SOLAR

CF-412-1
SUPERSEDING
CF-412

Technical Manual

MODEL CF CAPACITOR EXAM-ETER

This Manual for use with Exam-eter Serial No. E95226.

SOLAR MANUFACTURING CORPORATION
285 MADISON AVENUE • NEW YORK 17, N.Y.

MODEL CF CAPACITOR EXAM-ETER

Technical Manual

MODEL CF

CAPACITOR EXAM-ETER*

1. General Description

1.1 Purpose and Usefulness. The Solar Model CF Exam-eter is the most comprehensive capacitor analyzer available to the radio serviceman and electronic technician. A sturdy, reliable instrument designed to simplify and speed up electronic servicing, the Model CF Exam-eter is a "must" for every busy repair bench. More than just an accurate multi-range a-c capacitance-resistance bridge, the Exam-eter also contains insulation-resistance and electrolytic capacitor leakage current test circuits, and d-c and a-c vacuum-tube voltmeters, in addition to Solar's exclusive patented "Quick-Check" circuit for qualitative capacitor tests.

1.2 The "Quick-Check" Circuit for Qualitative Tests. This feature of the Model CF Exam-eter consists of a triple-balanced r-f oscillator circuit for rapid qualitative tests. Most intermittent, open-circuited and short-circuited capacitors of all types, as well as high r-f impedance electrolytics may be quickly located without the time-consuming work of unsoldering leads, disturbing wiring, etc.

1.3 Quantitative Tests

1.3.1 ***Capacitance.*** A 4-range capacitance bridge with high accuracy of indication from 10 mmf to 2000 mf is the basic part of the Exam-eter. This bridge measures the capacitance of all capacitors from tiny micas and ceramics to high-capacitance a-c motor-starting electrolytics and extra-high-capacitance electric-fence-control and dry-disc-rectifier filter capacitors.

1.3.1a *Power Factor.* The power factor of all electrolytic capacitors, polarized or non-polarized, is indicated on a calibrated 0 to 50 percent scale.

1.3.2 ***Electrolytic Capacitor Leakage.*** The leakage current of electrolytic capacitors with rated d-c working voltage applied is shown directly on the large 4½" meter. A self-contained power supply enables stepless selection of any direct test voltage up to 550 volts.

1.3.3 ***Insulation Resistance.*** The insulation resistance of mica, paper, air and ceramic capacitors is read directly on a special meter scale. Three ranges are provided to cover the span from 5 to 10,000 megohms. The electronic measurement circuit provides a certain check for "leaky" coupling capacitors and other parts in which low insulation resistance might impair circuit performance. It may also be used for high-value resistors used in photocell and other special circuits.

1.3.4 ***Resistance.*** A line-frequency a-c Wheatstone bridge is used for checking resistances from 100 ohms to 7.0 megohms.

1.3.5 ***Voltages.*** The vacuum-tube voltmeter circuits used in connection with the "Quick-Check" and a-c bridge circuits have been brought out to panel jacks so that they may be used externally.

1.3.5a *Direct Voltages.* Potentials up to 600 volts d-c are indicated on the long-scale meter. Three ranges are provided to facilitate the overload-proof measurements of such essentials as avc, bias, screen and plate voltages.

1.3.6a *Alternating Voltages.* A-C VTVM readings cover the range from 5 to 50 volts. They serve as a useful guide in making audio output measurements during circuit alignment.

1.4 Line Voltage and Frequency. The Solar Model CF Exam-eter is available in two types. The more popular, the Type CF-1-60 is intended for use on 115 volt, 50-60 cycle a-c lines; the other, the Type CF-2-U is intended for use on 25-60 cycle power lines of nominal 115, 150 or 230 volt ratings. Before using a Type CF-2-U instrument, the plate at the lower right side of the Exam-eter should be removed and the internal plug placed in the proper pinjack for the line voltage on which the instrument is to be used. Rated power consumption of Model CF instruments is 25 watts.

1.4.1 ***Not for Use on Direct Current.*** Under no circumstances should Solar Exam-eters be plugged into direct current outlets. Suitable auxiliary rotary-inverter or

[1] U. S. Patent 2,271,292

★Trade Mark.

vibrator-inverter power supplies should be used, in such cases, to supply a-c for operation of the Model CF Exam-eter.

1.5 Physical Appearance. A handsome, gray-wrinkle finished metal case, 12¾" high by 10" wide by 5½" deep, with sturdy leather carrying handle, and an attractively designed front panel make the Model CF Exam-eter a distinguished addition to any laboratory or service bench.

1.6 Weight. The Type CF-1-60 Exam-eter weighs 12¾ pounds and the Type CF-2-U instrument weighs 15½ pounds.

1.7 Components. Dependable components have been selected for all circuits to provide reliable operation in all climates. Special attention has been paid to tropicalizing. All fixed capacitors are hermetically-sealed against moisture; all hook-up wire meets Joint Army-Navy specifications; the power transformer is double vacuum-impregnated; the large 4½" indicating meter has a fume-proof white enamel scale to avoid discoloration, etc.

1.7.1 *Electron Tubes.* The tube complement of the Model CF Exam-eter consists of two 6J5G tubes and one 6L6 or 6L6GA tube.

2. The "Quick-Check" Test

2.1 Application. The "Quick-Check" is usually the first to be applied to a suspected defective capacitor in a circuit since it gives a rapid check of whether or not the capacitor is open- or short-circuited, is intermittent, or has a high r-f impedance.

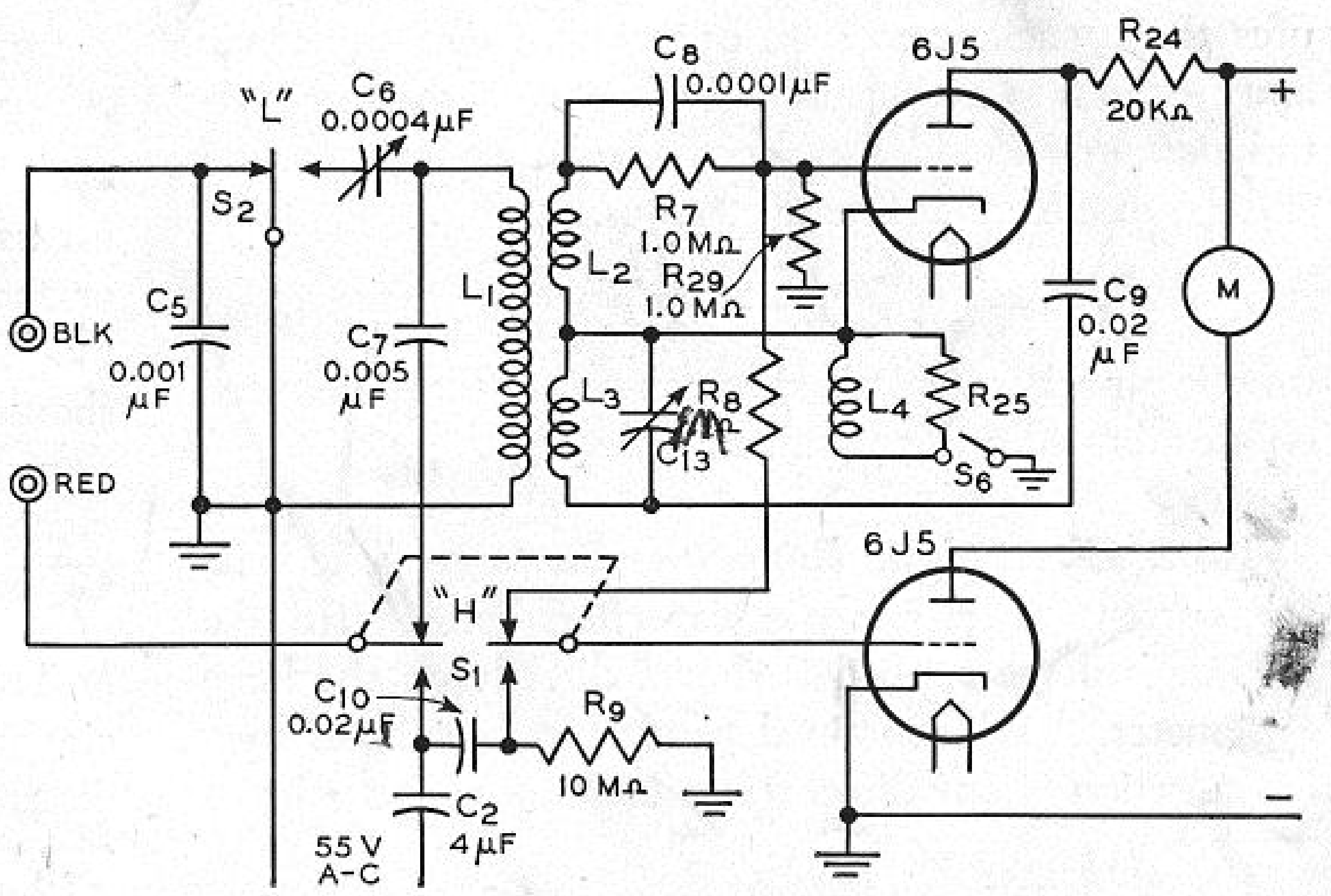
2.1.1 *"Hot" or "Cold" Circuits.* The "Quick-Check" test will operate with the set under test switched "on" or "off" and with the capacitor under examination in its normal circuit, even though it be shunted by an inductor or a resistor, except as noted under 2.3 (7b).

2.1.2 *Rapidity of Test.* The "Quick-Check" indications are definite and instantaneous.

2.2 Circuit. The schematic diagram of the "Quick-Check" section of the Model CF Exam-eter, simplified to omit the switching arrangement and the power supply, is shown in Figure 1. The circuit is fully protected by U. S. Patent 2,271,292. It will be seen that the "Quick-Check" consists essentially of a complex balanced r-f oscillator, a source of a-c voltage and an a-c vacuum-tube voltmeter. Under normal conditions, the circuit is balanced so that it will not oscillate with standard QC-465 test leads plugged in and the meter in the plate circuit of the vtvm tube will then be at full scale deflection (5 ma).

2.2.1 *Theory of Operation.* If the test clips are placed across an open-circuited capacitor, there will be no change in circuit conditions and the meter needle will not deflect. If the capacitor is intermittent, the needle will fluctuate violently as the oscillator goes in and out of oscillation. If the unknown capacitor causes the needle to drop downscale, the capacitor is not open-circuited and further "Quick-Check" tests must be performed. Pressing the "L" button for capacitors from 100 mmf to approximately 1000 mmf will stop the oscillation if the capacitor is short-circuited and the meter will return to full-scale. Capacitors from approximately 1000 mmf to 50 mf can be checked for shorts by pressing the "H" button. This places the unknown capacitor in series with a 4 mf capacitor across an a-c source and connects the vtvm across the unknown capacitor. If it is short-circuited, the meter needle will return to full-scale since

FIG. 1—THE "QUICK-CHECK" CIRCUIT
The "Quick-Check" section is comprised essentially of an a-c voltage supply source, an a-c vacuum tube voltmeter and a balanced radio-frequency oscillator. For diagrammatic simplicity, the switching system and power supply have been omitted.



there will be no voltage drop across the capacitor under test. (See also note following 2.3.7b.)

2.3 Operating Procedure—Shorts, Opens and Intermittents. To use the "Quick-Check" proceed as follows:

(1) Set the Master Selector Switch on "Q." Rotate main bridge control to "Short Cap."

(2) Plug the special twin-conductor QC-465 test leads securely into the "Quick-Check" jacks on the Exam-eter, red plug into red jack and black plug into black jack.

Note: The oscillator circuit is balanced for the inter-lead capacitance of the standard test leads. The "Quick-Check" will not operate properly unless these leads are used.

(3) Throw switch at top left of panel to "5 ma d-c" position.

(4) Throw switch at top right of panel to "hi volts d-c" position.

(5) Turn Exam-eter on by turning "Voltage Gain" control to right from "off" position. Adjust control until meter needle is at full scale (5 ma) deflection. Throw "Quick-Check" switch to "on." Allow 1 minute warm-up period. Readjust to full scale (5 ma) deflection.

(6) Snap test clips tightly across suspected capacitor leads as close to unit as possible. Connect black test prod to lead nearest ground. Watch meter needle. If needle does not drop back, capacitor is open-circuited. If needle fluctuates violently, capacitor is intermittent. In either case, replace capacitor. No further tests are necessary.

Warning: Capacitors below about 100 mmf will act as though they were open-circuits.

Note: Disregard slight flickers of the needle, which may be caused by line voltage variations.

(7a) Push red "L" button for short test of capacitors up to about 1000 mmf. If needle returns to full-scale, capacitor is short-circuited. Replace.

(7b) Push red "H" button for short test of capacitors above 1000 mmf (.001 mf) to 50 mf. If needle returns within ½ milliampere of full-scale, capacitor is short-circuited. Replace.

Note: Capacitors shunted by a resistor of less than about 25 ohms and capacitors in parallel with an inductor will appear to be short-circuited.

(7c) If approximate capacitance of unit under test is unknown, test by pressing "L" button and "H" button in sequence. If capacitor is shorted needle will return to full-scale position in *both* cases. If it returns to full-scale on only one of the two tests, it is not short-circuited.

Note: Make sure pushbuttons are pressed all the way in when making the short-circuit tests. *Warning:* Capacitors above 50 mf will act as though they were short-circuited.

2.4 Operating Procedure — Power Factor and High R-F Impedance. To check qualitatively for high power-factor and high r-f impedance of electrolytic capacitors without removing capacitors from the equipment circuits, proceed as follows:

(1)-(6) Duplicate procedure under 2.3.

(7) Depress red "L" button. If meter needle does not return to full-scale position (5 ma), then capacitor has high r-f impedance.

(8) With the set "hot," shunt the capacitor under test with a 0.1 mf Sealdtite or equivalent paper capacitor. This should clear up circuit disturbances due to high r-f impedance. If the high hum level persists, then the trouble will probably be due to high power factor or poor electrical connections.

Note: A further check of capacitors suspected of causing hum may be made on the capacitance bridge. High power-factor is quite often accompanied by a considerable drop in capacitance below the marked value.

Note: Sometimes electrolytic capacitors which have dried out or have been overheated will apparently be satisfactory on this test even though their capacitance is low and their power factor high. This may be accounted for by the fact that the electrostatic capacitance between the capacitor plates is greater than 100 mmf and it shunts the internal series resistance responsible for the high power factor. (See theory of operation, 2.2.1.)

2.5 Supplementary Information

2.5.1 *Intermittent Capacitors.* An intermittent capacitor may be the result of a pressure contact only between the capacitor section and the terminals. The connection may be broken as the result of mechanical vibration or displacement of the capacitor, or as the result of expansion of section leads, etc., under temperature rise. Slight rocking of a capacitor will often detect intermittents since it will cause the needle to fluctuate on the "Quick-Check" test as described under 2.3.6, or when the short test buttons (2.3.7) are held down. Where heat-caused intermittents are suspected (wax-end seals may hold defective parts together when set is first turned on), the "Quick-Check" test leads can be placed across the suspected capacitor and other work attended to while the Exam-eter stands guard over the set, waiting for it to fail. When fading or other defects appear, a glance at the Exam-eter tells whether the capacitor under test is faulty.

2.5.2 *Inductive Capacitors.* Some electrolytic capacitors and large paper capacitors (usually 1 mf or larger) may be indicated as open-circuited when they are actually satisfactory. This is caused by a particularly high self-inductance in the capacitor sections (or by long leads). For such capacitors it will be necessary to supplement the "Quick-Check" with a quantitative test.

Note: Capacitors with high values of inductance are not necessarily defective and will be perfectly satisfactory in some circuit applications. Steadfast rules cannot be given to substitute for experience and good judgment of the engineer or serviceman.

2.5.3 *Partial Short-circuits.* Occasionally, capacitors will not short-circuit completely but will have a residual resistance between terminals of upwards of 25 ohms. Such capacitors may not always cause sufficient loading of the analyzer to cause it to show them up as short-circuited. These capacitors will show up as defective quite quickly on the "M," "L" and "C" or "H" settings.

2.5.4 *Magnitude of "Quick-Check" Deflections.* When using the "Quick-Check" section of the instrument, indications are given by the variation in the meter deflection and not by the magnitude of the deflection. When working on various sets, there will be a difference in the magnitude of the meter deflection from one set to the other if one side of the capacitor is connected to the chassis. The magnitude of the deflection plays no part in the testing of the capacitor as indication of quality is given only by variation in the meter deflection. The difference in magnitude of the meter deflection from set to set is due to the variation in impedance from chassis to ground.

3. Quantitative Measurements

3.1 Capacitance

3.1.1 Capacitance measurements from 10 mmf to 2000 mf are made on a 4-range line-frequency capacitance bridge. Figure 2 shows a simplified schematic diagram of the DeSauty bridge employed for the Cx.0001 and Cx.01 ranges and the Wien bridge used on the Cx1 range. It will be seen that the main dial potentiometer acts as the continuously adjustable ratio arm of the bridges. Consequently, a highly accurate linear-taper wire-wound variable resistor must be used for the main bridge element in order to assure accurate matching of the calibrated scale. The standard capacitor for the CX.0001 range is a mica trimmer, which is adjusted to take into account variations in wiring capacitance. A simple vacuum-tube voltmeter is used as the bridge null detector. Figure 3 shows the circuit variation to extend the range of the Wien Bridge of Figure 2. Here R1 and R2 together comprise the calibrated adjustable ratio arm of the bridge. R5 is the power-factor balance rheostat in both figures.

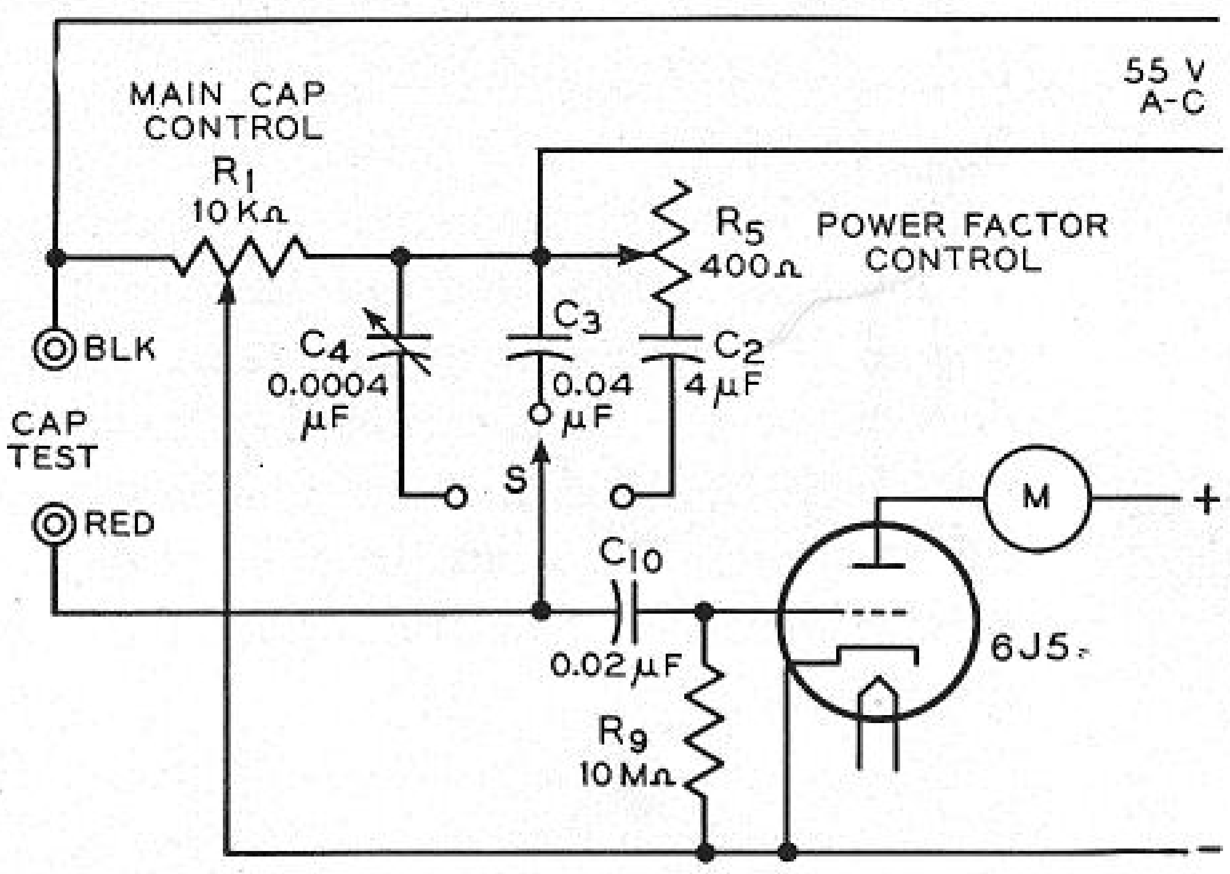


FIG. 2—LOW CAPACITANCE BRIDGE CIRCUIT

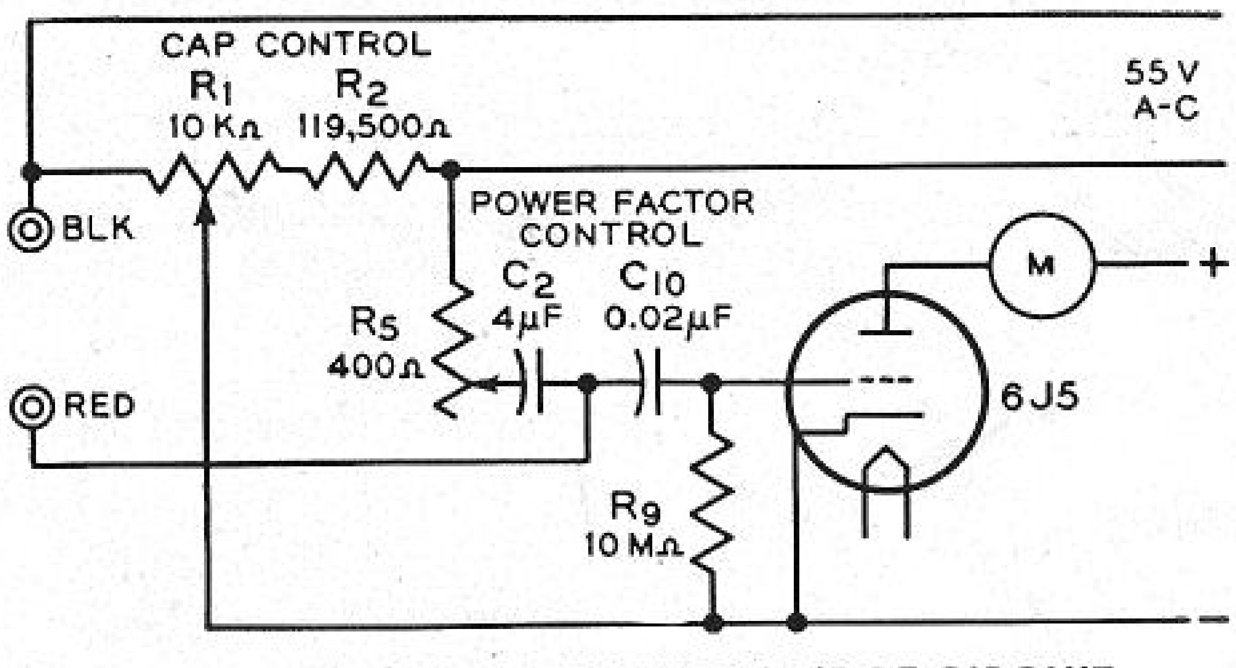


FIG. 3—HIGH CAPACITANCE BRIDGE CIRCUIT

3.1.2 *Operating Procedure*

(1) Set the master selector switch in accordance with the following table and the capacitance of the capacitor under test:

Capacitance (mf)	Switch Setting	Read on Scale	Multiply Scale by
.00001 to .007	Cx.0001	C/R	.0001
.001 to .7	Cx.01	C/R	.01
.10 to 70	Cx1	C/R	1.0
50 to 2000	Hx1	H	1.0

Note: 1,000,000 mmf = 1 mf

(2) Throw switch at top left of panel to "5 ma d-c."

(3) Throw switch at top right of panel to "hi volts d-c."

(4) Plug CF-27 separate conductor test leads into "bridge" jacks. Then connect clips across capacitor under test.

(5) Turn "Voltage Gain" control clockwise to turn Exam-eter on. Slowly adjust to a convenient deflection and permit instrument to warm-up for 1 minute.

(6a) Rotate main bridge control slowly until maximum deflection is obtained on meter. Readjust voltage control as necessary if pointer goes off scale. Read capacitance from calibrated scale and multiply as indicated under (1) above to obtain actual capacitance.

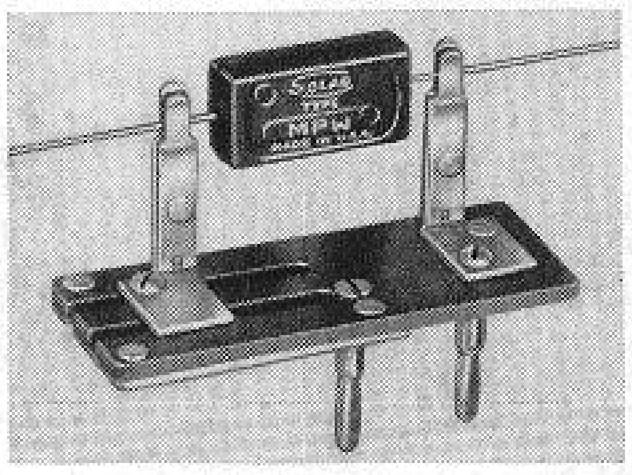
(6b) For electrolytic capacitors, balance as in (6a). Then adjust power-factor control for maximum deflection. Readjust main control, then p-f control for maximum deflection, as necessary. Read capacitance as in (6a) and read power-factor directly from calibrated scale. For line frequencies other than 60 cycles, refer to Fig. 5 for the necessary correction.

(6c) Capacitors which can be balanced only at the "open" position on the capacitance scale on all 4 ranges are open-circuited and should be discarded. Short-circuited capacitors will balance on the short position on all ranges if shorted "solidly." A "high-resistance" short-circuited capacitor will not balance on the "C" settings of the selector switch.

3.1.2a *Low-Capacitance Measurements.* In testing capacitors below about .001 mf (1000 mmf), it is important to keep the test leads as short as possible. The use of the RT-3 adjustable test fixture (Fig. 4) is recommended. If not available, plug the ends of the capacitor leads *directly* into the bridge jacks.

FIG. 4—TYPE RT-3 ADJUSTABLE TEST FIXTURE

This accessory greatly facilitates the testing of capacitors and resistors.



3.1.2b *Very Low-Capacitance Measurements.* To improve the accuracy of measurements of very low-capacitance mica, air or ceramic capacitors (about 25 mmf or less), place a 100 to 150 mmf capacitor across the test jacks. Balance the bridge and record the reading. Place the small capacitor in parallel with the 100 to 150 mmf unit and rebalance. Subtract from this reading the first reading. The remainder is the desired capacitance.

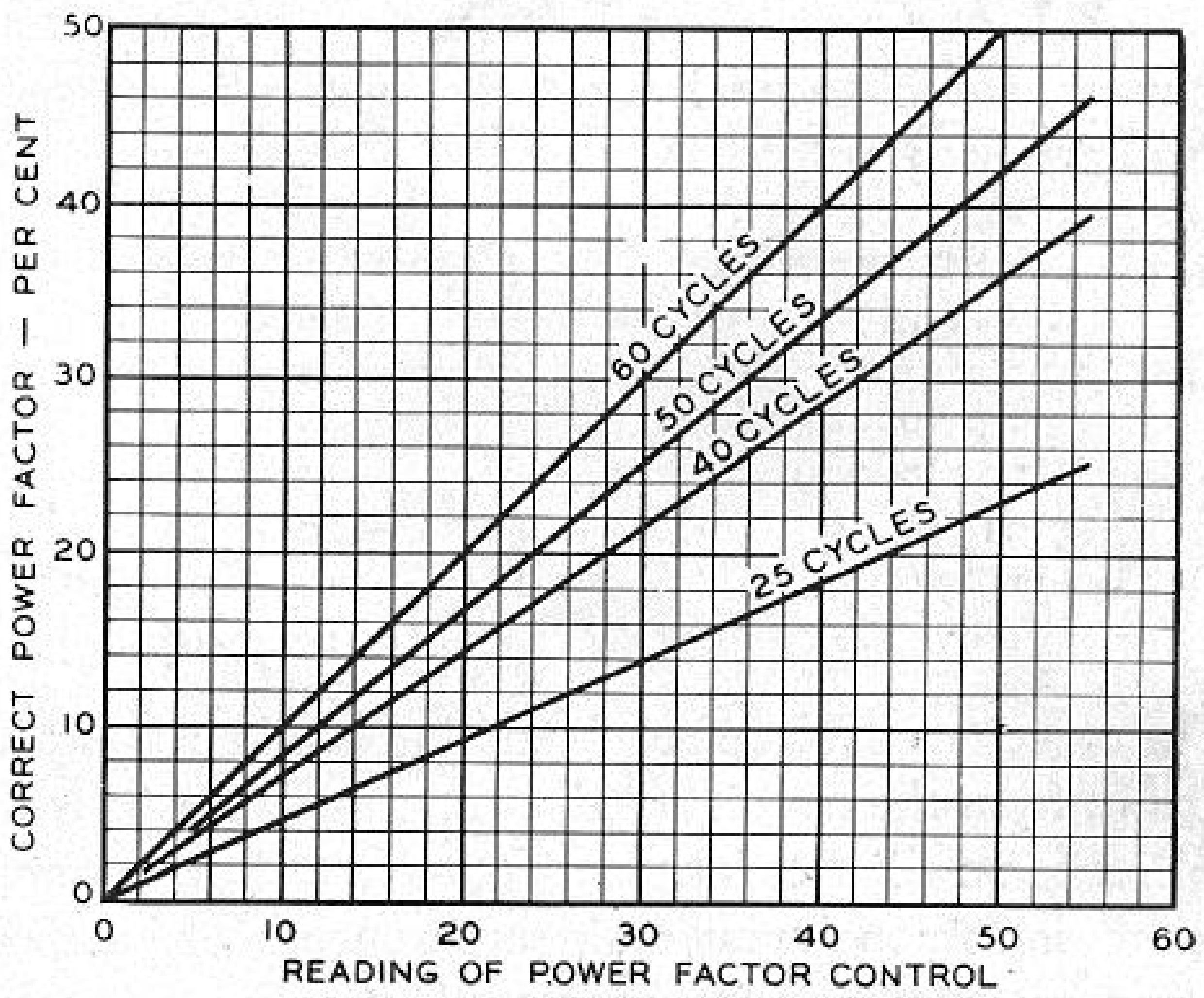


FIG. 5—POWER FACTOR CALIBRATION

Power factor reading correction curves for frequencies other than 60 cycles.

3.1.3 *Supplementary Information*

3.1.3a *Voltage-Control Setting.* The voltage-control setting is not critical and may be adjusted to any desired value giving a readable meter deflection. The vtvm null indicator is most sensitive at the higher deflections.

3.1.3b *Intermittent Capacitors.* Capacitors with intermittents will cause a noticeable flickering of the meter needle. Replace capacitors.

3.1.3c *Capacitance Tolerance—A-C Electrolytics.* A-C motor-starting electrolytic capacitors whose capacitance is more than 20 percent below their marked value should, in general, be replaced as the motor-starting torque will be too low.

3.1.3d *Capacitance Tolerance—D-C Electrolytics.* In general, capacitors which are 30 percent less than nominal value should be replaced. For by-pass capacitors, there is generally from the circuit standpoint no plus limit above nominal capacitance. The same holds true for filter capacitors, except for the input capacitors in R-C filters. Here the maximum capacitance is limited by the rectifier tube characteristics. For new dry electrolytic capacitors, the following tolerances have been proposed by the Radio Manufacturers Association:

Rated Voltage	Capacitance Tolerance (Percent)
0-50	−10, +250
51-350	−10, +100
351-450	−10, +50

3.1.3e *Capacitance Tolerance—Paper Capacitors.* Standard capacitance tolerances for paper tubular capacitors have been proposed by the RMA as follows:

Capacitance (mf)	Capacitance Tolerance (Percent)
Up to .0019	−25, +60
.002 to .009	−15, +40
.01 to .09	−20, +20
.1 to 1.0	−10, +20
Above 1.0	−10, +10

The capacitance tolerance of coupling and bypass capacitors is, from the circuit standpoint, quite wide, as is the tolerance on filter capacitors. Contrary to a wide-spread impression among many radio servicemen, metal-encased capacitors are not necessarily manufactured to tight tolerances. Even capacitors to government specifications may have tolerances as wide as −25, +60 percent.

3.1.3f *Capacitance Tolerance—Mica and Ceramic Capacitors.* Unless otherwise color-coded or marked, mica and ceramic capacitors are generally within ±20% of their nominal value. Standard tolerances on color-coded capacitors are ±2, ±3, ±5, ±10 and ±20%, depending on the intended circuit application.

3.1.3g *Power Factor — A-C Electrolytics.* In general, a-c electrolytic motor-starting capacitors with a power factor over 18 percent should be replaced.

3.1.3h *Power Factor—D-C Dry Electrolytics.* The 60 cycle power factor of new dry d-c electrolytic capacitors will generally fall below the limits listed in column 2 below. Capacitors should be replaced in sets if their power factor has increased beyond the value given in the last column.

Working Voltage	Max. Power Factor When New (percent)	Power Factor For Replacement (percent)
450	15	35
400	15	35
350	15	35
300	15	35
250	18	35
150	20	50
50	25	55
25	30	60
15	50	60
10	60	70
6	65	75

Generally, the power factor of new low-voltage (50 volt or less) sections in multiple-section capacitors having sections rated at 150 wvdc or higher, will be greater than the limits of column 2 above but it should not exceed the value given in column 3.

3.1.3i *Power Factor—D-C Wet Electrolytics.* The 60 cycle power factor of new wet electrolytic capacitors will generally fall below the following limits:

Peak Voltage	Power Factor (Percent)
600	65
550	55
500	45
450	40
400	40
300	35

These limits may be used as a guide for replacing old capacitors.

3.2 Resistance Measurements

3.2.1 *Theory of Operation.* Resistance measurements are made on a conventional 2-range a-c Wheatstone bridge. A simplified schematic diagram is shown in Figure 6. It will be seen at a glance that it is quite similar to the DeSauty capacitance bridge arrangement of Figure 2.

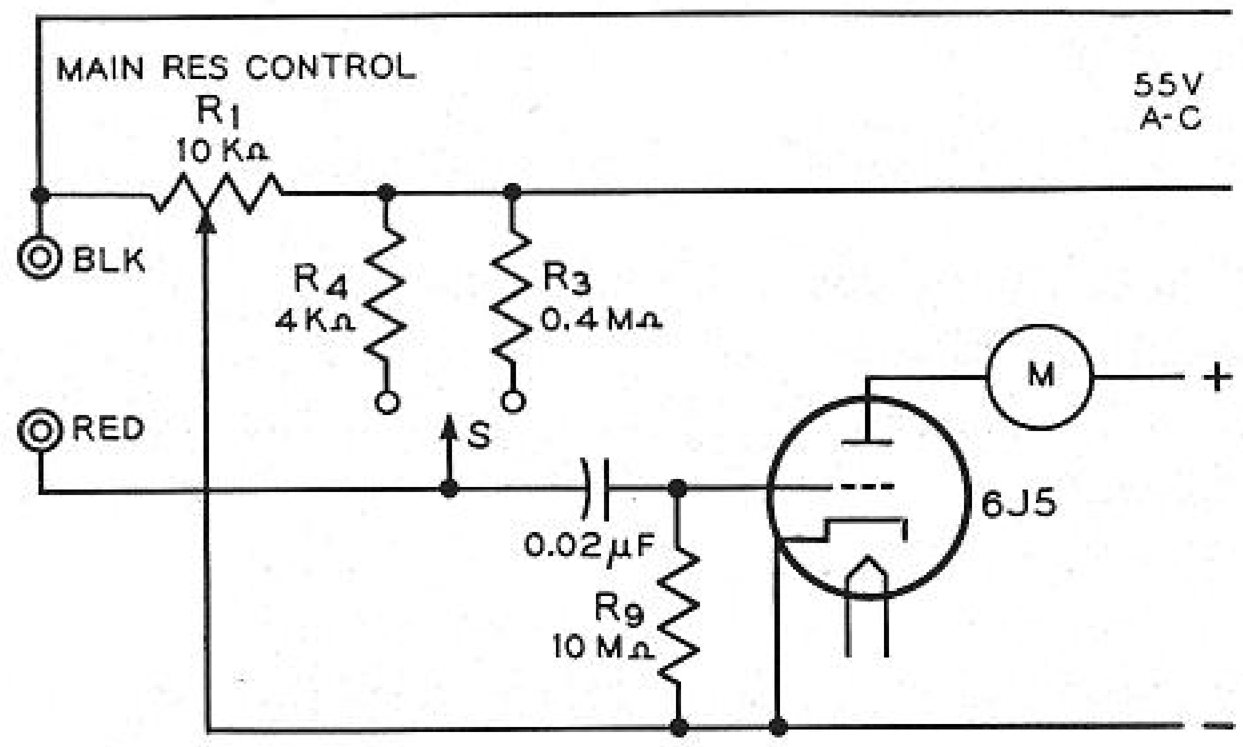


FIG. 6—RESISTANCE TEST CIRCUIT
Dual range a-c Wheatstone bridge used for resistance measurements.

3.2.2 *Operating Procedure*

(1) Set the master selector switch in accordance with the following table and the resistance of the resistor under test:

Resistance (ohms)	Switch Setting	Read on Scale	Multiply Scale by
100 to 70,000	Rx1,000	C/R	1,000
10 K to 7.0 Meg	Rx100,000	C/R	100,000

(2) Throw switch at top left of panel to "5 ma d-c."

(3) Throw switch at top right of panel to "hi volts d-c."

(4) Plug CF-27 test leads into "bridge" jacks, then connector test clips across resistor under test; or else plug RT-3 test fixture into "bridge" jacks and slip resistor into test fixture.

(5) Turn "Voltage Gain" control clockwise to turn Exam-eter on. Slowly adjust to a convenient deflection and permit instrument to warm up for 1 minute.

(6) Rotate main bridge control slowly until maximum deflection is obtained on meter. Read resistance from calibrated scale and multiply as indicated under (1) above to get actual resistance.

3.2.2a To improve accuracy of measurements at low values of resistance or to extend bridge range below 100 ohms, place a 500 to 600 ohm resistor across bridge and record reading. Then place unknown resistor in series with this resistor and record reading. Subtracting the first reading from the second will give the value of the unknown resistor.

3.2.2b Since an a-c bridge circuit is used for measurements, the analyzer will not read the correct resistance of windings in iron-core transformers or reactors.

3.3 Insulation Resistance

3.3.1 *Theory of Operation.* Insulation resistance measurements are made by the electronic test circuit of Figure 7. Leakage current through the capacitor or circuit element under test causes an increase in the negative bias on the triode grid and a consequent drop in plate current. The plate circuit milliammeter is calibrated directly in megohms.

3.3.2 *Operating Procedure*

(1) Set the master selector switch in accordance with the following table and the insulation resistance of the capacitor under test:

Insulation Resistance (megohms)	Switch Setting	Multiply Scale by
5 to 100	Mx1	1
30 to 1000	Mx10	10
300 to 10,000	Mx100	100

Note: If the approximate value of the I-R to be measured is unknown, start with the Mx1 switch setting. If the I-R exceeds 100 megohms, try Mx10, etc.

(2) Throw switch at top left of panel to "5 ma d-c."

(3) Throw switch at top right of panel to "hi volts d-c."

(4) Plug CF-27 test leads securely into "bridge" jacks; or else plug RT-3 test fixture into "bridge" jacks and slip capacitor into fixture.

Note: Never use "Quick-Check" leads for I-R tests.

(5) Turn "Voltage Gain" control clockwise to turn Exam-eter on. Adjust to ∞ (infinity) full-scale deflection of meter pointer after 1 minute warm-up period.

(6) Connect capacitor across test clips. Read "Megohms" scale of meter and multiply as indicated under (1) above.

Note: On low capacitances, readings may be taken almost immediately. On higher capacitances, it is necessary to allow sufficient electrification time to charge the capacitor. Usual test limit is 2 minutes.

Note: Because of circuit wiring and tube constants, minimum reading on the Mx1 scale will be approximately [illegible] megohms. greater than actual measurement

3.3.3 ***Supplementary Information.*** An insulation resistance of 50 megohms at the operating temperature of the equipment will be found satisfactory for most circuit applications. Coupling capacitors should have an I-R in excess of 200 megohms. Replacements should be made as indicated.

3.3.3a New mica capacitors will have an insulation resistance greater than 3000 megohms for RMA "A" classification units, and greater than 6000 megohms for other RMA classifications. New ceramic capacitors will also meet the 6000 megohm value. New halowax or mineral-oil impregnated, wax-filled or wax-molded paper tubular capacitors will usually meet the limits proposed

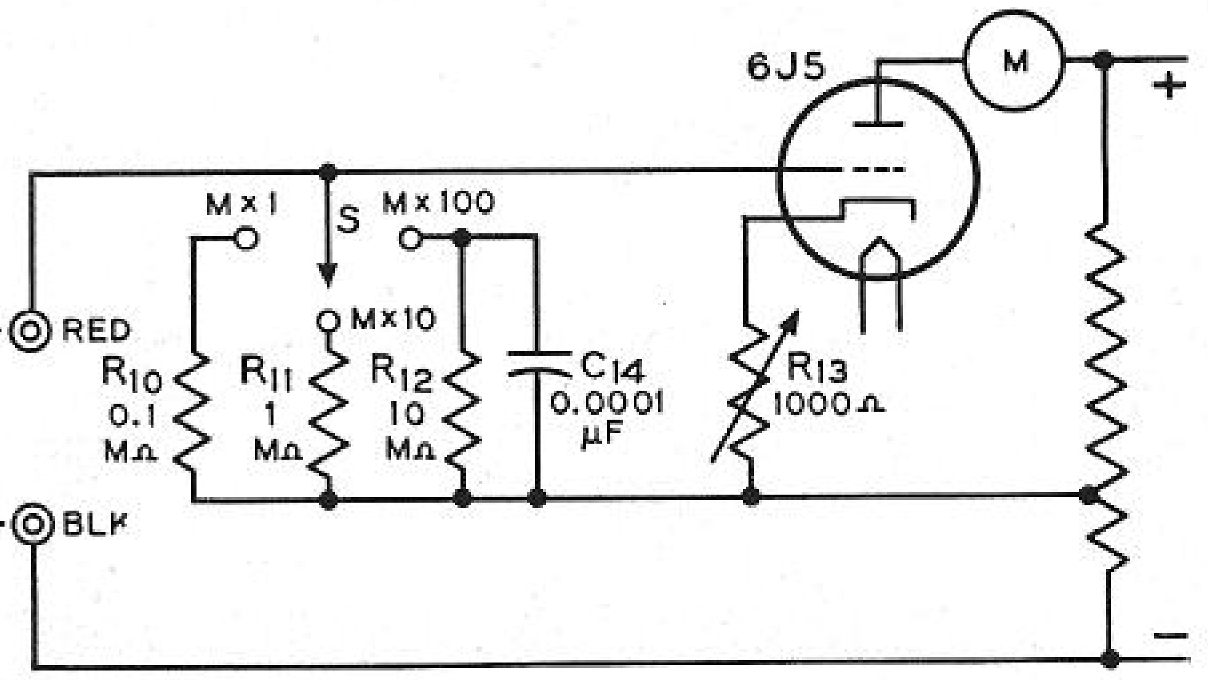


FIG. 7—FUNCTIONAL INSULATION-RESISTANCE TEST CIRCUIT

I-R measurements are read in megohms directly from the calibrated milliammeter (M).

by the Radio Manufacturers Association. These call for a minimum insulation resistance-capacitance product of 1000 megohm-microfarads or a maximum required insulation resistance of 5000 megohms, whichever is the smaller. For commercial, oil-impregnated, oil-filled capacitors in metal cases, trade limits are generally as follows:

Oil	Minimum RxC	or	Max. Req. I-R
Vegetable	400		1200
Mineral	1200		3600
Chlorinated Synthetic	1750		4250

All these values are for measurements at 25° C (77° F). Insulation resistance will decrease very rapidly as temperature increases. At 65° C (149° F), the insulation resistance of an ordinary wax tubular will be about 5 percent of its I-R at 25° C (77° F).

3.4 Leakage Current of Electrolytic Capacitors

3.4.1 The leakage current of electrolytic capacitors may be measured at rated d-c voltage by the test circuit shown in Figure 8. The circuit consists basically of a continuously adjustable voltage supply and a milliammeter to indicate the leakage current. The milliammeter current range may be increased by closing Switch S_4, or it may be made to act as a voltmeter, indicating the impressed voltage across the capacitor under test, by depressing Switch S_3. The test voltage is determined by the continuously adjustable voltage-divider resistor R_{21}, which sets the control grid voltage on the rectifier tube. Plate and screen grids of the rectifier are normally connected together by Switch S_5. When making measurements on capacitors rated at 100 volts d-c working or less, closer control of the test voltage is secured by throwing S_5 to connect the rectifier tube screen grid to the control grid instead of the plate (Lo position of switch).

3.4.2 *Operating Procedure*

(1) Set the master selector switch to "L."

(2) Throw switch at top left of panel to "50 ma d-c."

(3) Make certain "Quick-Check" switch at left center is in "off" position. Otherwise voltmeter readings will be incorrect.

(4) Plug CF-27 test leads securely into "bridge jacks" observing polarity.

(5) Set switch at top ~~left~~ Right of panel to "Lo" for testing capacitors rated at 100 volts working or lower, or to "Hi" for capacitors rated above 100 volts working.

(6) Rotate "Voltage Gain" control clockwise to turn Exam-eter on. Do not turn above 50.

(7) Simultaneously depress red button at right center, marked "volts," and rotate voltage-gain control clockwise until "V" scale on meter indicates rated working voltage.

(8) Connect test leads across capacitor to be measured for leakage. Observe polarity: red lead to +, black lead to –.

(9) Read leakage current directly on 50 ma scale on meter. If current is less than 5 ma, slide top left switch to 5 ma position to increase ease of reading.

Note: Always keep switch at "50 Ma" position except when actually taking readings. Otherwise, indicating meter may be accidentally damaged by high leakage or short-circuited capacitor.

3.4.3 *Supplementary Information*

3.4.3a Tests of electrolytic capacitors that have been out of service for long periods of time may be speeded up by continued adjustment of the voltage so that it is kept at the rated working voltage. For example, as the leakage current is reduced, the d-c test voltage will have a tendency to increase resulting in an increase in the leakage current. Reducing the test voltage to the rated value will reduce the leakage current proportionally to the reduction in voltage. When a capacitor has been out of service for 15 to 20 months, it may be more convenient to start with a d-c voltage less than rating in order to keep the leakage current below 10 milliamperes and then to increase the voltage (up to rated voltage) as the leakage current decreases. When rated voltage is reached, proceed as described above.

3.4.3b The leakage current of most dry electrolytic capacitors should come down to 2 ma or less when 30 minutes of continuous rated voltage application has elapsed. If it does not, the capacitor should be replaced. If there is appreciable fluctuation in the leakage current, the capacitor is probably intermittent and should be replaced.

Caution: If leakage current persists above 15 ma for 1 minute (at rated voltage), reduce current below 15 ma and keep adjusting voltage gain (to prevent overheating of capacitor) until rated voltage is again attained.

3.4.3c The Radio Manufacturers Association has proposed the following formula for leakage current limits for new d-c dry electrolytic capacitors (in no case should the leakage current exceed 10 ma for RMA-type capacitors):

$$I = KC + 0.3$$

Where I is the leakage in milliamperes

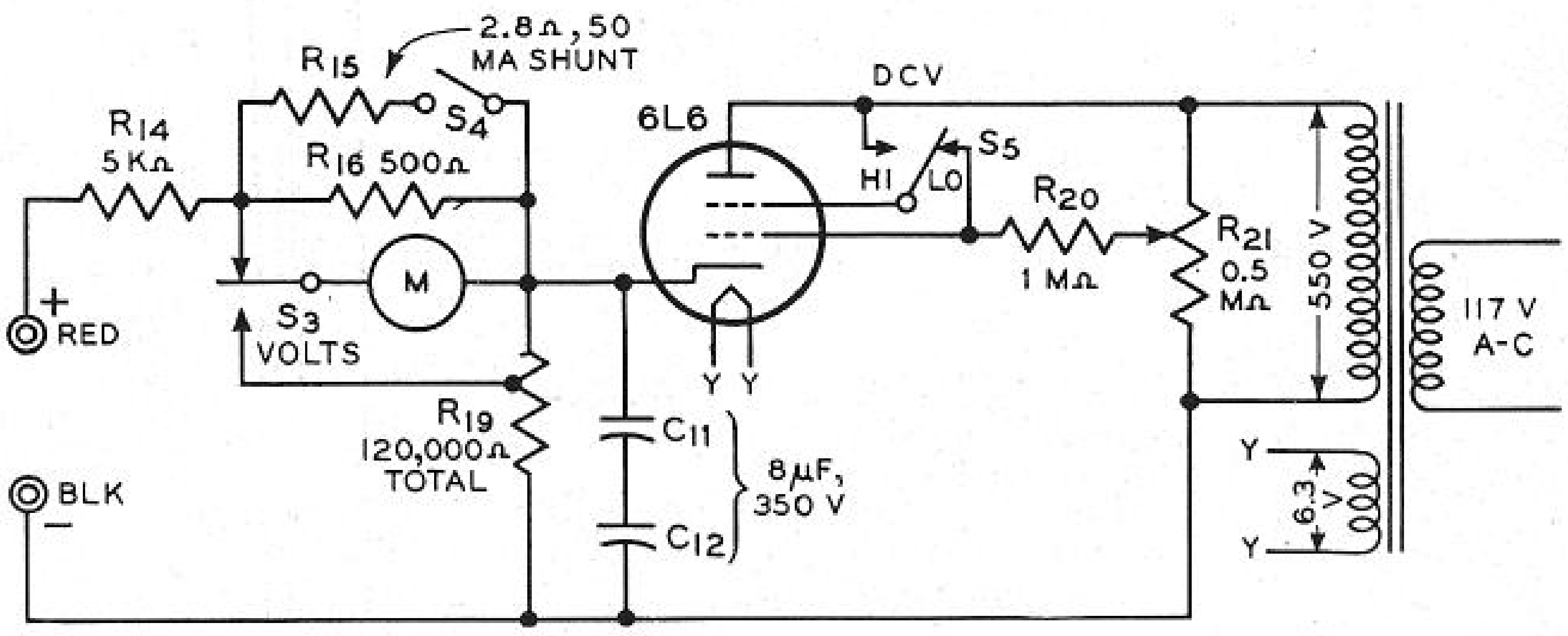
K is a constant as follows:

K	$WVDC$
.01	3 to 100
.02	101 to 250
.025	251 to 350
.04	351 to 450

C is the nominal capacitance in mf

FIG. 8—ELECTROLYTIC CAPACITOR LEAKAGE CURRENT TEST CIRCUIT

Simplified drawing showing continuously adjustable voltage power supply and instrumentation.



Readings should be taken 5 minutes after the capacitors are placed on leakage test. These limits may be used as a guide, bearing in mind that leakage current will increase with age and exposure to high temperatures.

3.4.3d The leakage current of new wet electrolytic capacitors will generally be within the limits of the formula:

$$I = KC$$

Where I is the leakage in milliamperes
K is a constant as follows:

K	*PVDC*
.3	600
.25	500
.2	450
.15	400
.1	300

C is the nominal capacitance in mf

3.5 D-C Vacuum-Tube Voltmeter

3.5.1 The Exam-eter provides a 3-range overload-proof vacuum-tube voltmeter. A simplified circuit is shown in Figure 9. It will be seen that application of a negative voltage through the voltage-divider network to the triode grid will cause a reduction in plate current of the tube. Special scales on the plate circuit milliammeter have been calibrated accordingly. Note that application of excessive potential will merely bias the tube beyond cutoff, the meter dropping back to 0 ma or full voltage deflection without the possibility of bending the pointer, etc. The input resistance on the 30 volt range is 700,000 ohms per volt, on the 60 volt range 70,000 ohms per volt and on the 600 volt range 3,500 ohms per volt.

3.5.2 *Operating Procedure*

(1) Set the master selector switch in accordance with the following table:

Voltage Scale On Meter Dial	Switch Setting
0-600	Mx1
0-60	Mx10
0-30	Mx100

(2) Throw switch at top left of panel to "5 ma d-c."

(3) Throw switch at top right of panel to "hi volts d-c."

(4) Plug CF-27 test leads securely into jacks marked "d-c volts."

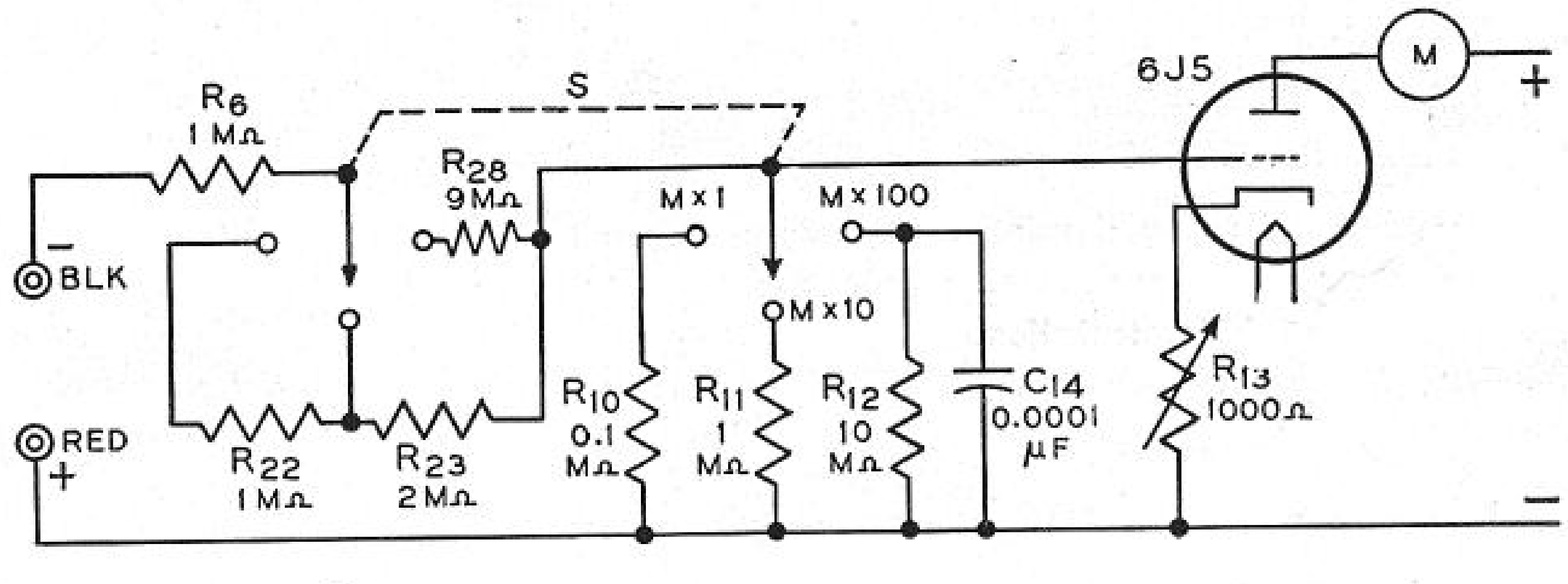
(5) Turn "Voltage Gain" control clockwise to turn Exam-eter on. Allow 1 minute to warm up, then adjust until meter pointer is at full deflection (0 vdc) reading.

(6) Make sure to observe polarity of test leads, red + and black –. Then connect test clips across unknown voltage and read directly from meter scale.

3.6 A-C Vacuum-Tube Voltmeter

3.6.1 The a-c vacuum-tube voltmeter may be used as an audio output indicator for output alignment. Figure 10 shows the circuit to be essentially that of a simple triode detector with a milliammeter in the plate circuit. As the signal strength increases, the plate current drops off in accordance with the tube characteristics. Since tubes may not be uniform, each Exam-eter is individually calibrated. The meter has a range of approximately 5 to 50 volts a-c.

FIG. 9—D-C VACUUM TUBE VOLTMETER CIRCUIT
Excessive applied potential biases tube beyond cutoff, thereby preventing meter overload.



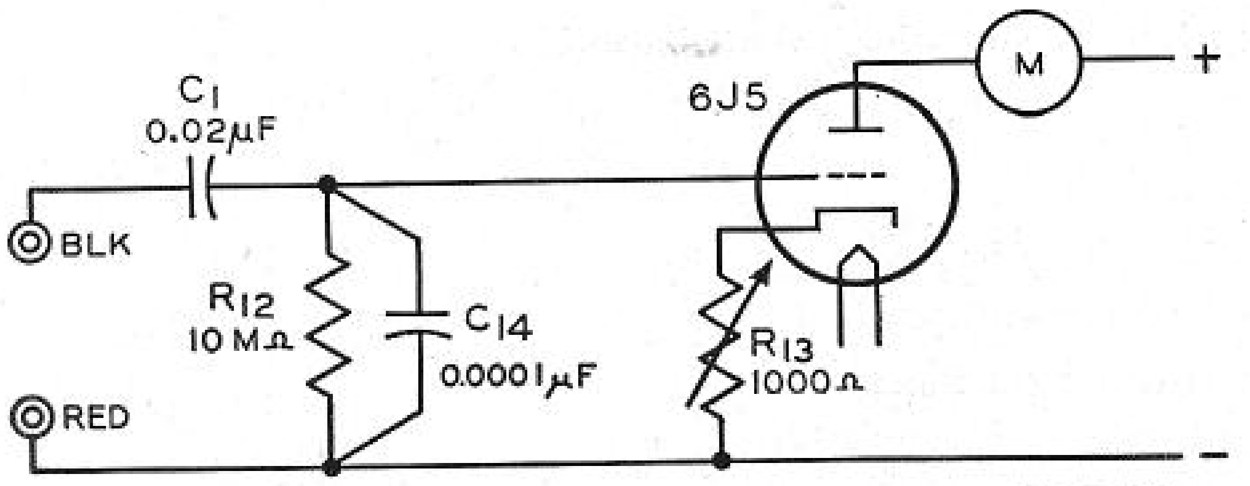


FIG. 10—A-C VACUUM TUBE VOLTMETER CIRCUIT

3.6.2 *Operating Procedure*

(1) Set the master selector switch at Mx100.

(2) Throw switch at top left of panel to "5 ma d-c."

(3) Throw switch at top right of panel to "hi volts d-c."

(4) Plug CF-27 test leads securely into jacks marked "a-c volts."

(5) Turn "Voltage Gain" control clockwise to turn Exam-eter on. Allow 1 minute to warm up. Then adjust until meter is at full scale deflection (5 ma).

(6) Connect test clips across unknown voltage and read meter deflection on "MA" scale. Now refer this value to curve in figure 11 for actual value of voltage measured.

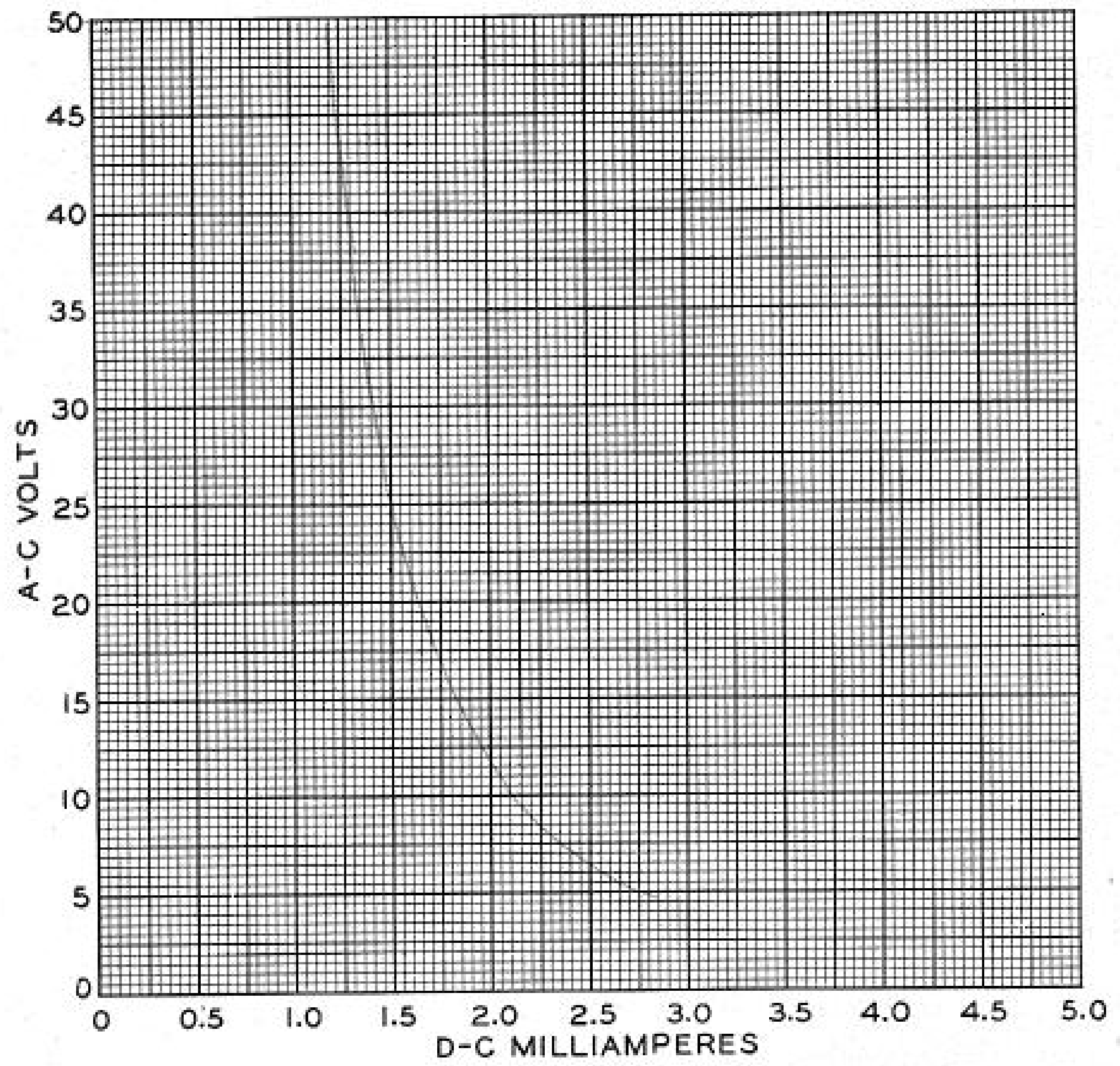


FIG. 11—A-C VTVM CALIBRATION CURVE

This curve is to be used only with the instrument whose serial number is on the front cover of this manual.

3.7 Continuity Checks

3.7.1 The leakage current test circuit may be used for continuity checks if desired.

3.7.2 *Operating Procedure*

(1) Set the master selector switch to "L."

(2) Throw switch at top left of panel to "50 ma d-c."

(3) Plug CF-27 test leads securely into bridge jacks.

(4) Throw switch at top right of panel to "Hi."

(5) Short circuit test clips and turn "Voltage Gain" control clockwise to turn Exam-eter on. Adjust until meter indicates below 15 milliamperes.

Caution: The higher the meter reading, the higher the test potential which will be applied on the continuity check. At 15 ma, there is a test potential in the order of 120 volts.

(6) Unshort test clips. The instrument is now ready for continuity tests.

(7) Place test clips across circuit to be tested. If meter needle does not move, circuit is open. If meter reads upscale, continuity exists.

3.8 Miscellaneous Hints

3.8.1 ***Bridge Accuracy.*** To obtain maximum accuracy, always use the bridge scale which will give a reading nearest the center of the scale arc.

3.8.2 ***Meter Accuracy.*** Electric indicating instruments are most accurate over the upper part of the scale arc; the permissible instrument error, at any point, being rated in percent of full scale length.

4. Service Notes

4.1 Removal of Analyzer from Case. To remove the Model CF Exam-eter from its case, remove the screws on the outside rim of the case. Then lift analyzer out of case. Do not remove any of the knobs or any screws on the front of the etched panel.

4.2 "Quick-Check" Circuit. Since the oscillator embodied in this analyzer is a sensitive high-frequency balanced circuit, it is subject to frequency drift caused by changes in temperature and humidity. This condition is common in high-frequency oscillatory circuits. Trimmer capacitors C_{13} and C_6 have been provided for oscillator readjustment.

4.2.1 *Symptoms of Improper Adjustment*

(1) It is impossible to set the meter on the null position; the meter giving an indication somewhat less than 5.0 ma even with the "voltage gain" control set at maximum.

(2) When meter is adjusted to the null position (5.0 ma), it will indicate a value slightly greater than 5.0 ma if the red test prod is grounded or touched by the hand.

(3) Lack of sensitivity. That is, the instrument will give no indication on low capacitances. The "Quick-Check" circuit should check all capacitances from 100 mmf and above.

4.2.2 *Readjustment Procedure*

4.2.2a *Trimmer* C_{13}

(1) Set the analyzer for "Quick-Check" and insert the test leads into the tip jacks. Do not short the test clips together. Now take the "red" test clip in one hand and adjust the voltage control so that meter deflection is 5.0 ma.

(2) Release the red test lead and adjust the trimmer control through the hole in the left side of the case to the point where the meter deflection changes sharply from a value less than 5.0 ma to 5.0 ma.

(3) Proper adjustment of the analyzer will be realized when the following conditions are fulfilled: a. The meter deflection can be readily set at 5.0 ma and will not vary when the red test clip is held in the hand. b. The meter reading will decrease from 5.0 ma to a somewhat lower value when a 100 mmf capacitor is connected across the test clips.

4.2.2b *Trimmer* C_6. After C_{13} has been properly adjusted, C_6 should be checked for correct setting. To do this:

(1) Short test clips together.

(2) Press "L" button. Meter should read 5 ma; if it does not, adjust C_6 until the meter does read 5 ma.

4.2.3 *Tube Failure.* Occasionally a replacement oscillator tube, even though new, will fail to work. Such tubes may show "good" on ordinary tube checkers. The only cure is to try another 6J5 tube.

4.3 Vacuum Tube Voltmeter. When replacing the 6J5 tube used in the vtvm circuit, it is necessary to check the analyzer for proper calibration. To do this, follow the procedure of 3.5.2, setting the selector switch at Mx100. Then rotate the selector switch to the Mx10 setting. If the meter needle drops below 4.8 ma on the 5 ma scale, try another tube.

4.4 Factory Readjustment of Analyzers. If it should ever be necessary to return your instrument for factory adjustment or recalibration, write for detailed shipping instructions. *Always mention the complete model, type and serial numbers of analyzers in correspondence concerning them.*

Maintenance Parts Price List

A maintenance parts price list is available upon request. In cases of emergency, maintenance parts will be sent C.O.D. via parcel post. Maintenance parts may be ordered either directly or through your Solar distributor. *Always give model, type, and serial number* of your instrument when ordering so as to be assured of the correct replacement parts.

LIST OF MAINTENANCE PARTS

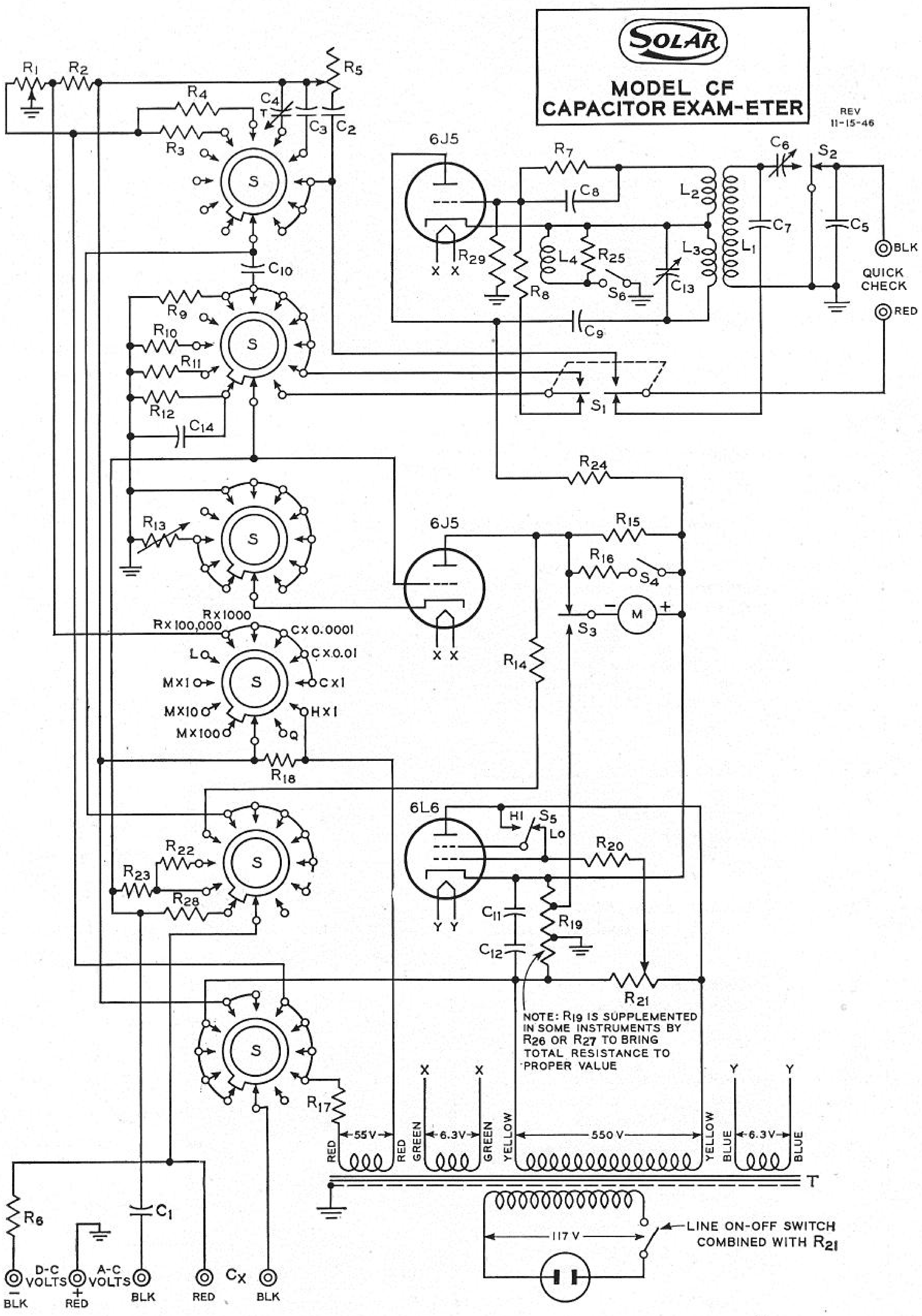
CIRCUIT SYMBOL	REPLACEMENT PART NO.	DESCRIPTION
C_1	CQZ-10-1	Capacitor, fixed, paper-dielectric, .02 mf ±20%, 200 wvdc, Solar Type XTI.
C_2	CDZ333-1	Capacitor, fixed, paper-dielectric, 4 mf ±2%, 100 wvdc, Solar Type XTI.
C_3	CDZ334-1	Capacitor, fixed, paper-dielectric, .04 mf ±2%, 100 wvdc, Solar Type XTI.
C_4	CFZ19	Capacitor, adjustable, mica-dielectric, range 250 to 500 mmf, 500 wvdc. *Note:* When used as C_4, this capacitor is adjusted to 400 mmf ±2%, including circuit wiring capacitance.
C_5	CQZ12	Capacitor, fixed, mica-dielectric, .001 mf ±20%, 500 wvdc, Solar Type MWB.
C_6	CFZ19	See C_4.
C_7	CQZ35	Capacitor, fixed, mica-dielectric, .005 mf ±50%, 500 wvdc, Solar Type MWB.
C_8	CQZ13	Capacitor, fixed, mica-dielectric, .0001 mf ±20%, 500 wvdc, Solar Type MOB.
C_9	CQZ10-1	See C_1.
C_{10}	CQZ10-1	See C_9.
C_{11}	CFZ20	Capacitor, fixed, polarized dry electrolytic, 8 mf, 350 wvdc, Solar Type M.
C_{12}	CFZ20	See C_{11}.
C_{13}	CCZ259-3	Capacitor, adjustable, mica-dielectric, 15 to 130 mmf. *Note:* This trimmer is adjusted for proper operation of "Quick-Check."
C_{14}	CQZ13	See C_8.

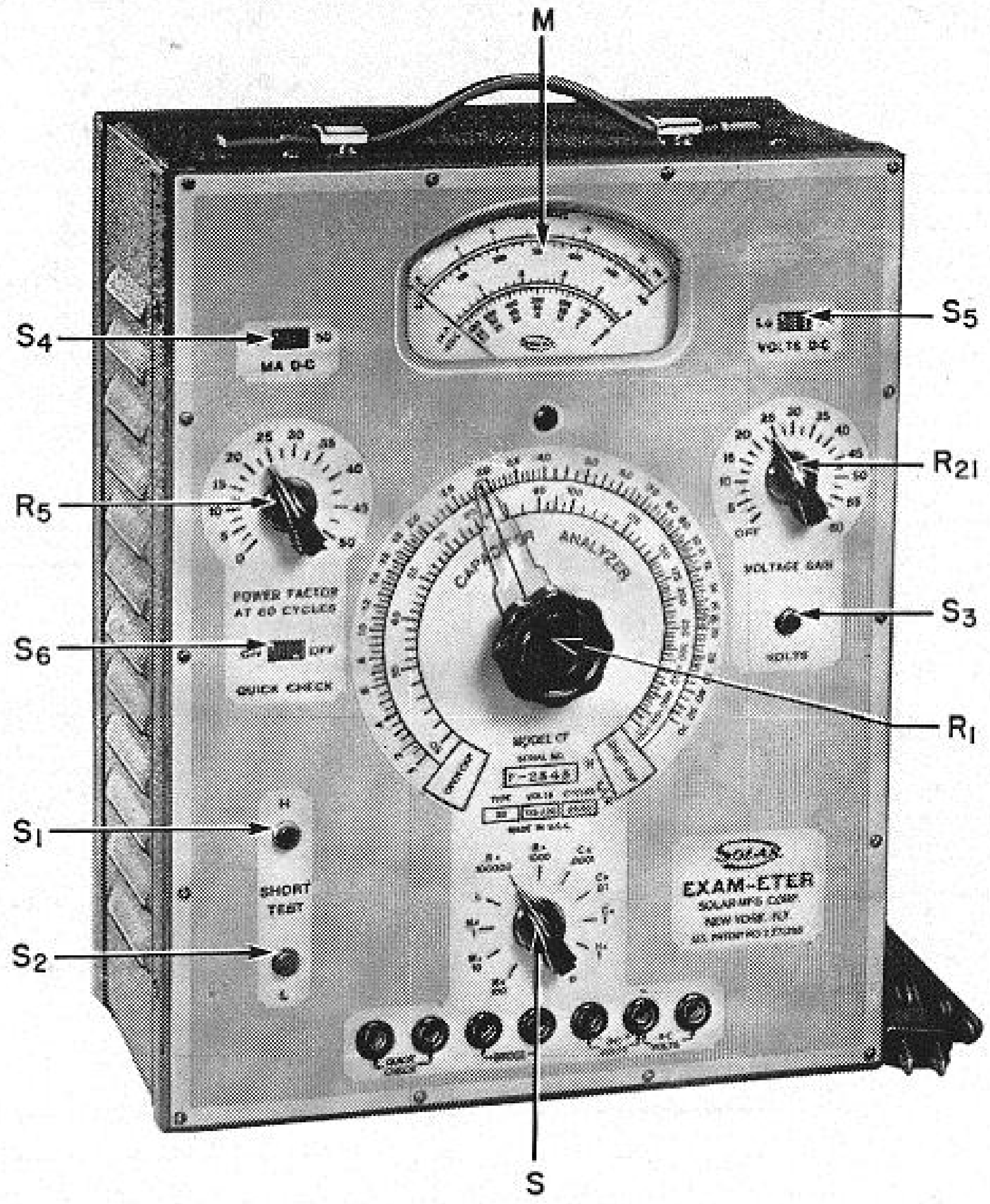
CIRCUIT SYMBOL	REPLACEMENT PART NO.	DESCRIPTION
L_1 L_2 L_3	CQ27	Coil, oscillator, special, per Solar Drawing L5108.
L_4	CQ30A	Inductor, r-f choke, special, wound on R_{25}.
M	CF400	Milliammeter, 0-5 ma d-c, special dial, internal resistance 25 ohms ±2%, 4½" rectangular face, Simpson Model 29 or equivalent.
R_1	CD324	Resistor, continuously-adjustable, wirewound, total resistance 10,000 ohms ±2%, linear taper, 280° effective rotation centered on 300° mechanical rotation, 3 watts.
R_2	CF17	Resistor, fixed, composition, high-stability, 119,500 ohms ±2%, 1 watt.
R_3	CD349	Resistor, fixed, composition, high-stability, 400,000 ohms ±2%, 1 watt.
R_4	CF23	Resistor, fixed, wirewound, 4000 ohms ±2½%, 5 watts.
R_5	CF9	Resistor, continuously-adjustable, wirewound, total resistance 400 ohms ±5%, linear taper, 280° effective rotation centered on 300° mechanical rotation, 3 watts.
R_6	CF14	Resistor, fixed, composition, high-stability, 1 megohm ±2%.
R_7	CF406	Resistor, fixed, composition, 1.0 megohm ±20%, ½ watt.
R_8	CF406	See R_7.
R_9	CF407	Resistor, fixed, composition, 10 megohms ±20%, ½ watt.
R_{10}	CF15	Resistor, fixed, composition, high-stability, 0.1 megohm ±2%, 1 watt.
R_{11}	CF14	See R_6.
R_{12}	CF13	Resistor, fixed, composition, high-stability, 10 megohms ±2%, 1 watt.

LIST OF MAINTENANCE PARTS—Continued

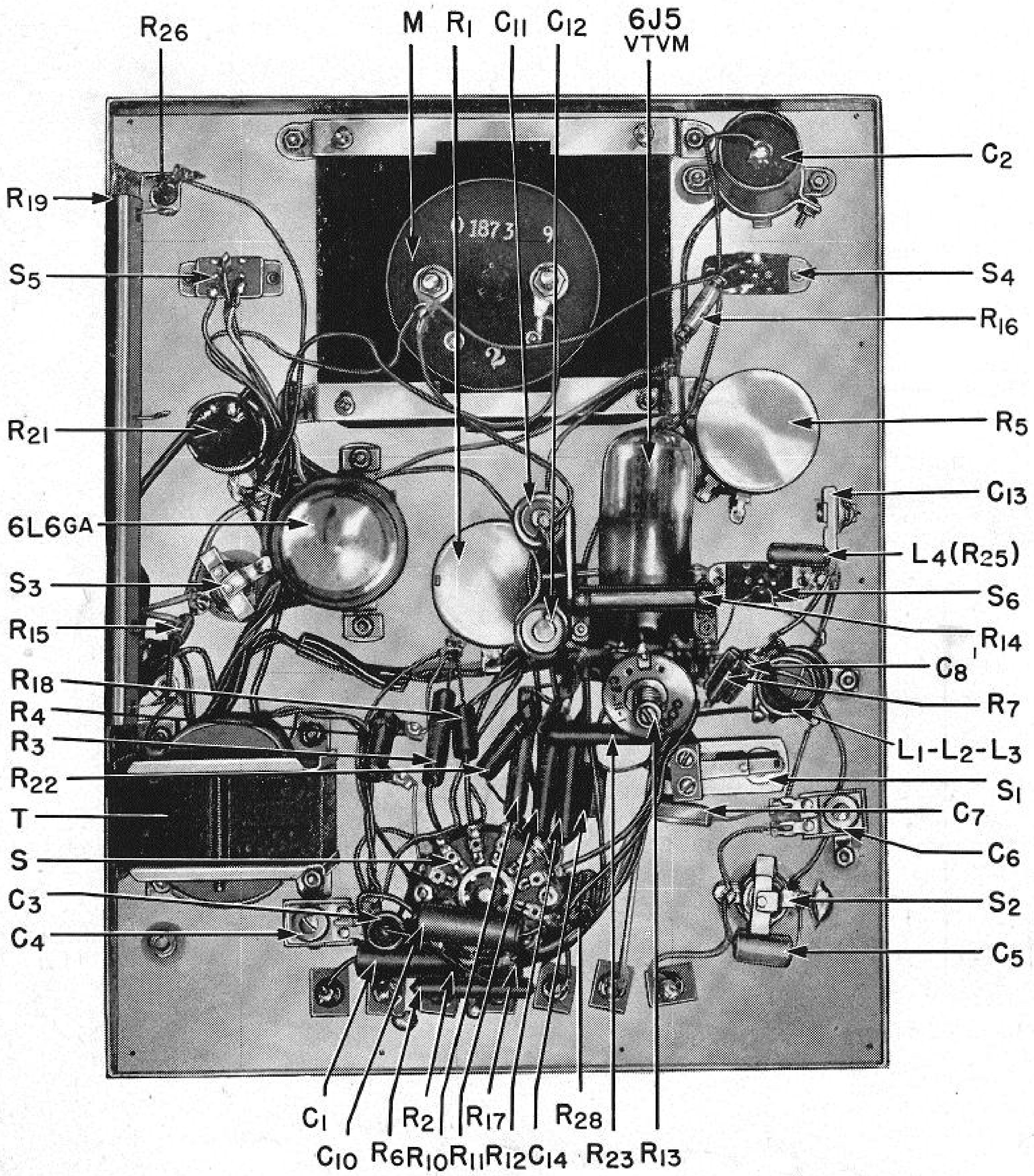
Circuit Symbol	Replacement Part No.	Description
R_{13}	CF11-1	Resistor, continuously-adjustable, wirewound, 1000 ohms ±5%, slotted stub shaft, 1 watt.
R_{14}	CF10-1	Resistor, fixed, wirewound, 5000 ohms ±10%, 10 watts.
R_{15}	CF408	Resistor, fixed, composition, 510 ohms ±5%, ½ watt.
R_{16}	CF12	Resistor, fixed, wirewound, 2.8 ohms ±2%, 1 watt.
R_{17}	CF409	Resistor, fixed, composition, 220 ohms ±20%, 2 watts.
R_{18}	CF409	See R_{17}.
R_{19}	CF410	Resistor, fixed, wirewound, total resistance 120,000 ohms +2% −8%, per Solar Drawing L5218, tapped at 500 ohms ±5% and 60,000 ohms ±10%, 30 watts. *Note:* A 4000 or 8000 ohm, 1 watt composition resistor (Parts CF419 or CF420) may be found soldered in series to adjust the combined resistance to 120,000 ohms ±2%.
R_{20}	CF406	See R_7.
R_{21}	CF6	Resistor, continuously-adjustable, composition, molded element, 0.5 megohm ±10%, linear taper, 2 watts, with spst switch.
R_{22}	CF14	See R_6.
R_{23}	CF415	Resistor, fixed, composition, high-stability, 2 megohms ±20%, 1 watt.
R_{24}	CF411	Resistor, fixed, composition, 20,000 ohms ±20%, ½ watt.
R_{25}	CF407	See R_9.
R_{26}	CF419	Resistor, fixed, composition, 4000 ohms ±5%, 1 watt. *Note:* See Note under R_{19}.
R_{27}	CF420	Resistor, fixed, composition, 8000 ohms ±5%, 1 watt. *Note:* See Note under R_{19}.
R_{28}	CF422	Resistor, fixed, composition, high-stability, 9 megohms ±2%, 1 watt.
R_{29}	CF406	See R_7.

Circuit Symbol	Replacement Part No.	Description
S	CD313	Switch, rotary, 11 points per gang, 6 gangs.
S_1	CQ15	Switch, push-button, dpdt.
S_2	CQ16	Switch, push-button, spdt.
S_3	CQ16	See S_2.
S_4	CF403	Switch, slide, spst.
S_5	CF404	Switch, slide, spdt.
S_6	CF403	See S_4.
T (CF-1-60)	CF5-1	Transformer; primary 117 v, 50-60 cycles; secondary 1, 550 v @ 15 ma continuous and 50 ma for 30 sec; sec 2, 55 v @ 30 ma; sec 3, 6.3 v @ 0.6a; sec 4, 6.3 v @ 0.9a.
T (CF-2-U)	CF5-x	Transformer; primary tapped for 117 v, 160 and 240 volts, 25-60 cycles; secondaries as in Part CF5-1.
	CAZ4032	Cabinet, for CF-1-60
	CAZ4032A	Chassis, for CF-1-60
	CAZ4032X	Cabinet, for CF-2-U
	CAZ4032AX	Chassis, for CF-2-U
	CB42	Handle, black leather, for cabinet.
	CB43	Loop, to hold leather handle.
	CQ32	Foot, rubber, for cabinet.
	CB7	Knob, fluted, black, for ¼" shaft.
	CF401	Pointer, transparent with hairline, for Knob CB7.
	CB23	Knob, pointer, black with white hairline.
	CQ23B	Jack, banana plug receptacle, black.
	CQ23R	Jack, banana plug receptacle, red.
	CF27	Leads, test, general purpose.
	CQ465	Leads, test, special twin-conductor for "Quick-Check."
6J5	6Q7	Tube, electron, 6J5.
6L6	CF3	Tube, electron, 6L6 or 6L6GA.
	CQ21	Socket, electron-tube, octal-base.

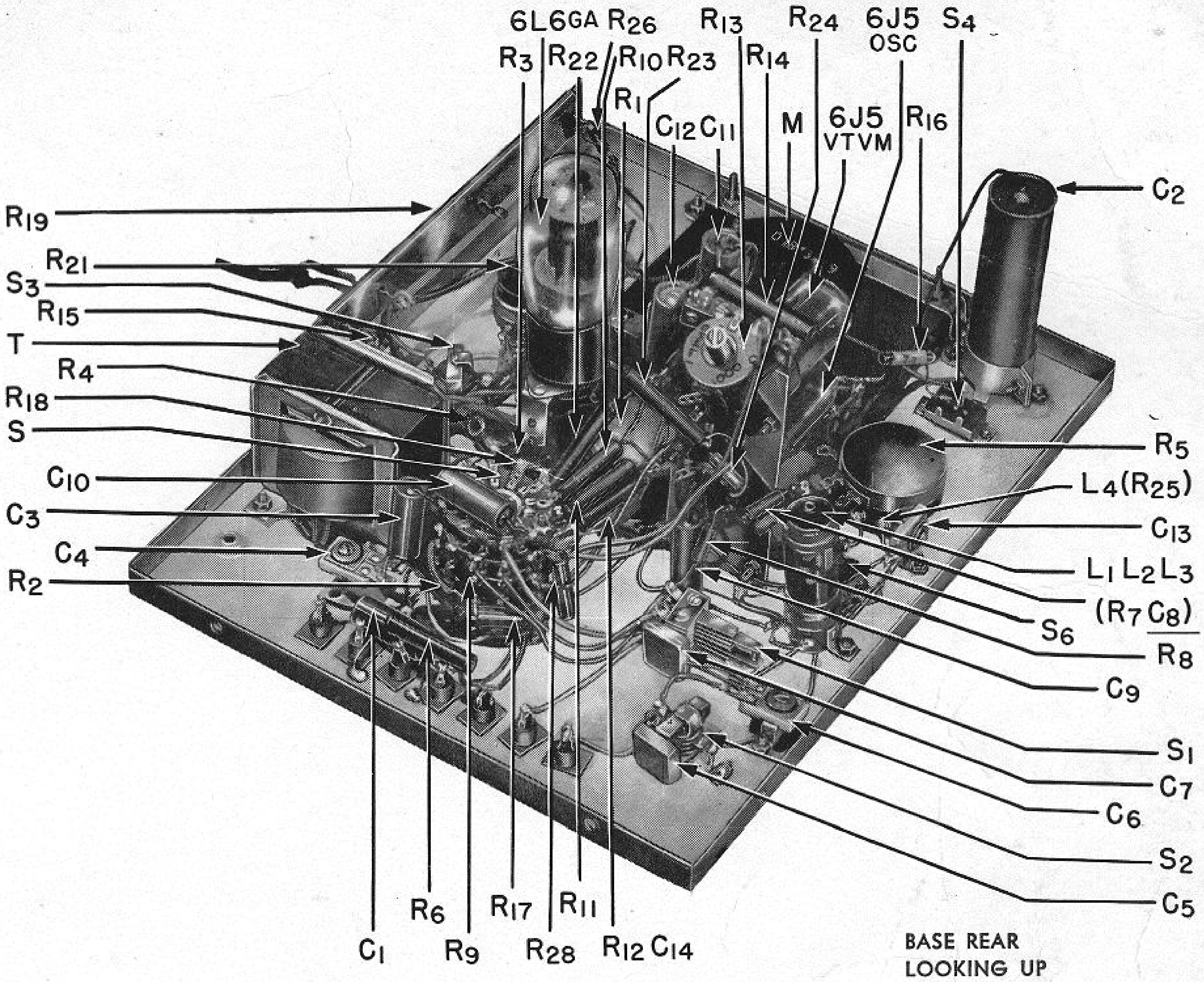

SOLAR
MODEL CF
CAPACITOR EXAM-ETER
REV 11-15-46
6J5
6J5
6L6
RX1000
RX100,000
CX0.0001
CX0.01
CX1
HX1
Q
LO
MX1
MX10
MX100
HI
Lo
QUICK CHECK
BLK
RED
NOTE: R19 IS SUPPLEMENTED IN SOME INSTRUMENTS BY R26 OR R27 TO BRING TOTAL RESISTANCE TO PROPER VALUE
55V
6.3V
550 V
6.3V
117 V
LINE ON-OFF SWITCH COMBINED WITH R21
D-C VOLTS
A-C VOLTS
Cx
BLK
RED
BLK
RED
BLK



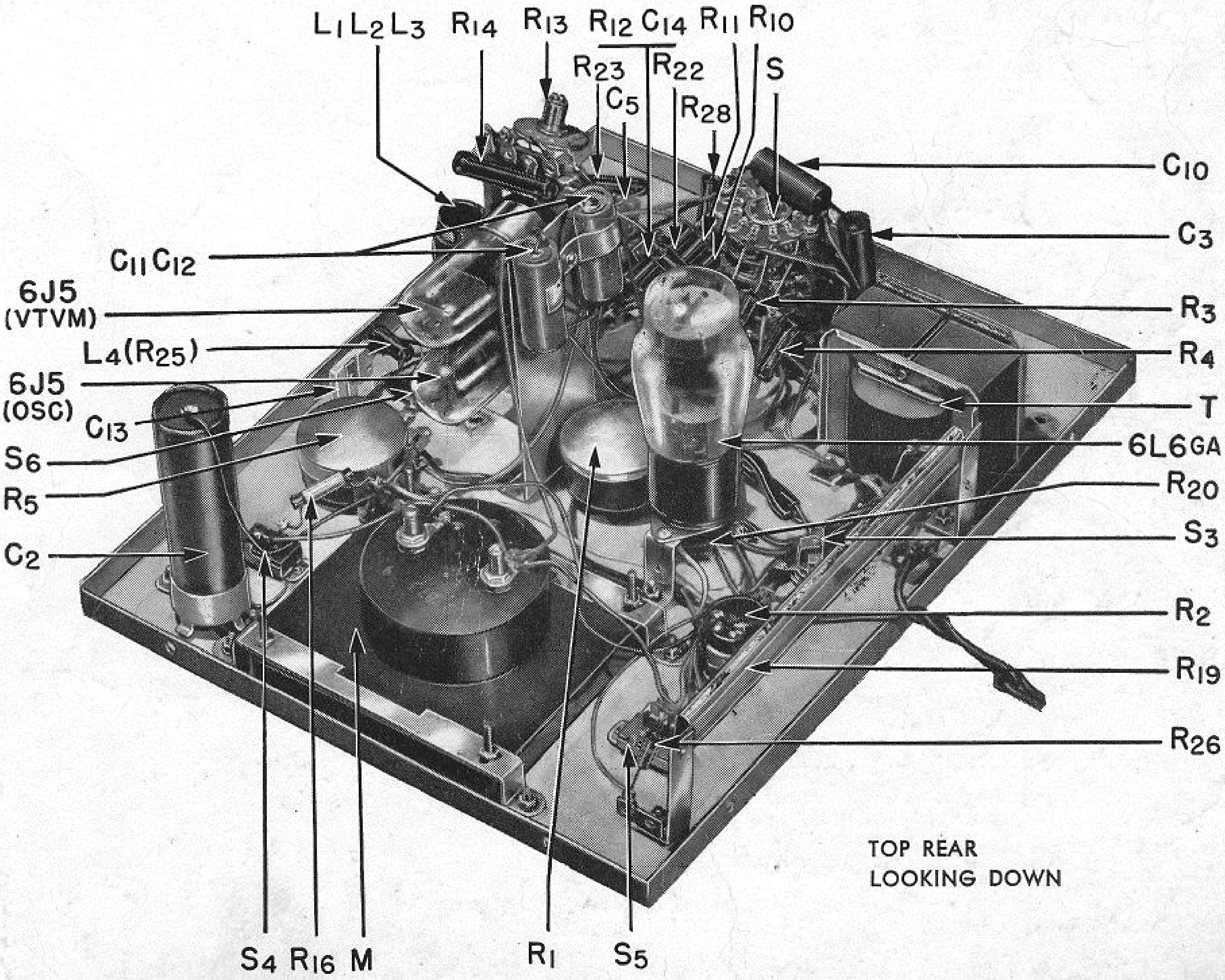
FRONT



REAR ELEVATION



BASE REAR
LOOKING UP



TOP REAR
LOOKING DOWN

Radiomen Wise

All Standardize

on

"QUALITY ABOVE ALL"

SOLAR
CAPACITORS

1470
40
5580

CF-412-1—6M—11-46 Colorpress, N. Y. Printed in U. S. A.

SUPPLEMENT TO TECHNICAL MANUAL
MODEL CF CAPACITOR EXAM-ETER

PAGE 2

2.2.1 Change "3000" to "1000."

Figure 1 Change value of R_8 to "1MΩ."

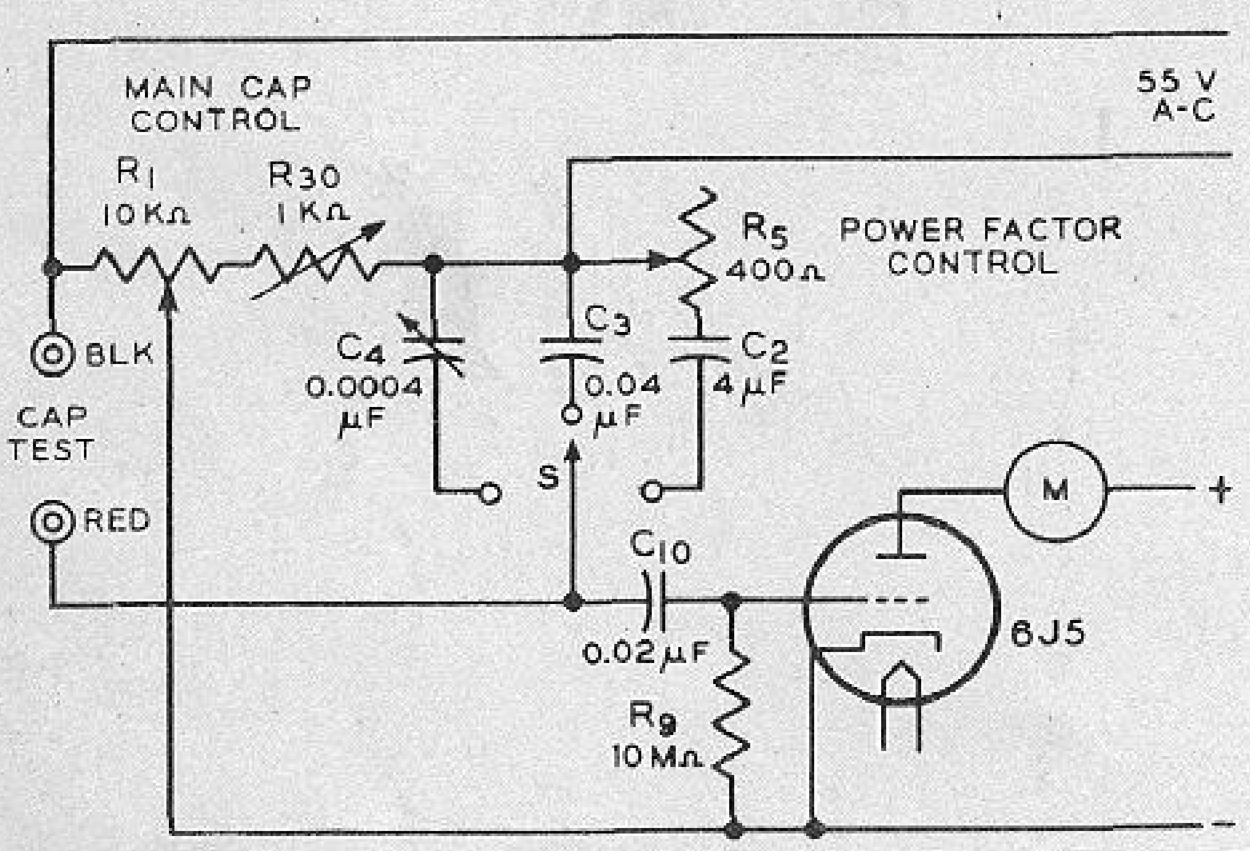
PAGE 3

2.3 (7a) Change "3000" to "1000."

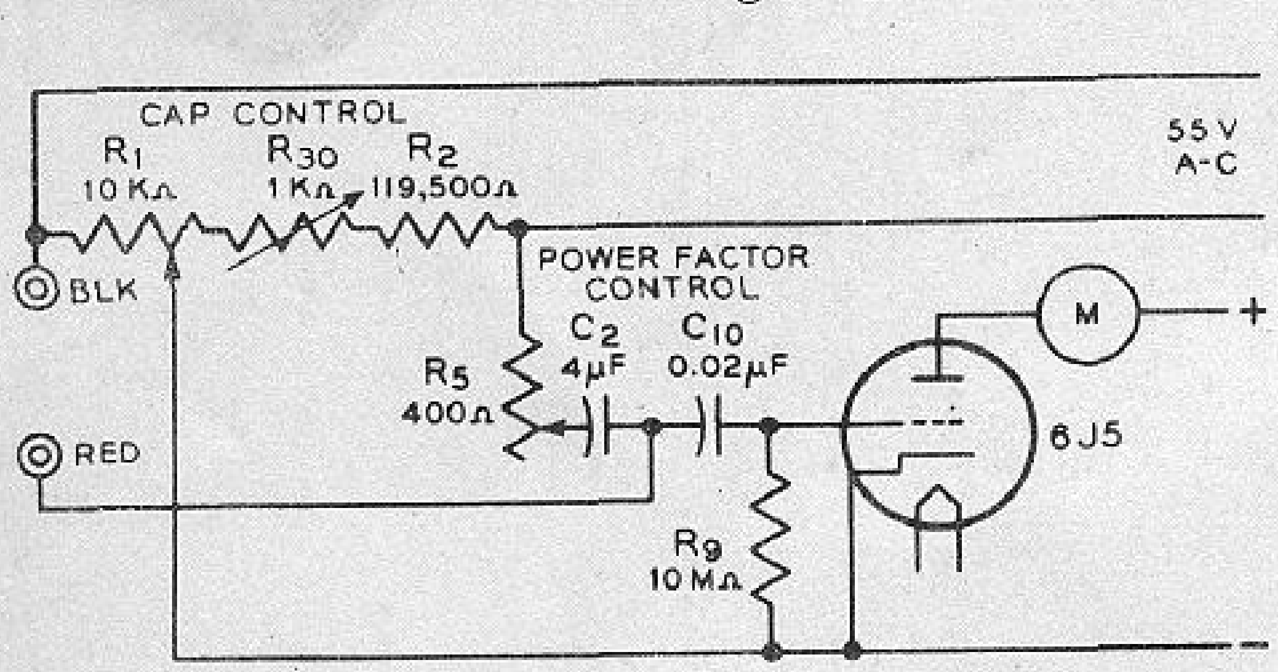
2.3 (7b) Change "3000" to "1000," and change ".003 to .001."

PAGE 4

Substitute revised Figure 2.

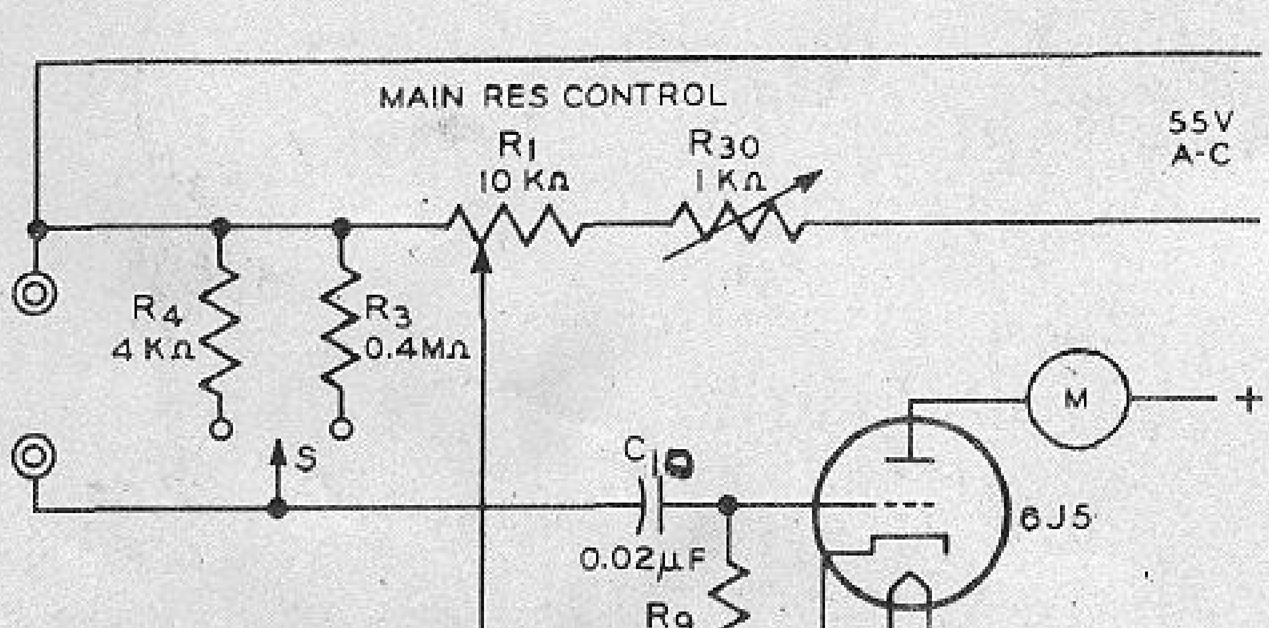


Substitute revised Figure 3.



PAGE 7

Substitute revised Figure 6.



PAGE 8

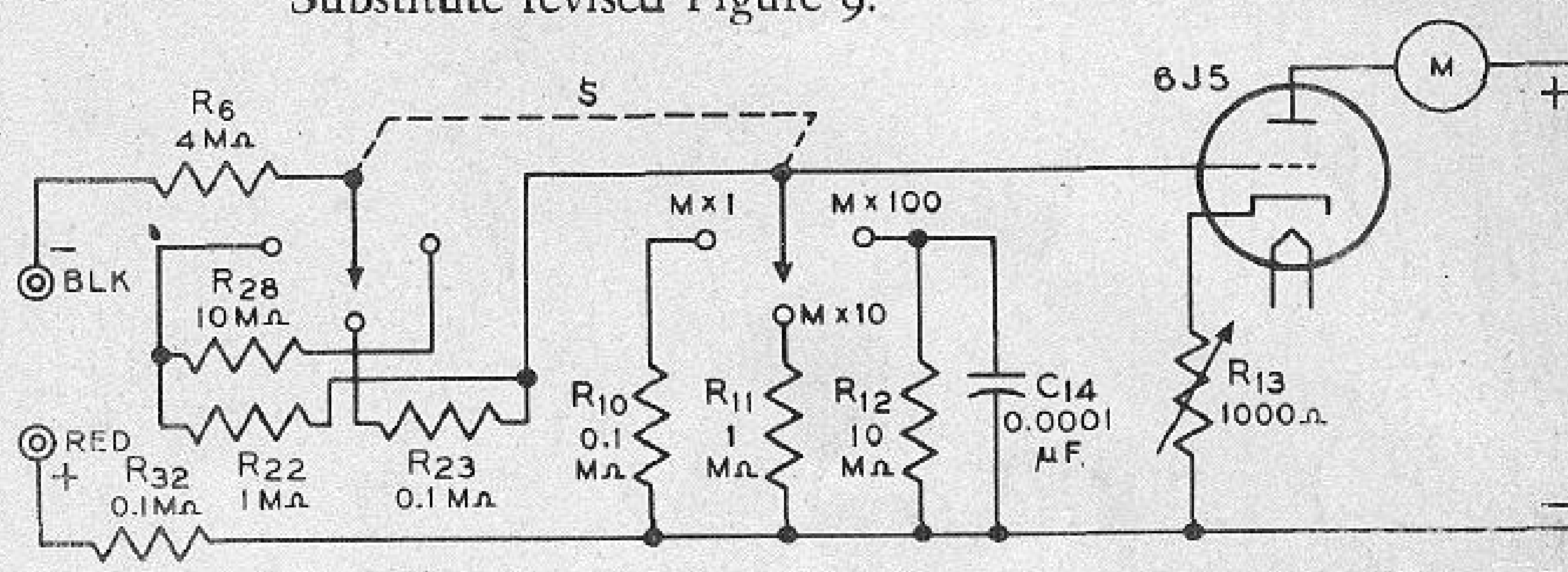
3.3.2 In final "note," change last line to read: "approximately 1 megohm greater than the actual resistance value."

PAGE 9

3.4.2 (5) Change "left" to "right."

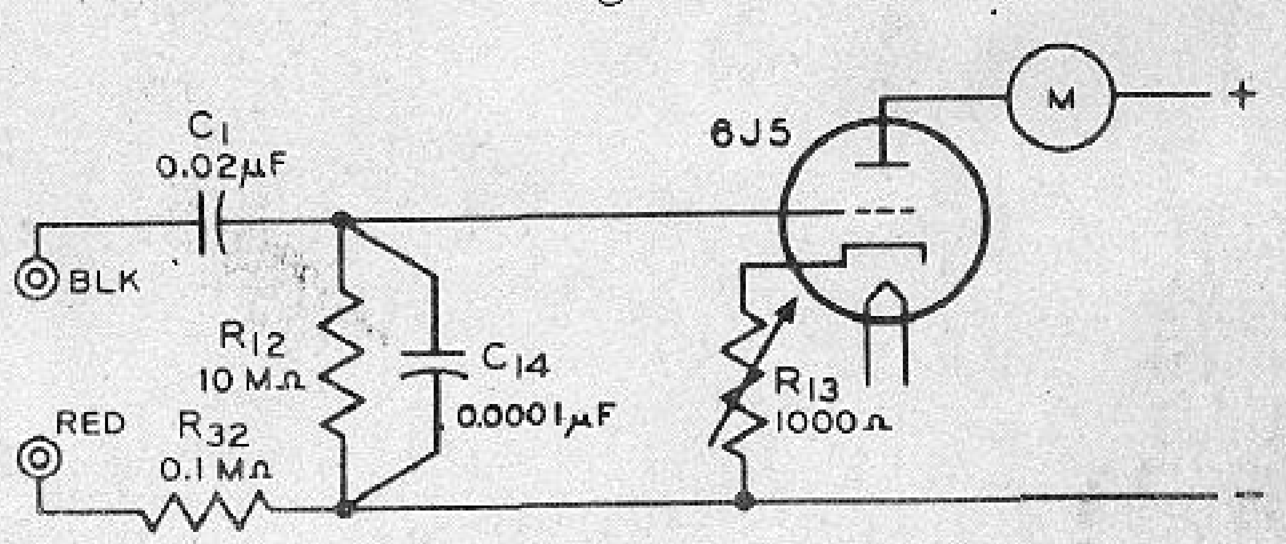
PAGE 10

Substitute revised Figure 9.



PAGE 11

Substitute revised Figure 10.



PAGE 13

Change replacement part number for R_6 to CF-16-1, 4 megohms ±2%.

Add as C_{15}, Part CFZ-426, 0.1 mf, 600 wvdc.

PAGE 14

Insert as value of R_{22}, Part CF-14, 1 megohm ±2%.

Change replacement part number for R_{23} to Part CF-427, 0.1 megohm ±20%.

Change replacement part number for R_{28} to Part CF-13, 10 megohms ±2%.

Add as R_{30}, Part CF-11-1. See R_{13} for description.

Add as R_{31}, Part CF-425, 0.15 megohm ±10%.

Add as R_{32}, Part CF-427, 0.1±20%.

Add as R_{33}, Part CF-425, 0.15 megohm ±10%.

SOLAR MANUFACTURING CORPORATION

1445 Hudson Blvd. • North Bergen, N. J.

PAGE 15

Substitute revised schematic diagram.