulated portion when discharging the capacitor.

-30-