Warranty

SIMPSON ELECTRIC COMPANY warrants each instrument and other articles of equipment manufactured by it to be free from defects in material and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory any instrument or other article of equipment which shall within 90 days after delivery of such instrument or other article of equipment to the original purchaser be returned intact to it or to one of its authorized service stations, with transportation charges prepaid, and which its examination shall disclose to its satisfaction to have been thus defective, this warranty being expressly in lieu of all other warranties expressed or implied and all other obligations or liabilities on its part, and SIMPSON ELECTRIC COMPANY waives and disclaims all liability to the extent that the said instrument or other article of equipment which shall have been repaired or altered outside the SIMPSON ELECTRIC COMPANY factory or authorized service stations, nor which has been subject to misuse, negligence or accident, incorrect wiring by others, or installation or use not in accord with instructions furnished by the manufacturer.

SIMPSON 160
VOLT-OHM-MILLIAMMETER

Courtesy Of:
Simpson260.com

SIMPSON ELECTRIC COMPANY
853 Dundee Ave., Elgin, Illinois 60120
Area Code 312, Telephone 697-2260
In Canada, Bach-Simpson, Ltd., London, Ontario

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TABLE OF CONTENTS

SECTION I
Introduction ........................................ 1-1
1.1 General ........................................ 1-1
1.2 Supplies and Accessories ...................... 1-2
1.3 Safety Consideration ........................... 1-2
1.4 Technical Data ................................ 1-2

SECTION II
Installation ........................................ 2-1
2.1 General ........................................ 2-1
2.2 Unpacking and Inspection ...................... 2-2
2.3 Warranty ....................................... 2-2
2.4 Shipping ...................................... 3-1
2.5 Installation ................................... 3-1

SECTION III
Controls, Connectors, and Indicators .......... 3-1
3.1 General ....................................... 3-1
3.2 Panel Description ............................. 3-2
Table of Contents

SECTION IV
Operation ........................................ 4-1
  4.1 Safety Precautions .......................... 4-1
  4.2 Zero Deflection .............................. 4-3
  4.3 Measuring DC Voltages, 250 Millivolt Range .......... 4-4
  4.4 Measuring DC Voltages, 1 Volt Range ............... 4-5
  4.5 Measuring DC Voltages, 2.5 through 500V Range ....... 4-5
  4.6 Measuring DC Voltages, 1000 Volt Range only ......... 4-7
  4.7 Measuring AC Voltages, 0-500 Volts ................ 4-8
  4.8 Measuring AC Voltages, 1000 Volt Range only ........ 4-10
  4.9 Measuring Decibels .......................... 4-10
  4.10 Measuring Resistances ...................... 4-12
  4.11 Direct Current Measurement .................. 4-14
  4.12 Measuring Direct Currents, 50 Microampere range .... 4-15
  4.13 Measuring Direct Current: 0-1 Through 0-500 Milliampere Ranges ... 4-16

SECTION V
Theory of Operation .............................. 5-1
  5.1 General ...................................... 5-1
  5.2 DC Voltmeter Circuit ........................ 5-1
  5.3 DC Milliammeter Circuit .................... 5-3
  5.4 AC Voltmeter Circuit ....................... 5-4
  5.5 Ohmmeter Circuit ........................... 5-5

SECTION VI
Operator Servicing .............................. 6-1
  6.1 Removal From the Case ...................... 6-1
  6.2 Battery Replacement ........................ 6-1
  6.3 Test Lead Inspection ....................... 6-2

SECTION VII
Servicing Instructions ......................... 7-1
  7.1 Replacement Parts and Schematic Diagram ............ 7-1
Table of Contents

LIST OF TABLES
1-1 Technical Data .......................... 1-2
1-2 Items and Accessories
   Supplied with This Instrument ... 2-1
1-3 Additional Accessories ............ 2-1
3-1 Controls, Connectors, and Indicators 3-2
7-1 Replacement Parts .................... 7-3

LIST OF ILLUSTRATIONS
1-1 160 Volt-Ohm-Milliammeter .......... iii
1-2 Typical Frequency Response Curve ... 1-4
5-1 Simplified Circuit     DC Volts .... 5-2
5-2 Simplified Circuit     DC mA ..... 5-3
5-3 Simplified Circuit     AC Volts .... 5-4
5-4 Simplified Circuit     DC Ohms ... 5-6
7-1 Schematic Diagram ................. 7-9

NOTE: This Operator's Manual contains information essential to the operation of this Instrument. Therefore, it should be kept in a convenient place and used for reference as required.

SAFETY SYMBOLS

This marking, adjacent to another marking, terminal, or operating device, indicates that the Operator must refer to an explanation in the operating instructions to avoid damage to the equipment and/or to avoid personal injury.

WARNING: The WARNING sign denotes a hazard. It calls attention to a procedure, practice or the like, which if not correctly performed or adhered to, could result in personal injury.

CAUTION: The CAUTION sign denotes a hazard. It calls attention to a procedure, practice or the like, which if not correctly adhered to could result in damage to or destruction of part or all of the Instrument.
WARNING
This Instrument is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely before making any measurements. Failure to follow directions can result in a serious or fatal accident.

SHOCK HAZARD: As defined in American National Standard, C39.5, Safety Requirements for Electrical & Electronic Measuring & Controlling Instrumentation, a shock hazard shall be considered to exist at any part involving a potential in excess of 30 volts rms (sine wave) or 42.4 volts DC or peak and where a leakage current from that part to ground exceeds 0.5 milliampere when measured with an appropriate measuring instrument defined in Section 11.6.1 of ANSI C39.5.

NOTE: The proper measuring instrument for the measurement of leakage current consists essentially of a network of a 1500 ohm non-inductive resistor shunted by a 0.15 microfarad capacitor connected between the terminals of the measuring instrument. The leakage current is that portion of the current that flows through the resistor. The Simpson Model 229 Series 2 AC Leakage Current Tester meets the ANSI C39.5 requirements for the measurement of AC leakage current and can be used for this purpose. To measure DC Leakage current, connect a 1500 ohm non-inductive resistor in series with a Simpson 0-500 DC microammeter and use this as the measuring instrument.

SECTION I
INTRODUCTION

1.1 GENERAL

1.1.1 The Simpson 160 Volt-Ohm-Milliammeter (hereafter referred to as the 160 or the Instrument) is a compact, easy-to-operate instrument which may be used for measuring electrical characteristics of circuits and circuit components. It features a taut-band movement suspension with diode overload protection to provide long, trouble-free service. The 100 degree mirrored dial arc and knife edge pointer provide excellent readability and eliminates parallax errors.

1.1.2 A polarity-reversing switch and one-knob Function/Range selector simplify operation of the Instrument. The internal batteries used to furnish the power required for resistance measurements are readily obtainable and replacement is accomplished quite easily.

1.1.3 Conforming to the latest engineering developments, most of the component parts are mounted on a printed circuit board. This ensures uniformity of performance, reduces maintenance and extends the useful life of the Instrument.
1.2 SUPPLIES AND ACCESSORIES

1.2.1 All supplies and accessories required for the operation of the 160 are furnished with each Instrument, and listed in Table 1-2. (Available replacement parts are listed in Table 7-1).

1.3 SAFETY CONSIDERATIONS

1.3.1 This Operator's Manual contains cautions and warnings alerting the user to hazardous operating and service conditions. This information is flagged by CAUTION or WARNING headings throughout this publication, where applicable, and is defined at the front of the manual under SAFETY SYMBOLS. To ensure the safety of operating and servicing personnel and to retain the operating conditions of the instrument these instructions must be adhered to.

1.4 TECHNICAL DATA

1.4.1 Table 1-1 lists the technical data for the 160.

Table 1-1. Technical Data

1. DC Volts:

| Ranges: | 2.5, 10, 50, 250, 500V; 0.25, 1.0 and 1000V on separate jacks. |

2. AC Volts:

| Ranges | 2.5, 10, 50, 250, 500V; 1000V on separate jack. |
| Sensitivity | 5000 ohms per volt. |
| Indication | Full-wave average-responding; calibrated in RMS for sinusoidal waveform. |
| Frequency Response | Rated accuracy to 100,000 Hz on all ranges through 50V; to 20 kHz on 250V range. |

2-A. ***Rated-Circuit To-Ground Voltage: 1000V AC/DC Max.***

3. Direct Current:

| Ranges: | 1, 10, 100, 250, 500 mA; 50 mA on separate jack. |
| Rated Accuracy | Within 3% full scale, all ranges. |

* See typical Response Curves, Figure 1-2.

* * * Per ANSI C39.5 April 1974: "The maximum voltage with respect to ground, which may safely and continuously be applied to the circuit of an instrument."
4. DC Resistance:

Ranges:  
- R x 1: 0-3000Ω (30Ω center)  
- R x 10: 0-30,000Ω (300Ω center)  
- R x 100: 0-300,000Ω (3 kΩ center)  
- R x 1K: 0-3 MΩ (30 kΩ center)  
- R x 10K: 30 MΩ (300 kΩ center)

Accuracy: 3° arc

Max. Voltage or Current Delivered:
- R x 1: 50 mA short circuit, 1.5V open circuit
- R x 10: 5 mA short circuit, 1.5V open circuit

5. dB Ranges:
- 20 dB to +10 dB on 2.5 VAC range  
- 8 dB to +22 dB on 10 VAC range  
- 6 dB to +36 dB on 50 VAC range  
- 20 dB to +50 dB on 250 VAC range

Zero dB referenced to 1 milliwatt at 600 ohms (0.775 volt)

6. Movement:
Taut-Band 100° arc, 50mA full scale.

7. Dial Arcs:
One arc for ohms, one arc for DC, two arcs for AC, one arc for dB.

8. Scale Length:
3.0 inches.

9. Lead Reversal:
Polarity Reverse Switch; on DC and ohms
10. Operating Position: Horizontal or vertical; rubber feet prevent slipping on moderate slopes.
11. Batteries: 1.5V AA penlight cell and No. 505 22.5V battery; simple removal via back of Instrument.
13. Test Leads: Custom molded elbow terminals; 3 ft flexible plastic leads with probe tips.
14. Operating Temperature Range: 75°F for rated accuracy; less than 4% additional error over the range of +25°F to +110°F.
15. Size: 4 1/4" x 3 3/8" x 1 3/4"
16. Weight: Approximately 12 ounces complete.
17. Construction: Combination high impact plastic and phenolic; P.C. Board.
18. Color: Black and white mirror scale and lettering.

Table 1-2. Items and Accessories Supplied with This Instrument

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe Tip Test Leads</td>
<td>02055</td>
</tr>
<tr>
<td>Operator's Manual</td>
<td>5-111658</td>
</tr>
</tbody>
</table>

Table 1-3. Additional Accessories CAT

<table>
<thead>
<tr>
<th>Description</th>
<th>CAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinyl Carrying Case</td>
<td>2935</td>
</tr>
<tr>
<td>Vinyl Carrying Case</td>
<td>2225</td>
</tr>
<tr>
<td>Vacuum Formed Carrying Case</td>
<td>2929</td>
</tr>
<tr>
<td>Simpson 150 AC Amp-Clamp</td>
<td>00532</td>
</tr>
<tr>
<td>160 Adapter Pins for Amp-Clamp</td>
<td>02056</td>
</tr>
<tr>
<td>Alligator Clip Leads</td>
<td>01927</td>
</tr>
</tbody>
</table>

SECTION II

2.1 INSTALLATION

2.1.1 This section contains instructions for the installation and shipping of the 160. Included are unpacking and inspection procedures, warranty, shipping, and installation.
2.2 UNPACKING AND INSPECTION

2.2.1 Examine the shipping carton for signs of damage prior to unpacking. Then unpack and inspect the Instrument for possible damage in shipment. If damage is noted, notify the carrier and supplier before using the Instrument. Also, check that all furnished items and accessories are included (Table 1-2).

2.2.2 Save all shipping materials for future use.

2.3. WARRANTY

2.3.1 The Simpson Electric Company warranty policy is printed on the inside front cover of this manual. Read it carefully prior to requesting a warranty repair.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact the nearest Authorized Service Center for instructions (listed on the last pages of this manual). If it is necessary to contact the factory directly, give full details of the difficulty and include the Instrument model number, serial number (at the back of the Instrument) and date of purchase. Service data or shipping instructions will be mailed promptly. If an estimate of charges for non-warranty or other service work is required, a maximum charge estimate will be quoted. This charge will not be exceeded without prior approval.

2.4 SHIPPING

2.4.1 Pack the Instrument carefully and ship it prepaid and insured to the proper destination.

2.5 INSTALLATION

2.5.1 The Instrument may be operated in a horizontal or vertical position. It can also be set at an angle by positioning the stand under the Instrument.

SECTION III
CONTROLS, CONNECTORS, AND INDICATORS

3.1 GENERAL

3.1.1 All operating and adjustment controls, connectors, and indicators are described in this section along with a list (Table 3-1) describing their function. Become familiar with each item prior to operating the Instrument.
3.2 PANEL DESCRIPTION

3.2.1 Table 3-1 lists all Controls, Connectors, and Indicators.

Table 3-1. Controls, Connectors, and Indicators

1. Function This control is located in the lower center of the panel. This switch combines the operations of selecting the desired range and function. The switch may also be turned in either direction to any of its 20 positions.

2. Zero Ohms Adjust Control: This control is located at the lower left on the front panel and is used to obtain a “0” indication on the ohms scale when the test leads are shorted together. During operation, the zero indication is checked each time the ohmmeter is to be used. This permits compensation for aging internal batteries, and allows them to be used for a longer period of time.

3. Input Jacks: There are six input jacks: Four of these are on the right side of the panel and two directly below the zero adjustment screw. The four jacks on the right are identified COM —, +, 3.
### Controls, Connectors, and Indicators

+1V, and +50μ+/−250 mV. The COM ± jack is used for all ranges and functions with the exception of the 1V, 50 μA, 250 mV, 1000 VDC and 1000 VAC ranges. The two jacks below the Instrument are identified 1000 VDC and 1000 VAC and are used to extend the 500 VDC and 500 VAC ranges.

#### 4. Polarity Reversing Switch:

This switch, located above the Ω ADJ control, allows simple lead polarity reversal when making DC or resistance measurements on any range except the 50 μA, 250 mV, or 1V positions. For normal operation, set this switch to + DC position. Using the COM — as the reference, positive polarity signals then will produce upscale pointer deflection. Conversely, negative polarity signals are accommodated without interchanging leads by setting the switch to the −DC position. When the VOM is set on any resistance range, the reversing switch controls the polarity of the measuring potential presented to the test jacks in the same manner.

### Operation

**NOTE:** When making measurements of the 50 μA, 250 mV, or 1V ranges, the reversing switch must be set to the + DC position to obtain readings.

### SECTION IV OPERATION

**WARNING**

Before proceeding with the operation of the 160 review the SHOCK HAZARD definition printed at the front of this manual.

#### 4.1 SAFETY PRECAUTIONS

4.1.1 Instruments of this type are intended for use only in low-power, consumer product type applications, such as TV or radio. Their use is not recommended in high-power circuits such as power plants, substations or high power transmitter circuits, where the likelihood of corona, together with sufficient energy to sustain flash-over arcs, is a serious hazard.
4.1.2 The small size of this instrument might tempt the user to hold it in his hand while making measurements. Avoid this practice when working in circuits that might contain a shock hazard.

4.1.3 Inspect the test leads, probes, connectors, and insulating boots for damage or deterioration before each use. If any defects are found, replace the leads immediately with leads designed for this instrument. Do not use test leads inferior to those furnished with the instrument.

4.1.4 Never disconnect the common lead from an active circuit while the other lead is connected to an energized circuit. The common lead becomes unexpectedly "hot" in such a case and can be a shock hazard to the user. Develop safe habits by always turning off power to the measured circuit and discharging any capacitors before handling the test leads.

4.1.5 Become familiar with the circuit to be measured and locate any shock hazards before attempting measurements. Keep in mind that high voltages might appear where not expected in a faulty circuit.

4.1.6 Electrical measurements in the presence of humidity or moisture are particularly hazardous. Hands, shoes, floor, and workbench must be dry.

4.1.7 Avoid making measurements in circuits where composite voltages can exceed the instrument's safe limits. When measuring DC voltages, the instrument will not respond to (and thereby not indicate) the presence of AC components.

4.1.8 Be alert for the presence of corona in the measured circuit. Its presence indicates high voltage; and unexpected or unknown path might lead to a flash-over. A buzzing sound, odor of ozone and a pale blue emanation are indications of its presence.

4.1.9 Do not work alone when making measurements where a shock hazard can exist. Notify a nearby person of your intentions.

4.2 ZERO DEFLECTION

4.2.1 Before making any measurements, check to see that the pointer indicates zero when the instrument is in the operating position. If the pointer is off zero, make the required correction by turning the screw located directly below the "Simpson 160" legend.
Operation

4.3 MEASURING DC VOLTAGES,
250 MILLIVOLT RANGE:

CAUTION

Use care when using the 160 on the 250 mV range.
An excessive voltage applied when in this range
can be detrimental to the instrument.

a. Connect the black test lead into the COM —
jack and the red test lead into the +50 µA
+250 mV jack.
b. Set polarity switch to the + DC position.
c. Set the Range Selector Switch to the 50 µA posi-
tion (common to the 10 VDC position).
d. Connect the black test lead to the negative (—)
side of the circuit to be measured and the red
test lead to the positive (+) side of the circuit.
e. Read the voltage on the black arc marked DC.
Use the figures marked 0-2.5 and multiply read-
ing by 100 for the millivolt reading. If the
pointer moves to the left of zero, reverse the test lead connections, as the reversing switch
must be kept in the +DC position for this range.

4.4 MEASURING DC VOLTAGES,
1 VOLT RANGE:

a. Connect the black test lead into the COM —
jack and the red test lead into the + jack.
b. Set the polarity switch to the + DC position.
c. Set the range switch to the 1 VDC position (com-
mon to the 10 VDC position).
d. Connect the black test lead to the negative (—)
side of the circuit to be measured and the red
test lead to the positive (+) side.
e. Read the voltage on the black arc marked DC.
Use the figures 0-10 and divide the reading by
10 to obtain voltage reading. If the pointer
moves to the left of zero, reverse the test lead
c connections, as the reversing switch must be kept
in the +DC position for this range.

4.5 MEASURING DC VOLTAGES,
2.5 THROUGH 500 VOLT RANGES:

a. Connect the black test lead into the COM —
jack and the red test lead into the + jack.
b. Set the range switch for any of the five DC vol-
tage range positions desired. These are marked 2.5,
10, 50, 250, and 500 VDC. When in doubt as to
which range to use, always start with the highest voltage range as a protection to the Instrument.

c. Connect the black test lead to the negative (—) side of the circuit to be measured and the red test lead to the positive (+) side of the circuit.

d. Set the polarity switch to the + DC position. Turn the power on in the circuit to be tested. If the pointer deflects to the left of zero, the actual circuit polarity is the reverse of that anticipated. In this case, turn off power in the circuit to be tested, set the polarity switch to the — DC position and turn power on again.

e. Read the voltage on the black arc marked DC which is second from the top of the dial. If the voltage is within a lower range, the switch may be set for a lower range to obtain a more accurate reading.

2.5 VDC range: Use the 0-2.5 scale and read the value directly.
10 and 50 VDC range: Read the corresponding scale directly.
250 VDC range: Use the 0-2.5 scale and multiply reading by 100.
500 VDC range: Use the 0-50 scale and multiply reading by 10.

Operation

4.6 MEASURING DC VOLTAGES,
1000 VOLT RANGE ONLY:

WARNING

Use extreme care when working in high voltage circuits. Even though the instrument and test leads are well insulated for this voltage, do not handle when power is on in the circuit.

a. Set the range switch to the 1000 VDC position (common with the 500 VDC position).

b. Connect the black test lead to the COM — jack and the red test lead to the 1000 VDC jack.

c. Set the polarity switch to the + DC position.

d. Connect the black test lead to the negative (—) side of the circuit and the red test lead to the positive (+) side.

e. If the pointer deflects to the left side of zero, the actual circuit polarity is the reverse of that anticipated. (In this case see Paragraph 4.5, step d.)

f. Read the voltage, using the 0-10 scale on the black arc marked DC and multiply the reading by 100.
4.7 MEASURING AC VOLTAGES
2.5 THROUGH 500 VOLT RANGE:

4.7.1 The 160 rectifier circuit responds to the full wave rectified average value of the AC voltage being applied. The Instrument dial, however, is calibrated in terms of RMS voltage, which will be correct for all sinusoidal waveforms.

**NOTE:** Since the 160 will respond to DC voltage when set on any AC volt range, an external blocking capacitor must be employed where measurements of AC superimposed on DC are encountered.

a. Connect the black test lead to the COM — jack and the red test leads to the + jack.

b. Set the range switch for any of the five VAC range positions desired. These are marked 2.5 VAC, 10 VAC, 50 VAC, 250 VAC, and 500 VAC. When in doubt as to which range to use, always start with the highest voltage range as a protection to the Instrument.

c. Turn power on in the circuit to be tested. Read the voltage on the red arc marked AC, as follows:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2.5 VAC range:</td>
<td>Read the value directly on the special arc marked 2.5 VAC.</td>
</tr>
<tr>
<td>10 VAC and 50 VAC ranges:</td>
<td>Read the red arc marked AC, and use the corresponding black numbers immediately below the arc.</td>
</tr>
<tr>
<td>250 VAC range:</td>
<td>Read the red arc marked AC using the 0-2.5 figures and multiply the reading by 100.</td>
</tr>
<tr>
<td>500 VAC range:</td>
<td>Read the red arc marked AC using the 0-50 figures and multiply the reading by 10. If the voltage is within a lower range, the switch may be set for the lower range to obtain a more accurate reading.</td>
</tr>
</tbody>
</table>
Operation

4.8 MEASURING AC VOLTAGES, 1000 VOLT RANGE ONLY:

WARNING

Use extreme care when working in high voltage circuits. Even though the VOM and test leads are well insulated for this voltage, do not handle either when power is on in the circuit.

a. Set the range switch at 1000 VAC position (common with the 500 VAC position).
b. Turn off power in the circuit being measured.
c. Connect the black test lead in the COM — jack, and the red test lead in the 1000 VAC jack.
d. Turn on power in the circuit being measured.
e. Read the voltage on the red arc marked AC using the 0-10 figures and multiply the reading by 100.

4.9 MEASUREMENT DECIBELS

4.9.1 For some applications, power loss or gain measurements in terms of dB are required. The dB is defined as:

$$ dB = 10 \log \frac{Power_1}{Power_2}, or \quad 20 \log \frac{E_1}{E_2} \quad \text{when} \quad R_1 = R_2 $$

The 160 is calibrated with 0 dB referenced to 1 MilliWatt at 600Ω; i.e., dB reading corresponds to 20 log E (reading) 0.775V (measured across 600Ω).

The decibel scale at the bottom of the dial is numbered from —20 through 0 to +10. To measure decibels, proceed according to instructions for AC voltages, and read the dB arc. The dB scale is calibrated for direct reading on the 2.5V range. Scale factors for other ranges and dB reference at 0.006 watts into 500 ohms are given in the table below.

<table>
<thead>
<tr>
<th>Range</th>
<th>1mW @ 600</th>
<th>6mW @ 500</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5V</td>
<td>direct</td>
<td>—7</td>
</tr>
<tr>
<td>10V</td>
<td>+12</td>
<td>+5</td>
</tr>
<tr>
<td>50V</td>
<td>+26</td>
<td>+19</td>
</tr>
<tr>
<td>250V</td>
<td>+40</td>
<td>+33</td>
</tr>
</tbody>
</table>
 Operation

4.10 MEASURING RESISTANCES

4.10.1 When DC resistances are measured, the internal batteries of the 160 furnish power for the measuring circuit. Correction for battery deterioration over long periods of time is provided by means of the Zero Adjust control which is part of the ohmmeter circuit.

a. Set the range switch at the desired resistance range position.

b. Connect the black test lead to the COM — jack, and the red test lead to the + jack.

c. Connect the contact ends of the test leads together.

d. Observe the Instrument indication. Look for a reading of “0” on the OHMS arc, which is at the top of the dial.

e. If the pointer does not read “0”, rotate the ZERO OHMS knob on the lower left on the front panel until it does. If the pointer cannot be brought up to the “0” mark, replace the appropriate battery.

 Operation

NOTE: Disconnect power from any resistor or circuit to be measured before measuring resistance. Do not apply any power before the measurements are completed and test leads are disconnected.

f. Connect the test leads across the resistance which is to be measured. If there is a “forward” and “backward” resistance, such as with diodes, observe polarity in the lead connections to control each direction of test. With the polarity switch in the + DC position, the + jack will provide a positive potential referred to COM — jack. Setting the switch to the — DC position will reverse this measuring potential.

g. Read the indication on the OHMS arc at the top of the dial. Note that the arc reads from right to left for increasing values.

h. Multiply the reading by the multiplier factor indicated at the switch position; the result is the resistance value in ohms. “K” on the dial and panel stands for “times one thousand.”
Operation

NOTE: The resistance of nonlinear components will measure as different values on different ranges of the 160. For example, a diode could measure 80 ohms on the R x 1 range, and 300 ohms on the R x 10 range. This is normal and is the result of the diode characteristic. The difference in readings does not indicate faulty operation of the ohmmeter circuit.

4.11 DIRECT CURRENT MEASUREMENT

WARNING

- Do not change the range setting of the Range or Function Switches while the circuit under measurement is energized.
- Never disconnect the test leads from the circuit under measurement while the circuit is energized.
- Always turn the power off and discharge all the capacitors before the setting of the switches is changed, or the leads disconnected.
- Never exceed the Circuit-To-Ground voltage of the instrument (1000 V max; Table 1-1, 2-A).
- Always connect the Instrument in series with the ground side of the circuit.
- In all direct current measurements, make certain the power to the circuit being tested has been turned off before connecting and disconnecting test leads or restoring circuit continuity.

Operation

4.12 MEASURING DIRECT CURRENTS,
50 MICROAMPERE RANGE:

CAUTION

Never connect the test leads directly across any source of voltage when the 160 is used for current measurements. This will damage the Instrument.

a. Connect the black test lead to the COM — jack, and the red test lead to the +50 µA jack.
b. Set the range switch at 50 µA (common with 50 VDC).
c. With the circuit power turned off, open the circuit at the point where current is to be measured. Connect the Instrument in series with the circuit, observing proper polarities when making connection.
d. Turn on power to the circuit being measured. If the pointer is deflected to the left of zero, the polarity is opposite to that anticipated. Turn power off and reverse the leads. The polarity switch must be kept in the + DC position on this range.
e. Read the current directly on the black arc marked DC, using the 0-50 scale. The current value is shown in microamperes.
Operation

f. Turn off power to the circuit. Remove the test leads and restore the circuit continuity.

4.13 MEASURING DIRECT CURRENT: 0-1 THROUGH 0-500 MILLIAMPERE RANGES:

a. Connect the black test lead to the COM — jack, and the red test lead to the + jack. Set the polarity switch to the + DC position.

b. Set the range switch to any of the five mA direct current range positions, as desired. The switch positions are marked 1 mA, 10 mA, 100 mA, 250 mA, and 500 mA. When in doubt as to which range to use, always start with the highest ranges as a protection to the Instrument.

c. When the circuit power is turned off, open the circuit at the point where current is to be measured. Connect the Instrument in series with the circuit, observing proper polarities.

d. Apply power to the circuit being measured. If the pointer deflects to the left of zero, the polarity is reversed. Turn off the power. Set the polarity switch to the — DC position and then re-apply the power.

e. Read the current on the black scale marked DC, which is second from the top of the dial.

<table>
<thead>
<tr>
<th>mA Range</th>
<th>Use Scale</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0-10</td>
<td>Divide by 10</td>
</tr>
<tr>
<td>10</td>
<td>0-10</td>
<td>Read direct value</td>
</tr>
<tr>
<td>100</td>
<td>0-10</td>
<td>Multiply reading by 10</td>
</tr>
<tr>
<td>250</td>
<td>0-2.5</td>
<td>Multiply reading by 100</td>
</tr>
<tr>
<td>500</td>
<td>0-50</td>
<td>Multiply reading by 10</td>
</tr>
</tbody>
</table>

f. Turn off power to the circuit. Remove the test leads and restore circuit continuity.
SECTION V
THEORY OF OPERATION

5.1 GENERAL

5.1.1 The taut-band indicating instrument used in the 160 responds linearly to direct current and requires less than 50 microamperes to cause full scale deflection. The indicating instrument and its associated calibration network, $R_1$ and $R_2$, are adjusted accurately to an equivalent circuit resistance of 5000 ohms. The resulting basic metering circuit, after calibration, requires precisely 50 microamps at 0.25 volts for full-scale deflection. The diode network, D, shown in the schematic diagram (Figure 7-1) provides an effective shorting path for metering signals appreciably in excess of full scale. The network can bypass excessive currents as high as several hundred milliamperes continuously, thereby affording considerable protection to the indicating instrument.

5.2 DC VOLTMEETER CIRCUIT

5.2.1 The basic circuit configuration employed for DC voltage measurements is shown in simplified form in Figure 5-1. The metering circuit (M) in this diagram includes the calibrating network as
Theory of Operation

described above. The precision voltage ranging resistors, R34, R8, R24, R25, R26, R27, R32, and R33 provide the necessary voltage drop to yield full-scale deflection for each corresponding range as shown in Figure 5-1. Note that the 250mV, 1V, and 1000V ranges utilize separate jacks.

5.3 DC MILLIAMMETER CIRCUIT

5.3.1 The basic circuit configuration utilized for direct current measurements is shown in simplified form in Figure 5-2. Resistors R19, R18, R17, R16, and R6 in the arrangement shown form an Ayrton, or "Universal" shunt. The values of these resistances can be computed as:

\[ R_x = \frac{20 \times 0.25\ \text{Volts}}{19 \times 1\ \text{(in Amps)}} \]

where \( R_x \) is defined as the total value of the shunt between the input terminals; i.e., R6 for the 500mA range, R6 || R16 for the 250mA range, etc. Measurement of current on the 50 microampere range utilizes the 50mA ± 250mV test jack as shown in Figure 5-1.

Figure 5-2. Simplified Circuit-DC mA
5.4 AC VOLTMETER CIRCUIT

5.4.1 The simplified circuit for the AC voltage ranges of the 160 is given in Figure 5-3. The modified full-wave bridge comprising D2, D3, R10, and R11 provides direct current to the metering circuit (M) proportional to the average rectified value of the AC voltage being measured. With the range switch set at 2.5 volts and calibration resistors R3 and R4 properly adjusted, an effective input resist-
ance of 12,500 ohms is attained. This corresponds to a sensitivity of $12,500 \Omega = 5.000 \Omega/V$.

Values of the range resistors R28, R29, R30, R31 and R32 are calculated on the basis of this sensitivity.

5.5 OHMMETER CIRCUIT

5.5.1 A simplified circuit for the 160 ohmmeter range is given in Figure 5-4. Note for ohms measurements the equivalent meter resistance is approximately 2000 ohms. The ohmmeter, as shown, is a "series" type employing a modified Ayrton shunt for multiple ranges. A 1.5 volt battery supplies the power for measurements on the R x 1, R x 10, and R x 100 ranges.

5.5.2 For the highest ranges, (R x 1K and R x 10K) a 22.5 volt battery is employed to obtain the required full-scale meter current. The Ohms Adjust resistors (R5) is adjusted manually by the operator to allow full-scale deflection (zero ohms) with the test leads shorted. A slight readjustment of R4 might be required when switching from the lower ohms scales to the higher (R x 1K or R x 10K) because of the difference in condition of the two batteries.
6.1 REMOVAL FROM THE CASE

6.1.1 The 160 has been designed to provide easy access for all necessary adjustments and replacement of parts. It is only necessary to remove one screw from the back of the 160 to gain access to the battery compartment.

6.2 BATTERY REPLACEMENT

6.2.1 After removal of the case back, loosen the screws at the top of the 160 panel assembly. After the screws are loosened sufficiently, the contact plate may be removed. Note battery polarity as indicated on the contact plate.

6.2.2 After removing the screw, the front panel including the radiating instrument, printed circuit board, and batteries can be removed as a unit. Press lightly against the threaded brass insert, using a punch or similar device, to facilitate separation of the 160 from its case.
Operator Servicing

NOTE: When the Ohms Adjust control cannot be adjusted for zero ohms (with shorted test leads), it is generally an indication that a battery has reached the end of its useful life. Consequently the defective battery must be replaced. Failure to do so promptly can result in damage to the 160 due to chemical leakage from the battery.

6.3 TEST LEAD INSPECTION
6.3.1 Periodic inspection of the test leads is recommended to detect cuts, burns, or other damage that could reduce the insulation strength of the leads. New leads may be purchased from the nearest Authorized Service Center.
SECTION VII
SERVICING INSTRUCTIONS

7.1 REPLACEMENT PARTS AND
SCHEMATIC DIAGRAM

7.1.1 This section contains information for ordering replacement parts. Table 7-1 lists parts in alphanumeric order of their reference designators and indicates the description. (Refer to Table 1-2 for Items and Accessories Furnished With This Instrument.)

7.1.2 To obtain replacement parts, address order to the nearest Authorized Service Center (listed on the last pages of this manual). Refer to paragraph 2.3.1 for ordering instructions.

NOTE
If it is necessary to replace components, do not apply heat directly to the circuit board. Cut leads close to component body and solder new component to the leads. Refer to an Authorized Service Center or the Simpson Electric Company, for recalibration or Servicing of the printed circuit board.
### Table 7.1. Replacement Parts

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Potentiometer 6 kΩ</td>
<td>5-110716</td>
</tr>
<tr>
<td>R2</td>
<td>Potentiometer 150 kΩ</td>
<td>5-111672</td>
</tr>
<tr>
<td>R3</td>
<td>Potentiometer 6 kΩ</td>
<td>5-110716</td>
</tr>
<tr>
<td>R4</td>
<td>Potentiometer 6 kΩ</td>
<td>5-110716</td>
</tr>
<tr>
<td>R5</td>
<td>Potentiometer 15 kΩ</td>
<td>5-111664</td>
</tr>
<tr>
<td>R6</td>
<td>Resistor 0.526Ω (Bobbin)</td>
<td>10-675295</td>
</tr>
<tr>
<td>R7</td>
<td>Resistor 300Ω ±1%</td>
<td>5-111683</td>
</tr>
<tr>
<td>R8</td>
<td>Resistor 45 Ω ±1%</td>
<td>5-114192</td>
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<tr>
<td>R9</td>
<td>Resistor 6.8 kΩ ±10%</td>
<td>1-118611</td>
</tr>
<tr>
<td>R10</td>
<td>Resistor 5 kΩ ±1%</td>
<td>5-113425</td>
</tr>
<tr>
<td>R11</td>
<td>Resistor 5 kΩ ±1%</td>
<td>5-113425</td>
</tr>
<tr>
<td>R12</td>
<td>Resistor 270Ω ±1%</td>
<td>5-111681</td>
</tr>
<tr>
<td>R13</td>
<td>Resistor 1.7Ω ±1%</td>
<td>5-111679</td>
</tr>
<tr>
<td>R14</td>
<td>Resistor 1 kΩ ±1%</td>
<td>1-117058</td>
</tr>
<tr>
<td>R15</td>
<td>Resistor 17 kΩ ±1%</td>
<td>5-113349</td>
</tr>
<tr>
<td>R16</td>
<td>Resistor 0.526Ω (Bobbin)</td>
<td>10-675295</td>
</tr>
<tr>
<td>R17</td>
<td>Resistor 1.58Ω (Bobbin)</td>
<td>10-675296</td>
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<tr>
<td>R18</td>
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<td>5-111684</td>
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<tr>
<td>R19</td>
<td>Resistor 237Ω ±1%</td>
<td>5-111682</td>
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<tr>
<td>R20</td>
<td>Resistor 2.7Ω ±10%</td>
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<tr>
<td>R21</td>
<td>Resistor 297Ω ±1%</td>
<td>5-111680</td>
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<tr>
<td>R22</td>
<td>Resistor 28.1 kΩ ±1%</td>
<td>5-111677</td>
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<tr>
<td>R23</td>
<td>Resistor 293 kΩ ±1%</td>
<td>5-111676</td>
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<tr>
<td>R24</td>
<td>Resistor 150 kΩ ±1%</td>
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<tr>
<td>R25</td>
<td>Resistor 800 kΩ ±1%</td>
<td>1-113363</td>
</tr>
<tr>
<td>R26</td>
<td>Resistor 4 MΩ ±1%</td>
<td>1-113362</td>
</tr>
</tbody>
</table>

### Replacement Parts

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>R27</td>
<td>Resistor 5 MΩ ±1%</td>
<td>5-110454</td>
</tr>
<tr>
<td>R28</td>
<td>Resistor 1.25 MΩ ±1%</td>
<td>5-111675</td>
</tr>
<tr>
<td>R29</td>
<td>Resistor 1 MΩ ±1%</td>
<td>1-117061</td>
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<tr>
<td>R30</td>
<td>Resistor 200 kΩ ±1%</td>
<td>1-113365</td>
</tr>
<tr>
<td>R31</td>
<td>Resistor 37.5 kΩ ±1%</td>
<td>1-113393</td>
</tr>
<tr>
<td>R32</td>
<td>Resistor 2.5 MΩ ±1%</td>
<td>5-111669</td>
</tr>
<tr>
<td>R33</td>
<td>Resistor 7.5 MΩ ±1%</td>
<td>5-111668</td>
</tr>
<tr>
<td>R34</td>
<td>Resistor 15 kΩ ±1%</td>
<td>5-110756</td>
</tr>
<tr>
<td>D1</td>
<td>Diode, Overload</td>
<td>1-110670</td>
</tr>
<tr>
<td>D2, D3</td>
<td>Diode, Germanium</td>
<td>1-115970</td>
</tr>
<tr>
<td></td>
<td>Molded Case Assembly</td>
<td>10-861393</td>
</tr>
<tr>
<td></td>
<td>Case Mounting Screw</td>
<td>5-111655</td>
</tr>
<tr>
<td>Probe Tips</td>
<td>Test Lead Set W Clips</td>
<td>02055</td>
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<tr>
<td></td>
<td>Range Knob</td>
<td>3-260548</td>
</tr>
<tr>
<td></td>
<td>Meter Cover Assy.</td>
<td>10-560115</td>
</tr>
<tr>
<td></td>
<td>Rubber Feet</td>
<td>5-111660</td>
</tr>
<tr>
<td></td>
<td>Battery, 22.5V-Photo flash-</td>
<td>Eveready 505</td>
</tr>
<tr>
<td></td>
<td>Battery Contact</td>
<td>5-111665</td>
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