INSTRUCTION MANUAL
PHILCO ELECTRONIC CIRCUIT MASTER
MODEL 7001

FOR THE
RADIO SERVICEMAN—RADIO AMATEUR—EXPERIMENTER
PUBLIC-ADDRESS SPECIALIST—AND RADIO-ELECTRONICS ENGINEER

The Philco Electronic Circuit Master, Model 7001 (see figure 1), is one of the most useful and versatile test instruments ever offered to the radio technician. The Electronic Circuit Master is capable of making all the measurements required by the everyday work of the serviceman—it is capable of more than this—with the High-Frequency Probe, Philco Part No. 45-1547 (see figure 2), the range of this instrument is extended so that radio and high audio-frequency measurements can be made; hence, it is possible to make delicate measurements easily and simply at high frequencies with a minimum of test equipment. The Electronic Circuit Master employs a sensitive vacuum-tube bridge, and operates entirely from the 110-volt, a-c power line (its accuracy is unaffected over a range of line voltage variations of from 105 to 125 volts); batteries are not required for any measurements. An outstanding design feature is embodied in the use of resistors of a new type. These resistors are specially coated for protection against moisture and abrasion. They can stand an overload of 200% for as long as fifteen minutes without a permanent change in value. Changing temperatures have practically no effect on their value (the temperature coefficient is less than .00045 per degree Centigrade). Thus a maximum possible change in accuracy of $\pm 1/4$ of 1 per cent (for resistors below one megohm), and ± 1 per cent (for resistors above one megohm) is maintained under any possible conditions. Because these resistors are employed wherever a precision resistor is required, an amazing degree of accuracy is maintained under all conditions. Another design feature is the use of a fuse in series with the common voltage lead and the case for protection against accidental contact of the case with ground when measuring a-c or d-c line voltages. Regardless of whether it is desired to measure the capacitance between two cabled leads in a radio, the a-v-c voltage on the grid of an r-f amplifier tube, the r-f excitation voltage applied to the grid of a transmitting radio-frequency amplifier, or the load current of a ½-hp a-c motor at full load, the Electronic Circuit Master can do the job.

TP-3273

Figure 1. Philco Electronic Circuit Master, Model 7001

Specifications

GENERAL

Overall Dimensions: Width 6½"; depth (probe cables attached), 8"; height, 12½"

Weight: 10 lbs. (probe cables attached)

Operating Voltage: 110—120 volts, 60 cycles, a.c.

Power Consumption: 25 watts (at 117 volts, 60 cycles)

Tube Complement:
- 1 6SN7 electronic bridge
- 2 7B5 bridge amplifiers
- 1 7Y4 rectifier

D-C VOLTAGE

Ranges: 1, 3, 10, 30, 100, 300, 1000, and 10,000 volts; up to 30,000 volts when used with the special high-voltage multiplier and cable, Philco Part No. 45-1550

Internal Resistance of Voltmeter: 15 megohms, fixed, up to 1000 volts; 100 megohms at 10,000 volts

Accuracy: ±3% of full scale on all ranges

D-C CURRENT

Ranges: 1, 10, and 100 milliamperes; 1 and 30 amperes

Accuracy: 1 milliampere range, ±2% of full scale; all other ranges, ±5% of full scale

A-C VOLTAGE

Ranges: 1, 3, 10, 30, 100, 300, 1000, and 10,000 volts (60 cycles); up to 30,000 volts when used with the special high-voltage multiplier and cable, Philco Part No. 45-1550
1, 3, 10, 30, and 100 volts (50—5000 cycles, audio)

Internal Resistance of Voltmeter: 15 megohms, fixed, up to 1000 volts; 100 megohms at 10,000 volts

Accuracy:
60-cycle voltage, ±3% of full scale (all ranges)
50—5000-cycle audio voltages (1 to 100 volts), ±5% of full scale

A-C CURRENT
Range: 10 amperes, fixed
Accuracy: ±5% of full scale

RADIO AND AUDIO-FREQUENCY VOLTAGE
Ranges:
When used with the Philco High-Frequency Probe, Philco Part No. 45-1547
1, 3, 10, 30, 100, and 300 volts for frequencies between 400 cycles and 200 megacycles
Accuracy: ±5% of full scale from 3000 cycles to 30 megacycles. Subject to a correction factor for frequencies less than 3000 cycles and more than 30 megacycles
Internal Resistance: 2.7 megohms
Input Capacitance: 5.5 mmf., approximately

RESISTANCE
Ranges: 1000, 10,000, and 100,000 ohms; 1, 10, 100, and 1000 megohms
Accuracy: ±3% of mechanical length of scale

CAPACITANCE
Ranges: 500, 50, 5, and .5 mf.; 50,000 and 5000 mmf.
Accuracy: ±3% of mechanical length of scale

DECIBELS
Ranges: Reference level, 6 milliwatts (500-ohm line):
1-volt a-c range, –21.5 to –5.5 db
3-volt a-c range, –12 to +4 db
10-volt a-c range, –1.5 to +14.5 db
30-volt a-c range, +8 to +24 db
100-volt a-c range, +18.5 to +34.5 db
300-volt a-c range, +28 to +44 db
1000-volt a-c range, +38.5 to +54.5 db
Accuracy: ±3% of full scale of all ranges

CIRCUIT-MASTER ACCESSORIES

The Philco Electronic Circuit Master is supplied with two probes and a common lead. The probe fitted with the coaxial plug is used for all voltage measurements up to 1000 volts, for all capacitance and resistance measurements, and for current measurements up to 100 milliamperes. The other probe, fitted with a self-insulating plug, is supplied for high-voltage measurements (both a.c. and d.c.) up to 10,000 volts. The common lead, fitted with the banana plug and alligator clip, is used with either probe. External binding posts are provided for current measurements of 1 and 30 amperes, d.c., and 10 amperes, a.c. No leads are furnished for these posts; any insulated wire of No. 14 gauge, or heavier, will do.

To supplement and extend the use of the Electronic Circuit Master, the following additional accessories are available, and may be purchased separately, or with the Circuit Master:

1—High-Frequency Probe, Philco Part No. 45-1547 (see figure 2).

1—High-Voltage Probe, with built-in multiplier, Philco Part No. 45-1550.

The High-Frequency Probe is used to extend the frequency range of the Circuit Master a-c voltage measurement from 5000 cycles to 200 megacycles.

The High-Voltage Probe is used to extend the a-c and d-c voltage-measurement range from 10,000 to 30,000 volts.

SUMMARY OF CONTROL FUNCTIONS

Two switches and two controls are used to adjust the Philco Electronic Circuit Master for proper operation as outlined below:

"Function" Switch: 9-position rotary switch, rotates counterclockwise from OFF position and clockwise from PROBE position. Connects the instrument for measurements of: CAP (Capacitance); OHMS (Resistance); A.C. CURRENT; D.C. CURRENT; A.C. VOLTS; D.C. VOLTS, positive (+) or negative (–); in the PROBE position, high-audio-frequency and radio-frequency voltage measurements when used with the High-Frequency Probe.

"Range" Switch: 8-position rotary switch, selects ranges as marked on the front panel and is not used for A.C. CURRENT measurements which are fixed at 10 amperes, maximum. For direct current, voltage, capacitance, and resistance measurements, set switch to the desired range.

ZERO ADJUST Control: Potentiometer, sets meter to electrical zero position, provided mechanical zero-set screw has been properly adjusted to zero with "function" switch on D.C. CURRENT. This control is not used for resistance measurements on the RX 1 range.

OHMS CAP. ADJUST Control: Potentiometer, adjusts meter for full-scale reading on all OHMS and CAP. ranges.

PRELIMINARY ADJUSTMENT OF THE ELECTRONIC CIRCUIT MASTER

Insert the line-cord plug into any 110-volt, 60-cycle receptacle, and turn "function" switch to D.C. CURRENT.

1. Allow the Circuit Master to warm up for at least 10 minutes.
2. Check mechanical zero-set screw, on front of meter, for proper zero setting.
3. Connect coaxial probe connector to J101 at bottom of unit; and connect banana-plug lead, with alligator clip, to J100 (black receptacle between pilot lamp and coaxial receptacle).
4. Short-circuit probe to common-lead alligator clip, set "function" switch to A.C. VOLTS, and set "range" switch to V 1. Adjust ZERO ADJUST control for zero meter indication. If meter cannot be set to zero and it fluctuates when hand is touched to probe (with probe input shorted), replace fuse F100 inside the unit. See figure 12.
5. With probe input shorted, rotate "function" switch from –D.C. VOLTS to CAP. position. The meter should indicate zero on each position of the "function" switch except OHMS position. In the OHMS position, the meter-lead resistance will produce an indication of approximately a quarter of an ohm. Do not try to readjust the meter to zero in RX 1 position because the control has no effect.
6. With "function" switch in OHMS position and "range" switch in RX 10 position, remove short from

probe-input leads and adjust OHMS CAP. ADJUST control for full scale reading. Turn "function" switch to CAP. position, and readjust OHMS CAP. ADJUST control for full scale indication.

If the above adjustments can be made, the Circuit Master is ready for operation. Otherwise the unit should be checked for faulty operation.

PROBE ADJUSTMENT

When the High-Frequency Probe, Philco Part No. 45-1547, is to be used with the Electronic Circuit Master, the internal probe-calibration control (R127) must be set for zero indication. This adjustment is necessary because the probe diode always produces a "back" voltage, which must be cancelled before an accurate scale reading can be obtained. To adjust the H-F Probe for use with the Circuit Master, proceed as follows:

1. Remove the 12 front-panel screws and remove unit from its case.
2. Attach H-F Probe by connecting coaxial plug to J101 and the short lead with the banana plug to J100. See figure 2.
3. Adjust ZERO ADJUST control for zero meter indication on –DC position of "function" switch, then set "range" switch to V 1000 (to prevent too great an off-scale swing), and set "function" switch to PROBE position. Allow five minutes for probe diode to warm up.
4. Adjust R127 (on rear panel of Circuit Master, see figure 12) until meter indicates zero with the "range" switch at V1.

NOTE: Both the H-F Probe and the Circuit Master must be allowed sufficient time for stabilization; otherwise the zero-set adjustment may have to be repeated.

5. Replace the unit in its case, and tighten the 12 front-panel screws.

The unit is now ready for use with or without the H-F Probe. No further adjustment should be required, and probes may be interchanged as needed; however, small deviations from this zero setting may occur occasionally and these deviations are compensated for by adjusting the ZERO ADJUST control. If the H-F Probe is not purchased, leave R127 set at its maximum counterclockwise position, as adjusted at the factory.

FUNCTIONAL ANALYSIS OF THE VACUUM-TUBE VOLTMETER OF THE CIRCUIT MASTER

The vacuum-tube voltmeter employed in the Circuit Master is an electronic circuit which isolates the circuit under measurement from the meter element. This means that the circuit under test furnishes only a controlling signal to the Circuit Master, while the Circuit Master furnishes the power to operate the meter element. Thus it is possible to use a relatively rugged meter movement (0-1 ma. instead of 0-50 or 0-100 microamperes) for portability, while still achieving a maximum of sensitivity. The circuit employed provides for the measurement of a-c and d-c voltages and d-c current. When used with the High-Frequency Probe, the a-c voltage range is extended from the commercial and audio frequencies into the very high radio frequencies. An ohmmeter circuit is included, with an internal power supply, so that resistance measurements into the hundreds of megohms may be made without the use of batteries.

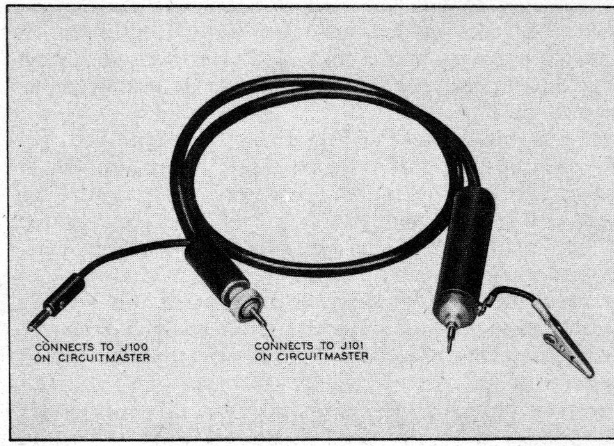

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Figure 2. Philco High-Frequency Probe, Part No. 45-1547

CIRCUIT DESCRIPTION OF THE CIRCUIT MASTER

Basically, two paralleled electronic bridge circuits are employed; one bridge is used to amplify the input signal and operate the other bridge circuit, across which the indicating meter is connected. See figure 3.

The input bridge circuit consists of the two 7B5 tubes and resistors R132 and R139. The screens of the tubes are connected to the plates, which are, in turn, directly connected to the grids of the 6SN7 twin-triode meter bridge. Use of low plate, screen, and filament voltages on the 7B5 tubes, together with a large negative voltage applied to the cathode circuit through a large value of resistance, provides degeneration and stability. The probe input is usually connected through attenuators or multipliers to ground and through the 5000-cycle compensating network of R131 (R131 also provides overload protection) and C110 to the grid of the one 7B5; the other 7B5 grid is grounded. Because the cathodes are connected directly through the ZERO ADJUST control (R135), any voltage appearing between the grid of the first 7B5 and ground also appears in opposite polarity across the cathode and grid of the grounded 7B5. Thus push-pull operation is obtained, providing greater sensitivity.

The meter bridge consists of the twin-triode 6SN7 and resistors R134, R138, and R137. The plates of the 6SN7 are tied in parellel; the cathodes are connected directly through the Balancing Control, R137.

When an unbalancing potential (input voltage) is applied to the grid of the 7B5 bridge, it is amplified in the plate circuit of these tubes, and applied as equal and opposite voltages to the 6SN7 bridge circuit. The meter bridge is connected so that when equal and oppositely polarized voltages are applied, the bridge is unbalanced; however, when equal voltages of the same polarity are applied, the bridge remains balanced. Thus plate voltage variations (produced by line-voltage fluctuations) or noise voltages in the plate or cathode circuits are cancelled, and do not interfere with the circuit operation. The indicating meter is connected across the cathodes of the twin-triode meter bridge and operates on the difference of potential between them.

The double-bridge arrangement is employed for more than one type of measurement; hence, for better understanding of circuit operation, the functional analysis of the Electronic Circuit Master is separated into each functional circuit application. The basic bridge circuit, shown in figure 3, is explained above; it is used for both positive and negative d-c voltage measurements. When switched from positive to negative or vice versa, the meter-lead connections are interchanged—as are the +DC (R108) and -DC (R116) calibrating controls. Separate calibrating controls are used because with the type of circuit used, a greater unbalance is obtained in the negative than in the positive direction, and separate calibration controls are necessary to avoid error when switching from one polarity to the other; otherwise the +DC and -DC circuits are identical.

The a-c voltage and a-c current-measurement circuits employ the basic bridge circuit and the usual voltage multipliers. These circuits are compensated by capacitance voltage dividers for frequencies up to 5000 cycles on the 1- to 100-volt ranges. See figure 4. Each range is adjusted at the factory for full-scale reading with the proper 5000-cycle calibrating potential applied. The a-c current-measurement circuit, shown in figure 4, utilizes the 0—1-volt a-c voltage-measuring circuit, with the input to the electronic bridge supplied through a voltage step-up transformer which is shunted by the 1-ampere d-c shunt, R115. At full-scale reading, the 10 amperes through this shunt produces a .5 volt drop across the transformer primary and an output of 1 volt from the secondary. The meter circuit employs a copper-oxide rectifier to provide d.c. for meter indications on any of the a-c voltage or current ranges. On a-c and d-c voltage ranges greater than 1000 volts, the common lead is no longer fused to ground; the fuse is shorted out by the rear wafer of S101E.

The d-c current-measuring circuit is shown in figure 5. This circuit and the RX 1 ohmmeter circuit are the only applications of the Circuit Master in which the electronic bridge is not used. A straightforward series meter circuit is employed, and appropriate shunts are switched in according to the range in use.

The capacitance-measuring circuit, shown in figure 6, employs the basic a-c voltage-measuring circuit. Approximately 1-volt a.c. is applied between the probe and ground, so that the reactance of the condenser de-

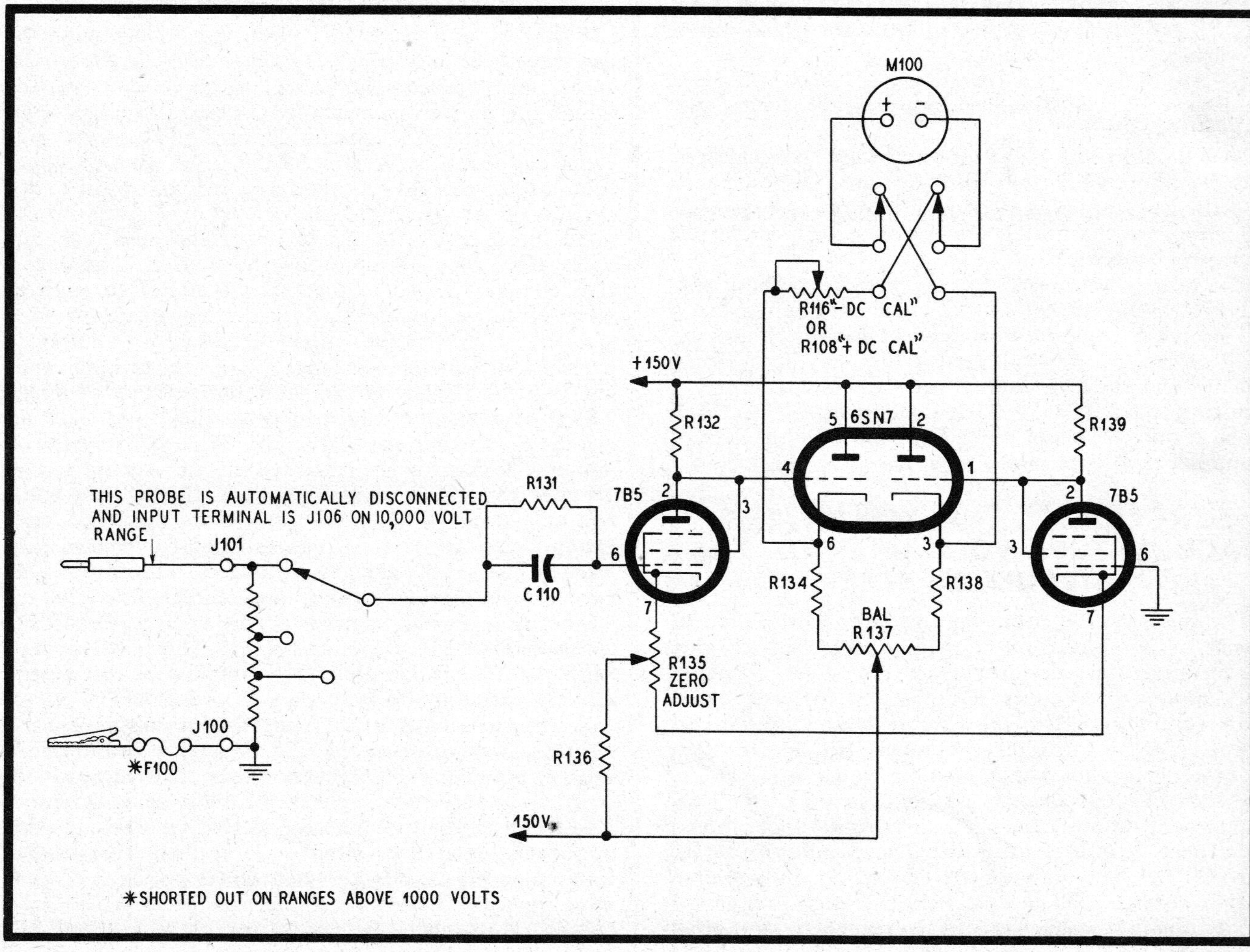

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Figure 3. Simplified Electronic-Bridge Circuit (± D-C Volts)

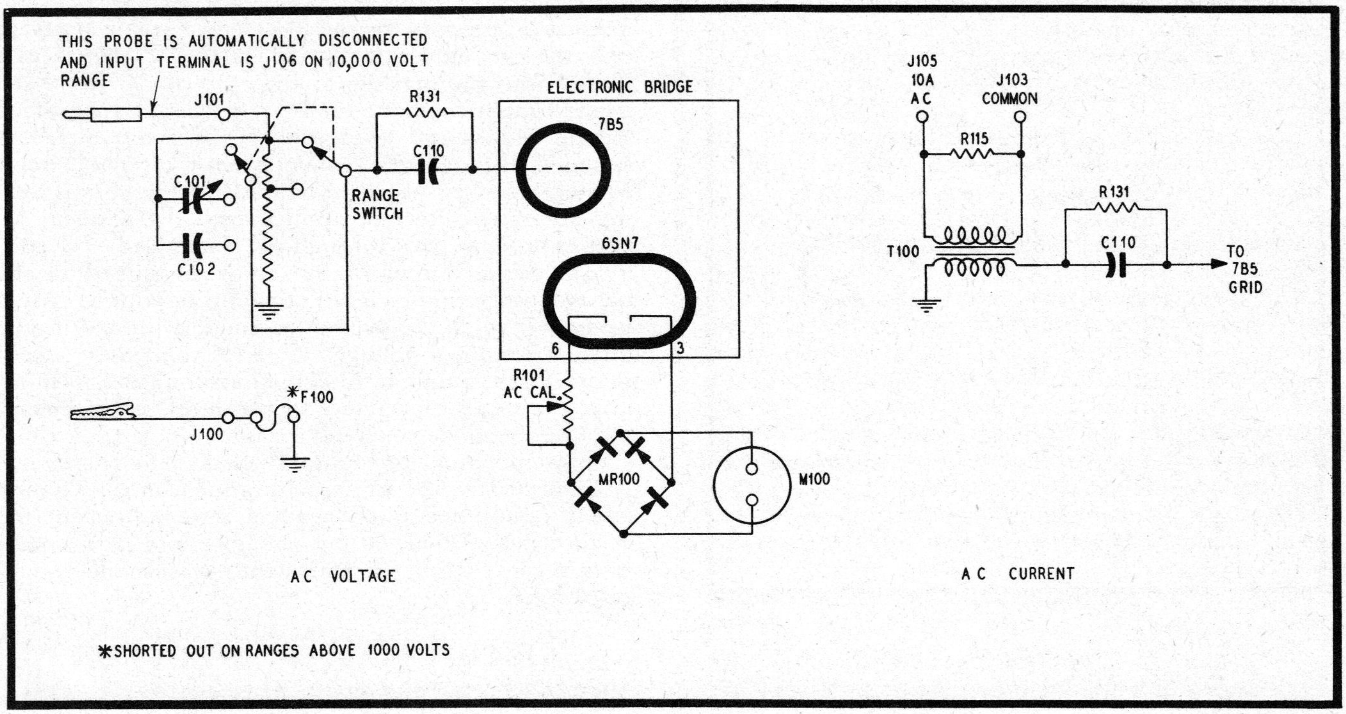

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Figure 4. Simplified A-C-Voltage-and-Current Measuring Circuits

termines the voltage applied to the bridge; the meter deflection directly indicates the capacitance on the scale range in use. This a-c voltage is so small that it has no objectionable effects on electrolytic condensers.

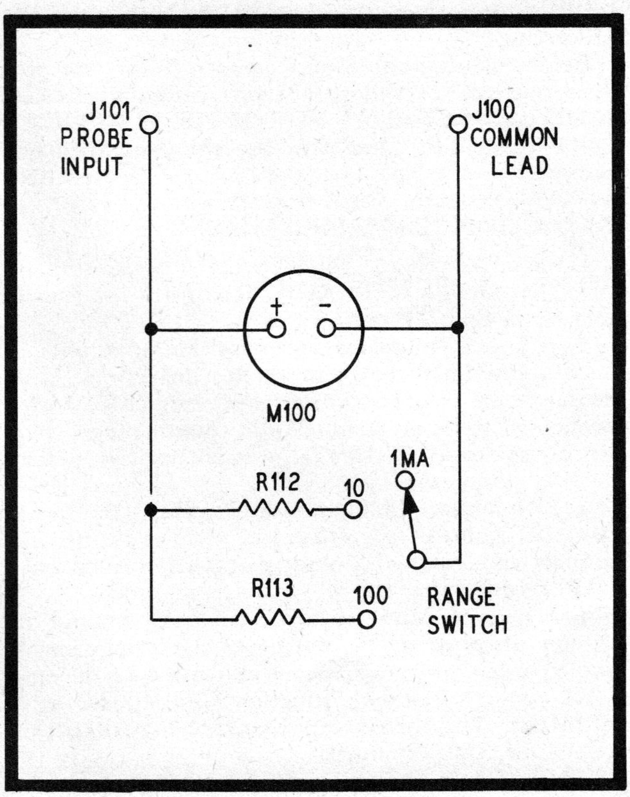

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Figure 5. Simplified D-C-Current Measuring Circuit

The ohmmeter circuit is shown in figure 7. On the RX 1 scale, the electronic bridge is not employed. This shunt-type circuit obtains its operating voltage (.15 volt, approximately) from the voltage drop across resistor R128. On the other ranges, the electronic bridge is employed, using the –D.C. VOLTS measuring circuit. A potential of approximately 1 volt (obtained across R128 and R129) is used to provide the drop across the resistance being measured so that external

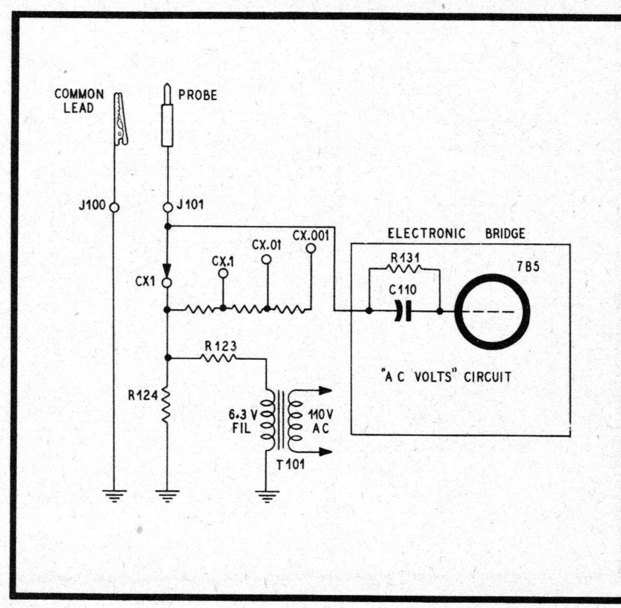

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Figure 6. Simplified Capacitance Measuring Circuit

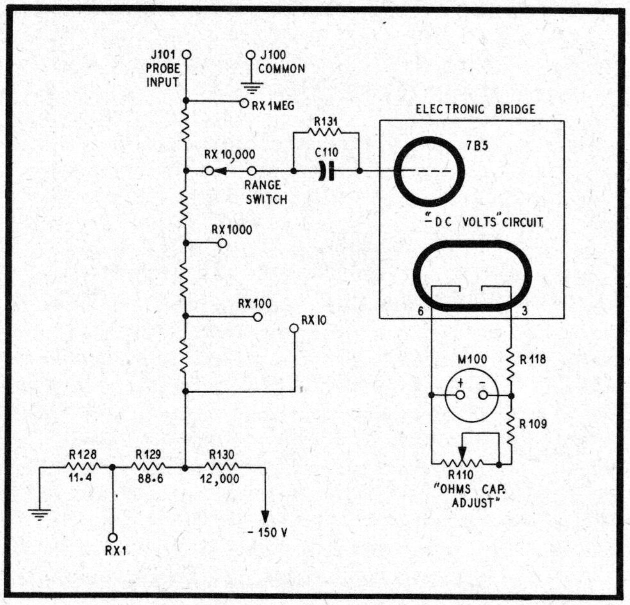

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Figure 7. Simplified Ohmmeter Circuit

or internal batteries are not needed, thereby providing a saving in cost, space, and weight.

The remaining circuit, shown in figure 8, consists of the –D.C. VOLTS measuring circuit in combination with the special High-Frequency Probe (obtainable as a separate accessory for the Electronic Circuit Master); this combination extends the range of the Circuit Master into the high-audio and r-f regions. Since the Probe contains a diode for r-f rectification (one diode section of a 6AL5 twin diode), filament voltage is supplied through the common lead of the Circuit Master, which is usually grounded to the chassis during other measurement applications; the filament return is brought back through the shield lead to chassis. The negative output of the diode is applied to the normal probe-input circuit, thereby providing ranges up to 300 volts; the maximum range is limited by the diode breakdown voltage. A series condenser is contained in the probe to isolate d-c circuits and to minimize the input capacitance of the probe arrangement. Because the diode generates a small voltage at all times (contact potential or "Edison" effect), the probe lead is connected to the probe-calibration control (R127) which is adjusted initially for a zero indication; the small negative diode-output voltage under static conditions is cancelled by an equivalent positive voltage supplied by R127.

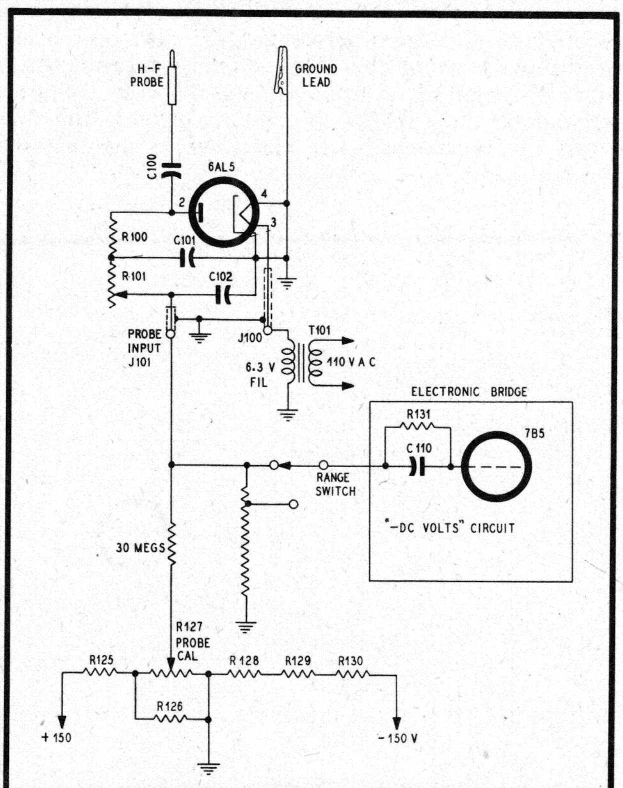

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Figure 8. Simplified Probe Circuit

CIRCUIT-MASTER OPERATION

After the user becomes familiar with the operation of the Philco Electronic Circuit Master, he probably will adopt procedures of his own for making the various measurements possible with this instrument. In the interim, however, the following general procedure and information should be followed to secure maximum performance and accuracy. At first glance, some of this detailed procedure may appear complicated; but after each operation is performed several times, it will be found that each measurement can be performed in less time than it takes to read the operating procedure.

Before making any measurements, follow the procedure outlined in the paragraph entitled "PRELIMINARY ADJUSTMENT OF THE ELECTRONIC CIRCUIT MASTER," and then use the procedure given below:

CAPACITANCE MEASUREMENT

1. Set "function" switch to CAP. position.
2. Set OHMS CAP. ADJUST control for full-scale (zero-capacitance) indication.
3. Choose "range" switch position that will produce approximate half-scale meter deflection. If condenser value is unknown, connect condenser between probe and common terminal and rotate "range" switch clockwise from CX 1MFD position until suitable deflection is obtained.
4. Disconnect condenser and readjust OHMS CAP. ADJUST control for zero-capacitance indication. Reconnect condenser and observe value indicated on red CAP. meter scale.

The correct value of capacitance is the indicated value multiplied by the setting of the "range" switch. For example, assume a meter indication of 80 on the CAP. scale with the "function" switch set at CX .001MFD. The correct capacitance value is 80 × .001 .08 mf. (80,000 mmf.).

The above procedure applies on all ranges except the CX 10MMF range. The lowest capacitance which can be measured on this range is very small, and all distributed capacitances must be accounted for. The following procedure will be found to produce consistent readings down to the lowest possible value measurable by the instrument:

1. Set "range" switch on CX .001MFD. position, and use OHMS CAP. ADJUST control to set meter for zero capacitance indication (full scale).

2. Turn "range" switch to CX 10MMF position, and position probe leads so that reading of more than "5" is obtained on meter scale (the meter scale is not calibrated between 0 and 5. If a reading of more than "5" cannot be obtained, reverse the line plug). Multiply this indication by 10 to secure minimum distributed capacitance value.

3. Without changing position of probe leads, connect condenser under test to leads and note indicated capacitance value, which is more than value obtained in step 2.

4. Subtract value in step 2 from value obtained in step 3, result is correct capacitance of condenser being checked. For example, assume first indication of 10; multiply it by "range" switch setting CX 10MMF; 100 mmf. is thereby obtained as minimum capacitance value. Assume second indication of 12.5 (125 mmf.); subtract first from second; 125 minus 100 gives 25 mmf. as capacitance of condenser being checked.

When checking capacitance values, it is advisable to first test for d-c continuity with the ohmmeter. If an appreciable reading is obtained, the condenser should be rejected as defective (this of course does not apply to electrolytics).

When making measurements on the CX 10MMF range, especially on condensers of extremely small values, it is advisable to keep the probe lead and the common lead close together; move them as little as possible when making the measurement. Removing the hand from the probe will also improve the accuracy of the measurement. Small condensers can be measured more accurately by removing the probe leads and connecting the condenser directly to the probe jacks. When measuring electrolytic condensers, it is not necessary to connect the Circuit Master leads in any particular polarity. Accurate measurements will be made regardless of which lead is connected to the positive terminal of the condenser. It is not necessary to previously polarize the condenser by application of a d-c voltage.

RESISTANCE MEASUREMENTS

1. Set "function" switch to OHMS position with "range" switch in any position, and set OHMS CAP. ADJUST control for full-scale indication.

2. Short-circuit probe and common terminals. Check for zero meter indication. If necessary, set ZERO ADJUST control for zero meter indication. No zero adjustment is provided on RX 1 range; therefore, with leads shorted on this range, the Circuit Master indicates the resistance of the probe leads (about .25 ohm). If the leads are removed and terminals J100 and J101 are shorted with a short piece of wire, the meter will indicate zero.

3. Connect resistor between probe terminal and common terminal, and read indicated value from OHMS scale on meter. Multiply indicated value by position of "range" switch to secure correct resistance value. For example, assume that the meter indicates 150 ohms; with the "range" switch in RX 1 position, the total resistance of the resistor is then 150 x 1, or 150 ohms. If the "range" switch had been in the RX 10 position the resistance would have been 1500 ohms.

A-C CURRENT MEASUREMENTS

1. Set "function" switch to A.C. CURRENT position.

2. Connect unit under test in *series* with COMMON and 10 AMPS. AC binding posts at top of the Circuit Master.

3. Read correct r-m-s value (for a sinusoidal a-c current) directly from AC CURRENT scale. The "range" switch is not used during this measurement because only one fixed range is available. *Do not* try to measure a-c current with the probe and common leads since they are not connected in the circuit. Use any insulated wire of No. 14 gauge or heavier.

D-C CURRENT MEASUREMENTS

1. Set "function" switch to D.C. CURRENT position.

2. For measurements up to 100 milliamperes, use probe lead and common lead connected in *series* with circuit under measurement. The probe is connected to the positive meter terminal, and the common lead is connected to the negative meter terminal with the proper shunts across the meter. Be certain to observe proper polarity when connecting Circuit Master to circuit under test; otherwise, a reverse deflection will occur which might damage meter.

3. Set "range" switch to MA 100 and read current value in milliamperes from DC CURRENT meter scale. Multiply this value by 10 to secure correct value. For example, on MA 100 range assume that the meter indicates 8; 8 x 10 gives total current as 80 milliamperes. The "range" switch position indicates the maximum-current range—on the MA 1 range, multiply by 0.1. Most accurate indications are obtained when the "range " switch is set to the position which produces the greatest meter deflection; that is, a 2-ma. current can be measured more accurately on the MA 10 range than on the MA 100 range.

4. When the current is greater than 100 ma., use either the 1- or 30-ampere range. On these ranges the "range" switch does not funtion; a fixed range is obtained by connecting between the 1 AMP. D.C. or the 30 AMPS. D.C. and the COMMON binding posts at the top of the Circuit Master. In these instances, do not use the probe lead and common lead; use any insulated wire of No. 14 gauge or heavier. On the 1-ampere range, the current value is obtained from the 0—10 DC CURRENT scale by dividing the meter reading by 10. For example, an indication of 2 on the meter scale is produced by a current of .2 ampere. On the 30-ampere range, the current value is read directly from the 0—30 DC CURRENT scale; a reading of 12 on the scale indicates 12 amperes.

NOTE

When measuring the current drawn by either a-c or d-c rotating machines, remember the fact that such equipment usually draws high starting current. To prevent damage to the instrument, short-circuit the instrument leads until the machine has reached its running speed.

A-C VOLTAGE MEASUREMENTS (60—5000 cycles)

1. Set "function" switch to A.C. VOLTS position.

2. Short-circuit probe and common terminals together, and set ZERO ADJUST control for zero meter indication, if necessary.

3. Connect common terminal and probe across points between which voltage is to be measured. Where one side of measured circuit is grounded, connect common lead to grounded side and probe to ungrounded side. This connection places the case of the instrument at ground potential, and avoids blowing the internal fuse.

4. Set "range" switch at a position producing half-scale deflection, or rotate "range" switch counterclockwise from V 1000 position until deflection for most accurate reading is secured.

5. The r-m-s value indicated on the red AC CURRENT-AC VOLTS scale can be read directly from the 0—10 and 0—30 scale for "range" switch positions of V 10 and V 30 respectively. For ranges greater than V 30, multiply meter indication by 10 on V 100 range and V 300 range, and by 100 on V 1000 range. For range positions less than V 10 and V 30, divide scale reading by 10. The "range" switch indicates the maximum-voltage range of each position. The instrument is calibrated for sinusoidal wave-forms only.

6. When voltages greater than 1000 volts but less than 10,000 volts are to be measured, connect the probe with the self-insulating jack to the 10,000-volt porcelain feed-through insulator (J106, see figure 1) and use it instead of the one previously used for all measurements. This probe and cable are sufficiently insulated to withstand very high voltages. Set the "range" switch to 10,000 VOLTS; use the 0—10 scale and multiply the meter indication by 1000 for correct voltage.

CAUTION: Exercise every precaution to avoid accidental contact with high-voltage circuits.

When making measurements on the 1- and 3-volt ranges it is advisable to hold the probe near the end of the handle because the extreme sensitivity of the instrument results in extraneous pickup if probe is held close to tip.

No provision has been made for frequency compensation and calibration of the instrument for audio-frequency voltages greater than 100 volts; audio measurements should be restricted to voltages below this value, and a blocking condenser should be connected in series with the probe lead if the circuit also contains d-c voltage. The blocking condenser should be large (.25 to 1 mf.) so that it offers a negligible reactance to the frequency being measured.

D-C VOLTAGE MEASUREMENTS

1. Set "function" switch to either +D.C. VOLTS or –D.C. VOLTS, as required by polarity of voltage to be measured. Where one side of the measured circuit is grounded, connect the common to grounded side and probe to ungrounded side. This connection places the case of the instrument at ground potential and avoids blowing the internal fuse.

2. Set "range" switch to appropriate position, or rotate it from V 1000 position until desired meter deflection is obtained.

3. Use DC VOLTS scale, and for V 10 and V 30 ranges, read values directly from scale. On lower ranges, divide indicated value by 10. On V 100 and V 300 ranges, multiply by 10; on V 1000 range, multiply by 100.

4. D-C voltages up to 10,000 volts may also be measured as outlined under A-C VOLTAGE MEASUREMENTS, step 6.

CAUTION: Exercise every possible precaution to avoid accidental contact with high-voltage circuits.

R-F VOLTAGE MEASUREMENTS (5000 kc. to 200 mc.)

1. Replace probe lead and common lead with the High-Frequency Probe, Philco Part No. 45-1547. Turn "function" switch to PROBE position and "range" switch to V 1000 position, and allow probe to warm up for five minutes.

2. For voltages greater than 3 volts, use DC-RF VOLTS scale. Read voltage directly from scale with "range" switch in V 10 or V 30 position; multiply meter reading by 10 on V 100 and V 300 ranges.

3. For r-f voltages between 0 and 1 volt, place "range" switch in V 1 position and use 0—1.0 RF VOLTS scale; read value directly from scale. For voltages between 1 and 3 volts, place "range" switch in V 3 position and read value directly from 0—3.0 RF VOLTS scale.

The probe diode breakdown voltage limits measurements to a maximum of 300 volts.

For accurate measurements below 3000 cycles and above 30 mc., use the correction multipliers to determine the final value, as shown on probe instruction sheet.

When making high-frequency measurements (above 30 megacycles), it may be found advantageous to unscrew the pointed probe tip, and to connect the circuit under measurement directly from the nut on the probe-tip screw to the ground terminal. This connection eliminates the inductance of the tip and ground leads.

DECIBEL MEASUREMENTS

The decibel ranges of the Circuit Master are calibrated with reference to a zero level of 6 milliwatts on a 500-ohm line. The procedure given below can be used only if the measurements are made on a *terminated* 500-ohm circuit. To make measurements on circuits other than 500 ohms, an impedance-correction factor must be applied to all readings.

1. Set "function" switch to A.C. VOLTS position.

2. Use suitable "range" switch position, and connect probe lead and common lead across circuit. Employ suitable blocking condenser (.25 to 1 mf.) if circuit also contains d-c voltage.

3. Read decibel values directly from red DB scale when "range" switch is in V 3 position.

4. When "range" switch is in V 1 position, add –9.5 db to meter indication; in V 10 position, add +10.5 db; in V 30 position, add +20 db; in V 100 position, add +30.5 db; in V 300 position, add +40 db; and in V 1000 position, add +50.5 db.

HIGH-VOLTAGE MEASUREMENTS (10,000 to 30,000 volts)

CAUTION: The user is cautioned to observe all possible safety precautions, even to the extent of keeping one hand in the pocket when making connections to the high-voltage equipment. NEVER connect or disconnect the Circuit Master, or any other instrument, to a high-voltage circuit while the power to the circuit is turned on. One side of the high-voltage circuit must be at ground potential in order to use the Circuit Master; otherwise the instrument may be damaged.

1. Connect special High-Voltage Probe with built-in multiplier, Philco Part No. 45-1550, to 10,000-volt terminal of Circuit Master.
2. With power switch of circuit under test in *OFF* position, ground points between which voltage is to be measured, with insulated shorting bar or cable. Then, and then ONLY, connect common lead of Circuit Master to ground side of circuit, and connect special multiplier probe to other point.
3. Set "function" switch to either A.C. VOLTS or (+ or −) D.C. VOLTS according to voltage to be measured. Set "range" switch to 10,000 VOLTS position.

Be certain that all grounded objects are kept at least several inches away from the test equipment and leads, and turn on the power switch of the circuit under test. CAUTION: *Do not touch* the leads or case of the Circuit Master; voltages encountered on this range are frequently fatal, and all possible precautions should be taken to avoid accidental contact with the circuit.

4. Observe d-c values on black 0—30 DC VOLTS scale, and multiply indicated value by 1000 to determine correct voltage value. Observe a-c values on red 0—30 AC VOLTS scale, and multiply indicated value by 1110 to determine correct voltage value.
5. Turn OFF the equipment under test and ground the circuit before removing the connections to the Circuit Master.

PRACTICAL APPLICATIONS

There are so many applications for the Philco Electronic Circuit Master that it is impossible to touch upon all of the possibilities in a manual of this nature. However, this manual presents a number of practical applications ranging from the more common and well known to the less common and more complicated types —with some suggestions that the user can use as a guide in developing his own applications.

The user should bear in mind that this instrument is calibrated for a-c voltages in terms of the r-m-s value of sinusoidal wave forms. That is, this instrument indicates the same value of a-c voltage as would be indicated by any standard a-c voltmeter. Peak-voltage values may be calculated by multiplying the meter reading by 1.414 if the measured wave form is sinusoidal. Any complex wave form will produce a relative reading, which is not a true value.

RADIO SERVICING (AM)

The Circuit Master may be used to determine true a-c or d-c voltage values in high-resistance circuits since its loading effect on the circuit under test is negligible.

The Circuit Master and a calibrated audio signal generator can be used to plot audio response curves. Plot frequencies along the X axis, and the measured output voltage of the stage under test along the Y axis.

The turns ratio of audio transformers (interstage and output) can be checked by applying a known voltage to the primary and measuring the voltage at the secondary with the Circuit Master. The turns ratio of output transformers can be used to match impedance; the impedance-transformation ratio is directly proportional to the square of the turns ratio.

Audio voltage-gain measurements can also be made by checking the voltage input and voltage output; use an audio signal generator to furnish a constant input voltage. The audio wave form should be sinusoidal for accurate measurement; however, useful measurements can still be obtained with nonsinusoidal wave forms.

When measuring a-c voltages in circuits where d.c. is also present, use a large value of capacitance as a blocking condenser. The condenser must be large enough to have negligible reactance at the frequencies being measured.

A-v-c voltage between the grid of a tube and ground may be measured accurately with the Circuit Master by using the −DC VOLTS measuring circuit. Push-button tuners may be aligned properly by using the signal from the broadcast station for an input signal, and by connecting the Circuit Master to the a-v-c bus as the alignment indicator.

All power-supply voltages (both a.c. and d.c.) can be accurately checked.

Capacitance values of all tubular, mica, and electrolytic condensers may be checked; any shunt resistance or impedance will affect the true indication, so that this check should be made with the condenser disconnected from the circuit. The serviceman can use the capacitance-meter function to select the closest possible replacement value where exact values of capacitance are needed. The use of the megohm scale is suggested as a means of checking the leakage resistance of the condenser dielectric.

All resistance values measurable with the conventional ohmmeter may be measured with the Circuit Master; and, in addition, resistors up to 1000 megohms may be checked.

The High-Frequency Probe, Philco Part No. 45-1547, may be used in conjunction with the Circuit Master to extend its usefulness. By using this Probe and an r-f signal generator, the r-f and i-f stage gain can be determined by checking from grid to plate in each stage. Loss of gain in any stage immediately indicates a defective circuit.

Measurement of oscillator-injection amplitude and the conversion efficiency of the mixer stage is also possible. In some instances, where local stations with field strengths within the range of the instrument are available, it is possible to align r-f and detector stages by using the probe as an r-f indicator across the tuned circuit.

By using a signal generator to supply the signal voltage, and the Probe as an r-f indicator, the resonant frequency of any component (within the range of the instrument) may be determined by noting the frequency at which a maximum r-f voltage indication is obtained as the frequency of the signal generator is varied.

Dynamic tube comparisons may be made by checking the gain of one tube against another in the same circuit. This method is especially useful in "souping up" ac-dc receivers which originally employed selected tubes to produce better than average performance.

When employed as an ammeter, the Circuit Master is invaluable for checking the a-c and d-c current drain of various circuits; abnormal current drain can be traced to the circuit causing the condition.

The D.C. CURRENT function is useful for checking auto-radio receivers to determine whether major shorts or loads are present.

The A.C. CURRENT function is helpful in checking the current drain and ratings of radios and household appliances such as toasters, flatirons, vacuum cleaners, and washing machines; on a-c circuits, the true wattage determination must include the power factor. In the case of flatirons it is possible to neglect the power factor because these appliances contain resistive components, so that the product of the current and the voltage should produce a wattage within very close agreement with that stated on the appliance. In the case of motors, transformers, and other such components (if the unit is rated in watts), a good approximation for test purposes will be obtained by assuming a power factor of 85%; thus the apparent wattage (EI), which will be about 15% greater than that stamped on the appliance, should be corrected by applying a power-factor correction ($P = EI \times P.F.$). If the appliance is rated in volt-amperes, an exact check can be made by calculating the product of the measured volts and amperes.

After numerous checks, it is possible that the user may be able, on the basis of his experience, to estimate the correct volt-ampere rating of units in watts; otherwise, it will not be possible to make a close check unless the power factor is known.

RADIO SERVICING (FM)

In addition to the above-mentioned uses of the Circuit Master (they are also generally applicable to FM servicing), the following uses are specifically applicable to FM:

Alignment of the discriminator stage and setting of the correct cross-over point. Discriminator alignment may be checked for balanced output by using the +D.C. VOLTS and –D.C. VOLTS functions.

Since FM stations operate at high frequencies, it is possible to employ the High-Frequency Probe to check the r-f and mixer tuning. This feature is especially valuable where complaints of poor reception indicate either low station field strength or poor receiver performance, because it is possible actually to determine which is at fault, and since the instrument is portable, to prove it to the customer.

Where limiters are used prior to detection, it is possible to check the saturation level by using an AM signal generator modulated at 400 cycles to furnish the input signal, and by increasing the signal input until no greater output amplitude is obtained.

AMATEUR RADIO AND THE EXPERIMENTER

The Philco Electronic Circuit Master and the High-Frequency Probe, Philco Part No. 45-1547, together form a most versatile instrument for the use of the amateur and the experimenter. The applications are limited only by the ingenuity of the user. Some uses are suggested in the following paragraphs:

The ability to measure r-f voltage immediately suggests the measurement of stage gain in low-powered transmitters, the measurements of grid excitation voltage, and correct adjustment of r-f amplifiers.

When the Circuit Master is employed to measure the voltage across a resistor which is equivalent to the antenna resistance or transmission-line impedance, the true power output is determined by using the $\frac{E^2}{R}$ wattage formula.

Correct neutralization can be obtained by employing the instrument as an r-f indicator. In most instances, the sensitivity provided in this unit allows exact neutralization, and indicates when neutralization cannot be obtained because of spurious coupling and pickup. The causes of previously unexplainable actions of the transmitter can thus be intelligently traced to their source.

When used with a tuned circuit resonant at the transmitter frequency, the Circuit Master may be employed as a field-strength indicator for adjusting antenna patterns, or for determining effective output tuning and antenna matching.

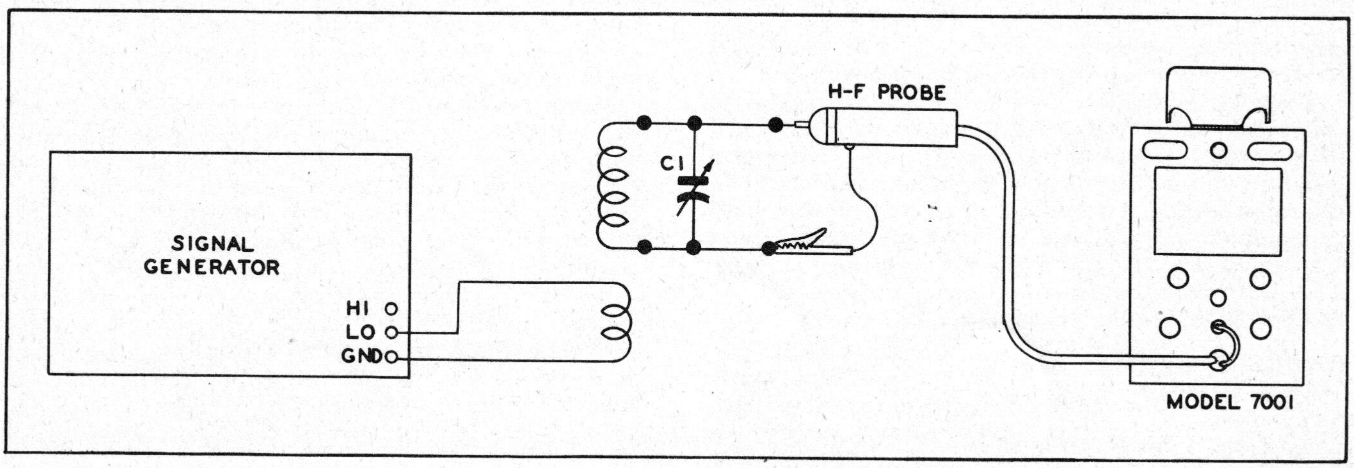


Figure 9. "Q"-Meter Circuit

R-f indication provided by the High-Frequency Probe permits employment of the unit as a Q meter so that the experimenter can accurately determine the inductance and Q of the coils he uses. A signal generator and a calibrated variable condenser are required in addition to the Circuit Master and High-Frequency Probe. Use the low-impedance output of the signal generator, and link-couple it to the tuned circuit consisting of C_1 and the coil to be measured, as shown in figure 9.

It is necessary that the Circuit Master be placed so that it does not pick up any r-f with the coil disconnected; otherwise an erroneous measurement will be made. The calibrated condenser can be one with good, solid plates, and a high dielectric resistance. It can be calibrated for a number of dial settings by using the capacitance function of the Circuit Master. With the signal generator set to some frequency within the range of the tuned circuit, adjust C_1 for resonance as indicated on the Circuit Master. Note the frequency setting of the signal generator and the capacitance of C_1; then set the signal generator to twice that frequency. Again adjust C_1 for resonance and note the capacitance. The inductance of the coil may then be calculated by the following formula:

$$L = \frac{1}{8422F_2} \times \frac{1}{C_1 - C_2}$$

L is in microhenries, C is in micromicrofarads, and frequency is in kilocycles. F_2 is the second harmonic of the original frequency setting; C_2 is the capacitance required to tune to F_2.

To measure r-f impedance and resistance (Q), connect the equipment as for the inductance measurement. Tune C_1 to resonance, and note the frequency and value of r-f voltage; then adjust the signal generator in either direction until 70.7% of the original r-f voltage amplitude is indicated. Note the frequency; return to the original frequency, and adjust the signal generator for 70.7% amplitude in the other direction. The frequency difference indicated between the two 70.7% settings is the band width between the points where the reactance is equal to the resistance. Therefore, the Q of the coil is equal to the original resonant frequency divided by this band width $Q = \frac{F}{\Delta F}$. While it is true that the accuracy of this method is affected somewhat by the Q of the condenser used for C_1, it is assumed that the results will be sufficiently accurate when an efficient air condenser is used, since the resistance of most condensers is low. Accuracy of measurement is generally dependent upon frequency; the largest error results at the higher frequencies. In any event, an elaborate set up can be made, using the Circuit Master as the VTVM portion if extreme accuracy is required.

TELEVISION

The Philco Electronic Circuit Master will be found to be a "must" item for adjusting and servicing television sets.

A-f-c circuits can be adjusted to the correct cross-over point by switching from +DC to –DC as the adjustment changes from positive to negative, noting the cross-over point and setting to the exact plus or minus voltage needed.

When used with the High Frequency Probe, the Circuit Master may be employed to check the gain per stage of r-f, i-f, and a-f circuits by measuring the input voltage to each stage and dividing it into the output voltage from each stage. Use a signal generator (r.f. or a.f., as required) to furnish a constant input voltage.

Video response curves may be plotted by using the signal generator to furnish the input voltage and the High-Frequency Probe and Circuit Master to measure the output at each frequency.

Sound i-f alignment may be checked by using the H-F Probe and Circuit Master as an r-f indicator, and tuning the sound i-f stages for maximum response at the center alignment frequency. Conversely, the sound-trap adjustment may be checked by employing the H-F Probe to indicate minimum response on the video side of the trap.

Both horizontal and vertical sweep voltages may be determined with the probe to give a relative indication as a quick check for circuit operation.

Picture-tube anode voltage for most direct-vision sets may be measured with the 10,000-volt probe furnished with the Circuit Master.

Projection-tube anode voltage may be measured by using the Circuit Master together with the special High-Voltage Probe containing built-in Multiplier, Philco Part No. 45-1550, for voltages greater than 10,000 volts.

Since the subject of television servicing is far too complex to be completely covered in a manual of this size, it is suggested that the serviceman be guided by the specific information supplied by the manufacturer of those models requiring his attention; use the Circuit Master when applicable.

PUBLIC-ADDRESS SYSTEM

The Circuit Master will be found extremely useful in this field. Measurements of audio stage gain and power output may be made.

The output of most microphones may be checked either directly or by using a step-up transformer with a known ratio.

Dynamic and other types of pickups may be checked in a manner similar to that used for microphones.

A special decibel scale, marked DB, is provided on the instrument for use by sound servicemen in making direct gain and comparison measurements. This scale is based on the voltage read across a 500-ohm impedance, using a reference level of 6 milliwatts. A table of decibels, based on the voltage read across 600 ohms for reference levels of 6 milliwatts and 1 milliwatt, are included for use with the A.C. VOLTS scale. Thus a minimum of calculation is required to secure decibel readings at other commonly used impedances and reference levels.

To use the decibel table, determine the output voltage in the normal manner for the a-c funtion, find the nearest voltage value on the table and read off the db values (rounded off to the nearest significant figure) under the desired reference level and impedance.

A graph indicating the relationship between power values and decibels for extended ranges, based on the 6-milliwatt level, is also supplied for the user's convenience. See figure 10.

DECIBEL TABLE

Power Level (DB)	VOLTS ACROSS 600 OHMS		Power Watts (1-Milliwatt Ref. Level)	Power Level (DB)	VOLTS ACROSS 600 OHMS		Power Watts (1-Milliwatt Ref. Level)
	(6-Milliwatt Ref. Level)	(1-Milliwatt Ref. Level)			(6-Milliwatt Ref. Level)	(1-Milliwatt Ref. Level)	
–21	.17	.069	.000007	18	15.07	6.15	.063
–20	.19	.077	.000010	19	16.91	6.90	.079
–19	.21	.087	.000013	20	18.97	7.75	.10
–18	.24	.09	.000016	21	21.3	8.70	.13
–17	.27	.10	.000020	22	23.9	9.75	.16
–16	.300	.12	.000025	23	26.8	10.94	.2
–15	.34	.14	.000032	24	30.	12.28	.25
–14	.38	.16	.000040	25	33.7	13.77	.32
–13	.425	.17	.000050	26	37.9	15.45	.4
–12	.48	.195	.000063	27	42.5	17.34	.5
–11	.54	.22	.000079	28	47.6	19.45	.63
–10	.60	.25	.00010	29	53.5	21.8	.79
–9	.67	.27	.00013	30	60.0	24.5	1.00
–8	.75	.31	.00016	31	66.7	27.5	1.259
–7	.85	.35	.00020	32	75.5	30.8	1.585
–6	.95	.39	.00025	33	85.0	34.6	1.995
–5	1.07	.44	.00032	34	95.0	38.8	2.512
–4	1.20	.48	.00040	35	106.7	43.6	3.162
–3	1.4	.54	.00050	36	119.7	48.9	3.98
–2	1.5	.61	.00063	37	134.3	54.8	5.01
–1	1.7	.69	.00079	38	150.7	61.5	6.31
0	1.90	.77	.0010	39	169.0	69.0	7.94
+1	2.13	.87	.0013	40	189.7	77.5	10.00
2	2.39	.98	.0016	41	212.9	86.9	12.59
3	2.68	1.09	.0020	42	238.9	96.6	15.85
4	3.00	1.23	.0025	43	268.0	109.4	19.95
5	3.37	1.38	.0032	44	300.7	122.8	25.12
6	3.79	1.55	.0040	45	337.4	137.75	31.62
7	4.25	1.73	.0050	46	379.6	154.6	39.81
8	4.77	1.95	.0063	47	424.7	173.4	50.12
9	5.35	2.18	.0079	48	476.6	194.57	63.10
10	6.00	2.45	.010	49	534.75	218.31	79.43
11	6.73	2.75	.013	50	600.0	244.9	100.00
12	7.55	3.08	.016	51	673.2	278.8	125.89
13	8.48	3.46	.02	52	755.4	346.00	158.49
14	9.51	3.88	.025	53	847.5	388.2	199.53
15	10.67	4.35	.032	54	950.9	435.6	251.19
16	11.97	4.89	.04	55	1067.	488.8	316.23
17	13.43	5.48	.05				

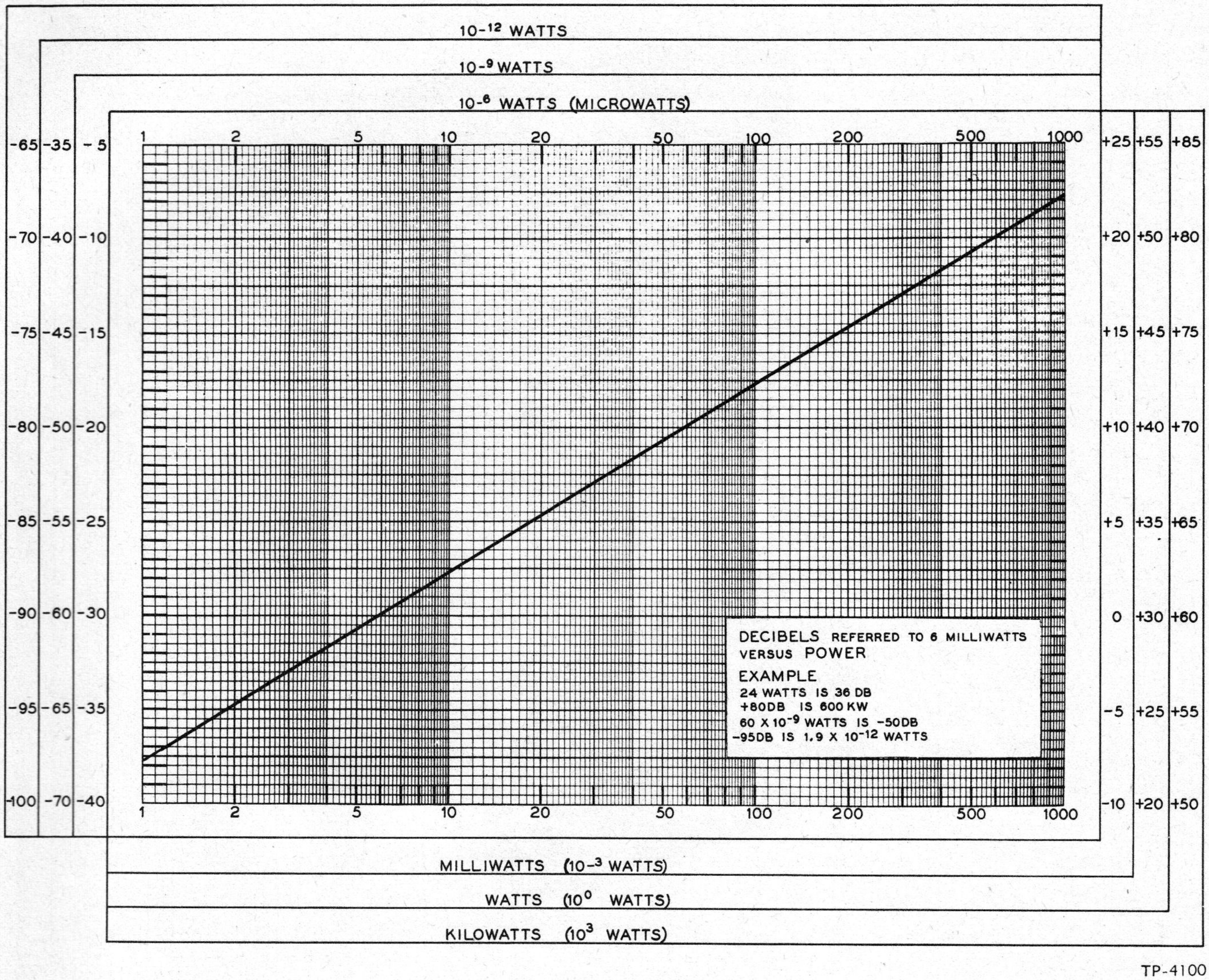


Figure 10. Decibel Power Chart

HIGH-FREQUENCY PROBE, PHILCO PART NO. 45-1547

The various applications of the High-Frequency Probe have been included in the list of practical applications because it is generally employed to measure all voltages between 0 and 300 volts, at frequencies between 5000 cycles and 200 megacycles, and also because it may be used for all kinds of servicing. The instructions supplied with the Probe should be consulted if more specific information is required.

SPECIAL HIGH-VOLTAGE PROBE WITH BUILT-IN MULTIPLIER, PHILCO PART NO. 45-1550

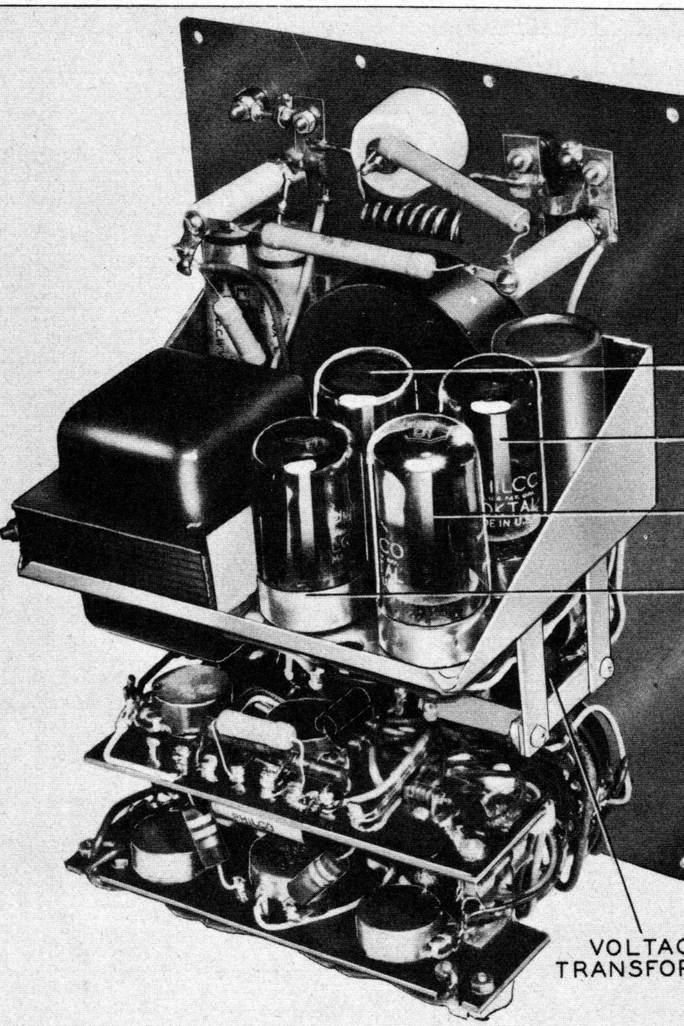
The applications of the extended voltage-measuring range supplied by this accessory to the Circuit Master have also been included in the above applications. If further information is required, consult the instruction sheet supplied with the High-Voltage Probe and Multiplier.

TUBE AND FUSE REPLACEMENT

Access to the tubes, fuse, and other components may be had by removing the 12 screws from the front panel of the Circuit Master, and removing the unit from its case. Figures 11 and 12 show the location of tubes, fuse, and internal calibration adjustments.

The tubes are standard types which may be tested in the conventional tube tester. Whenever tubes are replaced, the unit should be recalibrated as outlined below.

A defective fuse should be replaced with one of the same rating; otherwise, it may be possible to accidentally "blow" the line fuses should the case come in contact with "ground" when making power-line measurements. Connecting the common lead to the ground side of the line will prevent such mishaps. Replacement of the fuse with one of a lower current rating may result in too frequent blowing of fuses whenever the common lead is connected to ground.



TP-4371

Figure 11. Philco Electronic Circuit Master, Internal View

CALIBRATION OF THE UNIT

Whenever tubes are replaced, or if the calibration has changed because of tube aging after a long period of use, the unit should be recalibrated to regain the original accuracy of the instrument. If components are replaced, the lead dress should not be disturbed; otherwise the accuracy of the a-c voltage range might be changed at frequencies greater than 60 cycles per second.

Before calibrating the unit, operate it for a period of 10 minutes on 115-volt, 60-cycle a.c. with the "function" switch in D.C. CURRENT position, and be sure that the mechanical "zero-set" of the meter is correctly set to zero. Operation in this position of the "function" switch eliminates needless meter movement while the unit is being stabilized by removing the electronic bridge from the input and meter circuits. After the warm-up period, proceed as follows:

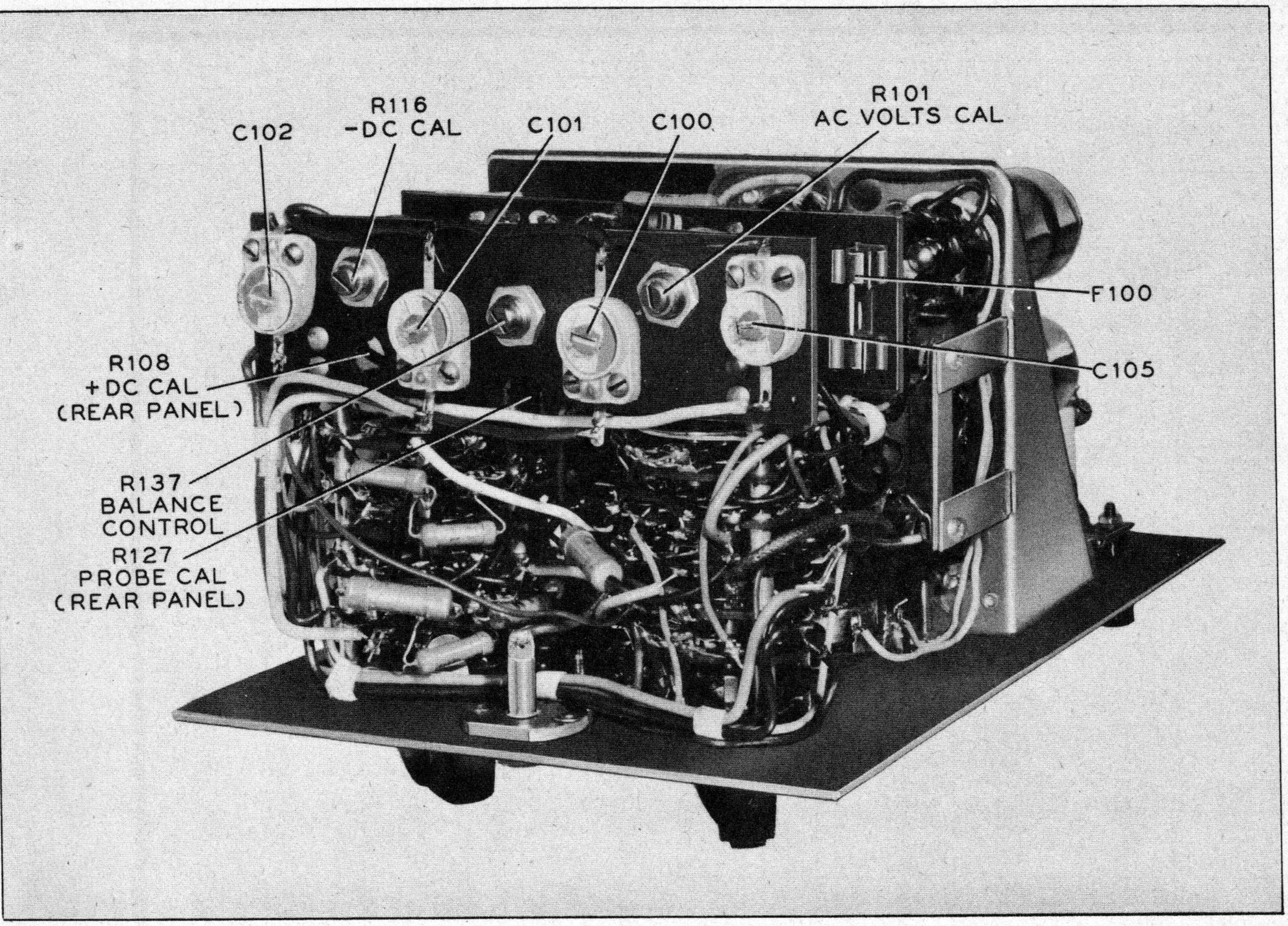
1. Remove unit from case and connect number 1 and 4 pins (grids) of 6SN7 together. Then set "function" switch to –DC VOLTS and "range" switch to V1.

2. Adjust balance control (R137, figure 12) until meter indicates zero. This adjustment balances the two sections of the 6SN7. Remove connection between grid pins.

3. Short probe input J101 to common lead J100 and adjust meter to zero, using ZERO ADJUST control (R135) on front panel.

4. Apply a negative d-c voltage of exactly 1 volt between probe and common terminals (J100 and J101), and adjust –DC calibration control (R116, figure 12) until meter reads 1 volt on DC VOLTS scale.

5. Turn "function" switch to +D.C. VOLTS, leave "range" switch on V 1, and apply a positive voltage of exactly 1 volt between probe and common terminals.



TP-4370

Figure 12. Calibration Adjustments

Adjust +DC calibration control (R108, figure 12) for full-scale reading of exactly 1 volt on DC VOLTS scale.

6. Turn "function" switch to A.C. VOLTS, and apply a sinusoidal 60-cycle voltage of exactly one volt r.m.s. between probe and common terminals. Adjust AC calibration control (R101, figure 12) until meter reads 1 volt at full scale on the AC VOLTS scale.

7. With "function" switch set at A.C. VOLTS, turn "range" switch to V 3. Apply a sinusoidal voltage of exactly 3 volts r.m.s. at 5000 cycles between probe and common terminals. Adjust condenser C102 (figure 12) for full-scale reading of 3 volts as indicated on AC VOLTS scale.

8. Turn "range" switch to V 10. Apply a sinusoidal voltage of exactly 10 volts r.m.s. at 5000 cycles between probe and common terminals. Adjust C101 (figure 12) for a full-scale reading of exactly 10 volts as indicated on AC VOLTS scale of meter.

9. Turn "range" switch to V 30. Apply a sinusoidal voltage of exactly 30 volts r.m.s. at 5000 cycles to input terminals and adjust C100 (figure 12) for exactly 30 volts as indicated on AC VOLTS scale.

10. Turn "range" switch to V 100. Apply a sinusoidal voltage of exactly 100 volts r.m.s. at 5000 cycles to input terminals, and adjust C105 (figure 12) for exactly 100 volts as indicated on AC VOLTS scale. The accuracy of the calibration should be checked at 3, 10, 30, and 100 volts r.m.s., 5000 cycles, and if necessary, steps 7 to 10, inclusive, should be repeated.

The voltages used for calibration may be obtained from standard cells, or may be obtained from a voltage-divider arrangement by using another correctly calibrated Circuit Master to indicate proper voltage settings. However, the user must note that the Circuit Master under calibration cannot be any more accurate than the voltage source used for calibration, or than the instrument used to check the voltage source; extreme care should be observed while calibrating the instrument to secure an accurate calibration.

REPLACEMENT PARTS LIST

NOTE

Part numbers marked with an asterisk (*) are general replacement items. These numbers may not be identical with those on factory assemblies; also, the electrical values of some replacement items may differ from the values indicated in the schematic diagram and parts list. The values substituted in any case are so chosen that the operation of the instrument will be either unchanged or improved. When ordering replacements, use only the "Service Part No."

Symbol	Description	Service Part No.
C100	Condenser, variable compensator, 1.5—7 mmf.	31-6480-2
C101	Condenser, variable compensator, 1.5—7 mmf.	31-6480-2
C102	Condenser, variable compensator, 7—45 mmf.	31-6480-3
C103	Not used.	
C104	Condenser, compensator, 200 mmf.	30-1224-24
C105	Condenser, variable compensator, 1.5—7 mmf.	31-6480-2
C106	Condenser, compensator, 1200 mmf.	60-20125404
C107	Condenser, noise filter, .25 mf.	61-0125
C108	Condenser, noise filter, .25 mf.	61-0125
C109	Condenser, filter, 20 mf.	61-0086-4
C110	Condenser, grid compensator, 2000 mmf.	30-1225-6
F100	Fuse, ½ ampere	45-2656-2
I100	Pilot lamp	34-2040
J100	Jack, black, banana plug, common lead or 6.3-v a.c.	76-2913
J101	Jack, coaxial (Jones S101D), probe input	76-3215
J102, J103	Twin binding post, 30 AMPS. D.C. and COMMON	76-2898
J104, J105	Twin binding post, 1 AMP. D.C. and 10 AMPS. A.C.	76-2898
J106	Jack, self-insulating, high voltage	56-4423
M100	Meter, 0—1 ma.	45-2971
MR100	Meter rectifier	34-8004
R100	Resistor, probe isolation, 30 megohms	33-1339-15
R101	Internal AC calibration control, 12,000 ohms	33-5550-6
R102	Resistor, attenuator, 10 megohms	33-1339
R103	Resistor, attenuator, 3.5 megohms	33-1339-1
R104	Resistor, attenuator, 1 megohm	33-1339-2
R105	Resistor, attenuator, .35 megohm	33-1339-3
R106	Resistor, attenuator, 100,000 ohms	33-1339-4
R107	Resistor, attenuator, 35,000 ohms	33-1339-5
R108	Internal +DC calibration control, 12,000 ohms	33-5550-6
R109	Resistor, current limiting, 56 ohms	66-0563240
R110	External OHMS CAP. ADJUST control, 1200 ohms	33-5550-5
R111	Resistor, attenuator, 15,000 ohms	33-1339-6
R112	Resistor, meter shunt, 10 ma., 5.55 ohms	33-1341
R113	Resistor, meter shunt, 100 ma., .505 ohm	33-1341-2
R114	Resistor, meter shunt, 30 amps., .00167 ohm	76-2955
R115	Resistor, meter shunt, 1 amp., .0505 ohm	76-2955
R116	Internal –DC calibration control, 12,000 ohms	33-5550-6
R117	Resistor, attenuator, 3300 ohms	66-2333240
R118	Resistor, attenuator, 3300 ohms	66-2333240
R119	Resistor, current limiting, 39 ohms	66-0393240
R120	Resistor, shunt, 9000 ohms	33-1339-10
R121	Resistor, shunt, 900 ohms	33-1339-11
R122	Resistor, capacitance voltage divider, 1350 ohms	33-1339-9
R123	Resistor, capacitance voltage divider, 750 ohms	66-1753240
R124	Resistor, capacitance voltage divider, 188 ohms	33-1341-4
R125	Resistor, voltage divider, 10,000 ohms	33-1335-79
R126	Resistor, voltage divider, 2700 ohms	66-2274240
R127	Internal probe calibration control, 12,000 ohms	33-5550-6
R128	Resistor, ohmmeter divider, 11.4 ohms	33-1341-1
R129	Resistor, ohmmeter divider, 88.6 ohms	33-1341-3
R130	Resistor, ohmmeter divider, 12,000 ohms	33-1335-80
R131	Resistor, grid compensation, 2.7 megohms	66-5273340
R132	Resistor, amplifier plate, 220,000 ohms	33-1339-12
R133	Resistor, filament dropping, 1.5 ohms	66-9154260
R134	Resistor, cathode, 24,000 ohms	66-3245251
R135	External ZERO ADJUST control, 1000 ohms	33-5550-1
R136	Resistor, cathode, 142,000 ohms	33-1339-14
R137	Internal bridge balance control, 5000 ohms	33-5550-3
R138	Resistor, cathode, 24,000 ohms	66-3245251
R139	Resistor, plate, 220,000 ohms	33-1339-12
R140	Resistor, a-c voltage divider, 90 megohms (two 45-megohm resistors in series)	33-1339-16
R141	Resistor, a-c voltage divider, 30 megohms	33-1339-15
S100	Wafer switch, function selection, 5 wafers	42-1763
S101	Wafer switch, range selection, 5 wafers	42-1762
T100	Voltage transformer, a-c step-down	32-8324
T101	Power transformer	32-8276-2
W100	Power-cord and plug assembly	41-3755-10

MISCELLANEOUS

Description	Service Part No.
Adjusting knobs	54-4258
Common lead assembly	
Alligator clip	56-4145
Cable, extra flexible	41-3794
Plug	76-2911
Rubber insulator	54-4440
Front panel	56-3049
Function and range-switch knobs	54-4271
Gaskets, high-voltage contact (J106), 2 required	54-4474-2
Handle	76-1979
High-voltage cable assembly	
Alligator clip	56-4145
Cable	41-3795
Handle	54-4442
Housing, plug	54-4447
Plug	76-2912
Retainer, cable	54-4448
Shield	54-4444
Spacer	54-4443
Stud	56-4636
Tip, probe	56-4444
High-voltage terminal, ceramic, male	54-4261
High-voltage terminal gasket	54-4474-1
High-voltage terminal, ceramic, female	54-4436
High-voltage terminal gasket	54-4474
Housing	56-3051
Input-cable assembly	
Alligator clip	56-4145
Cable	41-3793
Cap, probe	56-4638
Handle	54-4441
Plug	76-2022
Split sleeve	54-4461
Tip, probe	56-4443
Insulating mounting plate for condenser C109	27-9508
Mounting feet	54-4240
Model name plate	56-4455
Panel, bakelite, control mounting	76-2891
Panel, bakelite, control mounting	76-2890
Philco name plate	76-2114
Pilot-light assembly	76-1658
Socket, Loktal, 3 required	27-6138*
Socket, octal, 1 required	27-6174*
Standoff insulators, ceramic, 2 required	54-7309-4
Sleeve, rubber, input cable	54-4445

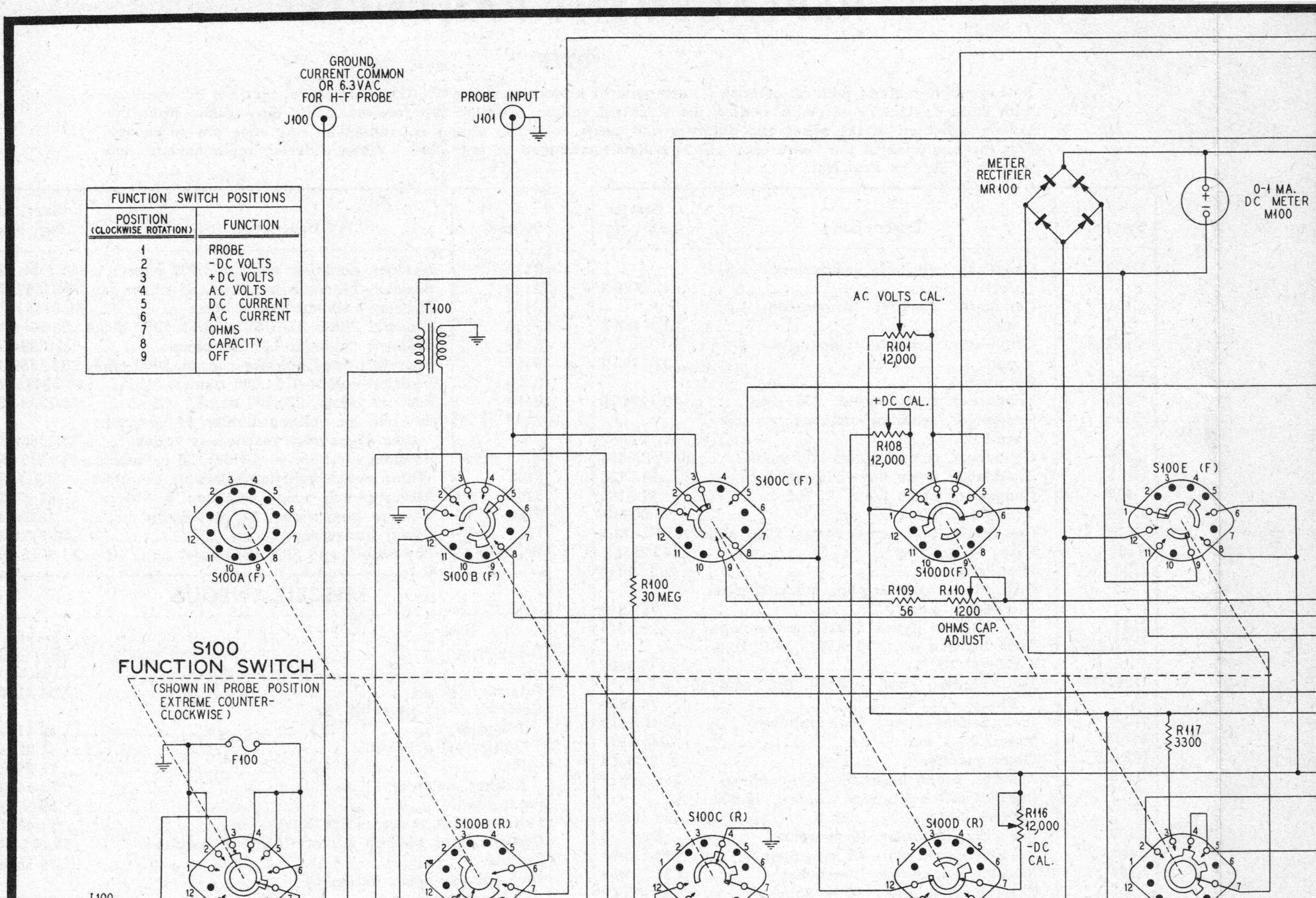
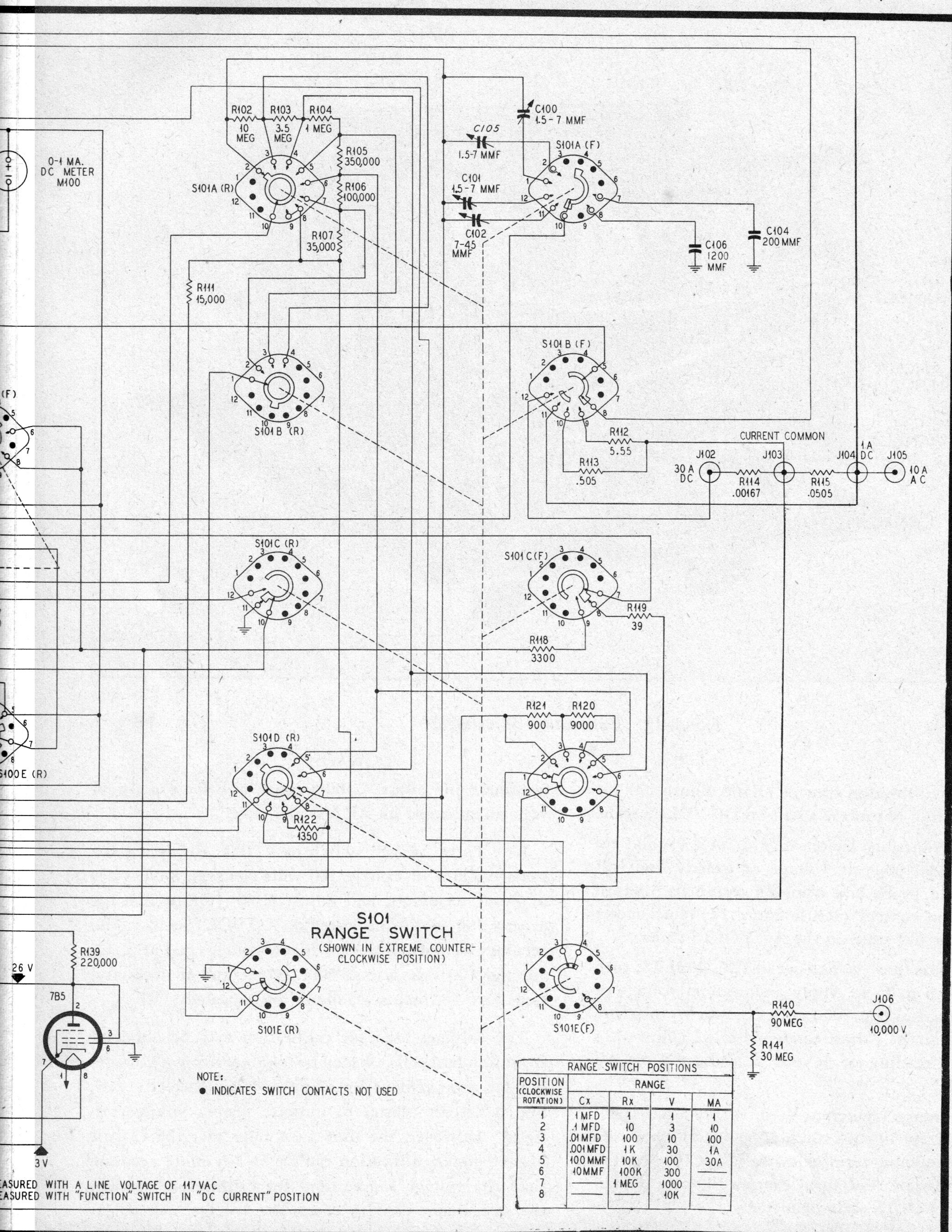


Figure 13. Philco Electronic Circuit Master, Schematic Diagram



RANGE SWITCH POSITIONS

POSITION (CLOCKWISE ROTATION)	RANGE Cx	Rx	V	MA
1	1 MFD	1	1	1
2	.1 MFD	10	3	10
3	.01 MFD	100	10	100
4	.001 MFD	1K	30	1A
5	100 MMF	10K	100	30A
6	10 MMF	100K	300	——
7	——	1 MEG	1000	——
8	——	——	10K	——