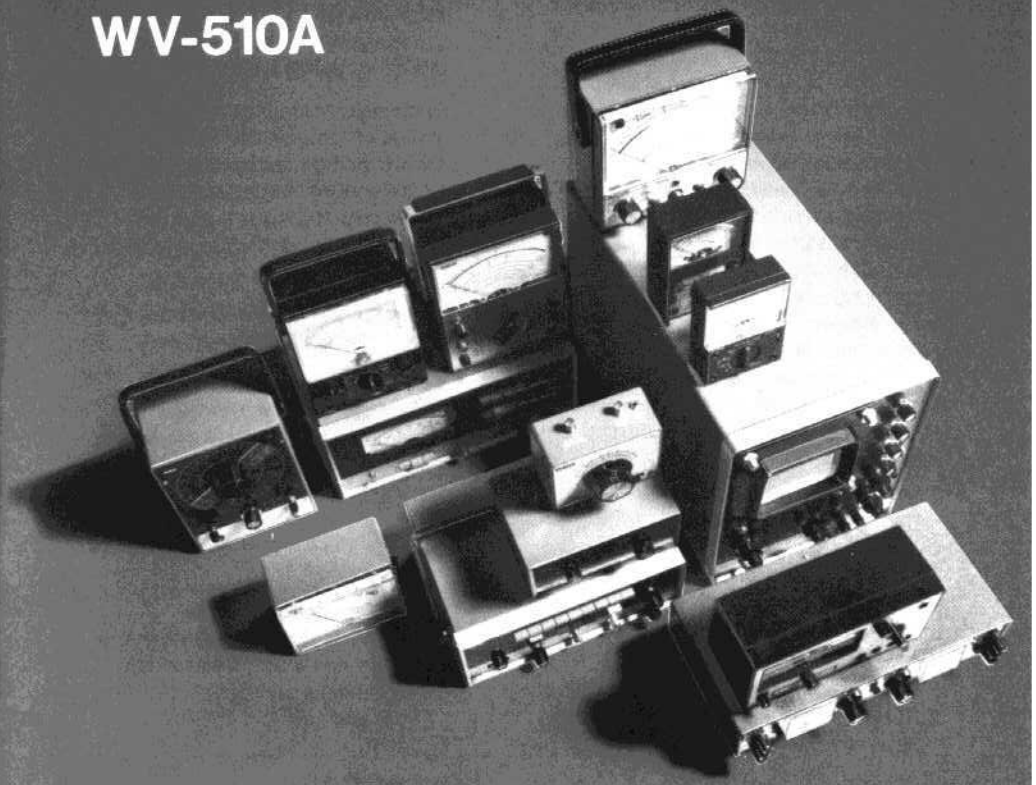
ISSUE 3

# Instruction Manual for

# Master VoltOhmyst®

# WV-510A



RCA Electronic Instruments

SUGGESTED PRICE 50 CENTS

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## Safety Precautions

For proper operation, the ground (black) lead of the WV-510A should be connected to the ground of the equipment under test before any other connections are made. To minimize shock hazard, the case of this instrument is isolated from the circuit ground by a resistor-capacitor parallel network. When the ground lead of the instrument is connected to a point with high above-ground potential, however, it is possible that there will be voltage on the case. For this reason, do not touch the instrument case or permit the case to touch other equipment when high voltage is being measured. An important point to remember is that there is always danger inherent in testing electrical equipment. Therefore, the operator should thoroughly familiarize himself with the equipment under test before working on it, bearing in mind that high voltages may appear at unexpected points in defective equipment. Additional precautions which experience in the industry has shown to be important are listed below:

1. Always use an isolation transformer, such as the WP-25A, WP-26A, or WP-27A Isotap, when working with AC/DC equipment having the chassis connected directly to one side of the AC power line. (Use the Isotap sockets marked "ISOLATED" for this purpose.)
2. It is good practice to remove power before connecting test leads to high-voltage points. If this is impractical, be especially careful to avoid accidental contact with equipment racks and other objects which can provide a ground. Working with one hand in your pocket and standing on a properly insulated floor lessens the danger of shock.
3. Filter capacitors may store a charge large enough to be lethal. Therefore, discharge filter capacitors before attaching test leads.
4. Remember that leads with broken insulation provide the additional hazard of high voltages appearing at exposed points along the leads. Check test leads for frayed or broken insulation before working with them.
5. To lessen the danger of accidental shock, disconnect test leads immediately after test is completed.
6. Remember that the risk of severe shock is only one of the possible hazards. Even a minor shock can place the operator in jeopardy of more serious risks, such as a bad fall or contact with a source of higher voltage.
7. The experienced operator continuously guards against injury and does not work on hazardous circuits unless another person is available to assist in case of accident.



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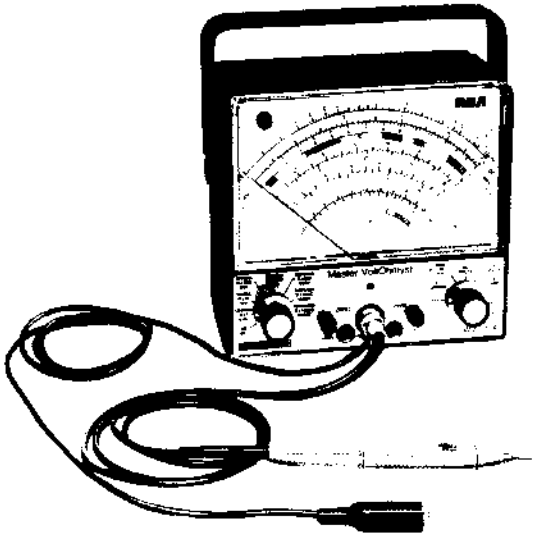


WV-510A

**Accessories Available Separately**

Crystal-Diode Probe ..... WG-301A
Increases AC frequency range to 250 MHz

High-Voltage Probe (less resistor) ..... WG-411A
Increases DC voltage range to 50,000 volts

Multiplier Resistor for WG-411A ..... WG-436A

## Description

The RCA WV-510A Master VoltOhmyst is a high-quality, solid-state electronic voltmeter especially designed for stable, drift-free operation. The instrument can be operated either from internal batteries (not included) or from a 120 volt AC power line. On battery operation, the power cord can be removed for complete portability. The many features of this VoltOhmyst make it ideally suited to service, industrial, and laboratory applications.

The WV-510A measures DC voltage from 0.01 to 1500 volts, direct current from .01 milliamperes to 1.5 amperes, AC RMS voltage from 0.2 to 1500 volts, AC peak-to-peak voltage of complex waveforms from 0.5 to 4200 volts, and resistance values from 0.2 ohms to 1000 megohms.

Seven overlapping ranges are provided for AC voltage, DC current, and resistance measurements, and eight ranges are provided for DC voltage measurement. Accuracy for all voltage and current functions is ±3% of full-scale reading.

The solid-state measuring circuit in the WV-510A features excellent stability and linearity, with minimum effect caused by temperature variations. Current drain is very low, assuring long battery life. Accuracy is maintained throughout the usable life of the batteries. A convenient battery test function is provided.

An input resistance of 21 megohms on all DC ranges permits accurate test results on even the most critical low impedance circuits.

All voltage and resistance measurements are made with the WG-401A single-unit probe with extra-flexible shielded cable. The cable is equipped with a high-quality BNC-type connector. The probe can quickly be adapted to measure DC or AC and resistance by a convenient built-in switch.

Separate test leads are provided for current measurement. The function switch is specially designed so that the two current input jacks are connected together in all functions except current measurement. This feature permits alternate voltage and current measurements without disconnecting the currect test leads from the test circuit.

The frequency response of the AC function can be extended to 250 MHz through the use of an accessory crystal diode probe, the WG-301A. This probe slips onto the WG-401A for a sturdy insulated RF probe without the use of an additional cable.

The DC voltage range can be extended to 50,000 volts through the use of the WG-411A Slip-On High Voltage Probe and WG-436A Multiplier Resistor.

A 1.5-volt "D" size battery is provided with the WV-510A for operation of the ohms circuit. For complete battery operation, four 9-volt batteries (RCA VS323 or equivalent) must also be installed. To assure maximum battery life, the WV-510A circuit provides a "trickle" charge to the 9-volt batteries when the unit is used on AC power.

The Master VoltOhmyst has a large, easy-to-read, two-color meter. A mirror scale is included to prevent inaccurate readings due to parallax. The instrument is attractively styled with a rugged diecast aluminum case and brushed aluminum panel. Weight is only 3½ pounds. Measurements are 6⅞ inches by 5¼ inches by 3⅛ inches.



## Specifications

### Electrical

NOTE: Performance figures are for line voltage of 120 volts, 60 Hz.

**DC Voltmeter**

| | |
|---|---|
| Ranges | 0 to .5, 1.5, 5, 15, 50, 150, 500, 1500 volts |
| Input Resistance (with switch on WG-401A set to "DC"): | |
| All Ranges | 21 Megohms |
| Accuracy | ±3% of full scale reading |

**DC Current**

| | |
|---|---|
| Ranges | 0 to .5, 1.5, 5, 15, 50, 150, 500, and 1500 mA |
| Accuracy | ±3% of full scale reading |
| Insertion Loss | 250 mV on all current ranges |

**AC Voltmeter**

| | |
|---|---|
| Ranges: | |
| RMS | 0 to 1.5, 5, 15, 50, 150, 500, and 1500 volts |
| Peak-to-Peak | 0 to 14, 42, 140, 420, 1400, 4200 volts |
| Accuracy | ±3% of full scale reading |
| (Accuracy of RMS ranges based on use of sine wave signals having less than ½ of 1.0% total harmonic content.) | |

**Input Resistance and Capacitance**

| | |
|---|---|
| (With WG-401A switch set to "AC-OHMS"): | |
| 1.5, 5, 50, 150 V Ranges | 0.83 meg, shunted by 70 pF |
| 500 V Range | 1.3 meg, shunted by 60 pF |
| 1500 V Range | 1.5 meg, shunted by 60 pF |

**Frequency Response**

| | |
|---|---|
| At 1.5 and 5.0 V AC | ±1 DB 30 Hz to 3 MHz |

**Maximum Input Voltages**

| | |
|---|---|
| DC Voltages with no AC voltage present: | 1500 volts |
| AC Voltages with no DC voltage present: | |
| RMS for Sine Waves | 1500 volts |
| Peak-to-Peak for Sine Waves | 4200 volts |
| Peak-to-Peak for Complex Waves | 2000 volts |
| Combined AC and DC Voltages: | |
| Sum of DC Voltage and AC Peak Voltage | 2000 volts |

**Ohmmeter**

| | |
|---|---|
| Ranges, Seven | 0 to 1000 megohms |
| Accuracy | ±3% of center scale reading |

**Meter Movement**

| | |
|---|---|
| DC Current for Full-Scale Deflection | 200 uA |

**Power Required**

AC Operation:

Voltage ..... 110-135 volts
(May be wired for operation on 240V. See page 22.)

Frequency ..... 50/60 Hz

Power Consumption ..... less than 5 watts

Battery Operation: ..... four 9-volt batteries
RCA VS323 or equiv.
(NEDA 1604)
(Not included)

Ohms Circuit ..... one 1.5-volt "D" cell,
RCA VS036 or equiv.

**Mechanical**

**Dimensions (less handle)**

Height ..... 6½ inches

Width ..... 7 inches

Depth ..... 3¾ inches

**Weight**

(With batteries) ..... 3½ pounds

## Operation and Applications

The WV-510A can be operated either from a 120 volt, 50/60 Hz AC power line, or from internal batteries. For AC operation simply connect the power-line cord from the instrument to a 120 volt outlet.

For battery operation, four 9-volt batteries must be installed. Follow battery installation instructions on page 18. The batteries can be kept in the instrument while it is being operated from an AC power line. For battery-operated portable use, the power line cord can be unplugged from the VoltOhmyst. Note: The pilot light will not glow when instrument is battery operated.

### Battery Test

If the four 9-volt batteries are installed, they can be tested as follows:

Unplug AC power cord and set function switch first to BATT TEST A, then to B. The meter pointer should not read below the green area on the BATT TEST scale on either A or B. If batteries do not test good, replace as described on page 18.

To test the 1.5 volt D cell used in the ohmmeter function, set the function switch to R OHMS. Short probe tip to ground lead clip, and adjust ZERO control so that pointer indicates "0". Disconnect probe tip from ground clip, and turn OHMS control fully clockwise. If battery is good, meter pointer can be adjusted to full-scale.

### Use of WG-401A Probe and Cable

The WG-401A DC/AC-OHMS Probe and Cable supplied with the WV-510A is equipped with a sliding switch in the probe body to permit changing the probe characteristics to suit the type of measurement being made. When the sliding switch is set forward to the "DC" position, a built-in 1-megohm resistor is placed in series with the probe tip and the input to the WV-510A. This resistor acts to isolate the instrument from the circuit under test when DC voltage measurements are made and is a part of the over-all input resistance of the voltmeter. The switch should always be set to the "DC" position when DC voltage measurements are made.



When the sliding switch is set to the "AC-OHMS" position, the isolating resistor is shorted out and the signal or test voltage is fed directly from the probe tip to the input of the WV-510A. The switch should always be set to the "AC-OHMS" position when resistance or AC voltage measurements are made.

### Use of Range Switch and Meter Scales

The meter scales on the WV-510A have been designed to provide ease of operation and quick readability over a wide range of measurements. Scales are grouped conveniently for the type of measurement for which they are used. The "R" scale, at the top of the scale plate, is used only for resistance measurements, and all resistance measurements are read from this one scale. All DC voltage and current is read from the two scales marked "A" and "B" in Figure 1. The remaining scales are used only for AC voltage measurements. The RMS values of sine-wave voltages above 5 volts are also read from scales marked "A", "B". The low AC RMS scales, "G" and "H", are used for RMS measurements below 5 volts. Peak-to-peak AC readings are made on the red scales, "C", "D", "E", and "F". The particular scale which is used for any given function is determined by the setting of the range switch.

The charts on the following pages have been prepared as an aid in selection of ranges, scales, and multiplying factors for all measurements which can be made with the WV-510A.

Because of the wide number of measurement ranges provided on the WV-510A, it is often possible to take readings on two ranges and scales. For greatest accuracy in voltage and current measurements, always use the range which will provide an on-scale

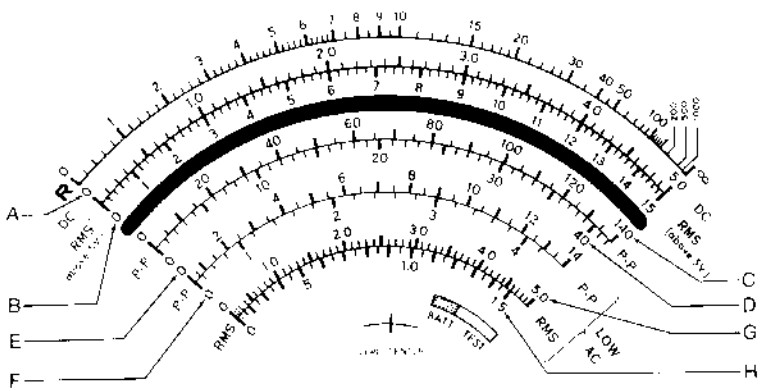



*Figure 1. WV-510A Meter Scales*

reading which is nearest to the full-scale point. For example, 48 DC volts can be read from either the 50 volt or the 150 volt range. Because the 50 volt range will provide a reading nearest the full-scale point, the 50 volt range only should be used if a reading of best accuracy is to be obtained. For ohms measurements, however, the range selected should be the one which provides a reading nearest the center of the scale because the VoltOhmyst provides the most accurate readings at mid-scale points.

For some measurements it will be necessary to use a multiplying factor with the scale reading to obtain the correct reading. The required multiplier is indicated by the setting of the range switch. These ranges correspond to the full-scale values shown on the right side of the meter scales. For example, when the range switch is set to the 500 volt position for a DC voltage measurement, the "A" scale (Figure 1) is used. Because this scale has a full scale value of "5", it is necessary to multiply any readings on this scale by 100 to obtain the correct value.

**DC-Voltage Measurements**

NOTE: The sliding switch on the WG-401A should be set to "DC" for all DC voltage measurements. Maximum input voltages must not be exceeded. See "Specifications" and "Safety Precautions".

The WV-510A has eight DC voltage ranges: 0 to .5, 1.5, 5, 15, 50, 150, 500, and 1500 volts. Although the meter is protected against burn-out under ordinary overloads, it is good practice to make a trial measurement at a range setting higher than the voltage expected. Continued or repeated overloads may impair the accuracy of the movement. To measure DC voltages, proceed as follows:

1. Set the function selector to "+ DC VOLTS" or to "− DC VOLTS", as required.
2. Connect the clip of the ground cable to the ground of the circuit under test.
3. Set the range selector to a range position higher than the voltage to be measured.
4. Touch or connect the probe tip to the high side of the source voltage.
5. Reset range selector to a position which gives a reading nearest to full scale.
6. Read the DC voltage from the scale corresponding to the range selector setting.

**Zero Center**

Zero-center indication is frequently useful because it allows observation of either positive or negative DC-voltage excursions without the necessity of resetting the function selector.

1. Set the function selector to "+ DC VOLTS".
2. Rotate the ZERO control to position the pointer at the zero center mark, which is located near the bottom center of the meter dial. If the ZERO control does not have sufficient range to center the pointer, switch the function selector to "− DC VOLTS".
3. Set the range selector to a position at least twice the voltage to be measured.
4. After a test reading has been made, the range control may be set to the lowest position which allows the pointer to remain on the scale.

**DC Current Measurements**

The WV-510A has eight DC current ranges: 0 to .5, 1.5, 5, 15, 50, 500, and 1500 mA (1.5A). Separate leads are provided for measuring current — the WG-401A probe is not used. Insert the black lead into the "−mA" panel jack, and the red test lead in the "+mA" jack. The current test jacks are shorted together on all functions except "DC CURRENT". Voltage and current measurements can alternately be made without disconnecting the current test leads.

1. Remove power from the circuit under test.
2. Set the function switch to "DC CURRENT" and the range switch to a position higher than the current to be measured.
3. Connect the test leads in series with the circuit in which the current is to be measured. If necessary, break the circuit at a convenient point by disconnecting or unsoldering a connection. Connect

**DC-VOLTAGE MEASUREMENTS**
**(Set Function switch to "−DC VOLTS" or "+DC VOLTS" and set probe switch to "DC".)**

| Voltage to be measured | Set Range Switch to: | Read from Scale | Multiply Reading by |
|---|---|---|---|
| 0 to .5V | .5V DC | A | .1 |
| .5 to 1.5V | 1.5V | B | .1 |
| 1.5V to 5V | 5V | A | 1 |
| 5 to 15V | 15V | B | 1 |
| 15 to 50V | 50V | A | 10 |
| 50 to 150V | 150V | B | 10 |
| 150 to 500V | 500V | A | 100 |
| 500 to 1500V | 1500V | B | 100 |

**DC CURRENT MEASUREMENTS**
**(Set Function switch to DC Current. Use red "+mA" lead and black "−mA" lead.)**

| DC Current to be measured | Set Range Switch to: | Read from Scale | Multiply Reading by |
|---|---|---|---|
| 0 to .5 mA | .5V/mA | A | .1 |
| .5 to 1.5 mA | 1.5V/mA | B | .1 |
| 1.5 to 5 mA | 5V/mA | A | 1 |
| 5 to 15 mA | 15V/mA | B | 1 |
| 15 to 50 mA | 50V/mA | A | 10 |
| 50 to 150 mA | 150V/mA | B | 10 |
| 150 to 500 mA | 500V/mA | A | 100 |
| 500 to 1500 mA (1.5A) | 1500V/mA | B | 100 |

the black test lead to the negative side of the circuit and the red lead to the positive side of the circuit.

4. Apply power to the circuit under test. Reset the range switch to a position which gives a suitable meter pointer deflection.
5. Read current from the scale corresponding to the range switch setting.

**AC-Voltage Measurements**

CAUTION: Maximum input voltages must not be exceeded. The accuracy of meter indications is dependent upon the frequency of the AC voltage being measured, the waveshape, repetition rate, and the impedance of the voltage source. See "Specifications", page 5, and the section below for additional information.

The switch on the WG-401A Probe should be set to "AC-OHMS" for all AC voltage measurements.

1. Set the function selector to "AC".
2. Adjust the ZERO control if necessary to position the meter pointer at the left-hand "0".
3. Set the range control to a position considerably higher than the voltage to be measured.
4. Connect the ground cable to the ground side of the voltage to be measured.
5. Touch or connect the probe tip to the high side of the source voltage.
6. Reset the range control for a convenient deflection.
7. Read the AC voltage from the scale corresponding to the range control setting.

The meter scales of the WV-510A are calibrated in both RMS and peak-to-peak voltages. Peak-to-peak voltage values are read from the red scales marked "P-P"; RMS values of sine waves are read from the black scales marked "RMS".

When it is desired to know which peak-to-peak scale is used, the indication is taken from the markings on the range switch positions. Position 2 for example, is labeled "5V" and "14V". These figures correspond to the full-scale values of the corresponding RMS and peak-to-peak scales.

**AC RMS VOLTAGE MEASUREMENTS**
**(Set Function switch to "AC" and set probe switch to "AC-OHMS".)**

| RMS voltage to be measured | Set Range Switch to: | Read from Scale | Multiply Reading by | To get equivalent peak-to-peak-value: | |
|---|---|---|---|---|---|
| | | | | Use Scale | Multiply by |
| 0.1 to 1.5V | 1.5V | H | 1 | F | 1 |
| 1.5V to 5V | 5V | G | 1 | E | 1 |
| 5 to 15V | 15V | B | 1 | D | 1 |
| 15 to 50V | 50V | A | 10 | C | 1 |
| 50 to 150V | 150V | B | 10 | D | 10 |
| 150 to 500V | 500V | A | 100 | C | 10 |
| 500 to 1500V | 1500V | B | 100 | D | 100 |



**AC PEAK-TO-PEAK VOLTAGE MEASUREMENTS**
**(Set Function switch to "AC" and set probe switch to "AC-OHMS".)**

| Peak-to-peak voltage to be measured | Set Range Switch to: | Read from Scale | Multiply Reading by | To get equivalent RMS value: | |
|---|---|---|---|---|---|
| | | | | Use Scale | Multiply by |
| 0.2 to 4V | 4.0V | F | 1 | H | 1 |
| 4 to 14V | 14V | E | 1 | G | 1 |
| 14 to 40V | 40V | D | 1 | B | 1 |
| 40 to 140V | 140V | C | 1 | A | 10 |
| 140 to 400V | 400V | D | 10 | B | 10 |
| 400 to 1400V | 1400V | C | 10 | A | 100 |
| 1400 to 4200V | 4000V | D | 100 | B | 100 |

Examples of typical voltage waveforms found in television circuits are shown in Figure 2. Examples of other types of basic waveforms which can be measured by the WV-510A are shown in Figure 3.

The instrument has a maximum rated input for non-symmetrical waveforms of 200 peak-to-peak volts. Sine waves and symmetrical complex waves up to 4200 peak-to-peak volts can be measured with somewhat reduced frequency response. (See Maximum Input Voltages under "Specifications".)

Reliable AC voltmeter readings can be assured only if the characteristics of the voltmeter are compatible with the characteristics of the circuit under test. When the WV-510A is used to measure AC voltages, the "Specifications" on page 5 should be considered. Information on input resistance and capacitance, frequency response, and pulse response is given.

When any voltmeter is used to measure AC voltages, certain precautions in the interpretation of readings are necessary because connection of the

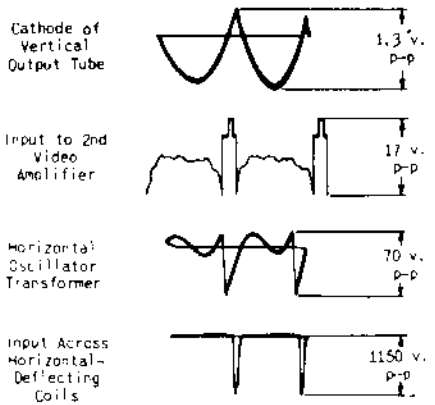



***Figure 2. Typical television waveforms***

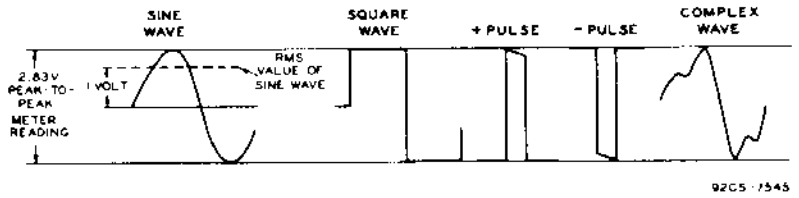



*Figure 3. Typical voltage waveforms*

meter to the circuit may cause some disturbance. This is also true of the VoltOhmyst but its high input impedance minimizes such disturbances. The amount of circuit disturbance caused by the voltmeter is usually reflected in a decreased circuit voltage, the amount of decrease being dependent upon the characteristics of both the voltmeter and the test circuit.

For example, inaccurate readings of normal circuit conditions can be obtained from any one or a combination of the following conditions:

1. If measurements are made in high-impedance circuits. The instrument will cause loading of the circuit to a degree dependent upon the ratio of the circuit impedance to the voltmeter impedance. As this ratio increases, the loading effect of the voltmeter is increased with a corresponding change in the normal operating conditions of the circuit.
2. If the capacitance of the circuit is low in relation to the input capacitance of the voltmeter.
3. If the frequency of the source voltage is higher than the upper frequency rating of the voltmeter.
4. If the voltage waveform in the test circuit consists of narrow pulses with a low repetition rate.

The last of these four conditions needs careful consideration in order to interpret correctly the peak-to-peak readings of the VoltOhmyst. The values of the circuit capacitors and resistors used in the peak-to-peak rectifier circuit of the WV-510A have been chosen to give a discharge time which will provide a reliable peak-to-peak reading over its specified frequency range. If pulses of extremely short duration are applied to the rectifier circuit, the capacitors may not charge to the peak-voltage value of the pulse. If pulses with a low repetition rate are applied to the rectifier circuit, the capacitors will dissipate an appreciable part of the charge by the time the next pulse is applied. As a result, the capacitors are not charged to the full peak-to-peak value of the voltage. Therefore, both the RMS and peak-to-peak voltage indications will be lower than the true value of the applied voltage.

**DBM Measurements**

The graph on page 14 can be used to determine dbm values corresponding to RMS AC-voltage values across a 600-ohm resistive load. A dbm value is defined as the number of decibels above or below a reference level of 1 milliwatt in 600 ohms at 1000 cycles.



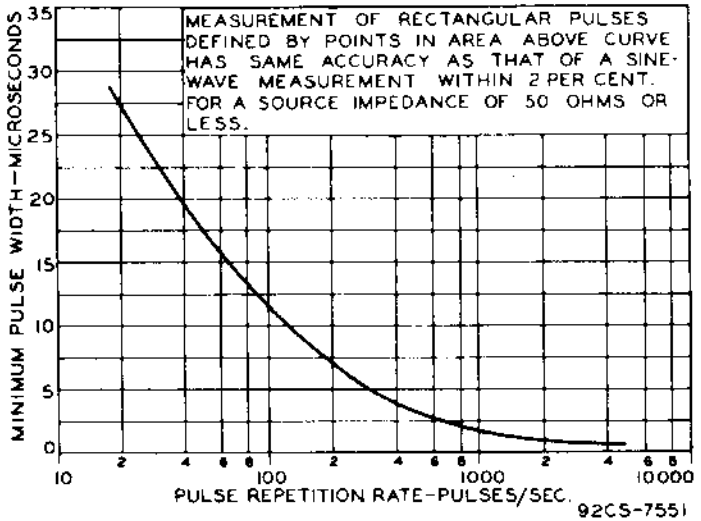



*Figure 4. Pulse repetition capability of the WV-510A*

Zero dbm, therefore, would indicate a power level of 1 milliwatt; 10 dbm, 10 milliwatts; and 20 dbm, 100 milliwatts.

The graph makes possible rapid conversion of RMS voltages to corresponding dbm values. Associated power levels can be read along the top of the graph. If the RMS voltage is measured across a resistive load other than 600 ohms, the correction factors given below must be added algebraically to the dbm values read from the graph in Figure 5. For resistive loads not given in the table, the following formula should be used for determining the correction factor:

$$\text{Correction Factor} = 10 \log \frac{600}{R}$$

where R is the load in ohms. If R is greater than 600 ohms, the correction factor is negative.

Because dbm is defined with respect to a 600-ohm load, power levels correspond to voltage values. DBM can be measured in terms of RMS voltages across a 600-ohm resistive load. For example, 0.775 RMS volt indicates 0 dbm; 7.75 RMS volts indicate 20 dbm. While these measurements must be made with a sine waveform to avoid waveform error, any frequency can be used which is within the range of the WV-510A. The decibel and ear-response curves have their closest correlation at 1000 cycles.

| Resistive Load at 1000 cps | DBM* |
|---|---|
| 600 | 0 |
| 500 | +0.8 |
| 300 | +3.0 |
| 250 | +3.8 |
| 150 | +6.0 |
| 50 | +10.8 |
| 15 | +16.0 |
| 8 | +18.8 |
| 3.2 | +22.7 |

*DBM is the increment to be added algebraically to the dbm value read from Figure 5.

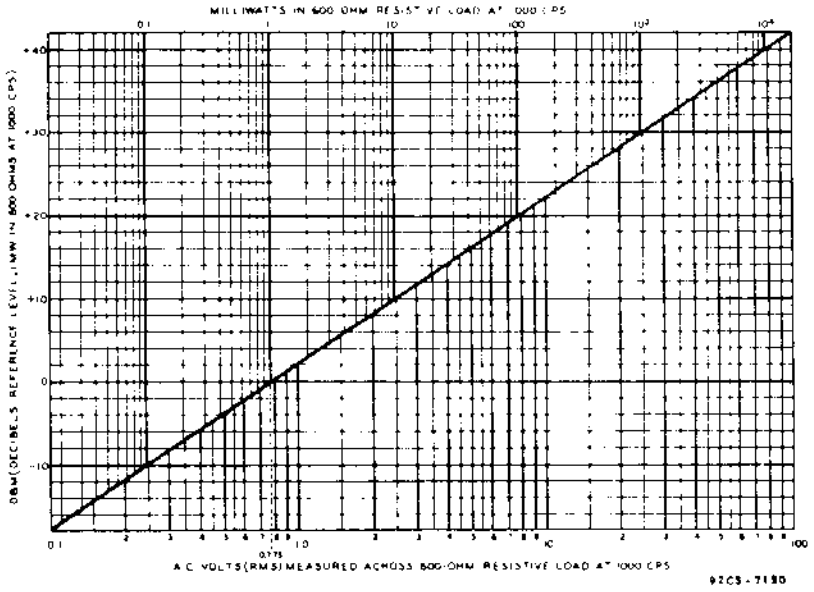



*Figure 5. Graph for conversion of rms to dbm values*

**Resistance Measurements**

NOTE: The sliding switch on the WG-401A probe should always be set to "AC-OHMS" when resistance measurements are to be made.

CAUTION: The power should be removed from the equipment under test, and any capacitors should be discharged so that no voltages are present in them.

1. Set the range selector to the position nearest to the value under measurement.
2. As a preliminary step, set the function selector to the "+DC" position and adjust the ZERO control to position the pointer at the left-hand "0", if necessary.
3. Set the function selector to "R OHMS". Adjust the OHMS control to bring the meter pointer to exactly full-scale.
4. Connect the clip of the ground cable to one terminal of the resistance to be measured.
5. Touch or connect the probe tip to the other terminal of the resistance to be measured.
6. Reset the range control to give a convenient deflection on the "R" (ohms) scale.
7. Multiply the reading on the "R" scale by the factor indicated by the range control setting.

NOTE: The cable provided with the WG-401A probe has been especially selected not only for its electrical qualities, but also for its convenient flexibility and thin diameter. However, the cable does have a small amount of resistance, approximately 0.6 ohms. When measuring resistances less than 10 ohms, this value (0.6 ohms) should be subtracted from the actual meter reading. On readings above 10 ohms, this resistance will have no significant effect.

CAUTION: Low-current, low-resistance devices, such as thermocouples, meter movements, and semi-conductor devices may be damaged unless a range higher than "R x 10" is used because the WV-510A applies up to 1.5 volts across the resistance under measurement when the range control is set at "R x 1" or "R x 10".



**RESISTANCE MEASUREMENTS**
**(Set Function switch to "R OHMS" and set probe switch to "AC-OHMS".)**

| Resistance to be measured | Set Range Switch to: | Read from Scale | Multiply Reading by |
|---|---|---|---|
| 0.2 to 1000Ω | R X 1 | R | 1 |
| 1000 to 10000Ω | R X 10 | R | 10 |
| 10000 to 1000000Ω | R X 100 | R | 100 |
| 1000000Ω to 1 MEG | R X 1000 | R | 1000 |
| 1 MEG to 10 MEG | R X 10K | R | 10000 |
| 10 MEG to 100 MEG | R X 100K | R | 100000 |
| 100 MEG to 1000 MEG | R X 1 MEG | R | 1 MEG |

**Measurement of Resistance Values Above 1000 Megohms**

The leakage resistance of small mica and paper capacitors is usually above 1000 megohms. The circuit shown in Figure 2 can be used to measure resistance values above 1000 megohms. An external DC-voltage source between 20 and 500 volts is utilized to obtain a measurable pointer deflection. Make circuit connections as shown in Figure 6 and proceed as follows:

1. Set function selector to "– DC VOLTS" and measure the voltage at point B.
2. Measure the voltage at point A.
3. Compute the unknown resistance from the following formula:

$$Rx\ (\text{megohms}) = 11\ \frac{[(\text{Volts at "A"}) - (\text{Volts at "B"})]}{(\text{Volts at "B"})}$$

EXAMPLE: The value of an unknown resistance is to be determined with the circuit of Figure . An external voltage of 500 volts is applied. The WV-510A measures 2.5 volts at "B", and 500 volts at "A". Then,

$$Rx = \frac{11\ (500-2.5)}{2.5}$$

= 2200 megohms (approx.)

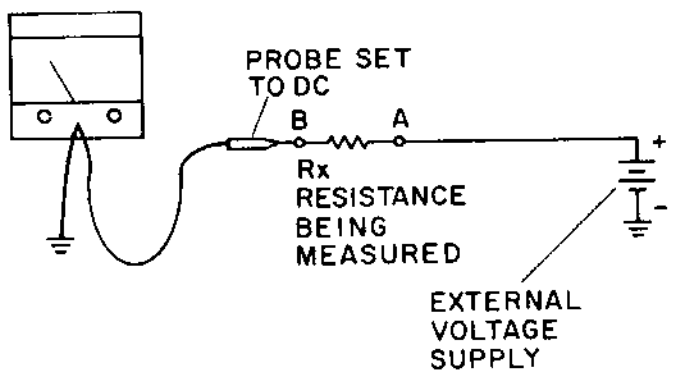
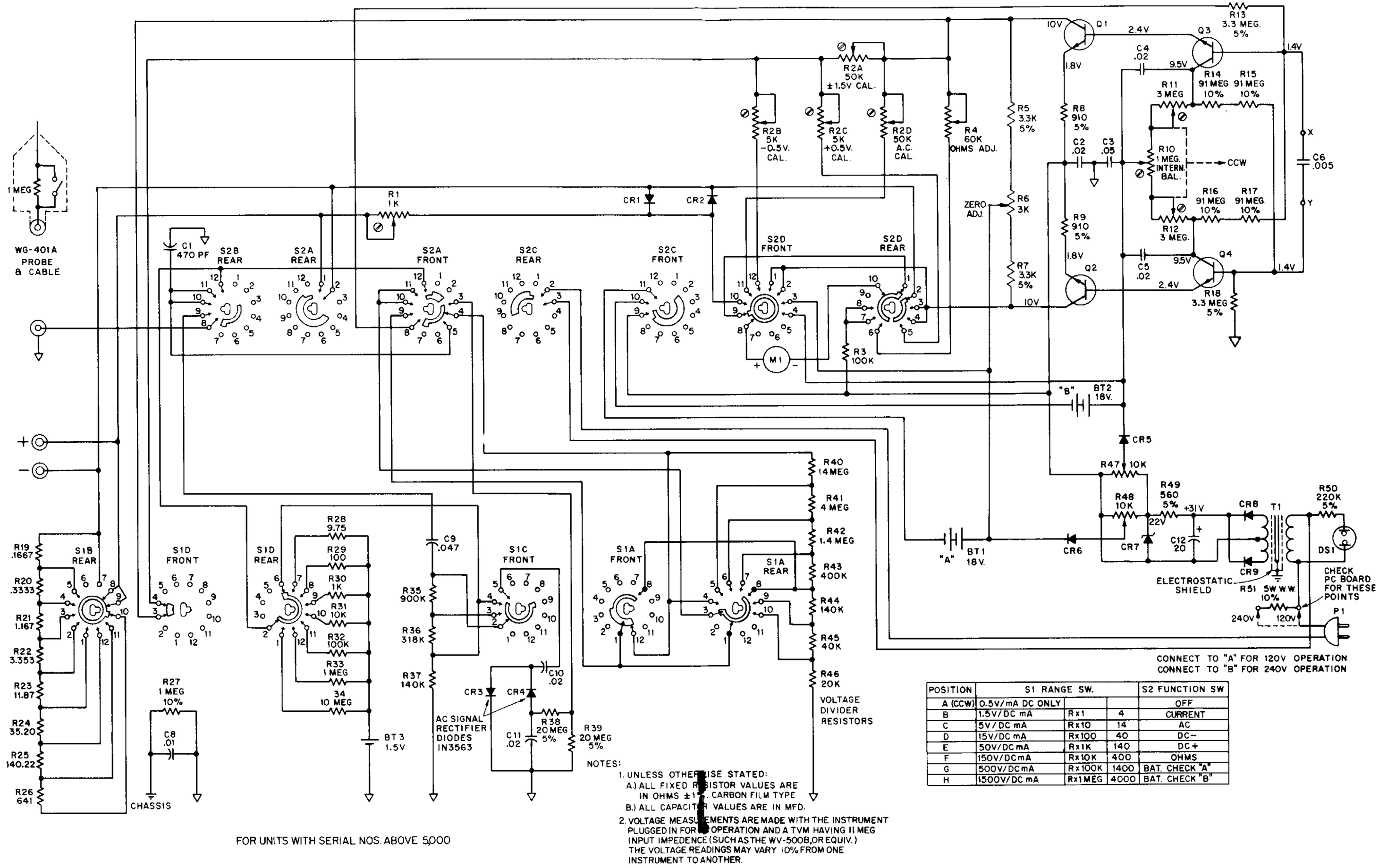



*Figure 6. Circuit for resistance measurements above 1000 megohms*

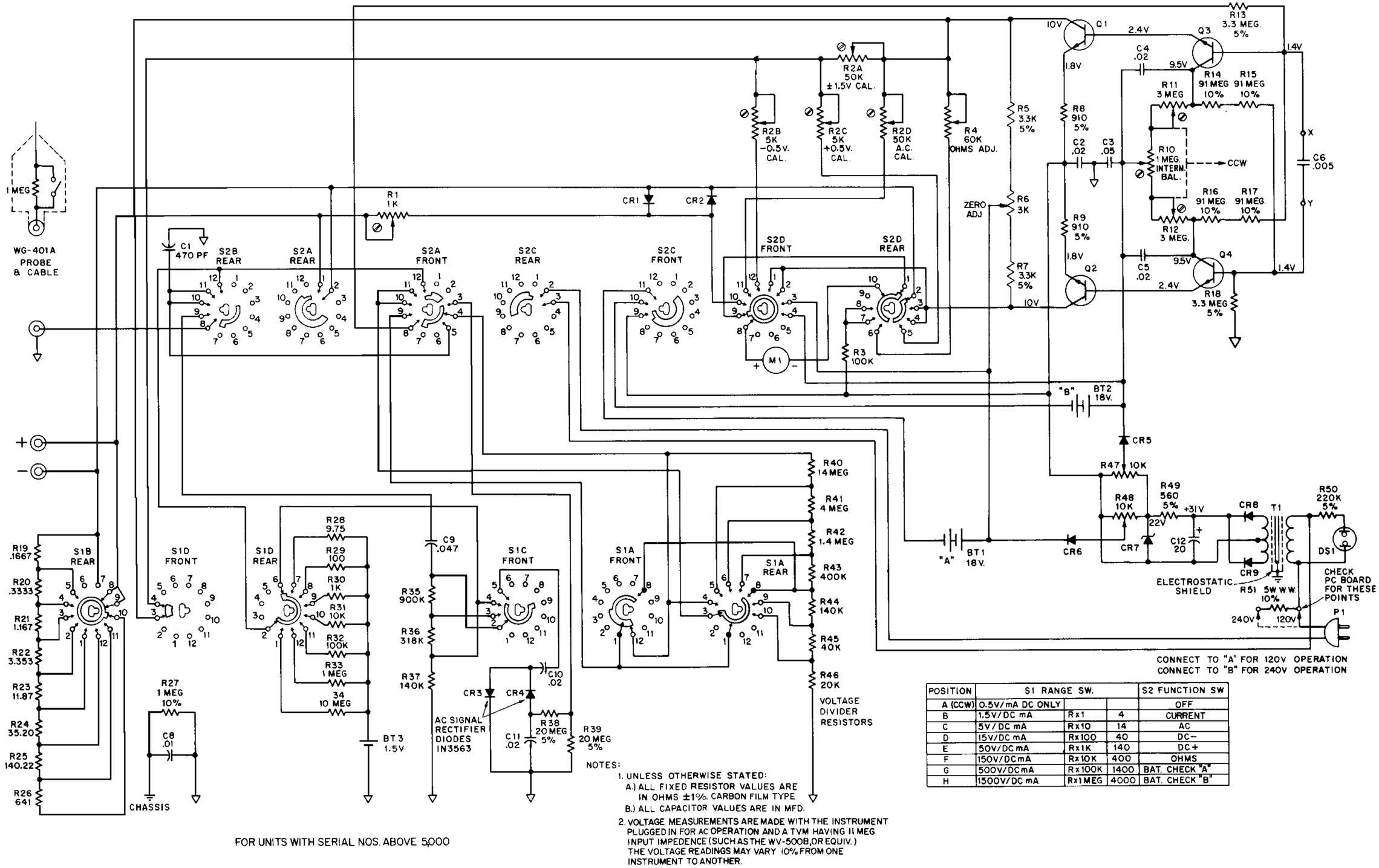



| POSITION | S1 RANGE SW. | | | S2 FUNCTION SW |
|---|---|---|---|---|
| A (CCW) | 0.5V/mA DC ONLY | | | OFF |
| B | 1.5V/DC mA | Rx1 | 4 | CURRENT |
| C | 5V/DC mA | Rx10 | 14 | AC |
| D | 15V/DC mA | Rx100 | 40 | DC- |
| E | 50V/DC mA | Rx1K | 140 | DC+ |
| F | 150V/DC mA | Rx10K | 400 | OHMS |
| G | 500V/DC mA | Rx100K | 1400 | BAT. CHECK "A" |
| H | 1500V/DC mA | Rx1MEG | 4000 | BAT. CHECK "B" |

FOR UNITS WITH SERIAL NOS. ABOVE 5,000

NOTES:
1. UNLESS OTHERWISE STATED:
   A.) ALL FIXED RESISTOR VALUES ARE IN OHMS ±1%. CARBON FILM TYPE
   B.) ALL CAPACITOR VALUES ARE IN MFD.
2. VOLTAGE MEASUREMENTS ARE MADE WITH THE INSTRUMENT PLUGGED IN FOR [illegible] OPERATION AND A TVM HAVING 11 MEG INPUT IMPEDENCE (SUCH AS THE WV-500B, OR EQUIV.) THE VOLTAGE READINGS MAY VARY 10% FROM ONE INSTRUMENT TO ANOTHER.

*WV-510A Schematic Diagram*




| POSITION | S1 RANGE SW. | | | S2 FUNCTION SW |
|---|---|---|---|---|
| A (CCW) | 0.5V/mA DC ONLY | | | OFF |
| B | 1.5V/DC mA | Rx1 | 4 | CURRENT |
| C | 5V/DC mA | Rx10 | 14 | AC |
| D | 15V/DC mA | Rx100 | 40 | DC− |
| E | 50V/DC mA | Rx1K | 140 | DC+ |
| F | 150V/DC mA | Rx10K | 400 | OHMS |
| G | 500V/DC mA | Rx100K | 1400 | BAT. CHECK "A" |
| H | 1500V/DC mA | Rx1MEG | 4000 | BAT. CHECK "B" |

NOTES:

1. UNLESS OTHERWISE STATED:
   A.) ALL FIXED RESISTOR VALUES ARE IN OHMS ±1%. CARBON FILM TYPE
   B.) ALL CAPACITOR VALUES ARE IN MFD.
2. VOLTAGE MEASUREMENTS ARE MADE WITH THE INSTRUMENT PLUGGED IN FOR AC OPERATION AND A TVM HAVING 11 MEG INPUT IMPEDENCE (SUCH AS THE WV-500B, OR EQUIV.) THE VOLTAGE READINGS MAY VARY 10% FROM ONE INSTRUMENT TO ANOTHER.

FOR UNITS WITH SERIAL NOS. ABOVE 5,000

*WV-510A Schematic Diagram*

## Battery Replacement

Four 9-volt batteries are used in the WV-510A. Two of these batteries are designated as "A", and two are designated as "B", as shown in Figure 7. When replacing batteries, always replace both A batteries or both B batteries, as required.

The 1.5-volt battery is soldered in the circuit to assure low-resistance terminal connections. To remove this battery, unsolder the wires connected to the terminals. Before installing a new battery, "tin" (apply a small amount of solder) the terminals. Insert new battery in the same position as the original battery. Solder the red wire to the positive terminal (battery cap) and the black wire to the negative terminal.

### When to Replace Batteries

Replace the "A" or "B" set of 9-volt batteries when they no longer test in the green area of the battery test scale.

Replace the 1.5-volt battery only when it is no longer possible to obtain full-scale calibration on the ohms function.

To replace the batteries, remove the case from the unit by taking-out the four screws on the back. Lift up the protective plastic flap and insert the 9-volt batteries into the metal bracket as shown. Snap the connectors onto the battery terminals.

### Battery Life

The WV-510A is especially designed to obtain maximum life from the batteries. A constant "trickle" charge is applied to the four 9-volt batteries when the instrument is used on AC power. To extend battery life, the instrument should always be turned off when not in use. Since no warm-up time is required, as with a tube operated voltmeter, the WV-510A can be used immediately after being turned on.

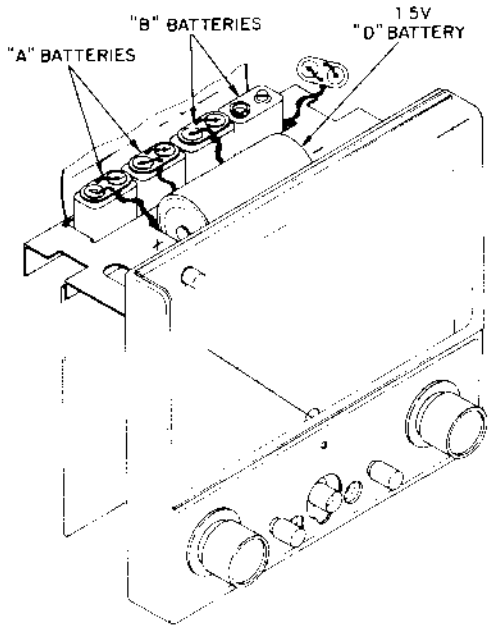



*Figure 7. Battery Installation*



Operating and storage temperature is one of the most important factors determining battery life. In general, the life of carbon-zinc batteries such as the VS323 will be decreased as temperature is increased above normal room temperature (70 degrees F). If the instrument is kept in a high temperature area, the batteries will require more frequent replacement.

Low temperature will not have an adverse effect on battery life. On the contrary, battery life will actually be extended. At temperatures below 4 degrees F however, the battery capacity will be reduced, and at temperatures below —22 degrees F, the battery will become inoperative.

## Battery Operation Hints

To insure the best performance and longest battery life, it is important that you follow the procedures noted below:

1. The WV-510A will provide a trickle charge to the batteries when it is used on AC (power must be turned on). To maintain the battery charge, it is recommended that as a general rule, the instrument be turned on AC for approximately the same amount of time it is used on batteries.
2. Test the batteries periodically using the battery test function. When in continuous use, test the batteries once a day.
3. If batteries test weak, recharge them by operating the unit on AC for 6 to 8 hours. If the batteries still test weak, replace them (or at least remove them from the instrument) as soon as possible. Shorted or leaky batteries can affect instrument accuracy, even when it is operated from the AC line.
4. Remove the batteries if the instrument is to be stored, or is not to be used for an extended period of time.
5. If you use the instrument on battery operation frequently, in time the two 9V "A" batteries will run down and require recharging or replacement. The two 9V "B" batteries should last much longer, actually the entire period of their useful "shelf life." For this reason, if you remove the batteries temporarily, it is recommended that the "A" and "B" batteries not be mixed. For example, do not take batteries that have been used as "A" batteries, then at a later date reinstall them as "B" batteries.

## Accessories

**Available on Separate Order**

The RCA WG-301A Crystal-Diode Probe may be used with the VoltOhmyst to extend the frequency range to 250 megacycles. This probe circuit consists of a diode rectifier and an RC network. The probe, which slips onto the front of the WG-401A Probe and Cable, eliminates the need for an extra cable.

The WG-301A may be used in RF circuits to measure sine-wave voltage values up to 20 RMS volts in the presence of DC voltage as high as 250 volts. The over-all frequency range of the probe is from 50 kHz to 250 MHz. All RF voltages are read from the DC scales in terms of RMS volts for sine waves. For example: A reading of 5 volts DC indicates that the sine wave being measured has an RMS value of 5 volts. The over-all accuracy of the WV-510A when used with the WG-301A is ±10%.

The RCA WG-411A High-Voltage Probe may be used to measure DC voltages as high as 50,000 volts. The probe uses the WG-436A Multiplier Resistor, having a value of 2079 megohms, to present an over-all voltmeter input resistance of 2100 megohms. With a multiplying factor of 100, the VoltOhmyst provides six full-scale positions of 150, 500, 1500, 5000, 15,000, and 50,000 volts. Do not measure voltages higher than 50,000 volts, because the maximum voltage rating of the probe may be exceeded. The extremely high impedance of the WG-411A is especially desirable when it is necessary to measure voltages found in phototubes, geiger-counter tubes, television, and other high-impedance circuits which would not function properly if loaded down by a low-impedance voltmeter. The WG-411A High-Voltage Probe offers distinct advantages in high-voltage circuits as well as low-voltage circuits characterized by high impedance or poor regulation.

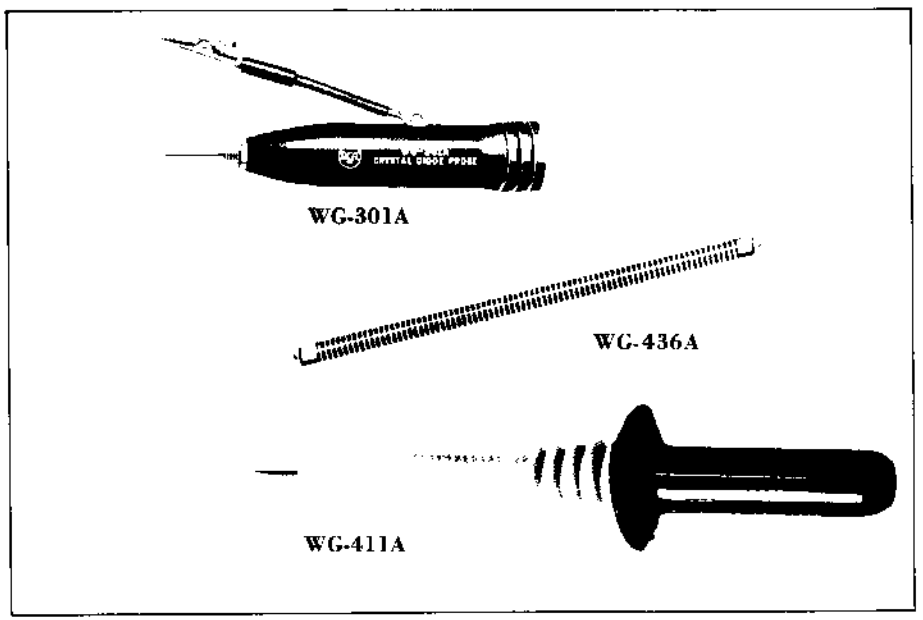



*Figure 8. Accessories available for WV-510A*



## Circuit Description

The operation of the WV-510A Solid-State Master VoltOhmyst is based on a four-transistor amplifier circuit, especially designed for high input impedance with good stability and linearity.

**Power Supply**

The WV-510A can be operated either from an AC power line or from internal batteries. On AC operation, the voltage is applied through the power transformer, then rectified by diodes CR8 and CR9. A zener diode, CR7, regulates the power supply output so that varying line voltage will not cause zero shift. Diodes CR5 and CR6 isolate batteries BT1 and BT2 preventing them from discharging through the power supply circuit.

For battery operation, four 9-volt batteries must be installed. Two of these are used as BT1 (designated "A") providing 18 volts to operate transistors Q1 and Q2. The other two 9-volt batteries are used as BT2 (designated "B"), and provide bias voltage for Q3 and Q4.

When the unit is used on AC power, the 9-volt batteries receive a constant "trickle" charge. The charge level is established by adjusting potentiometers R47 and R48.

**Metering Circuit**

The input voltage (from the AC/DC voltage divider or ohms divider) is applied across the bases of Q3 and Q4, positive to Q3 base and negative to Q4 base. These transistors provide a nearly infinite impedance. This high impedance is achieved through a controlled positive feedback network, R14, R15 and R16, R17 and the two impedance adjust potentiometers, R11 and R12. Q3 and Q4 serve as preamplifiers driving the bases of Q1 and Q2. In effect, transistors Q3 and Q1 amplify the positive portion of the signal, and Q4 and Q2 amplify the negative portion of the signal. Negative feedback through R8 and R9 result in high impedance at the Q1 and Q2 bases to prevent loading the Q3 and Q4 emitters. The output of Q1 and Q2 drive the meter movement.

Potentiometer R10 is used to balance the Q3/Q4 input. This is a factory adjustment and need not be readjusted unless the transistors are replaced. The front panel ZERO control, R6 balances the amplifier output with no input signal applied.

Resistors R13 and R18 serve to isolate and protect the amplifier circuit. Capacitors C2 through C6 are by-pass capacitors to prevent AC signals from affecting the metering circuit.

**DC Voltage Function**

DC voltage input is applied through the isolation resistor in the probe to the voltage divider network (range), resistors R40 through R46. The voltage from the divider network is then connected to the transistorized metering circuit.

**DC Current Function**

The transistor amplifier is not used in the DC current function. A separate shunt resistor (R19 through R26) is connected across the meter for each of the current ranges. The current input is connected directly to the meter and shunt circuit. Potentiometer R1 is used to calibrate the current measuring function. Diodes CR1 and CR2 are connected across the meter terminals in the current function to prevent meter damage due to accidental overload.

**AC Function**

When the VoltOhmyst is used to measure AC voltage, the signal is first rectified by diodes CR3 and CR4 which form a full wave peak-to-peak rectifier. The circuit components are chosen to provide a long time constant. When the signal swings negative, C10 is charged through CR3 to the negative peak value of the voltage. As the input signal

starts in a positive direction, C11 charges to a value equal to the sum of the positive and negative peaks. Because of the relative time constant, the voltage across C11 will be maintained at the peak-to-peak value of the AC signal. This signal, now DC, is fed through the voltage divider network to the metering circuit.

**Resistance Function**

The voltage from battery BT3, 1.5 volts, is applied through the selected ohms divider resistor (R28 through R34) to the external resistance under test. A voltage divider is formed by the range resistor and the external resistance. The output of this divider is fed to the metering circuit.

**Battery Test**

There are two battery test positions on the WV-510A; one for battery group "A" (BT1) and one for battery group "B" (BT2). In each of the battery test positions, the batteries operating under their normal load are connected to the meter movement through resistor R3.

## Maintenance

The WV-510A is manufactured, tested, and calibrated under strict engineering supervision. Should the instrument require adjustment or repair, the procedure outlined below should be followed. If it becomes necessary to replace any of the component parts, only RCA replacement parts, or their equivalent should be used. Order parts through an authorized RCA Parts & Accessories Distributor.

The schematic diagram for the instrument is on page 16, the Replacement Parts List is on page 28. To service the instrument, take out the four screws in the back and remove the case. To remove meter and case-front assembly, take off the two screws fastening the upper chassis to the case-front, and the nuts on the front panel switches and potentiometers.

**240 Volt Operation**

The WV-510A can be used on 240 volt AC by re-connecting one lead as described below:

Refer to Figure 11. Unsolder the lead connected to hole ±1 in the circuit board. Insert the lead in hole #3. Solder the connection.

**Mechanical Zero Adjustment:**

The meter pointer should rest at the left-hand zero mark when the function switch is turned to the "OFF" position. If the pointer should come to rest at a deflected position, the position may be corrected mechanically as follows:

CAUTION: Extreme care must be taken in the next step to prevent insertion of the tool to a depth which will injure the pointer spring. The meter warranty does not cover such damage.

Insert a scriber or similar tool to engage the zero-adjustment lever, and move the lever laterally as required to bring the pointer to "0".

Anti-static treatment: The clear plastic meter case has been factory-treated to prevent static charges from forming on the case. If the meter pointer is "sticky" and acts erratically, the anti-static treatment may no longer be effective. Check meter by rubbing the outside surface of the case vigorously with a soft, dry cloth. If the pointer moves away from its original position and remains at another position for several minutes, the case should be re-treated. To restore the anti-static coating, apply a small amount of liquid detergent (the type used in washing dishes) to a soft cloth and gently wipe the front of the meter case.



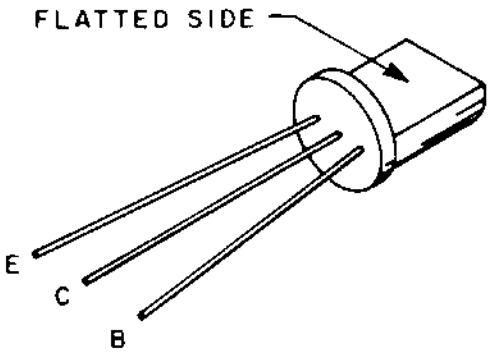



*Figure 9. Transistor lead identification*

**Transistor Replacement**

The four transistors used in the WV-510A are specially selected and matched. Should transistor replacement become necessary, all four transistors must be replaced with a matched group. A set of four matched transistors, properly selected and matched, are available from RCA as one stock number. See Parts List, page 28.

### CALIBRATION

The internal calibration adjustments of the WV-510A require recalibration only if the transistors or other major circuit components are replaced.

Note: The accuracy of the recalibrated instrument cannot exceed the accuracy of the voltage sources that are used.

**Internal Balance Adjustment**

1. Check the mechanical zero position of the pointer. If necessary, reset mechanical zero as described on page 22.
2. Temporarily connect a jumper wire between Q3 base and Q4 base.
3. Turn function switch to "−DC VOLTS" and range switch to "0.5V DC". Adjust ZERO control to bring meter pointer exactly to "0". Check for correct zero setting by switching function switch from "+DC VOLTS" to "−DC VOLTS"; the pointer should not shift. Remove jumper wire.
4. Set the function switch to the +DC position. Adjust R10, the "INT BAL" control to bring the meter pointer to "0". Again, check for correct adjustment by switching the function switch from "+DC VOLTS" to "−DC VOLTS"; the pointer should not shift.

**Input Impedance Adjustment**

1. Set function switch to "R OHMS", and the range switch to "R x 1". Adjust "OHMS" control for exactly full scale reading.
2. Set range switch to "R x 1 MEG". If meter drops below "1000" on the OHMS scale, simultaneously adjust both "IMPED. ADJ" potentiometers, R11 and R12 for a full scale meter reading.
3. Repeat Internal Balance Adjustment above.

**DC Voltage Calibration**

1. Turn the function switch to "+DC VOLTS", the range switch to "0.5V DC", and the probe switch to "DC". Adjust ZERO control to bring meter pointer exactly to "0".
2. Turn the range switch to "0.5 V DC". Apply +0.5 volts from a precision voltage source to the probe and

ground lead. Adjust R2C, the "+.5" control to bring the meter pointer to the full scale mark on the 0-to-5.0 scale.

3. Set function switch to "−DC VOLTS", and reverse test lead connection to voltage source so that −0.5 volts DC is applied. Adjust R2B, the "−0.5V" calibrate control to bring the meter pointer to the full scale mark on the 0-to-5.0 scale.
4. Connect the output of a precision 1.5-volt DC voltage source to the probe and ground lead. Adjust R2A, the DC CAL control to bring the meter pointer exactly to the full scale "15" mark on the 0-to-15 scale.

**DC Current Calibration**

1. Set the function switch to "DC CURRENT" and the range switch to "0.5V/mA".
2. Apply 0.5 mA to "+mA" and "−mA" test leads with proper polarity. Adjust potentiometer R1 (located on range switch), to bring the meter pointer to exactly the full scale "5.0" mark on the 0-to-0.5 scale.

**AC Calibration**

1. Set the function switch to "AC", the range switch to "50V", and the probe switch to "AC/OHMS". Adjust ZERO control to bring meter pointer exactly to "0".
2. Connect the ground lead and probe to an AC voltage source of 50 volts (RMS). Adjust R2D, the "AC CAL" control to bring the meter pointer exactly to the full-scale "5.0" mark on the 0-to-5.0 scale.

**Battery Charge Adjustment**

1. Unplug the AC power cord, and remove the four 9-volt batteries. Connect a jumper wire between lugs #2 and #3 on wafer C of S-2, the function switch. These lugs can be identified by noting that the wires connected to them lead to the AC plug in the rear of the instrument.
2. Plug in the AC power cord, and set the function switch to the "BATT TEST A" position. Use a variac to adjust line voltage to 120 volts. Adjust R48 (located closest to transformer) so that the meter reads 4.7 on the 5.0 DC scale. (This actually corresponds to 18.8V DC).
3. Set the function switch to the "BATT TEST B" position. Adjust R47 (located near 4-section pot) so that the meter reads 4.7 on the 5.0 DC scale.

   Remove jumper wire.

   Replace batteries.



## Troubleshooting Hints

**Instrument fails to operate on all functions.**

9-volt batteries dead.
Probe defective. Check continuity.

**Voltage readings low on battery operation, especially at right-hand side of meter scale.**

9-volt batteries require replacement.

**Meter cannot be adjusted full-scale on ohms function.**

1.5-volt battery weak.

**Instrument cannot be zeroed on any voltage function.**

Check transistor amplifier circuit.

**Meter pointer bangs hard left or right, depending on function switch setting.**

Open or short circuit in amplifier metering circuit.

**Meter pointer sticks, or is sluggish on all functions.**

Meter movement defective.

**Instrument fails to indicate properly on any AC voltage range; operates normally on DC volts and ohms.**

Diodes CR3 or CR4 defective.
C1, C10, C11, R35 to R37 defective.

**Instrument inaccurate on 500 and 1500 volt AC ranges.**

Resistors R35, R36, or R37 defective.

**Instrument inaccurate on any AC or DC voltage range. Ohms OK.**

Check voltage divider resistors, R40 through R46.

**Resistance readings inaccurate.**

Check resistors R28 through R34.
Poor connection to 1.5-volt battery.
High internal resistance in battery.

**Instrument inaccurate or inoperative on current ranges only.**

Check resistors R19 through R26.

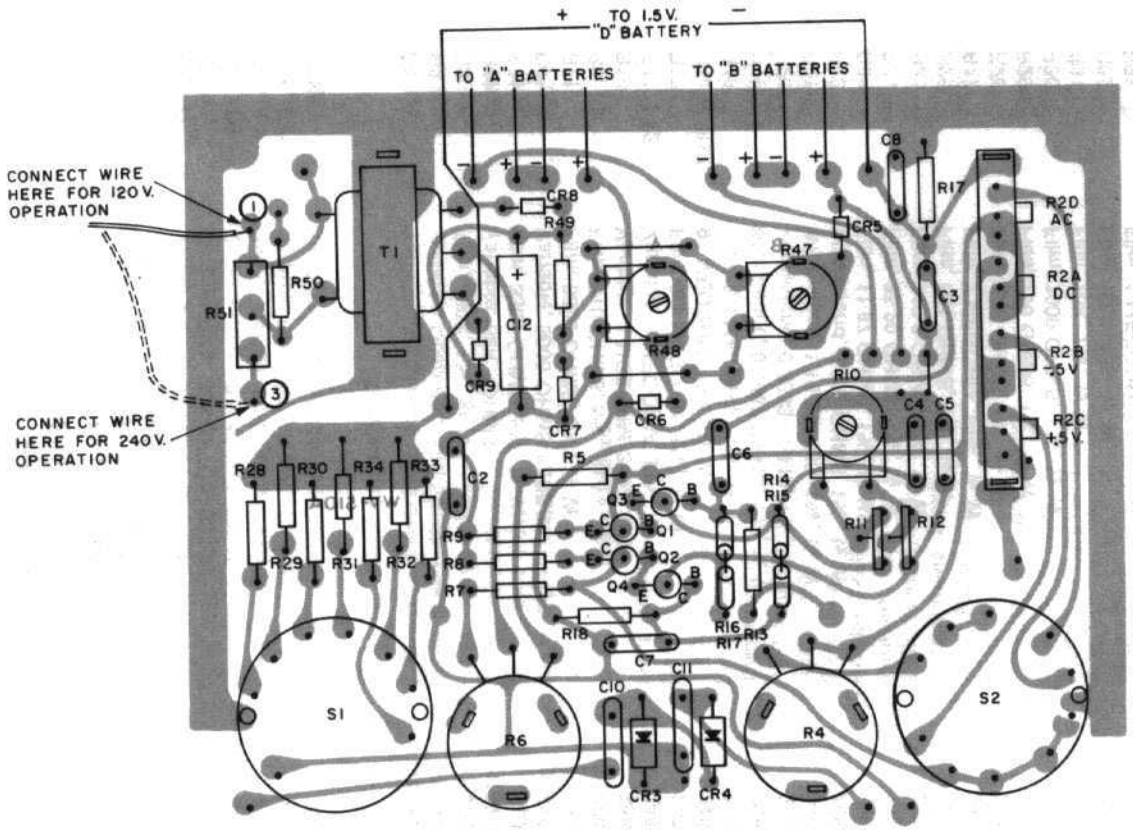



Figure 11. Circuit board component layout. View from component side



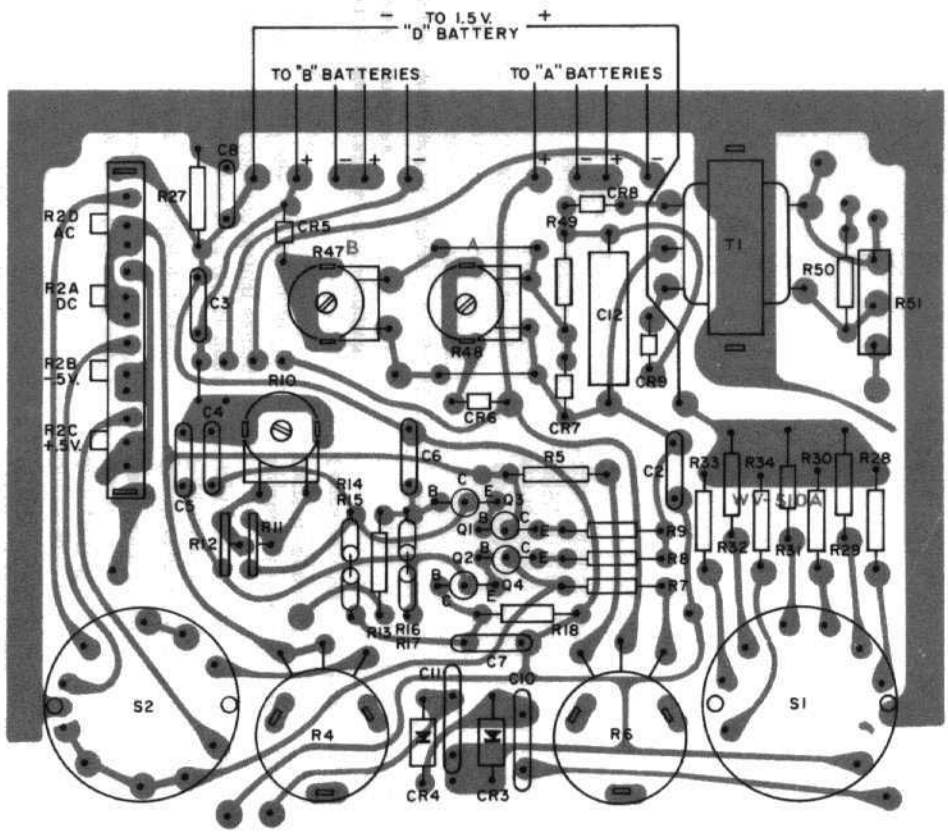



Figure 10. Circuit board component layout. View from foil side

# Replacement Parts List
## WV-510A Master VoltOhmyst

**When ordering replacement parts, include the stock number and description of the part, as well as the serial number and code number of instrument. Parts should be ordered through a local RCA parts and accessories distributor.**

| Symbol | Description | Stock No. |
|---|---|---|
| | **Capacitors** | |
| C1 | Ceramic Disc, 470 PF 20% 1500 V | 248589 |
| C2 | Ceramic Disc, .02 MF 20% 600 V | 210685 |
| C3 | Ceramic Disc, .05 MF 500 V | 424029 |
| C4, C5 | Ceramic Disc, .02 MF 20% 600 V | 210685 |
| C6* | Ceramic Disc, .005 MF 20% 600 V | 424028 |
| C7,* C8 | Ceramic Disc, .01 MF 20% 600 V | 211723 |
| C9 | Paper, .047 MF 10% 400 V | 227754 |
| C10, C11 | Ceramic Disc, .02 MF 20% 1000 V | 231326 |
| C12 | Electrolytic, 20 MF 50 V | 240305 |
| | **Resistors** | |
| R1 | Variable, Wirewound, 1000 OHMS 30% 1 W | 248615 |
| R2 | Variable, Quad Pot, 50K, 5K, 5K, 50K | 248614 |
| R3 | Film, 100K, 1%, ½ W | 237540 |
| R4† | Variable, 60K "OHMS" | 420129 |
| R5† | Film, 3300 OHMS, 5%, ½ W | 133463 |
| R6† | Variable, 3000 OHMS "ZERO" | 420130 |
| R7† | Film, 3300 OHMS, 5%, ½ W | 133463 |
| R8, R9 | Film, 910 OHMS, 5%, ½ W | 228914 |
| R10 | Variable, 1 MEGOHM, 30%, ¼ W | 248611 |
| R11, R12 | Variable, 3 MEGOHM, 30%, ¼ W | 245902 |
| R13 | Film, 3.3 MEGOHM, 5%, ½ W | 243005 |
| R14 to R17 | 91 MEGOHM, 10%, ½ W | 248610 |
| R18 | Film, 3.3 MEGOHM, 5%, ½ W | 243005 |
| R19 | Wirewound, 0.1667 OHMS, 1%, ½ W | 248597 |
| R20 | Wirewound, 0.3333 OHMS, 1%, ½ W | 248599 |
| R21 | Wirewound, 1.167 OHMS, 1%, ½ W | 248598 |
| R22 | Wirewound, 3.353 OHMS, 1%, ½ W | 248609 |
| R23 | Film, 11.87 OHMS, 1%, ½ W | 248608 |
| R24 | Film, 35.20 OHMS, 1%, ½ W | 248607 |
| R25 | Film, 140.2 OHMS, 1%, ½ W | 248606 |
| R26 | Film, 641 OHMS, 1%, ½ W | 248605 |
| R27 | Film, 1 MEGOHM, 10%, ½ W | 243004 |
| R28 | Film, 9.75 OHMS, 1%, ½ W | 242147 |
| R29 | Film, 100 OHMS, 1%, ½ W | 237414 |
| R30 | Film, 1000 OHMS, 1%, ½ W | 236062 |
| R31 | Film, 10K, 1%, ½ W | 236087 |
| R32 | Film, 100K, 1%, ½ W | 237540 |
| R33 | Film, 1 MEGOHM, 1%, ½ W | 247716 |

*C7 used only in units with serial numbers below 5000.
†In units with serial numbers below 5000:
R4 is 75K, stock #248613
R5 is 2200, stock #228712
R6 is 5K, stock #248612
R7 is 2200, stock #228712



| Symbol | Description | Stock No. |
|---|---|---|
| R34 | Film, 10 MEGOHM, 1%, ½ W | 248604 |
| R35 | Film, 900K, 1%, 1 W | 242146 |
| R36 | Film, 318K, 1%, ½ W | 243003 |
| R37 | Film, 140K, 1%, ½ W | 099318 |
| R38, R39 | Film, 20 MEGOHM, 5%, ½ W | 242142 |
| R40 | Film, 14 MEGOHM, 1%, ½ W | 248603 |
| R41 | Film, 4 MEGOHM, 1%, ½ W | 248602 |
| R42 | Film, 1.4 MEGOHM, 1%, ½ W | 248601 |
| R43 | Film, 400K, 1%, ½ W | 055862 |
| R44 | Film, 140K, 1%, ½ W | 099318 |
| R45 | Film, 40K, 1%, ½ W | 248600 |
| R46 | Film, 20K, 1%, ½ W | 236777 |
| R47, R48 | Variable, 10,000 OHMS, 30%, ¼ W | 248094 |
| R49 | Film, 560 OHMS, 5%, ½ W | 224252 |
| R50 | Film, 220K, 5%, ½ W | 237000 |
| R51 | Wirewound, 5600 OHMS, 10%, 5 W | 120081 |
| | **Semiconductors** | |
| Q1 to Q4 | Transistor, Type 2N5232 (set of 4) | 248619 |
| CR1, CR2 | Diode, Type 1N914A | 239164 |
| CR3, CR4 | Diode, Type 1N3563/1N4007 | 242141 |
| CR5, CR6 | Diode, Type 1N4002 | 234761 |
| CR7 | Diode, Type 1N969A | 248592 |
| CR8, CR9 | Diode, Type 1N4002 | 234761 |
| | **Miscellaneous** | |
| DS1 | Lamp, Neon | 048474 |
| M1 | Meter | 248594 |
| S1 | Switch, Range | 248616 |
| S2 | Switch, Function | 248617 |
| T1 | Transformer | 248618 |
| | Alligator Clip | 035262 |
| | Case, Front | 248590 |
| | Case, Rear | 249528 |
| | Handle, Leather | 210093 |
| | Insulating Boot | 099539 |
| | Jack, Banana, Red | 230283 |
| | Jack, Banana, Black | 225222 |
| | Knob, Plastic | 227050 |
| | Knob, Rubber | 094878 |
| | Meter Cover, Clear Plastic | 210287 |
| | Panel, Aluminum | 248595 |
| | Printed Circuit Board | 248591 |
| | Post | 248596 |
| | Power Cord | 420635 |
| | Receptical, AC Cord | 74594 |
| | Test Leads (for current meas.) | |
| | Red | 245597 |
| | Black | 245596 |

## RCA Repair Service

Authorized RCA Service Depots throughout the United States are available for repair and calibration of RCA Electronic Instruments. For up-to-date listings of these Depots, contact your RCA Distributor, or write to RCA Electronic Instruments, 415 South 5th Street, Harrison, New Jersey 07029.

If it becomes necessary to service this equipment, fill out one of the Test Equipment Service order forms supplied with the instrument. It is important that:

1. Test equipment be packed carefully. The instrument should be double-packed. It is best to pack the unit in its original carton, or similar container, then "float" this carton in at least a 3-inch layer of shredded paper inside the outer carton.
2. A full description of the trouble be included in the report.
3. All probes, cables, and test leads used with the equipment be included in the shipment.

Attention to these details will help prevent damage in transit and delay in repairs.