PYRAMID

technical manual

pyramid model cra-1

capacitor-resistor analyzer

PYRAMID ELECTRIC COMPANY

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PYRAMID MODEL CRA-1

CAPACITOR-RESISTOR ANALYZER

technical manual
for
PYRAMID MODEL CRA-1*
CAPACITOR-RESISTOR ANALYZER

1. DESCRIPTION

1–1. GENERAL.

The Pyramid Model CRA–1 Capacitor-Resistor Analyzer is a modern, carefully-engineered precision test instrument. Its design includes a multitude of useful up-to-date features, making it the ideal unit for use by technicians, servicemen and engineers in television (color as well as black and white), industrial electronics and all related fields. The equipment is well-suited to rear-echelon maintenance work in the military services.

1–2. FUNCTION.

Both qualitative and quantitative tests can be performed by this reliable unit. Included in its facilities are tests for opens, shorts and intermittents, as well as capacitance, resistance, power factor, leakage current and insulation resistance. (See figure 8, for operating controls.)

1–3. QUALITATIVE TESTS—THE QUICK CHECK CIRCUIT.

Practical rapid qualitative testing is made possible with the special Quick Check circuit, which speedily locates most shorted, open and intermittent capacitors of all types while they remain connected in their operational circuits. Electrolytic capacitors with high RF impedance also may be found without disturbing wiring or unsoldering leads. This circuit includes a balanced RF oscillator, an electron-ray indicator tube and an AC voltage source.

1–4. QUANTITATIVE TESTS.

a. CAPACITANCE. The fundamental circuit of the CRA–1 consists of a highly accurate capacitance bridge. This circuit is equipped with four measuring ranges, covering all values from 10 uuf to 2000 uf, making it possible to test small ceramic and mica capacitors as well as large rectifier filter and AC motor-starting capacitors, and extremely high-capacitance capacitors, such as those used for cathode bypass, electric fence control and photoflash applications.

b. POWER FACTOR. A scale, calibrated from 0 to 65 per cent, indicates the power factor of polarized or non-polarized electrolytics.

c. CAPACITOR LEAKAGE. The large 4-1/2-inch meter shows the leakage current of electrolytic capacitors during application of rated DC working voltage. Continuously-adjustable test voltages up to 600 volts are available from an integral DC power supply.

d. INSULATION RESISTANCE. Ceramic-, mica-, air- and paper-dielectric capacitors may be checked for insulation resistance; the result is displayed directly on a special meter scale. The values are divided into two ranges, covering from about 5 to 20,000 megohms. Thus, a positive check can be made on capacitors in which low insulation resistance would be detrimental to equipment performance. High-valued resistors, such as those used in photo-electric and other circuits, also may be measured.

e. RESISTANCE. Exact resistance measurements from 100 ohms to 25 megohms can be made using the AC Wheatstone bridge provided. This bridge operates at line frequency.

1–5. LINE POWER REQUIREMENTS.

MODEL	VOLTS	CYCLES	WATTS
CRA–1	115	60	30
CRA–1S	115/150/230*	25–60	30

*** *Note:* Before connecting a Model CRA–1S to the power line, remove the cover plate adjacent to the line cord at the lower right-hand side of the instrument case. Insert the phone tip that is connected to a flexible lead into the appropriate pin jack for the line voltage to be used. Replace the cover plate.**

CAUTION

Never connect the Pyramid Capacitor-Resistor Analyzer to a DC power line. Doing so will result in serious damage to the equipment. If operation from a DC power line should be necessary, an appropriate rotary converter or vibrator inverter must be used to furnish the required AC power.

1–6. PHYSICAL DATA.

a. APPEARANCE. The metal case of the CRA–1 is finished in a fine, black wrinkle baked enamel and supplied with a sturdy leather carrying handle. The modern, well-designed front panel is intended for simplicity of operation as well as eye-appeal.

b. WEIGHTS AND DIMENSIONS.

MODEL	WEIGHT (PACKED)	LENGTH (IN.)	WIDTH (IN.)	DEPTH (IN.)
CRA–1	15 lb.	14	9-1/4	5-1/2
CRA–1S	19 lb.	14	9-1/4	5-1/2

*T.M.Reg. U.S. Pat. Off.

1–7. COMPONENTS USED.

Reliable components of the highest quality have been used in the construction of the Analyzer to render dependable operation under all climatic conditions. For example, tropicalization has been given special attention; fixed capacitors are sealed against moisture; wire and wiring meet military specifications; the power transformer is double vacuum-impregnated; a fume-proof white enamel scale is used on the meter to prevent discoloration, etc.

1–8. ELECTRON TUBE COMPLEMENT.

The tubes used in the CRA–1 Capacitor-Resistor Analyzer are as follows:

1—6SN7GT
1—6L6 or 6L6GA
1—6E5 Electron-ray Tube

2. QUICK CHECK CIRCUIT FOR QUALITATIVE MEASUREMENTS

2–1. FEATURES AND USE.

a. Because it affords a series of rapid, simple checks on a capacitor, the Quick Check circuit normally is applied as the first step in isolating a faulty component. Quick Check offers facilities for locating short circuits, open circuits, intermittents, high RF impedance and high power factor in capacitors.

b. The positive and immediate indications of Quick Check may be utilized, if desired, with operating power applied to the equipment under test, without disconnecting the suspected unit from its normal circuit; even with resistors or inductors in parallel with it.

2–2. FUNCTIONAL DESCRIPTION.

a. The Quick Check portion of the CRA–1 Capacitor-Resistor Analyzer is shown schematically in figure 1. For simplicity, the power supply and switching facilities have been omitted. The circuit consists of a balanced RF oscillator, a source of AC voltage and an electron-ray indicator tube. The circuit is so arranged that it will not oscillate with the special Quick Check test leads plugged into the Analyzer but with the test clips unconnected. The wedge in the electron-ray indicator tube will be fully open. This is an indication of the absence of internal RF voltage. It is important to note that only Quick Check test leads can be used for this test.

b. When the test clips are connected across a capacitor to be checked, one of the following conditions will occur:

(1) The electron-ray indicator wedge will not deflect. This is an indication that the capacitor under test is open.

(2) The electron-ray indicator wedge will fluctuate violently, as a result of the oscillator going into and out of oscillation. This is an indication that the capacitor is intermittent.

(3) The electron-ray indicator wedge will close. This indicates that the capacitor is not open. Further tests must be performed to determine whether or not the capacitor is shorted.

c. Should the condition described in (3), above, be indicated, short-circuit Quick Checks must be performed by using the "L" or "H" toggle switches on the operating panel. The "L" switch is used for capacitors from 100 uuf

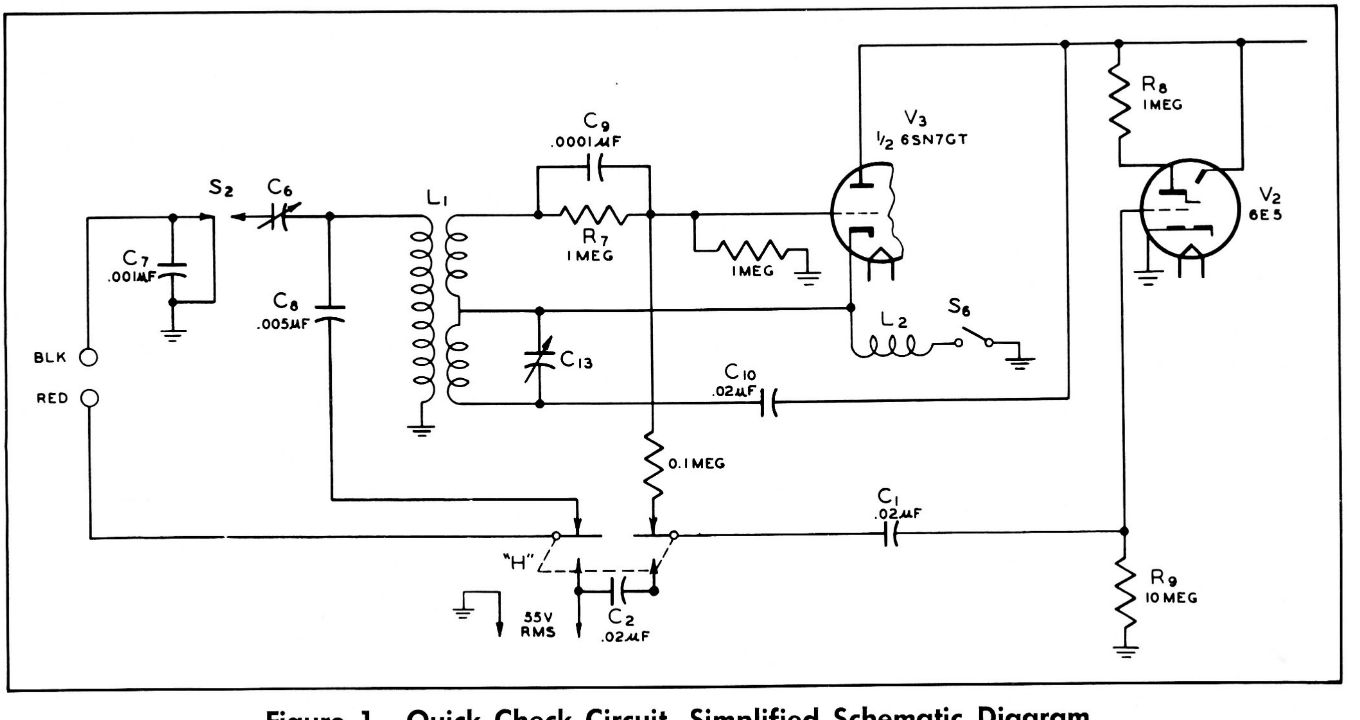


Figure 1. Quick Check Circuit, Simplified Schematic Diagram

to approximately 2000 uuf; the "H" switch for capacitors from 2000 uuf to 50 uf.

Operation of the "H" switch places the capacitor under test in series with an internal 2-uf capacitor across a source of AC voltage and connects the electron-ray indicator tube circuit across the capacitor under test.

In either case, if the indicator wedge opens, oscillation has stopped and a short-circuited capacitor is indicated.

2–3. OPERATING PROCEDURE.

a. OPENS, SHORTS AND INTERMITTENTS. To perform checks for opens, shorts and intermittents using the Quick Check circuit, proceed as follows:

(1) Turn the master selector switch to QUICK CHECK and rotate the main bridge control clockwise to SHORT.

(2) Connect the special Quick Check test leads to the QUICK CHECK pin jacks on the front panel of the Analyzer. Make sure that the colors of each plug and jack correspond.

Note

The distributed capacitance of the special Quick Check test leads has been taken into consideration in the finial adjustment of the oscillator circuit. The Quick Check circuit operates correctly only when these leads are used.

(3) Set the METER RANGE switch to the 5 MA position.

(4) Apply operating power to the Analyzer by turning the ADJUST VOLTS knob clockwise. Set this knob to about 450. Slide the QUICK CHECK switch to ON. Allow a one-minute warm-up period.

(5) Connect the test clips securely across the suspected capacitor. If the capacitor has pig-tail leads, connect the clips as close to the body of the unit as possible. Connect the black-coded test lead to the lower-potential terminal of the capacitor to be tested.

(6) Observe the electron-ray indicator tube. If the wedge remains open, the capacitor is open-circuited. If the wedge fluctuates violently, the capacitor is intermittent. If either of these conditions occurs, replace the capacitor.

Notes

1. Disregard slight flickers of the wedge; they are usually caused by line-voltage fluctuations.
2. Capacitors smaller than 100 uuf, though they may be perfectly good units, will appear as open circuits on this test, due to their high reactance at the oscilator frequency.

(7) To test for shorts in capacitors from 100 uuf to about 2000 uuf, operate the "L" toggle switch. If the indicator wedge remains closed, the capacitor is good. If the indicator wedge opens fully, the capacitor is short-circuited and must be replaced.

(8) To test for shorts in capacitors from about 2000 uuf (0.002 uf) to 50 uf, operate the "H" toggle switch. If the indicator wedge remains closed, the capacitor is good. If the indicator wedge opens fully, the capacitor is short-circuited and must be replaced.

Note

In cases where a capacitor is shunted by a resistor of 25 ohms or less, or by a low-impedance inductor, this test may indicate a "short" even though the unit is good.

(9) If the capacitance of the capacitor under test is not known (high or low), test it for "shorts" by operating first the "L" switch and second the "H" switch. If the capacitor is short-circuited, the indicator wedge will open fully on *both* tests. If the wedge opens on *only one* of the tests, the capacitor is not short-circuited.

Note

Capacitors greater than 50 uf, though perfectly good, will appear as if shorted on this test, due to their low reactance at the test frequency.

b. HIGH POWER FACTOR AND HIGH RF IMPEDANCE. To perform qualitative tests on electrolytic capacitors for high power factor and high RF impedance, proceed as follows:

(1) Perform steps (1) through (6) of subparagraph 2–3a.

(2) Operate the "L" toggle switch. The indicator wedge should return to the fully-open position. If the wedge does not open fully, the capacitor under test has a high RF impedance. Electrolytic capacitors with high power factors must be checked on the bridge section of the Analyzer, since they will not always have a high RF impedance.

Note

High power factor in capacitors is often accompanied by a drop in capacitance considerably below the rated value. This can be checked by using the capacitance-measuring section of the Analyzer.

(3) Connect a 0.1-uf paper capacitor across the capacitor under test. If this causes the indicator wedge to open fully, it is a further indication that the capacitor under test has a high RF impedance and should be replaced.

2–4. SUPPLEMENTARY DATA.

a. INTERMITTENT CAPACITORS. "Intermittents" in capacitors are caused by either poor internal electrical connections or momentary internal shorts. These can be detected by observing the electron-ray indicator while "jiggling" the capacitor or striking it lightly with a pencil. This test is made while using the Quick Check procedure described in subparagraphs 2–3a(5 to 8 incl.).

Capacitors with intermittents due to thermal causes often operate properly when the equipment is first turned on, but fail after the equipment heats up. When such a condition is suspected, the Quick Check test leads can be connected across the capacitor and allowed to remain connected over a period of time while the equipment is in operation. When intermittents occur, as evidenced by fading or other indication, a glance at the Capacitor-Resistor Analyzer will show whether or not the suspected capacitor is defective.

b. INDUCTIVE CAPACITORS. In some cases, electrolytic capacitors and certain inductively-wound paper capacitors (ordinarily over 1 uf) will check as open on the Quick Check when actually they are satisfactory. The explanation for this phenomenon is the presence of high inductance within the capacitor, or excessive lead inductance. Capacitors in this category must be checked further by means of quantitative tests, as described below.

Note

Highly self-inductive capacitors are not necessarily defective and will perform quite satisfactorily in circuits for which they are designed.

c. "LEAKY" PAPER CAPACITORS. Sometimes a capacitor will be encountered exhibiting a high-resistance "short"; that is, the capacitor is shorted for practical applications but is high enough in resistance to prevent the capacitor from loading the analyzer oscilator circuit and giving a "short" indication. Such a capacitor can be isolated quickly by quantitative leakage tests. These are described below.

d. MAGNITUDE OF QUICK CHECK INDICATOR DEFLECTION. The quality indications of capacitors tested on the Quick Check circuit are indicated by the presence or absence of change in wedge size in the electron-ray indicator, but not by the amount of such change. Different amounts of change in wedge size are due to variations in circuit impedance to ground, and are not related to the quality of the component being tested.

3. QUANTITATIVE MEASUREMENTS

3–1. CAPACITANCE.

a. FUNCTIONAL DESCRIPTION. A four-range combination Wien and Wheatstone bridge circuit is used to measure capacitance at line frequency. The bridge can measure capacitance values from 10 uuf to 2000 uf. A simplified schematic diagram of the circuit employed for the C x .0001, C x .01 and C ranges is given in figure 2. Figure 3 is the circuit used for the HIC range, which measures higher capacitances—those in the range from 50 uf to 2000 uf. The main bridge control potentiometer, R1, which is the continuously-adjustable element of the bridge, is an accurately-calibrated wire-wound potentiometer, thus ensuring accurate values for various dial settings. On the C x .0001 range, the standard capacitor used is a mica trimmer, thus permitting accurate adjustments to be made, compensating for distributed capacitance of the wiring in the test equipment. As shown in figure 3, a large fixed resistor, R2, is added to the resistance arm of the bridge to extend the coverage for the HIC range. An electron-ray indicator tube serves as a sensitive null detector.

b. OPERATING PROCEDURE.

(1) Set the master selector switch to the correct range for the capacitor being measured (see table on page 5).

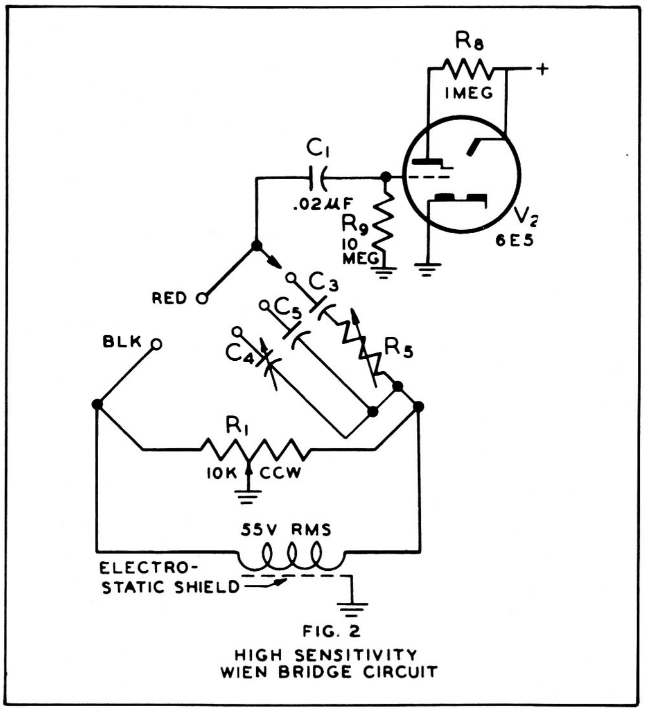


Figure 2. Bridge Circuit for C x .0001, C x .01 and C Ranges, Simplified Schematic Diagram

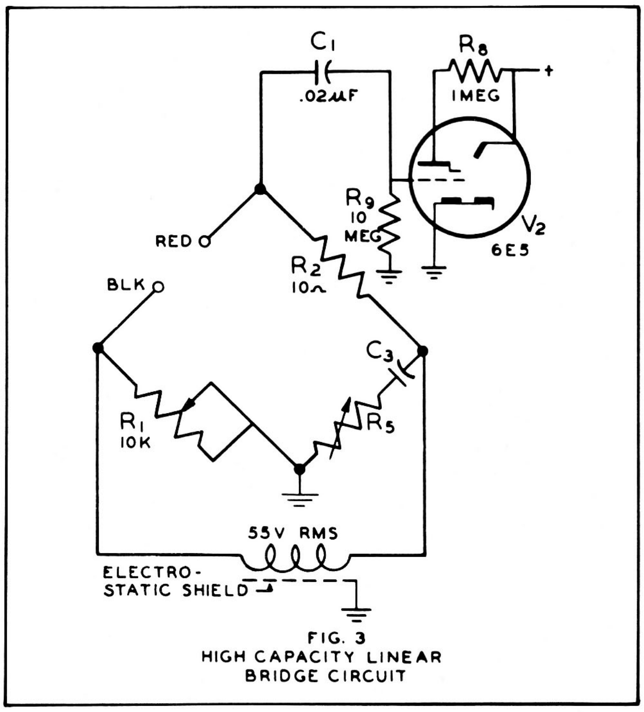


Figure 3. Bridge Circuit for HIC Range, Simplified Schematic Diagram

SIZE OF CAPACITOR	SWITCH SETTING	READ ON SCALE (CAPACITY MFDS.)	MULTIPLY READING BY
10 uuf to 1000 uuf	C x .0001	C, C x .01, C x .0001	0.0001
1000 uuf to 0.1 uf	C x .01	C, C x .01, C x .0001	0.01
0.1 uf to 50 uf	C	C, C x .01, C x .0001	1.0
50 uf to 2000 uf	HIC	HIC	1.0

Note. 1000 uuf = 0.001 uf.

(2) Plug the Bridge test leads into the pin jacks marked C-R, LEAKAGE, I-R. Connect the clips at the other end of the test leads securely to the terminals or leads of the capacitor under test.

(3) Set the METER RANGE switch to the 5 MA position.

(4) Apply operating power to the Analyzer by turning the ADJUST VOLTS control knob clockwise. Set the control to about 450.

(5) After allowing the equipment to warm up for at least one minute, slowly rotate the main bridge control until a null condition is obtained, as indicated by the widest possible opening of the wedge on the electron-ray indicator tube.

(6) To determine the capacitance, obtain the reading from the appropriate scale, and multiply by the proper scale factor as indicated by the setting of the master selector switch.

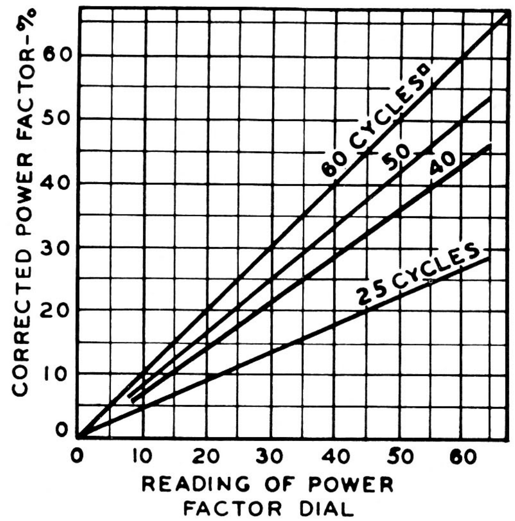
(7) To check electrolytic capacitors, balance the bridge as in step (5), above. Set the POWER FACTOR control for maximum opening of the indicator wedge. Then reset the main bridge control for maximum opening. Since these two controls interact, readjust one and then the other, alternately, until the widest wedge is obtained and no further change can be observed. Both capacitance and power factor now can be read directly from the respective scales. If the line-power frequency is of a value other than 60 cycles, refer to the appropriate curve shown in figure 4 for the true power factor at such frequency.

CAUTION

When measuring a capacitor in excess of 100 uf, the capacitor should not be left connected to the bridge terminals any longer than necessary to obtain satisfactory reading. High capacitances may overload the main bridge potentiometer and damage the instrument (see figure 4).

(8) If a capacitor gives a null reading on all four ranges at the OPEN dial position only, the capacitor is open-circuited and should be replaced. Similarly, if a capacitor can be nulled only at the SHORT position on all four ranges, it is "shorted". A capacitor which normally should balance on one of the "C" ranges of the bridge, but will not, has a high power factor and should be replaced.

c. LOW-CAPACITANCE MEASUREMENTS. In order to minimize significant errors due to stray wiring capacitance when testing capacitors smaller than about 1000 uuf, lead length must be kept as short as possible. Where possible,



ᵅ= SCALE ON PANEL

FIG. 4

POWER FACTOR VS POWER LINE FREQUENCY

Figure 4. Power Factor Calibration Curves

it is recommendd that the capacitor lead be inserted directly into the C-R, LEAKAGE, T-R pin jacks on the panel.

d. VERY-LOW-CAPACITANCE MEASUREMENTS. When measuring mica-, air-, or ceramic-dielectric capacitors of 25 uuf or less, the substitution method is recommended. Connect a 100-uuf capacitor to the C-R, LEAKAGE, I-R test jacks and balance the bridge. Record this reading. Shunt the small capacitor to be measured across the capacitor already connected. Balance the bridge again and note the new reading. Subtract the first reading from the second. The difference is the unknown capacitance.

e. SUPPLEMENTARY DATA.

(1) ADJUST VOLTS SETTING. The setting of the ADJUST VOLTS control may be any desired value which gives a bright green color to the screen of the electron-ray indicator. The optimum position is at about three-fourths of full rotation, or approximately 450 on the scale. The setting is not critical.

(2) INTERMITTENT CAPACITORS. Intermittent short circuits in capacitors connected to the Analyzer will cause a noticeable fluctuation of the indicator wedge (refer to subparagraph 2–3a(6)). Such capacitors should be replaced.

(3) CAPACITANCE TOLERANCE — MOTOR-STARTING ELECTROLYTICS. The capacitance of an AC motor-starting electrolytic capacitor should not be less than 80% of its

rated value. A lower value will not provide sufficient starting torque for the motor.

(4) CAPACITANCE TOLERANCE—DC ELECTROLYTICS. In the case of DC electrolytic capacitors, replacement should be made of those units whose capacitance has fallen to less than 70% of their rated values. From the viewpoint of circuit operation, there is usually no upper capacitance limit on the value of capacitors used for filter and bypass purposes. An exception to this sometimes applies to capacitors used at the input of RC filters, where rectifier tube characteristics limit the maximum capacitance. The recommended tolerances for new dry electrolytic capacitors, as given in the RETMA standards, are listed below:

WORKING VOLTAGE	TOLERANCE (FROM RATED NOMINAL CAPACITANCE)
0–50	—10%, +250%
51–350	—10%, +100%
351–450	—10%, +50%

(5) CAPACITANCE TOLERANCE — TUBULAR PAPER-DIELECTRIC CAPACITORS IN NON-METALLIC CASES. Recommended tolerances for tubular paper capacitors, as given in the RETMA standards, are as follows:

NOMINAL CAPACITANCE (uf)	CAPACITANCE TOLERANCE
0.001	—25%, +60%
0.002 0.003 0.005	—20%, +40%
0.01 0.02 0.03 0.05 0.10	—20%, +20%
0.15 0.25 0.50 1.00	—10%, +20%

From the viewpoint of circuit operation, a wide tolerance is normally acceptable in capacitors used in filter, bypass and coupling circuits. There is a rather widespread impression in the radio and television service field that metal-encased capacitors are made to tighter tolerances than others. This is not so. Even capacitors which meet military specifications are acceptable with tolerances as wide as —25%, +60%.

(6) CAPACITANCE TOLERANCE — CERAMIC AND MICA CAPACITORS. Uncoded and unmarked ceramic and mica capacitors are generaly within ±20% of their rated values. Color-coded capacitors indicate other standard tolerances, as follows: ±2%, ±3%, ±5%, ±10%, and ±20%.

(7) POWER FACTOR—AC ELECTROLYTICS. AC motor-starting electrolytic capacitors generally should be replaced if their power factor is greater than 20%.

(8) POWER FACTOR—DC DRY ELECTROLYTICS. The power factor of new DC dry electrolytic capacitors at 60 cycles usually will be lower than the figures in the second column of the table below. If the power factor has increased beyond the figure listed in the third column of the table, the capacitor should be replaced. In the case of multiple-section capacitors containing sections operating at 50 volts or less, in combination with sections rated at 301 volts or more, the power factor of the low-voltage section(s) usually will be higher than the value given in the second column of the table, but lower than that given in the third column. This should be borne in mind when determining whether a low-voltage electrolytic capacitor in a multiple unit needs replacement.

WORKING VOLTAGE	MAXIMUM 60-CYCLE POWER FACTOR (WHEN NEW)	POWER FACTOR LIMIT (REPLACE IF HIGHER)
450	15%	35%
400	15%	35%
350	15%	35%
300	15%	35%
250	18%	35%
150	20%	40%
50	25%	50%
25	30%	55%
15	50%	60%
10	55%	65%
6	60%	70%

(9) POWER FACTOR—DC WET ELECTROLYTICS. The 60-cycle power factor for new wet electrolytic capacitors should be less than the figures given below.

PEAK VOLTAGE	POWER FACTOR
600	65%
550	55%
500	45%
450	40%
400	40%
300	35%

3–2. RESISTANCE.

a. FUNCTIONAL DESCRIPTION. A conventional AC Wheatstone bridge is used for making resistance measurements. It has two ranges. A simplified schematic diagram is shown in figure 5.

RESISTANCE	SWITCH SETTING	READ ON SCALE (OHMS)	MULTIPLY READING BY
100–10,000 ohms	R x 1000	R x 1000, R x 100,000	1,000
10,000 ohms–25 megohms	R x 100,000	R x 1000, R x 100,000	100,000

b. OPERATING PROCEDURE.

(1) Set the master selector switch to the correct range for the resistor being measured (see table above):

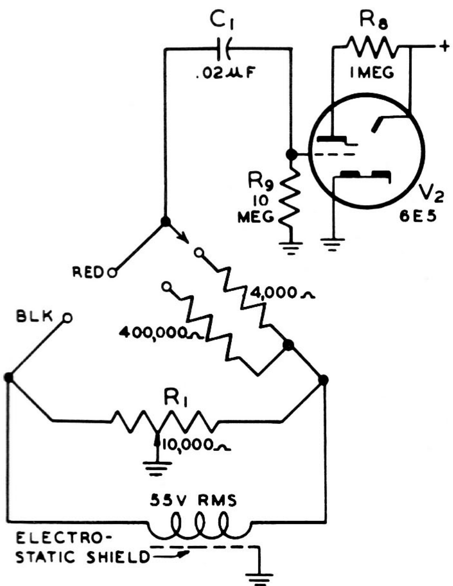


FIG. 5
A.C. WHEATSTONE
RESISTANCE CIRCUIT

Figure 5. Wheatstone Bridge Circuit Used for Resistance Measurements

(2) Set the METER RANGE switch to the 5 MA position.

(3) Connect the Bridge test leads to the pin jacks marked C-R, LEAKAGE, I-R. Connect the clips at the other end of the test leads securely to the terminals or leads of the resistor under test.

(4) Apply operating power to the CRA–1 by turning the ADJUST VOLTS control knob clockwise. Set the control to about 450.

(5) After allowing the equipment to warm up for at least one minute, slowly rotate the main bridge control until a null condition is obtained, as indicated by the widest possible opening of the wedge in the electron-ray indicator.

(6) Obtain the reading from the appropriate scale, and multiply by the proper scale factor as indicated by the setting of the master selector switch (refer to (1), above) to determine the actual resistance.

c. SUPPLEMENTARY DATA.

(1) LOW-RESISTANCE MEASUREMENTS. To obtain more accurate measurement of low resistances, or to extend the range of the bridge to values below 100 ohms, use of the substitution method is recommended. Connect a 500- or 600-ohm resistor to the C-R, LEAKAGE, I-R test jacks and balance the bridge. Record this reading. Then connect the resistor to be measured in series with the resistor already connected. Rebalance the bridge and note the new reading. Subtract the first reading from the second. The difference is the desired resistance.

(2) LIMITATIONS OF USE. Since an AC source is used for making measurements on the bridge, the Analyzer cannot be used to make accurate resistance measurements of the windings of iron-core inductances.

3–3. INSULATION RESISTANCE.

a. FUNCTIONAL DESCRIPTION. The test circuit used for making insulation resistance measurements is shown in figure 6. The bias voltage on the grid of a triode is controlled by the leakage current through the component under test, thus controlling the flow of plate current through the tube. A milliammeter in the plate circuit of the triode reads the change in plate current. The meter is calibrated to read directly in megohms.

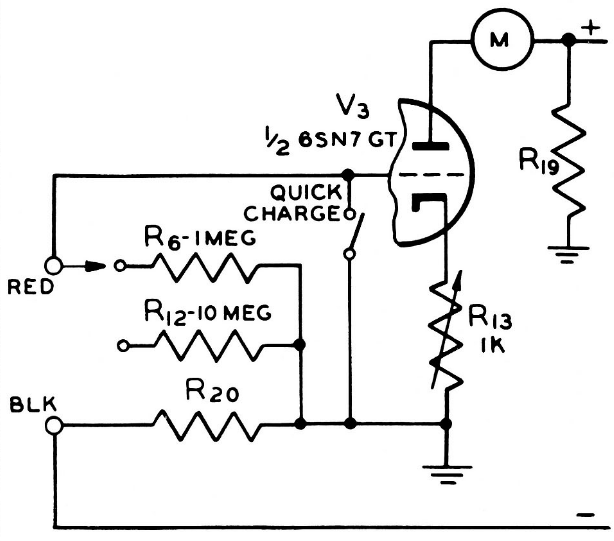


FIG. 6
INSULATION RESISTANCE
MEGOHMS CIRCUIT

Figure 6. Insulation Resistance Test Circuit

b. OPERATING PROCEDURE.

(1) Set the master selector switch to the correct range for the insulation resistance of the component being tested (see table on page 8):

INSULATION RESISTANCE	SWITCH SETTING	MULTIPLY READING BY
5–2000 megohms	MEGOHMS	1
50–20,000 megohms	MEGOHMS x 10	10

Note

If the range of the insulation resistance to be measured is not known, try the MEGOHMS range first.

(2) Set the METER RANGE switch to the 5 MA position.

CAUTION

Make sure that the QUICK CHECK switch is in the OFF position.

(3) Plug the Bridge test leads into the pin jacks marked C-R, LEAKAGE, I-R.

CAUTION

Never use the Quick Check test leads for insulation resistance measurements.

(4) Apply operating power to the CRA–1 by turning the ADJUST VOLTS control knob clockwise.

(5) After allowing a one-minute warm-up period, set the ADUST VOLTS control for full-scale (∞) deflection of the meter needle.

(6) Connect the clips at the other end of the test leads securely to the terminals or leads of the capacitor (or resistor) to be measured.

(7) Obtain the reading from the MEGOHMS scale of the meter and, if necessary, multiply by the proper scale factor as indicated by the setting of the master selector switch (refer to (1), above) to determine the actual resistance.

(8) When measuring the insulation resistance of low-valued capacitors, immediate readings may be taken. When measuring capacitances of higher values, time must be allowed for the capacitor to charge before taking the reading. The QUICK CHARGE toggle switch should be operated for about one second and then released. A correct reading is obtained only after a two-minute electrification time (by definition). An indication that the insulation resistance is satisfactory, however, usually will be obtained in a much shorter time.

Note

Because of tube and circuit parameters, the minimum reading on the MEGOHMS scale will be approximately 5 megohms.

c. SUPPLEMENTARY DATA.

(1) In most applications, 50 megohms is an adequate insulation resistance value at the ambient temperature of the equipment. The insulation resistance of coupling capacitors should be greater than 200 megohms.

(2) The insulation resistance requirement for new mica capacitors in the RETMA classification "A" is 300 megohms or more; for new ceramic capacitors and mica capacitors in other RETMA classifications, the requirement is 6000 megohms or more.

(3) The insulation resistance limit proposed by RETMA for new halowax or mineral-oil impregnated, wax-filled or wax-molded tubular paper capacitors is expressed as an insulation resistance-capacitance product (megohms x microfarads). Its value is 1000 megohm-uf. For the smaller values of capacitance the insulation resistance need not exceed 5000 megohms, however, regardless of the megohm-uf product.

(4) Industry limits for commercial metal-encased oil-impregnated or oil-filled capacitors are as follows:

IMPREGNANT	I-R x C LIMIT (MEGOHMS x UF)	"NEED NOT EXCEED" VALUE (MEGOHMS)
Vegetable Oil	400	1200
Mineral Oil	1200	3600
Chlorinated Synthetic Oil	1750	4250

Note

All the values above are for measurements at 25°C (77°F). Insulation resistance decreases very rapidly as the temperature increases. For example, the insulation resistance of a wax-filled tubular paper capacitor at 65°C (149°F) is only about 5% of its value at 25°C (77°C).

3–4. LEAKAGE CURRENT OF ELECTROLYTIC CAPACITORS.

a. FUNCTIONAL DESCRIPTION. Figure 7 is a simplified schematic diagram of the circuit used for measuring the leakage current of electrolytic capacitors at the rated DC working voltage. The principal features of the circuit are a continuously-adjustable DC voltage supply, and a milliammeter to indicate either the leakage current or the voltage across the capacitor, depending upon how it is used. The range of the milliammeter can be increased by changing the setting of the METER RANGE switch. Operating the METER RANGE switch to the 60 VOLTS or 600 VOLTS position changes the meter circuitry to indicate the voltage applied to the capacitor under test. This voltage is controlled by the position of the ADJUST VOLTS potentiometer, which sets the control grid voltage of the 6L6 grid-controlled rectifier tube. For measuring capacitors whose DC working voltage is over 60 volts, the screen grid of the 6L6 is connected to the plate. When checking capacitors of less than 60 volts DC rating, the VOLTS D.C. switch connects the screen grid of the 6L6 to its control grid. This permits closer control of the test voltage.

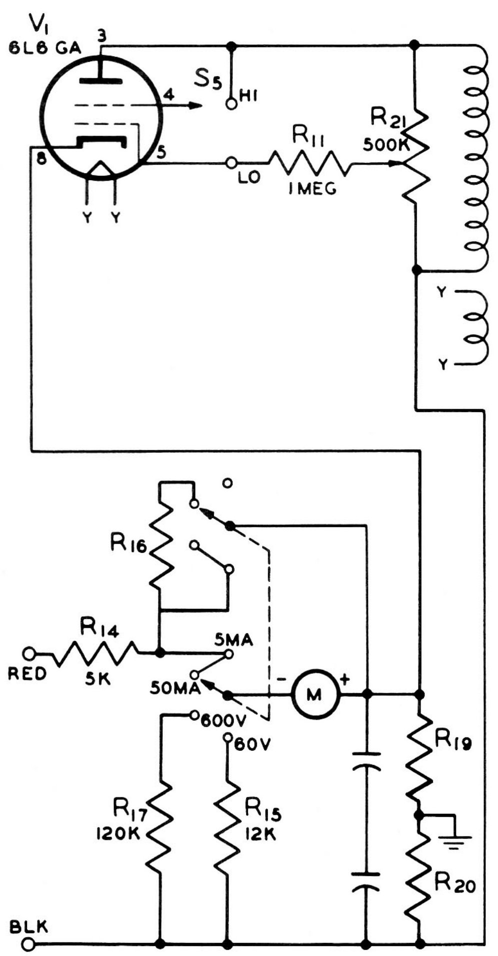


FIG. 7
ELECTROLYTIC CAPACITOR LEAKAGE CURRENT
& ADJUSTABLE VOLTAGE TEST CIRCUIT

Figure 7. Leakage-Current Test Circuit

b. OPERATING PROCEDURE.

(1) Set the master selector switch to LEAKAGE.

(2) Set the METER RANGE switch to the 50 MA position.

CAUTION

Make sure that the QUICK CHECK switch is in the OFF position.

(3) Connect the Bridge test leads to the pin jacks marked C-R, LEAKAGE, I-R. Be sure to observe polarity and color-coding.

(4) Place the VOLTS D.C. switch in the LO position when testing capacitors whose rated working voltage is less than 60 volts DC; set the switch in the HI position when testing capacitors whose rated DC working voltage is over 60 volts.

CAUTION

When set in the LO position for a test, the switch must remain in this position until the test has been completed.

(5) Apply operating power to the CRA–1 by turning the ADJUST VOLTS control knob clockwise. Do not turn the knob beyond 50.

(6) Set the METER RANGE switch for the 60 VOLTS or 600 VOLTS range, depending upon the voltage rating of the capacitor to be checked. After a one-minute warm-up period, turn the ADJUST VOLTS control until the meter indicates the rated working voltage of the capacitor (V.D.C. scale). Return the switch to the 50 MA range.

(7) Connect the clips at the other end of the test leads securely across the terminals or leads of the capacitor to be checked. Be careful to observe polarity; connect the red lead to the + terminal or lead, and the black lead to the — terminal or lead.

(8) Read the leakage current directly on the 50 MA D.C. scale of the meter. If the current reading is lower than 5 ma, the METER RANGE switch may be turned to the 5 MA position to increase the accuracy.

CAUTION

Except when actually taking low leakage-current readings, the METER RANGE switch should always be kept in the 50 MA position. If this is not done, the meter may be damaged by a capacitor that is shorted or has high leakage current.

c. SUPPLEMENTARY DATA.

(1) When electrolytic capacitors have not been in use for long periods of time, they must be "formed" before the voltage and leakage-current conditions can be stabilized. If time is available, this can be done by first applying 50–60% of the rated voltage to the capacitor, allowing it to remain at this voltage until the leakage current has dropped to below 10 ma. Time can then be saved by applying 80–90% of the rated voltage to the unit and continuing to readjust the applied voltage to keep the leakage current below 10 ma. As the leakage current drops, the DC voltage across the capacitor will increase. The final voltage reached should not exceed the rated working voltage.

(2) After the rated working voltage has been applied for 30 minutes or so, the leakage current of most dry electrolytic capacitors will drop to 2 ma or less. If the reading is much greater, it should be compared with the RETMA standard given below before discarding the capacitor. A value greater than 2 ma is allowed by RETMA for high-voltage capacitors of high-capacitance value. If there is considerable fluctuation in the leakage current, the capacitor may be intermittent or defective, and should be replaced.

CAUTION

If a leakage-current reading of more than 15 ma continues for longer than one minute at the rated voltage, reduce the applied voltage so that the current drops to less than 15 ma. Readjust the voltage periodically until the rated voltage level has been reached. If this caution is not observed, severe overheating and damage to the capacitor may occur.

(3) The leakage current for new dry electrolytic capacitors meeting RETMA standards should never exced 10 ma. RETMA has proposed the following formula for calculating such leakage current limits:

$$I = KC + 0.3$$

where I = leakage current in milliamperes
C = rated capacitance in microfarads
K = a constant as given in the table of the following column:

DC WORKING VOLTS	K
3–100	0.01
101–250	0.02
251–350	0.025
351–450	0.04

Allow capacitors to remain connected to the test voltage for at least five minutes before taking readings. When using these limits as a guide, remember that age and exposure to high temperatures will increase the leakage current.

(4) The formula proposed by RETMA for the leakage current of new wet electrolytic capacitors is

$$I = KC$$

where I = leakage current in milliamperes
K = a constant as given in the table in next column:

DC PEAK VOLTS	K
300	0.10
400	0.15
450	0.20
500	0.25
600	0.30

3–5. CONTINUITY CHECKS.

a. FUNCTIONAL DESCRIPTION. The circuit used for continuity checks is identical with that used for leakage-current tests. It is shown schematically in figure 7.

b. OPERATING PROCEDURE.

(1) Set the master selector switch to LEAKAGE.

(2) Set the METER RANGE switch to the 50 MA position.

(3) Connect the Bridge test leads to the pin jacks marked C-R, LEAKAGE, I-R.

(4) Place the VOLTS D.C. switch in the HI position.

(5) Apply operating power to the CRA–1 by turning the ADJUST VOLTS control knob clockwise. Allow at least one minute for the equipment to warm up.

(6) Short-circuit the clips at the remote end of the test leads. Turn the ADJUST VOLTS control until the meter needle indicates 15 ma or somewhat less. With a reading of 15 ma, the test potential available at the test leads is approximately 120 volts. If the meter reading is higher than 15 ma, the test voltage is proportionately higher.

(7) Unshort the test lead clips. The equipment is now set up to make continuity tests.

(8) Connect the test-lead clips across the circuit or component to be tested. If the meter needle shows definite movement, there is continuity in the circuit. If the meter needle remains at rest, the circuit is open.

4. MAINTENANCE AND SERVICE NOTES

4–1. REMOVAL OF CRA–1 FROM CASE.

Remove two screws from the rear and six screws from the side of the case. Carefully lift the Analyzer chassis from the case.

CAUTION

Do not, under any circumstances, loosen, readjust or remove the knob from the main bridge control.

4–2. READJUSTMENT PROCEDURE FOR QUICK CHECK CIRCUIT.

a. TRIMMER CAPACITOR C13. The oscillator frequency is controlled by capacitor C13. A very slight turn of this capacitor generally is all that is required to obtain the desired condition.

(1) Turn the ADJUST VOLTS control clockwise to apply power to the instrument.

(2) Set the QUICK CHECK switch to ON. Connect the Quick Check test leads to the QUICK CHECK pin jacks on the front panel.

(3) Adjust trimmer capacitor C13 through the hole marked F on the bottom of the case (without removing the chassis from the case) until the wedge on the electron-ray

indicator changes sharply from a narrow wedge to a wide wedge position. The green color on the indicator face should become slightly darker at this point, which is very critical. This condition is known as "oscillator plop". The indicator wedge should remain in the wide-open position and should not vary, except for a very slight flicker when the red test clip is held in the hand.

b. CAPACITOR C6. Perform the following steps after trimmer capacitor C13 has been adjusted.

(1) Short-circuit the test clips.

(2) Operate the "L" toggle switch. The indicator wedge should be wide open.

(3) If it is not wide open, adjust C6 until it is.

4–3. OSCILLATOR TUBE FAILURE.

Sometimes a 6SN7 oscillator tube is replaced with a new one that fails to oscillate, even though the tube checks perfectly in a tube tester. The practical solution for this is to try another 6SN7GT.

4–4. RETURNING EQUIPMENT FOR FACTORY SERVICING.

If your Pyramid Analyzer should ever require factory adjustment or recalibration of any kind, always write to the Pyramid Electric Co. for detailed shipping instructions before returning the instrument. In all your correspondence, be sure to mention the model and serial numbers, and also the defect and symptoms observed.

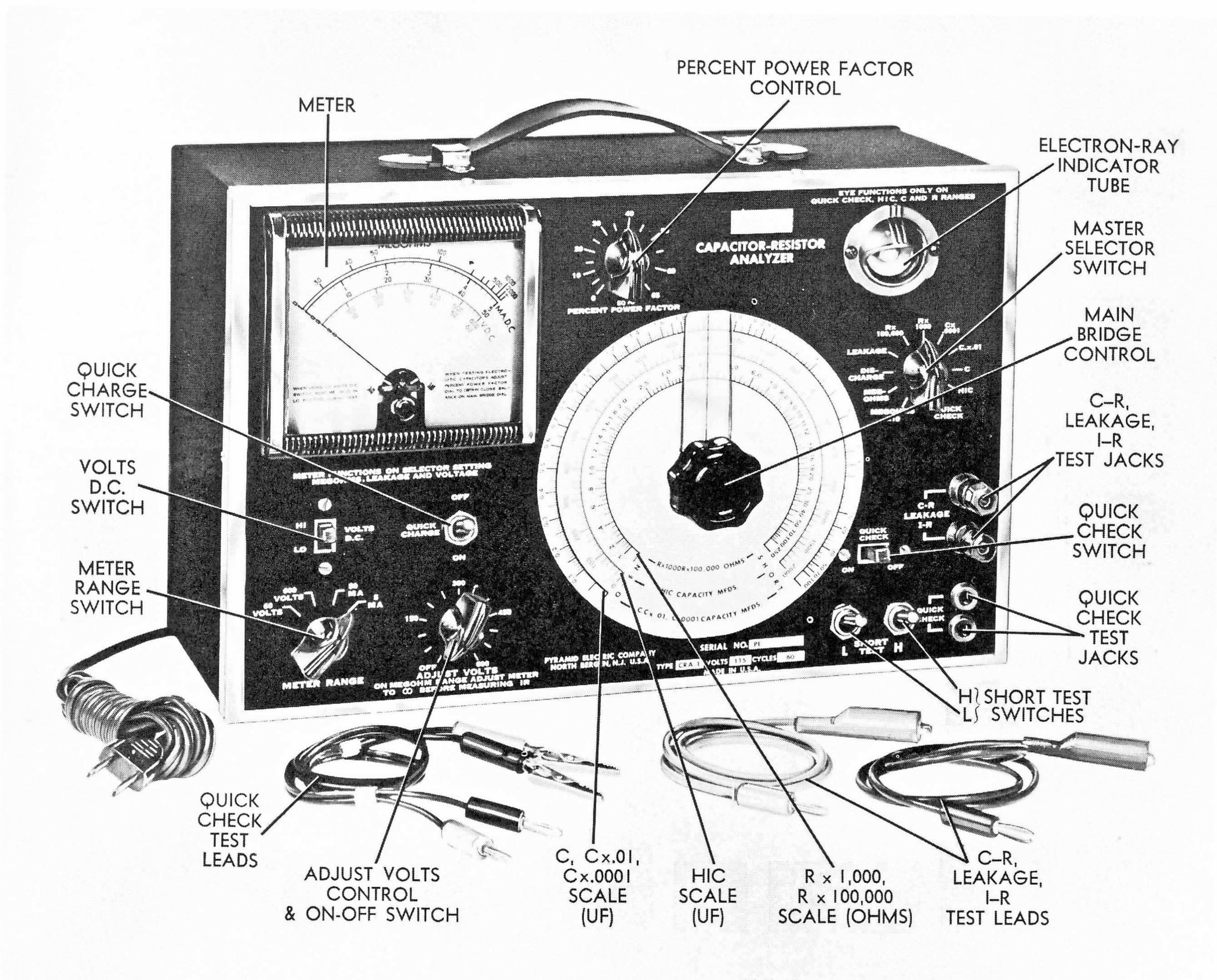


Figure 8. CRA–1 Front Panel

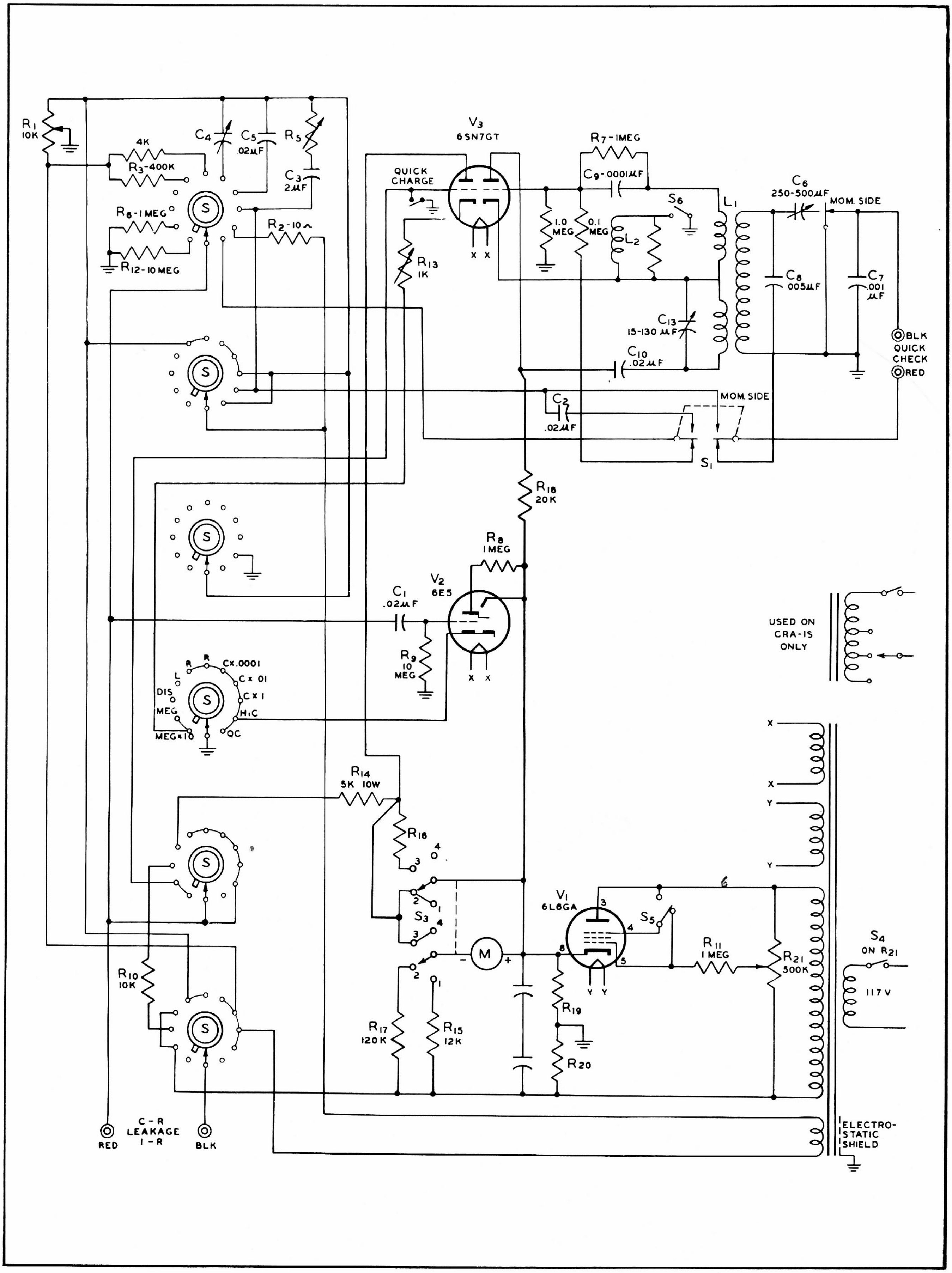


Figure 9. CRA–1 Schematic Diagram

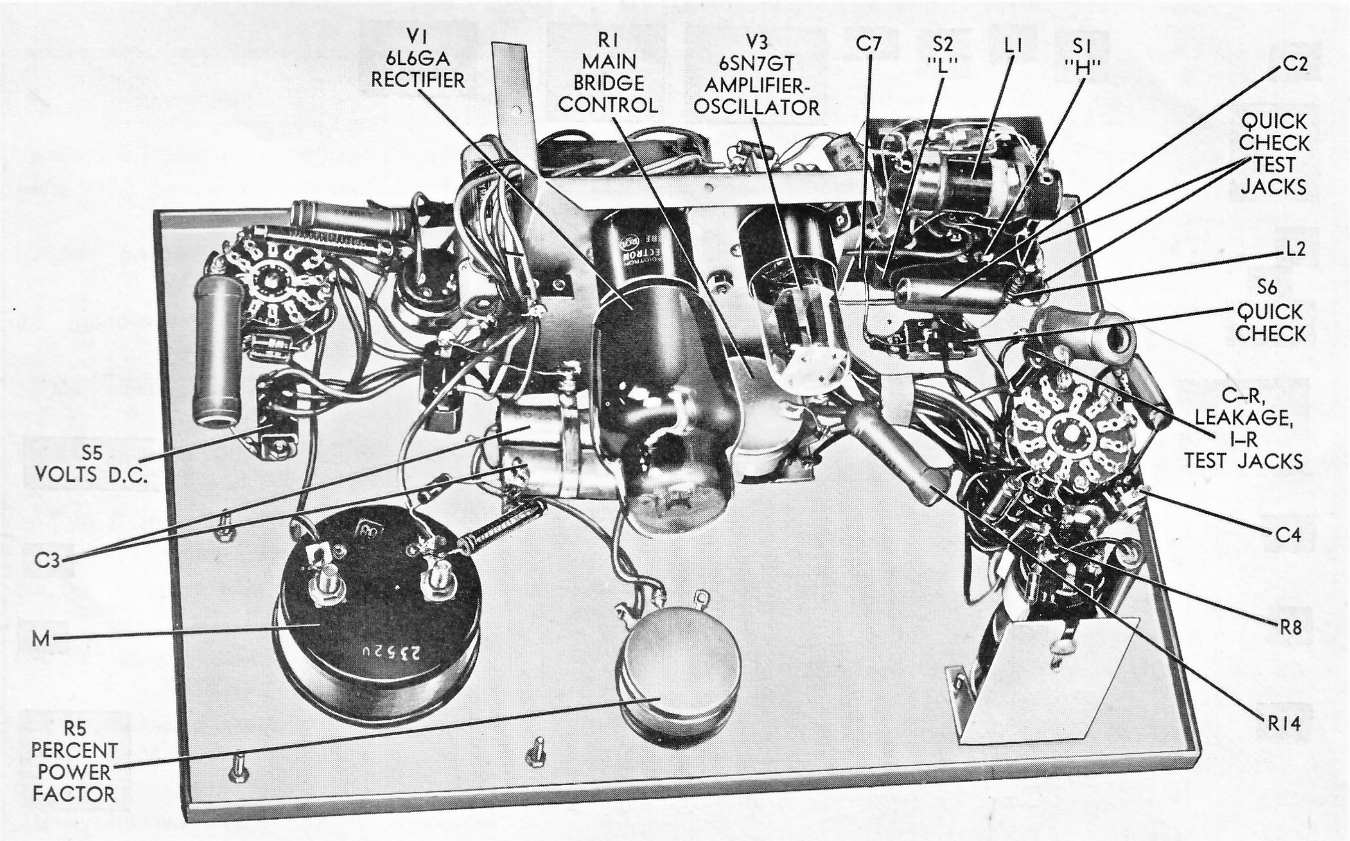


Figure 10. Top Rear View of Panel

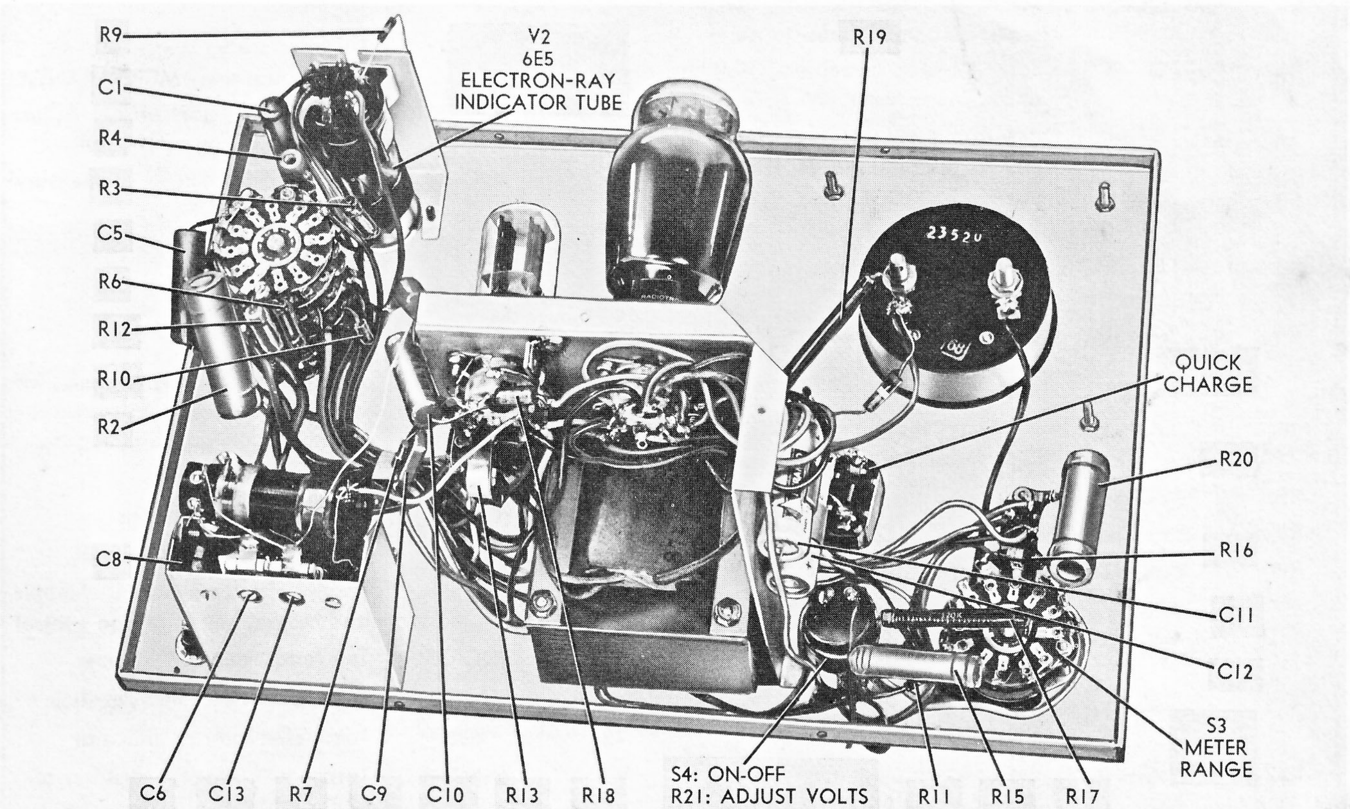


Figure 11. Bottom Rear View of Panel

5. MAINTENANCE PARTS LIST

CIRCUIT SYMBOL	REPLACEMENT PART NO.	DESCRIPTION
C1, C2	Pyramid Cat. No. 85TOC6–S2	Capacitor, paper .02 uf, 600 VDCW
C3	Pyramid Cat. No. 85TOC6–S2 special	Capacitor, paper .02 uf, 600 VDCW, bridge standard
C5	Pyramid Cat. No. PGIX	Capacitor, paper, 2 uf $\pm$1%, bridge standard, matched pair
C4	QC–1	Capacitor, adjustable, bridge standard
C6	QC–2	Capacitor, adjustable, used for "L" Quick Check short test adjust
C7	QC–2	Capacitor, mica, .001 uf, 500 VDCW
C8	QC–2	Capacitor, mica, .005 uf, 500 VDCW
C9	QC–2	Capacitor, mica, .0001 uf, 500 VDCW
C11, C12	Pyramid Cat. No. TD–8–450	Capacitor, electrolytic, 8 uf, 450 VDCW
L1	QC–3	Coil, oscillator, to spec.
L2	QC–4	Coil, RF, to spec.
M	QC–5	Meter, 0–5 ma DC with special scale, 25 ohms DC resistance
R1	QC–6	Potentiometer, precision, 10,000 ohms, linear taper, 4W
R2	QC–7	Resistor, wire wound, 10 ohms $\pm$2%, 20 W, bridge standard
R3	QC–8	Resistor, 400,000 ohms $\pm$2%, 1 W, bridge standard
R4	QC–9	Resistor, 4,000 ohms $\pm$2%, 5 W, bridge standard
R5	QC–10	POWER FACTOR Potentiometer, precision, 1,030 ohms, linear taper, 4 W
R6	QC–11	Resistor, 1 megohm $\pm$2%, 1 W, high stability
R7, R8	QC–12	Resistor, 1 megohm $\pm$20%, ½ W
R9	QC–13	Resistor, 10 megohms $\pm$20%, ½ W
R10	QC–14	Resistor, 10,000 ohms $\pm$20%, 1 W
R11	QC–12	Resistor, 1 megohm $\pm$20%, ½ W
R12	QC–15	Resistor, 10 megohms $\pm$2%, 1 W, high stability
R13	QC–16	Resistor, adjustable, 1,000 ohms
R14	QC–17	Resistor, wire wound, 5,000 ohms $\pm$10%, 10 W
R15	QC–18	Resistor, wire wound, 12,000 ohms $\pm$2%, 10 W
R16	QC–19	Resistor, shunt calibrating, 2.8 ohms
R17	QC–20	Resistor, 120,000 ohms $\pm$2%, high stability
R18	QC–21	Resistor, 20,000 ohms $\pm$10%, 1 W
R19	QC–22	Resistor, 60,000 ohms, 3 W, precision high stability
R20	QC–23	Resistor, wire wound, 60,000 ohms $\pm$3%, 20 W
R21	QC–36	Resistor, wire wound, 60,000 ohms $\pm$3%, 20 W
S	QC–24	Switch, rotary, 6 sections, 11 positions per section, Master Selector
S1	QC–25	Switch, toggle, network, DPDT, ST–52R, momentary one side, "H" SHORT TEST
S2	QC–26	Switch, toggle, SPDT, ST–42F, momentary one side, "L" SHORT TEST
S3	QC–27	Switch, rotary, single section, 2 pole, 4 position, METER RANGE
S4	QC–36	Switch, SPST, part of R21 Adjust Volts control; on-off
S5	QC–29	Switch, slide, SPDT, momentary one side, HI-LO.
S6	QC–30	Switch, slide, SPST, QUICK CHECK
T	QC–31	Transformer, power, to spec., for 115 V, 60 cycles
TX	QC–31	Transformer, power, to spec., for 115–230 V, 25–50 cycles
	QC–465	Test leads, Quick Check, adjusted
	QC–32	Handle, with two loops
	QC–33	Rubber feet, 8 per package
	QC–34	Knob, with transparent pointer and hairline; main bridge control
	QC–35	Test leads, general purpose
V1	6L6GA	Tube, grid-controlled rectifier
V2	6E5	Tube, electron-ray indicator
V3	6SN7GT	Tube, twin-triode, oscilator-amplifier

A maintenance parts price list is available upon request.

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