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Simpson

INSTRUMENTS THAT STAY ACCURATE

OPERATOR'S MANUAL

SIMPSON 461-2 AND 461-2R DIGITAL MULTIMETERS

WARNING

For safe usage, it is essential that the operator read this manual carefully before using the instrument for any measurements.

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

DIGITAL INSTRUMENT
Warranty

SIMPSON ELECTRIC COMPANY warrants each digital instrument 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 digital instrument which shall within one (1) year 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 of all other obligations or liabilities on its part, and SIMPSON ELECTRIC COMPANY neither assumes nor authorizes any other persons to assume for it any other liability in connection with the sale of its products.

This warranty shall not apply to any digital instrument 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
INSTRUMENTS THAT STAY ACCURATE

ELECTRIC COMPANY
853 Dundee Ave., Elgin, Illinois 60120 Phone: (312) 697-2260
IN CANADA: Bach-Simpson, Ltd., London, Ontario
IN ENGLAND: Bach-Simpson (U.K.) Limited, Wadebridge, Cornwall
IN INDIA: Ruttonsha-Simpson Private, Ltd., International House, Bombay-Agra Road, Vikhroli, Bombay

KATY INDUSTRIES
INDUSTRIAL EQUIPMENT GROUP

OPERATOR'S MANUAL

SIMPSON 461-2 AND 461-2R

DIGITAL MULTIMETERS

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

9M2C280 (123.03) Part No. 6111623
EFFECTIVE DATE: Immediately
EDITION: 1st

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

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 or a 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.

SYMBOL DEFINITIONS

A terminal to which or from which a direct voltage or current may be applied or supplied.

A terminal to which or from which an alternating (sinewave) voltage or current may be applied or supplied.

A terminal to which or from which an alternating or direct current or voltage may be applied or supplied (AC and/or DC).

HIGH VOLTAGE WARNING: An output terminal at which a voltage, with respect to another terminal or to earth ground, exists or may be adjusted to exceed 1000 volts AC or DC if a current exceeding 0.5 milliampere can be delivered into a 1500 ohm resistive load connected between the same points. The symbol is an additional warning that a very dangerous voltage may exist at the terminal, and the terminal and its connecting leads must not be handled while energized.

GROUNDED TERMINAL (PROTECTIVE): A terminal which must be connected to earth ground by the Operator or Installer prior to making any other connections to the equipment for personal protection from electric shock.

Symbol Definitions

GROUNDED TERMINAL: A terminal which is connected to earth ground by means of an earth grounding system and which is intended to be connected to other circuits or equipment by the Operator or Installer for purposes other than protection from electric shock.

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 ohms 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.

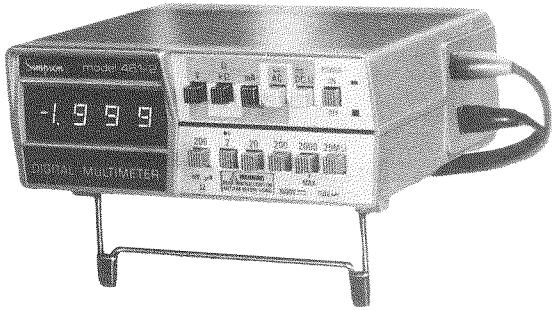


FIGURE 1-1. 461-2 DIGITAL MULTIMETER

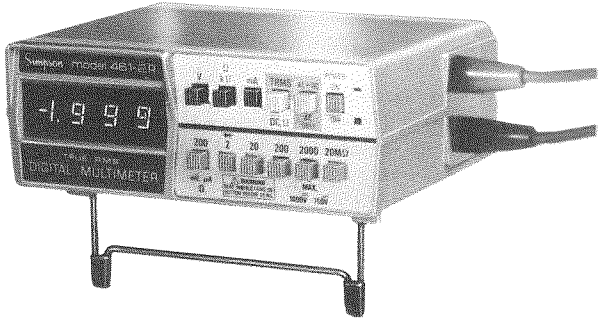


FIGURE 1-2. 461-2R (TRUE RMS) DIGITAL MULTIMETER

SECTION I
INTRODUCTION

1.1 GENERAL

1.1.1 This Operator's Manual applies to both the Simpson Models 461-2 and 461-2R Digital Multimeters. Except for the difference in the AC measuring technique, both models are identical. The Model 461-2 uses an Average-Responding circuit; the Model 461-2R uses a true RMS (Root-Mean-Square) circuit. Except where noted, all information which follows is common to both Instruments and is referred to as the 461 or the Instrument.

1.1.2 The Instrument is a compact, 3½ digit instrument suitable for use in general electronic maintenance, production and laboratory. It features 0.1 percent DCV accuracy, integrated circuit electronics, solid-state Light-Emitting-Diode (LED) display, and pushbutton switch selection for ranges and functions. Additional features are automatic polarity, automatic zeroing, high input impedance for voltage measurements, and excellent temperature characteristics.

1.1.3 The 461 (Figures 1-1 and 1-2) measures AC and DC voltages, AC and DC currents, and resistance as specified in Table 1-1. The Analog-to-Digital (A/D) conversion circuitry is contained in one Large-Scale-Integration (LSI) module which provides high reliability and compact design.

1.1.4 The 461 is operated by nickel-cadmium rechargeable batteries and will operate for eight hours continuously on a full charge. Recharging is auto-

matic when the Instrument is in the OFF position and with the charger connected to the 120 VAC line. (Refer to paragraph 6.3 for precautions and instructions.)

1.1.5 The numerical display is a 7-segment LED display for easy-viewing and solid-state reliability. The numerals are 0.3 inch high and in a single plane for distant and wide-angle viewing. Ambient lighting effects are minimized by a filter which reduces reflections and background illumination.

1.2 SUPPLIES AND ACCESSORIES

1.2.1 All supplies and accessories required for the operation of the 461 are furnished with this Instrument, and listed in Table 1-2. Available replacement parts are listed in Table 6-2.

1.3 SAFETY CONSIDERATIONS

1.3.1 This Operator's Manual contains cautions and warnings alerting the user to hazardous operating and maintenance 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 461-2 and 461-2R. (Except where noted, all Technical Data are the same for both models.)

TABLE 1-1. TECHNICAL DATA

(1) DC VOLTAGE

Range	Maximum Indication	Input Resistance	Overload Protected To
200 mV	±199.9 mV	10 MΩ	±1000 V
2 V	±1.999 V	10 MΩ	(DC + Peak AC)
20 V	±19.99 V	10 MΩ	ALL RANGES
200 V	±199.9 V	10 MΩ	
1000 V	±1000 V (Max. Input)	10 MΩ	

Accuracy: (from +18°C to +28°C)	±(0.1% of input + 1 count)
Sensitivity:	100 μV on 200 mV range
Step Response: (to rate accuracy)	1 second
Normal Mode Rejection:	55 dB minimum at 60 Hz
Common Mode Rejection:	120 dB minimum at 60 Hz

(2) (a) AC VOLTAGE: Model 461-2
(Average-Sensing, RMS Calibrated Sine Wave)

Range	Maximum Indication	Input Impedance	Overload Protected To (DC + Peak AC)
200 mV	199.9 mV	10 MΩ & 100 pF	750 V
2 V	1.999 V	10 MΩ & 100 pF	750 V
20 V	19.99 V	10 MΩ & 100 pF	1000 V
200 V	199.9 V	10 MΩ & 100 pF	1000 V
750 V	750 V (Max. Input)	10 MΩ & 100 pF	1000 V

Accuracy:
(from +18°C to +28°C) % of input + number of counts

Range	20 Hz to 400 Hz	400 Hz to 1 kHz	1 kHz to 10 kHz
200 mV 2 V 20 V 200 V	±(.5% + 2)		±(5% + 2)
750 V	+(1% + 3)		

Full Range Step Response:
(To rated accuracy) 3 seconds

(b) AC VOLTAGE: Model 461-2R

True RMS (AC or AC + DC)

Range	Maximum Indication	Input Impedance	Overload Protected To (DC + Peak AC)
200 mV	199.9 mV	10 MΩ & 100 pF	250 V
2 V	1.999 V	10 MΩ & 100 pF	250 V
20 V	19.99 V	10 MΩ & 100 pF	1000 V
200 V	199.9 V	10 MΩ & 100 pF	1000 V
750 V	750 V (Max. Input)	10 MΩ & 100 pF	1000 V

Accuracy:
(from +18°C to +28°C) % of input + number of counts

Range	20 Hz to 400 Hz	400 Hz to 1 kHz	1 kHz to 10 kHz	10 kHz to 20 kHz	20 kHz to 50 kHz
200 mV 2 V 20 V 200 V	±(.5% + 3)			±(5% + 3)	
750 V	±(1% + 3)				

Sensitivity: 100 μV on 200 mV Range

Crest Factor: (At full scale) 3

Full Range Step Response:
(to rated accuracy) 3 seconds

(3) RESISTANCE

Range	Maximum Indication	Open Circuit Voltage	Overload Protected To
200 Ω	199.9 Ω	< 3 V	250 V RMS
2 kΩ	1.999 kΩ	ALL	ALL
20 kΩ	19.99 kΩ	RANGES	RANGES
200 kΩ	199.9 kΩ		
2000 kΩ	1999 kΩ		
20 MΩ	19.99 MΩ		

Accuracy:
(from +18°C to +28°C) ±(0.25% of input + 2 counts) except on the 20 MΩ range, which is ±(0.75% of input + 2 counts)

Sensitivity: 0.1Ω on 200Ω range

Full Range Step Response:
(to rated accuracy) 1 second, except on 20 MΩ range which is 3 seconds

(4) DC CURRENT

Range	Maximum Indication	Full Range Voltage Drop	Overload Protected To
200 μA	±199.9 μA	200 mV	±2.0 Amps
2 mA	±1.999 mA	200 mV	Fuse
20 mA	±19.99 mA	200 mV	Protected
200 mA	±199.9 mA	200 mV	ALL
2000 mA	±1999 mA	200 mV	RANGES

Accuracy:
(from +18°C to +28°C) ±(0.5% of input + 2 counts) except on 200 mA and 2000 mA range which is ±(0.75% of input + 2 counts)

Sensitivity: 100 nA on 200 μA range

Full Range
Step Response:
(to rated accuracy) 1 second

(5) AC CURRENT (20 Hz to 1 kHz) 461-2 & 2R

Range	Maximum Indication	Full Range Voltage Drop	Overload Protected To
200 μA	199.9 μA	200 mV	2.0 Amps
2 mA	1.999 mA	200 mV	Fuse
20 mA	19.99 mA	200 mV	Protected
200 mA	199.9 mA	200 mV	ALL
2000 mA	1999 mA	200 mV	RANGES

Accuracy:
(from +18°C to +28°C) ±(1% of input + 2 counts) except 200 mA and 2000 mA range which is ±(1.5% of input + 2 counts).

Sensitivity: 100 nA on 200 μA range

Full Range
Step Response:
(to rated accuracy) 3 seconds

(461-2R) Crest Factor: 3 at full range

(6) RATED CIRCUIT-TO-GROUND VOLTAGE ⚠

(Maximum Common Mode Voltage) 300 volts (DC plus peak AC) maximum for the "—" measuring terminal to powerline (earth) ground.

(7) TRANSIENT PROTECTION

Protected against transients on all voltage and resistance ranges: 6 kV at 100 μs max.

(8) DISPLAY

Numerical Display: 3½ digit, 7-segment light-emitting-diode (LED)

Conversion Rate: 3 readings per second, nominal

DC Polarity Selection: Automatic "—" sign displayed; "+" sign implied.

(9) POWER REQUIREMENT

Battery Charging:
(AC operating) 120 VAC ±10%, 50-400 Hz, 3 VA nominal

Battery Operation: Two batteries consisting of four nickel-cadmium "AF" size rechargeable cells are included. (See Paragraph 6.3.1 for use with "AA" size rechargeable nickel-cadmium cells.)

Battery Operation Time:
(continuous with fully charged battery) 8 hours, nominal

Battery Recharge Time: 12 hours, nominal

(10) TEMPERATURE RANGE

Operating: 0°C to +55°C

Storage: –40°C to +60°C

(11) RELATIVE HUMIDITY

Operating: 0 to 90% (non-condensing)

(12) TEMPERATURE COEFFICIENT
(0°C to +18°C and +28°C to +55°C). Less than 0.1 times the applicable accuracy specification per °C.

(13) DIMENSIONS

Height:	2" (50.8 mm)
Width:	5.63" (143 mm)
Depth:	4.6" (166.8 mm)

TABLE 1-2. ITEMS AND ACCESSORIES FURNISHED WITH THIS INSTRUMENT

Quantity	Description	Part No.
1	Operator's Manual	6-111623
2	Battery, 2 AF size, Nickel-Cadmium	6-111333
1	Test Lead Set: One black and one red insulated lead having probe tips with provisions for screw-on alligator clips.	00043
1	Battery Charger, 120 VAC	00743

SECTION II
INSTALLATION

2.1 GENERAL

2.1.1 This section contains instructions for the installation and shipping of the 461. Included are unpacking and inspection procedures, warranty, shipping, power source requirements, installation, and care.

2.2 UNPACKING AND INSPECTION

2.2.1 Examine the shipping carton for obvious signs of damage. Inspect the Instrument for possible damage incurred during shipment. If damage is noted, notify the carrier and supplier and do not use the Instrument. If Instrument appears to be in good condition, read Operator's Manual in its entirety. Become familiar with the Instrument as instructed in the manual, then proceed to check the electrical performance as soon as possible. Also, check that all items are included with the Instrument (Table 1-2).

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 any warranty repairs.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact the nearest Authorized Service Cen-

ter 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 POWER SOURCE REQUIREMENTS

2.5.1 The 461 is a battery-operated instrument. The batteries are factory installed. Connect the charger supplied to the appropriate external power source. (Refer to the markings on the charger for power source requirements.)

WARNING

The 461 is designed specifically to be used with the Simpson 120 VAC Charger (Catalog Number 00743) which is adequately insulated to permit use of the 461 while being charged.

CAUTION

Do not operate the Instrument unless the batteries are properly installed. (See paragraph 6.3.)

2.6 INSTALLATION

2.6.1 The Instrument may be operated either in the horizontal or vertical position. It can also be set at an inclined angle by positioning the stand under the unit.

SECTION III
CONTROLS, CONNECTORS, AND INDICATORS

3.1 GENERAL

3.1.1 All operating controls, connectors, and indicators are described in Table 3-1. Become familiar with each item prior to operating the Instrument for the first time.

3.2 FRONT AND SIDE PANEL DESCRIPTION

3.2.1 Table 3-1 lists all front and side panel controls, connectors, and indicators (Figures 3-1, 3-2, 3-3 and 3-4 for identification).

TABLE 3-1. FRONT AND SIDE PANEL DESCRIPTION

1. POWER
   Switch:
   ON / OFF — Pushbutton switch used to apply or turn off power to the Instrument.

2. FUNCTION
   Switches: Connect the input to the appropriate measuring circuits as follows:

   A. 461-2
   - V — Selects the DC voltage or AC voltage measuring circuit, depending on the selection of either the DC, Ω or the AC pushbutton switch.
   - Ω, kΩ — Selects the resistance measuring circuits in conjunction with the selection of the DC, Ω pushbutton switch.
   - mA — Selects the DC current or AC current measuring circuit, depending on the selection of either the DC, Ω or the AC pushbutton switch.

   - $\widetilde{AC}$ — Selects the AC voltage or AC current measuring circuits, depending on the selection of either the V or mA pushbutton switch.
   - $\overline{\overline{DC}}, \Omega$ — Selects the DC voltage, DC current, or resistance measuring circuits, depending on the selection of the other function switches.

   B. 461-2R:
   - V — Selects the DC voltage or AC voltage measuring circuits, depending on the selected position of the DC, Ω TRMS switch.
   - Ω, kΩ — Selects the resistance measuring circuits in conjunction with the DC, Ω-TRMS switch set in the DC, Ω position (out ■).
   - mA — Selects the DC current or AC current measuring circuits, depending on the selected position of the DC, Ω TRMS switch.
   - TRMS — The IN position selects the AC voltage or AC current measuring circuits, depending on the selection of either the V or mA pushbutton switch.
     $\overline{\overline{DC}}, \Omega$ ■
     The OUT position selects the DC voltage, DC current, or resistance measuring circuits, depending on the selection of the other function switches.
   - AC + DC / AC ONLY ■ — In AC TRMS voltage or current measurements, the IN position provides AC + DC coupling, the OUT position provides AC coupling only (blocks the DC component of the signal).

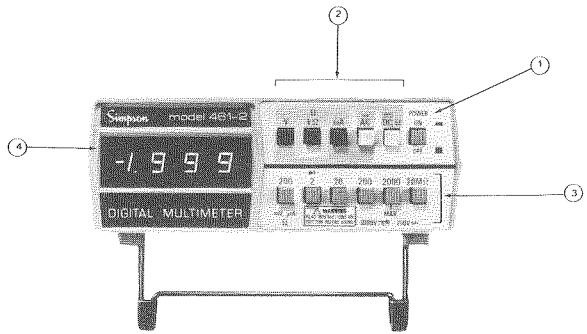


FIGURE 3-1. FRONT PANEL DESCRIPTION (461-2)

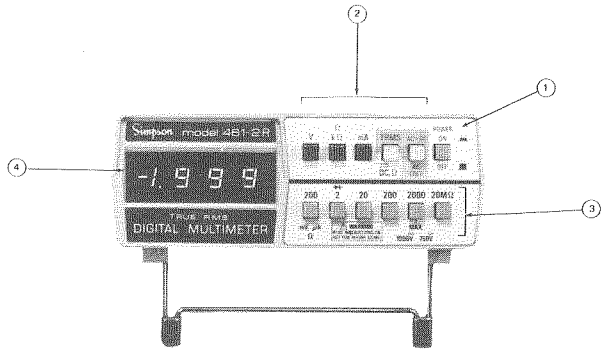


FIGURE 3-2. FRONT PANEL DESCRIPTION (461-2R)

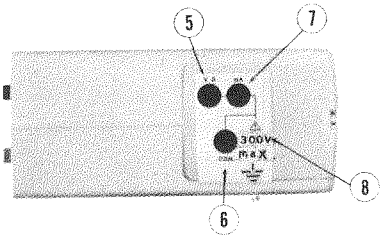


FIGURE 3-3. RIGHT SIDE PANEL DESCRIPTION
(461-2 and 461-2R)

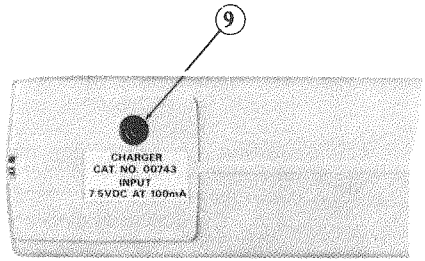


FIGURE 3-4. LEFT SIDE PANEL DESCRIPTION
(461-2 and 461-2R)

3. RANGE Switches: Select the appropriate circuits required to obtain full range measurements as follows:

   Voltage: 200 mV, 2 V, 20 V, 200 V, 1000 VDC / 750 VAC

   Current: 200 μA, 2 mA, 20 mA, 200 mA, 2000 mA

   Resistance: 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2000 kΩ, 20 MΩ

4. Numerical Display: The digital display uses LED'S and includes a "–" polarity sign; "+" sign is implied, a "1" digit, three 7-segment type 0 to 9 digits, and a decimal point to indicate the polarity and the value of the signal being measured. The decimal point is properly positioned by the selection of the range switch.

   Over-range (or out of range) conditions are indicated by a blank display, except for the most significant "1" digit.

5. V-Ω Jack: This terminal is used to connect the high side of the circuit being measured to all voltage and resistance measuring circuits through the range and function switches.

6. COM Jack: This jack is used to connect the low side of the circuit measured to the internal circuit COMMON and is isolated from the AC powerline ground. *Do not float this terminal more than 300 volts away from earth ground.*

7. mA Jack: This jack is used to connect, via the red test lead, the "high" or "+" side of the current being measured to the measuring circuits through the range and function switches.

8. ⚠ Refer to Table 1-1, item 6. (See Safety Symbols.)

9. CHARGER INPUT: This receptacle accepts the DC power from the battery charger.

SECTION IV
OPERATION

4.1 GENERAL

WARNING

Before proceeding with the operation of the 461, review the SHOCK HAZARD definition at the front of this manual.

4.1.1 This section of the manual contains information required to use and operate the 461 in a safe and proper manner.

4.2 SAFETY PRECAUTIONS

4.2.1 The 461 is designed to be used only by personnel qualified to recognize shock hazards and trained in safety precautions required to avoid possible injury.

4.2.2 Do not work alone when making measurements where a shock hazard can exist. Notify another person that you are, or intend to make such measurements.

CAUTION

Voltages might appear unexpectedly in defective equipment. An open bleeder resistor can result in a capacitor's retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured before making connections from it. The Instrument itself is well protected against electrical overload, as noted throughout Table 1-1. However, these precautions are wise even in the laboratory, and especially in field usage where unknown safety hazards might prevail.

4.2.3 Locate all voltage sources and accessible paths prior to making any measurements or connections.

4.2.4 Inspect the test leads, prods, connectors, and power cable for cracks, breaks, or crazes in the insulation. If any defects exist, destroy and replace defective item(s) immediately.

4.2.5 Do not make measurements in a circuit where corona is present. Corona can be identified by a pale blue color eminating from sharp metal points in the circuit, a buzzing sound, or the odor of ozone. In rare instances, such as around germicidal lamps, ozone might be generated as a normal function. Ordinarily, the presence of ozone indicates presence of high voltage, and probably a malfunction of some kind.

4.2.6 Hands, shoes, floor, and workbench must be dry. Avoid making measurements under humid, damp, or other environmental conditions that could affect the dielectric withstanding voltage to the test leads of the Instrument.

4.2.7 Do not touch test leads, circuit, or the Instrument while power is applied to the circuit being measured.

4.2.8 Use extreme caution when making measurements where dangerous composite voltages could be present, such as in an r-f amplifier.

4.2.9 Do not use test leads which differ from those originally furnished with the Instrument.

4.2.10 Do not float the COM measuring terminal more than 300 volts (DC plus AC peak) with respect to the powerline or earth ground.

4.3 PRELIMINARY NOTES AND CHECKS

NOTE: Prior to operating the Instrument, review and perform (where applicable) the following notes and checks. These steps can be used also as a general functional check.

4.3.1 The 461 is supplied with rechargeable nickel-cadmium batteries that are factory installed. *Charge the batteries overnight before operating the Instrument for the first time.*

CAUTION

Do not operate the Instrument with cells in the completely discharged state.

4.3.2 To recharge the battery, follow these procedures:

a. Set the POWER switch to the OFF position and connect the charger to the 461.

b. Connect the charger into a power outlet which conforms to the power requirements of the charger and to the latest electrical code.

c. The battery is being charged at full rate (allow 12 hours for full charge).

4.4 GENERAL FUNCTIONAL CHECK:

a. Connect the black test lead to the COM jack and the red test lead to the V-Ω jack. Short the test leads together.

b. 461-2: Depress and set the kΩ and "$\overline{\overline{\text{DC}}}$, Ω" function and the "2" switch.

c. 461-2R: Depress and set the kΩ function and release the TRMS switch ($\overline{\overline{\text{DC}}}$, Ω position). Depress and set the "2" range switch.

d. Separate the test leads. The numerical display will blank in the out-of-range condition.

e. Short the test leads together. The display reading will return to .000 ±1 digit.

f. If difficulty is encountered in the above steps, see Section VI, Table 6-1.

4.5 DC VOLTAGE MEASUREMENTS:

a. Review the Safety Precautions in paragraph 4.2.

b. Connect input test leads to the V-Ω and COM terminals.

c. 461-2: Depress the V and "$\overline{\overline{\text{DC}}}$, Ω" function switches.

d. 461-2R: Depress the V and release the TRMS switch ($\overline{\overline{\text{DC}}}$, Ω position).

e. Depress the appropriate voltage range switch. If the voltage being measured is unknown, begin with the 1000 volt DC range switch.

f. Turn off the power to the device or circuit under test and discharge all capacitors.

CAUTION

Do not attempt to measure voltages on the 1000 VDC range which might be greater than 1000 volts DC.

g. Connect test leads to the circuit being measured.

h. Apply power to the circuit being measured. The Instrument will automatically indicate the correct polarity (–) to indicate negative and no sign to imply positive polarity. The value of the voltage being measured will be indicated on the numerical display.

i. Remove all power from the circuit being measured and discharge all capacitors prior to disconnecting test leads.

4.6 AC VOLTAGE MEASUREMENT:

4.6.1 Model 461-2:

a. Review Safety Precautions in paragraph 4.2.

b. Connect input test leads to the V-Ω and COM terminals.

c. Depress the V and $\widetilde{AC}$ function switches.

d. Depress the appropriate voltage range switch. If the voltage being measured is unknown, begin with the 750 VAC range switch.

CAUTION

Do not attempt to measure voltages on the 750 VAC range which might be greater than 750 volts.

e. Remove all power from the circuit being measured and discharge all capacitors.

f. Connect test leads to the circuit being measured.

g. Apply power to the circuit being measured. The value of the voltage being measured will be indicated on the numerical display.

h. Remove all power from the circuit being measured and discharge all capacitors prior to disconnecting test leads.

4.6.2 Model 461-2R:

a. Review Safety Precautions in paragraph 4.2.

b. Connect input test leads to the V-Ω and COM terminals.

c. Depress the TRMS function switch to the IN position (TRMS position), and the V function switch to the IN position.

d. Select either AC coupling or AC + DC coupling by using the AC only (OUT position) or AC + DC (IN position) function switch.

e. Use the AC + DC coupling function when the DC component of an AC voltage is desired. This function will also measure DC voltages, but there will be no polarity indication.

f. Use the AC only coupling function when the DC component of an AC voltage is not desired.

g. Depress the appropriate voltage range switch. If the voltage being measured is unknown, begin with the 750 VAC range switch.

CAUTION

Do not attempt to measure voltages on the 750 VAC range which might ge greater than 750 volts.

h. Remove all power from the circuit being measured and discharge all capacitors.

i. Connect test leads to the circuit being measured.

j. Apply power to the circuit being measured. The value of the voltage being measured will be indicated on the numerical display.

k. Remove all power from the circuit being measured and discharge all capacitors prior to disconnecting test leads.

4.7 RESISTANCE MEASUREMENTS:

a. Review the Preliminary Notes and Checks in paragraph 4.3.

b. Connect input test leads to the V-Ω and COM terminals.

c. 461-2: Depress the kΩ and "$\overline{\overline{\text{DC}}}$, Ω" function switches.

d. 461-2R: Depress kΩ and release the TRMS function switch to the OUT position ($\overline{\overline{\text{DC}}}$, Ω position).

e. Depress the appropriate resistance range switch.

f. If the resistance being measured is connected into a circuit, be certain that all power is removed from the circuit and all capacitors are discharged. Check for current paths other than through resistance being measured. These paths can result in a measured value which is lower than the actual value of the resistance being measured.

g. Connect the test leads to the resistance being measured. Be careful not to contact adjacent points, even if insulated, particularly when making high resistance measurements. Some insulators can have relatively low insulation resistance which can sufficiently shunt the resistance being measured to result in a low measured value, lower than the presumed value.

h. Allow time for the display to stabilize. This procedure is especially important when measuring a high value resistance shunted by a large value of capacitance.

i. Disconnect test leads.

4.7.1 Diode Test:

a. Review the preliminary notes and checks in paragraph 4.3.

b. Connect input test leads to the V-Ω and COM terminals.

c. 461-2: Depress the kΩ and $\overline{\overline{\text{DC}}}$, Ω function switches.

d. 461-2R: Depress the kΩ and release the TRMS function switch to the out position ($\overline{\overline{\text{DC}}}$, Ω position).

e. Depress the $\overline{\overline{\text{2}}}$ range switch.

f. To measure the forward resistance of a semiconductor junction, connect the cathode of the diode to the COM terminal and anode to the V-Ω terminal. For silicon diodes, the Instrument should display .550 or higher. For germanium diodes, the Instrument should display .450 or lower.

g. When measuring the reverse resistance of a semiconductor junction, the Instrument should display over-range.

4.8 DC CURRENT MEASUREMENTS:

a. Review Safety Precautions in paragraph 4.2.

b. Connect the test leads to the mA and COM terminals.

c. 461-2: Depress the mA and "$\overline{\overline{DC}}$, Ω" function switches.

d. 461-2R: Depress the mA and release the TRMS function switch to the OUT position ($\overline{\overline{DC}}$, Ω position).

e. Depress the appropriate current range switch. If the current being measured is unknown, begin with the 2000 switch.

f. REMOVE ALL POWER TO THE CIRCUIT BEING MEASURED AND DISCHARGE ALL CAPACITORS.

g. Connect the test leads.

h. Open the circuit in which the current is to be measured and securely connect the test leads in series.

WARNING

Ensure that a current range is never connected across a voltage source and that the circuit into which the 461 is connected (in series) does not have a voltage, with respect to ground, exceeding the rated circuit-to-ground voltage of the 461 (refer to Table 1-1, item 6).

i. Apply power to the circuit being measured.

j. The value of the current being measured is indicated on the numerical display.

k. REMOVE ALL POWER FROM THE CIRCUIT BEING MEASURED AND DISCHARGE ALL CAPACITORS.

l. Disconnect the test leads and reconnect the circuit which was originally opened.

4.9 AC CURRENT MEASUREMENTS:

4.9.1 Model 461-2:

a. Review Safety Precautions in paragraph 4.2.

b. Connect the test leads to the mA and COM terminals.

c. Depress the mA and $\widetilde{AC}$ function switches.

d. Depress the appropriate current range switch. If the current being measured is unknown, begin with the 2000 switch.

e. REMOVE ALL POWER FROM THE CIRCUIT BEING MEASURED AND DISCHARGE ALL CAPACITORS.

f. Open the circuit in which the current is to be measured and securely connect the test leads in series.

WARNING

Ensure that a current range is never connected across a voltage source and that the circuit into which the 461 is connected (in series) does not have a voltage, with respect to ground, exceeding the rated circuit-to-ground voltage of the 461 (refer to Table 1-1, item 6).

g. Connect the test leads.

h. Apply power to the circuit being measured.

i. The value of the current being measured is indicated on the numerical display.

j. REMOVE ALL POWER FROM THE CIRCUIT BEING MEASURED AND DISCHARGE ALL CAPACITORS.

k. Disconnect the test leads and reconnect the circuit which was originally opened.

4.9.2 Model 461-2R:

a. Review Safety Precautions in paragraph 4.2.

b. Connect the test leads to the mA and COM terminals.

c. Depress the mA function switch.

d. Depress the TRMS function switch to the IN position (TRMS Position).

e. Select either AC coupling or AC + DC coupling by using the AC only (OUT position) or AC + DC (IN position) function switch.

f. Use the AC + DC coupling function when the DC component of an AC current is desired. This function will also measure DC currents, but there will be no polarity indication.

g. Use the AC only coupling function when the DC component of an AC current is not desired.

h. Depress the appropriate current range switch. If the current being measured is unknown, begin with the 2000 switch.

i. REMOVE ALL POWER FROM THE CIRCUIT BEING MEASURED AND DISCHARGE ALL CAPACITORS.

j. Open the circuit in which the current is to be measured and securely connect the test leads in series.

WARNING

Ensure that a current range is never connected across a voltage source and that the circuit into which the 461 is connected (in series) does not have a voltage, with respect to ground, exceeding the rated circuit-to-ground voltage of the 461 (refer to Table 1-1, item 6).

k. Connect the test leads.

l. Apply power to the circuit being measured.

m. The value of the current being measured is indicated on the numerical display.

n. REMOVE ALL POWER FROM THE CIRCUIT BEING MEASURED AND DISCHARGE ALL CAPACITORS.

o. Disconnect the test leads and reconnect the circuit which was originally opened.

SECTION V
THEORY OF OPERATION

5.1 OVERALL SYSTEM

5.1.1 The basic system block diagram for the 461 is shown in Figure 5-1.

5.1.2 Signal Conditioning Section.

5.1.3 The parameter being measured is connected to the input terminals. The corresponding Signal Conditioning circuits convert this parameter into a proportional DC voltage. The conversion is accomplished by the Attenuator, Current Shunts, Resistance Converter, AC-to-DC Converter, and associated switching.

5.1.4 Analog-to-Digital Converter Section.

5.1.5 The Analog-to-Digital (A/D) Converter section changes the DC output voltage from the Signal Conditioning section to the digital information. Using a Large Scale Integration (LSI) circuit, the unique A/D converter automatically eliminates zero error.

5.1.6 Display Section.

5.1.7 The Analog-to-Digital (A/D) Converter decodes the internal BCD into 7-segment information by the on-board decoder driver. The decoded digital information is visually presented on the numerical display.

5.2 INPUT CIRCUITS

5.2.1 DC Voltage Measurements.

5.2.2 The basic DC voltage circuit is shown in Figure 5-2(A). The DC voltage being measured is connected to the V-Ω and COM jacks, attenuated according to the range selected and converted into digital information by the A/D Converter.

5.2.3 The A/D Converter circuit provides two basic full range sensitivities: 200 mV and 2 V. No attenuation is required on the 200 mV and 2 V ranges. The attenuator is used on the 20 V, 200 V, and 1000 V ranges.

5.2.4 AC Voltage Measurements.

5.2.5 The basic AC voltage measurement circuit is shown in Figure 5-2(B). The AC voltage being measured is connected to the V-Ω and COM jacks, attenuated according to the range selected and applied to the amplifier. The output of the amplifier is converted into DC voltage by an active rectifier (461-2) or by a true RMS converter (461-2R) and the resulting DC voltage is measured by the A/D Converter.

5.2.6 The AC-to-DC Converter (461-2) (Figure 5-2B) provides two basic full range sensitivities: 200 mV and 2 V. The converter is average responding but its calibration (gain) is based on the RMS value of a sine wave.

5.2.7 The output of the Operational Amplifier has two rectifying diodes and two feedback resistors, R1 and R2. These components drive a summing resistor R3. The junction of the summing resistor and the feedback resistor is connected to the amplifier input to provide negative feedback. With a sine wave input signal, the positive half cycles of the output waveform

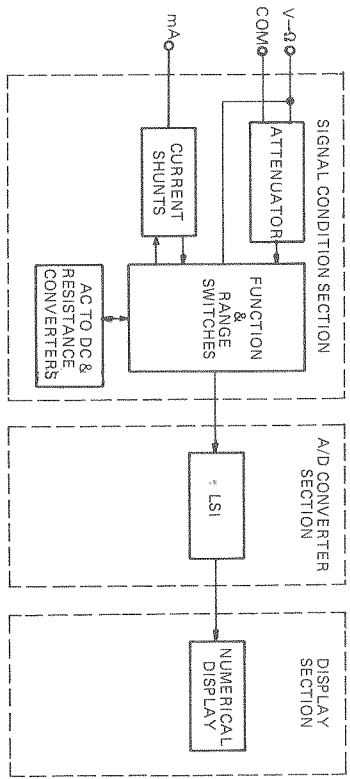


FIGURE 5-1. BASIC SYSTEM DIAGRAM

go through one diode, the negative half of the output waveform go through the other diode. Both the positive and negative cycles are filtered and the resulting DC voltage between the positive and negative cycle is measured by the A/D converter. This full-wave rectified voltage reduces the requirement of filtering.

5.2.8 On the 461-2R, the AC-to-DC (Figure 5-2C) conversion is accomplished with a true RMS (TRMS) converter. A buffer is used between the attenuator and the TRMS converter to provide gains of x1 and x10 and also allow for selection of AC or AC + DC coupling. The output of the TRMS converter is applied to the input of the A/D converter.

5.2.9 True RMS conversions are limited by their crest factors as to the type of waveform which it can measure. The crest factor is defined as the ratio of the peak value to the RMS value of a periodic waveform.

5.2.10 DC Current Measurements.

5.2.11 The basic DC current measurement circuit is shown in Figure 5-3A. The current being measured is connected in series with the mA and COM jacks across an internal precision shunt resistance. The value of the shunt resistance depends on the current range selected. The DC voltage developed across the shunt resistor is measured by the A/D Converter.

5.2.12 The full range sensitivity of the A/D Converter is set for 200 mV. The internal shunt resistance for each current equals 200 mV divided by the full range current. For example, if the full range current is 200 μA, the shunt resistance is 1000 ohms.

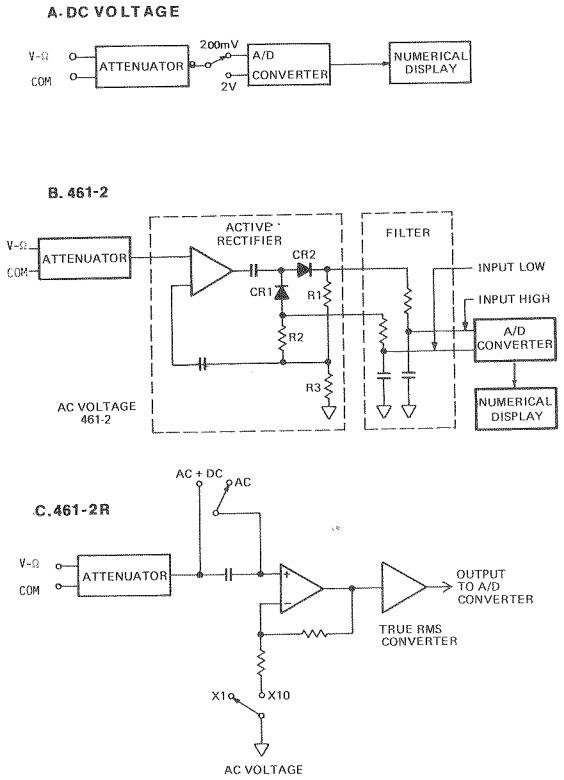


FIGURE 5-2.
BASIC VOLTAGE MEASUREMENTS CIRCUIT

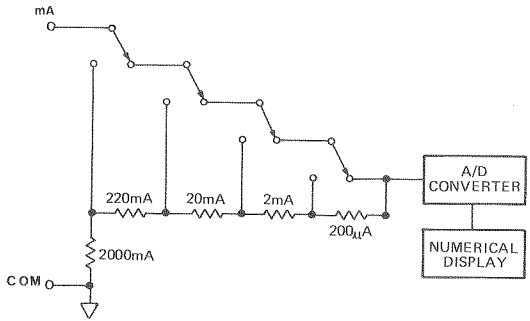
5.2.13 AC Current Measurements.

5.2.14 The basic AC current measurement circuit is essentially the same as the DC current measurement circuit (paragraph 5.2.10), except that the voltage developed across the internal shunt resistance is measured by the AC voltage measurement circuit.

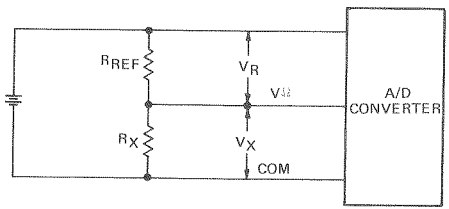
5.2.15 Resistance Measurements.

5.2.16 The basic resistance circuit is shown in Figure 5-3(B). The resistance being measured, Rx, is connected to the V-Ω and COM jacks.

5.2.17 A voltage ratio is made by comparing the unknown resistance (Rx) with an internal standard resistance (R Ref). The voltage ratio is applied to the A D Converter to yield a numerical value which is proportional to the unknown resistance as shown in Figure 5-3(B). The ranges of the resistance measurement circuit are determined by the range switch selected.



A. DC CURRENT



B. RESISTANCE

FIGURE 5-3. BASIC DC CURRENT AND RESISTANCE MEASUREMENT CIRCUITS

WARNING

These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

SECTION VI
SERVICING INSTRUCTIONS

6.1 GENERAL

6.1.1 This section describes the necessary procedures needed to effectively service the Instrument.

6.2 COVER REMOVAL

6.2.1 The rear cover can be removed for maintenance purposes by the following procedures:

WARNING

Remove all power and connections to the Instrument before removing the case cover. Do not operate the Instrument with the rear cover removed.

a. Depress the POWER switch to the OFF position.
b. Disconnect the charger and the test leads from the Instrument.
c. Turn the two screws on the back cover counterclockwise until the rear cover is removed. (The two screws will remain in the cover.)
d. Reverse this procedure when replacing the cover.

6.3 BATTERY INSTALLATION

6.3.1 Only use the rechargeable nickel-cadmium batteries supplied with this Instrument. In an emergency, "AA" size rechargeable nickel-cadmium cells (rated 1.25 V 0.5 ampere-hour) can be considered as a replacement. However, continuous operation of the 461 will reduce the operating time of these cells to six hours.

6.3.2 Replace the Batteries as Follows:

a. Remove rear cover (paragraph 6.2). Remove the old batteries from the battery holder. Insert two new batteries into the holder. Ensure that the cells are installed according to the polarity orientation designated on the battery holder label. Failure to do so can damage the 461.
b. Check that the battery contacts are clean and making good connection.
c. Replace the rear cover.
d. For battery recharging, refer to paragraph 6.4.

6.4 BATTERY CHARGING

WARNING

To avoid dangers associated with recharging batteries, use only the two nickel-cadmium type batteries as specified. Do not attempt to use carbon zinc, alkaline or the like that is not designed to be recharged.

6.4.1 The battery is being charged at full rate when the POWER switch is set to the OFF position and AC power is applied to the charger. Approximately 12 hours are required to fully charge the battery in this mode of operation.

6.5 BATTERY CARE

6.5.2 Do not operate the Instrument with discharged cells. Make sure to recharge all newly purchased batteries (paragraph 6.4.1) for at least 15 minutes before operating the Instrument.

6.5.3 When the charger is not connected and the Instrument is not in use, remember to set the POWER switch to the OFF position.

6.6 FUSE REPLACEMENT

6.6.1 The current fuse is mounted inside on the battery board as shown in Figure 6-1. Use the following procedures to replace the fuse.

WARNING

Remove all power and input connections to the Instrument before removing rear cover.

6.6.2 Remove rear cover as described in paragraph 6.2.

CAUTION

Do NOT replace a blown fuse with a fuse that has a larger rating or slower time lag characteristic than those specified.

6.6.3 Carefully lift the defective fuse from the holder and replace with appropriate fuse (Table 6-2).

6.6.4 Replace the rear cover.

6.6.5 If the current ranges are still inoperative, it may be possible that fuse F2 is blown. If this is the case, a large amount of energy has been applied to the current ranges. (F2 is inside the unit and can be replaced by ordering a duplicate at an Authorized Service Center.)

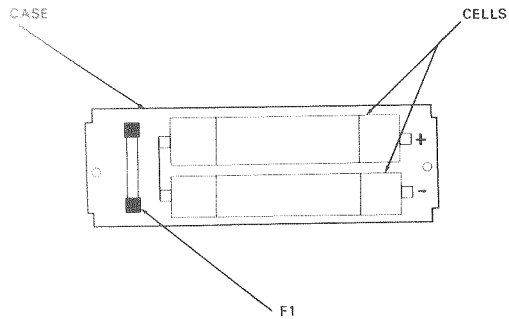


FIGURE 6-1. 461-2, FUSE LOCATION

6.7 TROUBLESHOOTING

6.7.1 If the Instrument does not yield satisfactory results, follow these procedures before attempting maintenance on the Instrument:

a. Review and comply with the Preliminary Notes and Checks, listed in paragraph 4.3.

b. Check that all switches are positioned correctly for the parameter and range of the value being measured and that the measurement situation is within the ratings of the Instrument.

c. Be sure that the cells are charged and properly installed (paragraph 6.3).

d. If the 461 has been operated with a charger, ensure that the power source is within the Instrument specifications, and free from excessive fluctuation and transients.

e. Ensure that the environment in which the Instrument is being used is within the Instrument specifications.

f. Inspect the device being measured and the measurement test set-up to ensure that proper shielding and grounding techniques have been used. Also, consider whether the Instrument is significantly affecting the circuit being measured.

6.7.2 If the steps taken in paragraph 6.7.1 do not yield satisfaction, refer to the troubleshooting chart (Table 6-1). Direct all other repair and adjustment needs to an Authorized Service Center.

TABLE 6-1. TROUBLESHOOTING CHART

* **Symptom:** LOW intensity on numerical display in battery operation.

  Probable Causes: Cells not fully charged.

  Cure: Recharge batteries overnight.

* **Symptom:** Batteries do not respond to charge. Display is dim when charger is used.

  Probable Causes: Cells defective, not installed properly, making poor contact, or missing.

  Cure: Remove cover and check that cells are installed correctly and making good contact. (Refer to paragraph 6.3.) If they are, check the voltages of the individual cells. Replace those which check significantly lower than normal (1.25 volts) after charging.

* **Symptom:** Indication fluctuates under all conditions.

  Probable Causes: Batteries not making contact, or Instrument is without batteries.

  Cure: Locate the defective contact or install a new set of batteries.

* **Symptom:** Indications fluctuate and/or drift, even though indication is OK at 000 with the input terminals shorted, and at 1000 counts when using a stable and low impedance input.

  Probable Causes: Fluctuations and/or drift are being generated by the device being measured or the measurement test set up.

  Cure: Use proper shielding, grounding techniques and connections to minimize "pick-up" of unwanted signals due to ground loops, poor connections, and capacitive and/or inductive coupling.

- **Symptom:** Slow response. Operation OK when using a low impedance input.

  Probable Causes: Parameter being measured has a high source impedance.

  Cure: None required.

- **Symptom:** Accuracy not within specifications when checked with a stable higher accuracy (at least 5 times better) low impedance (voltage measurements) source.

  Probable Causes: Instrument is out of calibration.

  Cure: Contact the nearest Authorized Service Center.

- **Symptom:** Accuracy of Instrument is within specifications but measurements appear in error.

  Probable Causes: Instrument affects circuit being measured.

  Cure: Study circuit being measured vs Instrument specifications. Correct indications accordingly.

- **Symptom:** Operation normal on all functions and ranges except AC and DC current.

  Probable Causes: Current fuse F1 open.

  Cure: Replace fuse F1. Refer to paragraph 6.6.

- **Symptom:** Operation normal on all functions and ranges except AC and DC current.

  Probable Causes: Current fuse F2 open.

  Cure: If F2 has been blown, a large amount of energy has been applied to the current ranges. This measurement condition must be corrected before replacing F2.

- **Symptom:** Ohms reading erratic.

  Probable Causes: TRMS switch (461-2R) in wrong position.

  Cure: Place the TRMS switch in the OUT position (DC, Ω position).

6.8 CARE:

WARNING

Do not attempt to clean this Instrument with the test leads connected to a power source or when it is connected to a charger.

a. Immediately clean all spilled materials from the Instrument and wipe dry. If necessary, moisten a cloth with soap and water to clean plastic surfaces.

b. Do not allow the battery to fully discharge. (A completely discharged battery may be forced into reverse polarity which will shorten battery life.)

c. Whenever possible, avoid exposure or usage in areas which are subject to temperature and humidity extremes, vibration or mechanical shock, dust or corrosive fumes, or strong electrical or electromagnetic interference.

6.8.1 Monthly Care: Verify Instrument calibration by performing operational checks using known value sources. If a need for calibration is indicated, contact the nearest Authorized Service Center.

6.8.2 Annual Care: It is recommended that the Instrument be returned annually to an Authorized Service Center or the factory for a complete overall check and calibration.

6.8.3 Storage: When the Instrument is not in use, store it in a location free from temperature extremes, dust, corrosive fumes, and mechanical vibration or shock.

6.9 REPLACEMENT PARTS AND SCHEMATIC DIAGRAM

6.9.1 The following (Table 6-2) 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.)

6.9.2 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.

TABLE 6-2. REPLACEMENT PARTS

F1	Fuse, 2A, 250 V	1-112911
F2	Fuse, 3A, 600 V	6-110906
C101	Capacitor, 82 pF, ±5%, 500 V	6-111631
C102	Capacitor, 619 pF, ±1%, 125 V	6-111632
C103	Capacitor, Trimmer, 4.5-60 pF	6-110125
C104	Capacitor, 6.8 pF, ±5%, 1 kV	5-110057
C105	Capacitor, Trimmer, 2-15 pF	6-111158
C106, 108	Capacitor, .01 μF, 100 V	5-117969
C109	Capacitor, 22 pF, ±5%, 1 kV	5-117042
C201	Capacitor, .047 μF, 630 V	6-111599
C202, 209, C210, 211, C213, 214, C215, 216, C219	Capacitor, 15 μF, 16 V	5-115534
C203	Capacitor, 100 pF, 1 kV	5-113217
C204, 206	Capacitor, .47 μF, 100 V	6-111168
C205	Capacitor, .22 μF, 100 V	6-110364
C207, 208	Capacitor, .033 μF, 100 V	5-117732
C212	Capacitor, 100 μF, 10 V	5-117206
C218	Capacitor, 180 pF, ±20%, 1 kV	5-119651
C220	Capacitor, .01 μF, 100 V	5-117278
C221, 222	Capacitor, .47 μF, 35 V, Tantalum	5-118564
D101	Diode (IN5059)	5-113826
D201	Diode, Silicon (IN914)	5-112004
D202	Diode, Zener (IN4570)	5-119942
IC201	I.C A/D Converter	6-110919
IC202	I.C OP Amp	6-110628
IC203	I.C DC Converter, P.P.	6-111607
IC204	I.C TRMS Converter, P.P. (461-2R)	6-111608

R101	Resistor, 100 kΩ, ±5%, ½ W	5-118625
R102	Resistor, 1.2 kΩ, ±5%, 1 W	5-118155
R103	High Voltage Current Limiter, 1 kΩ	6-111157
R104	Resistor, 9 MΩ, ±.1%, 1 W	5-119932
R105	Resistor, 900 kΩ, ±.1%, ¼ W	5-119933
R106	Resistor, 90 kΩ, ±1%, ¼ W	5-115497
R107	Resistor, 9 kΩ, ±.1%, ¼ W	5-115492
R108	Resistor, 1 kΩ, ±1%, ¼ W	5-115489
R109	Resistor, 100 Ω, ±.1%, ¼ W	6-111153
R110	Resistor, 900 Ω, ±.25%	5-116273
R111	Resistor, 90 Ω, ±.25%	5-116272
R112	Resistor, 9 Ω, ±.25%, WW	5-118410
R113	Resistor, .1Ω, ±.9 Ω, P.P.	6-111234
R114-116	Resistor, 560 Ω, ±5%, ¼ W	5-118154
R117	Resistor, 4080 Ω, ±.25%, ¼ W	5-118412
R201, 203, R207	Resistor, 100 kΩ, ±5%, ¼ W	5-118168
R202	Resistor, 10 kΩ, ±5%, ¼ W	5-118161
R204	Resistor, 39 kΩ, ±5%, ¼ W	5-112166
R205, 222	Resistor, 330 kΩ, ±5%, ¼ W	5-115965
R206	Resistor, 1 kΩ, ±5%, ¼ W	5-118155
R208, 209	Resistor, 470 kΩ ±5%, ½ W	1-114227
R210	Resistor, 448 Ω, ±.25%, ¼ W	5-118411
R212	Resistor, 4 kΩ, ±1%, ¼ W	5-117695
R214	Resistor, 28 kΩ, ±1%, ¼ W	5-117499
R215	Resistor, 2.74 kΩ, ±1%, ¼ W	5-114496
R216, 217	Resistor, 100 Ω, ±5%, ¼ W	5-118152
R218	Resistor, 270 kΩ, ±5%, 2 W	6-111664
R223	Resistor, 10 MΩ, ±5%, ¼ W	5-116632
R231	Resistor, 20 Ω, ±5%, 1 W	6-110123
R232	Resistor, 22 MΩ, ±5% ¼ W	5-118756
R233	Resistor, 4.99 kΩ, ±1%, ¼ W	5-115502
R234	Resistor, 442 Ω, ±.25%, ¼ W	6-111633
R235	Resistor, 4.7 kΩ, ±1%, ¼ W	5-115501
R236, 237	Resistor, 470 kΩ, ±5%, ¼ W	5-118169
MOV 101-104	Resistor, Special Varistor	6-110694
	Switch, Function	6-111600
	Switch, Range	6-111602

NOTES

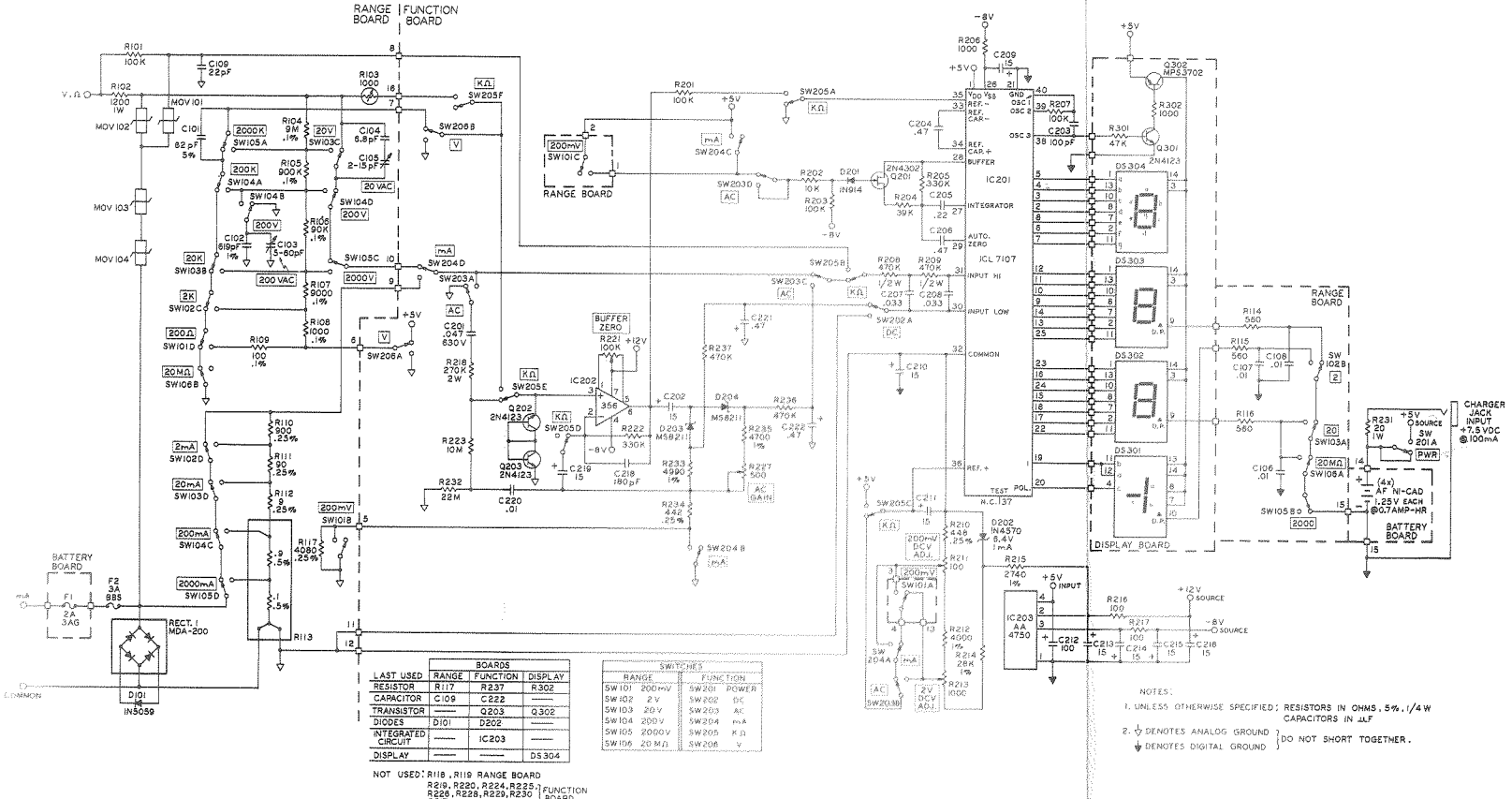
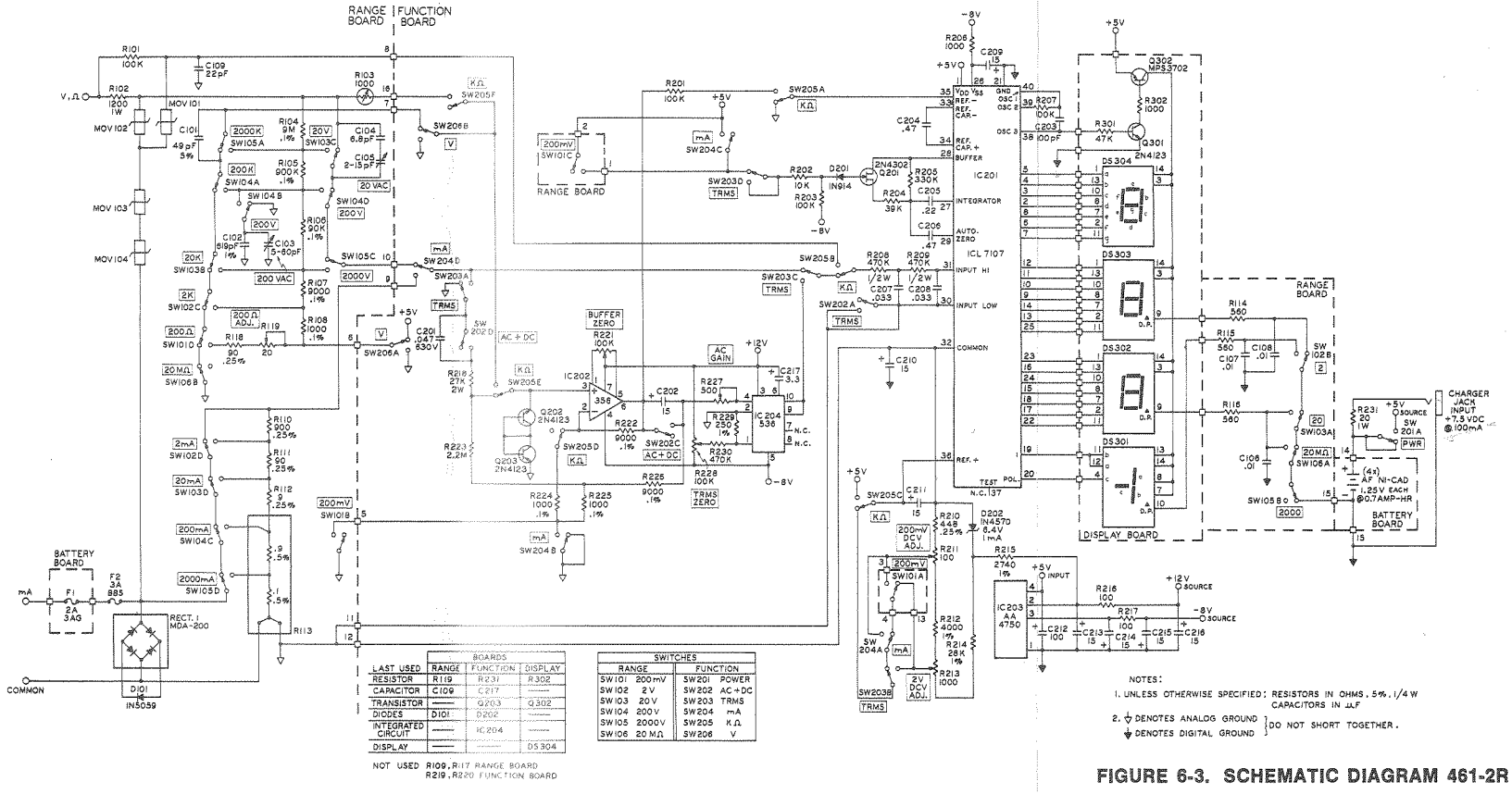


FIGURE 6-2. SCHEMATIC DIAGRAM 461-2



BOARDS			
LAST USED	RANGE	FUNCTION	DISPLAY
RESISTOR	R119	R231	R302
CAPACITOR	C109	C217	———
TRANSISTOR	———	Q203	Q302
DIODES	D101	D202	———
INTEGRATED CIRCUIT	———	IC204	———
DISPLAY	———	———	DS304

NOT USED R109, R117 RANGE BOARD
R219, R220 FUNCTION BOARD

SWITCHES	
RANGE	FUNCTION
SW101 200mV	SW201 POWER
SW102 2V	SW202 AC+DC
SW103 20V	SW203 TRMS
SW104 200V	SW204 mA
SW105 2000V	SW205 KΩ
SW106 20 MΩ	SW206 V

NOTES:
1. UNLESS OTHERWISE SPECIFIED: RESISTORS IN OHMS, 5%, 1/4 W
CAPACITORS IN μF
2. ⏚ DENOTES ANALOG GROUND
⏚ DENOTES DIGITAL GROUND
} DO NOT SHORT TOGETHER.

FIGURE 6-3. SCHEMATIC DIAGRAM 461-2R

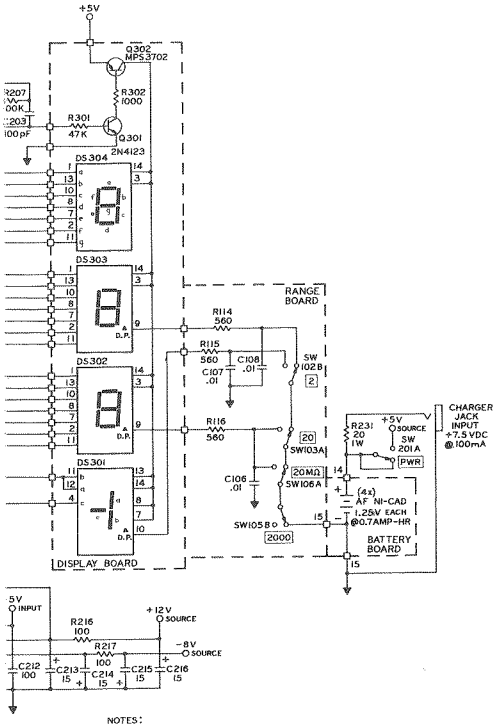


FIGURE 6-3. SCHEMATIC DIAGRAM 461-2R

AUTHORIZED SERVICE CENTERS

SIMPSON ELECTRIC COMPANY

853 Dundee Avenue, Elgin, Illinois 60120 — Phone: (312) 697-2260

* Parts Sales & Repair Service Only
** Parts, General Test Equipment & Panel Instrument Sales & Service
*** Same Service As (**) Above Plus Panel Instrument Modification
***□ Additionally Authorized for Service on Recorders, Controllers, Digital Products and Lab Portables

***ALABAMA, MOBILE 36617
□ BROWNELL-ELECTRO INC.
2660 Airmour Drive
Tel. 205/479-8551

*ALASKA, ANCHORAGE 99501
□ ALASKA RADIO SUPPLY, INC.
2808 Commercial Drive
P.O. Box 406
Tel. 907/277-1497

*ALASKA, ANCHORAGE 99500
□ W. W. ZOOK & ASSOCIATES
1049 E. 27th Avenue
Tel. 907/272-8817

*ALASKA, FAIRBANKS 99701
□ ALASKA RADIO SUPPLY, INC.
1712 Cushman Street
Tel. 907/452-1011

***ARIZONA, PHOENIX 85040
□ WATTSMASTER INC.
4134 E. Wood Street
Tel. 602/243-4111

**CALIFORNIA, LOS ANGELES 90040
□ E.I. INSTRUMENTS INC.
6612 Pearmree St.
Tel. 213/685-7020

***CALIFORNIA, GLENDALE 91201
□ WEATHERFORD INSTRUMENT DIV.
WESTERN ELECTRONIC SUPPLY CORP.
542 Allen Street
Tel. 213/245-4861

***CALIFORNIA, LOS ANGELES 90040
□ WATTSMASTER, INC.
5545 Bandini Street
Tel. 213/685-4340

***CALIFORNIA, PALO ALTO 94303
□ WATTSMASTER, INC.
3388 E. Bayshore Road
Tel. 415/968-0313

***CALIFORNIA, SAN DIEGO 92123
□ WATTSMASTER/SAN DIEGO
8988 Balboa Avenue
Tel. 714/565-4841

***CALIFORNIA, SAN FRANCISCO 94105
PACIFIC ELECTRICAL INSTRUMENT LAB
150 Folsom
Tel. 415/543-3104

***CALIFORNIA, SANTA CLARA 95050
□ FISHER-BROWNELL
3381 Edward Avenue
Tel. 408/988-6041

***CALIFORNIA, SOUTH PASADENA 91030
□ ETALON COMPANY
1323 Huntington Drive
Tel. 213/257-5410

***COLORADO, DENVER 80223
□ METER MASTER INSTRUMENT CORPORATION
1165 S. Cherokee
Tel. 303/722-5766

***CONNECTICUT, MIDDLETOWN 06457
□ THE MANCIB COMPANY
Subsidiary of E.I.L. Instruments
Randolph Road and Coe
Tel. 203/346-6646

***FLORIDA, HIALEAH 33014
□ KIMBALL ELECTRONIC LAB., INC.
8060 W. 20th Avenue
Tel. 305/635-9712

**FLORIDA, MIAMI 33136
FLORIDA PRECISION INSTRUMENT COMPANY
800 N.W. 7th Avenue
Tel. 305/324-1731

***FLORIDA, ORLANDO 32806
□ BROWNELL-ELECTRO INC.
307 27th St., Box 8945
Tel. 305/843-6775

**FLORIDA, TAMPA 33614
TAMPA INSTRUMENTATION CENTER
A.C. FERNANDEZ ELECTRIC
4807 N. Church Avenue
Tel. 813/870-0183

***GEORGIA, ATLANTA 30354
□ BROWNELL-ELECTRO INC.
3020 Commerce Way
Tel. 404/762-5181

**HAWAII, HONOLULU 96819
EMC CORPORATION
2979 Ualena Street
Tel. 808/847-1138

****HAWAII, HONOLULU 96819**
KEMS INCORPORATED
239 Puuhale Road
Tel. 808/847-1395

*****ILLINOIS, BRIDGEVIEW 60455**
E.I.L. INSTRUMENTS, INC.
9708 Industrial Drive
Tel. 312/430-2292

*****ILLINOIS, ELK GROVE VILLAGE 60007**
METERMASTER, INC.
121 Gordon Street
Tel. 312/593-8650

*****ILLINOIS, OAK PARK 60302**
PACIFIC INDICATOR COMPANY
6603 W. North Avenue
Tel. 312/261-1330

*****INDIANA, EVANSVILLE**
☐ ELECTRO-LAB SERVICES INC.
1302 N. Fulton 47710 (UPS)
P.O. Box 6011 47712 (MAIL)
Tel. 812/423-5211

****KANSAS, OVERLAND PARK 66206**
BROOKS ELECTRONICS INC.
3761 W. 95th Street
Tel. 913/648-3131

*****KANSAS, WICHITA 67211**
☐ MAIN ELECTRONICS INC.
225 Ida
Tel. 316/267-3581

*****LOUISIANA, HARAHAN 70123**
☐ INDUSTRIAL INSTRUMENT WORKS
134 Laitram Lane
Tel. 504/733-8355

*****MARYLAND, ELKRIDGE 21227**
☐ SUNSHINE SCIENTIFIC INSTRUMENTS, INC.
5800 Main Street
Tel. 301/796-5600

*****MARYLAND, GAITHERSBURG 20760**
☐ PIONEER/INSTRUMENTATION
Div. of Pioneer Standard Electronics Inc.
9100 Gaither Road
Tel. 301/948-0710

*****MARYLAND, SAVAGE 20863**
☐ INSTRUMENT SPECIALTIES INC.
Div. of Pyttronic Ind.
8220 Wellmoor Court
Tel. 301/792-0780

*****MARYLAND, TIMONIUM 21093**
☐ E.I.L. INSTRUMENTS, INC.
1830 York Road
Tel. 301/252-1260

****MASSACHUSETTS, BILLERICA 01821**
METERMASTER, INC.
13 Fortune Drive
Tel. 617/667-8346

*****MASSACHUSETTS, BURLINGTON 01803**
☐ THE MANCIB COMPANY
Subsidiary of E.I.L. Instruments Inc.
21 "A" Street
Tel. 617/272-9450

*****MICHIGAN, FERNDALE 48220**
☐ RAM METER, INC.
1100 Hilton Road
Tel. 313/398-6767

*****MINNESOTA, MINNEAPOLIS 55427**
☐ INSTRUMENTATION SERVICES INC.
957 Winnetka Avenue North
Tel. 612/544-8916

*****MISSOURI, ST. LOUIS 63108**
☐ INDUSTRIAL SERVICE LABORATORIES CORP.
4354 Olive Street
Tel. 314/535-5760

*****MISSOURI, ST. LOUIS 63143**
☐ SCHERRER INSTRUMENTS INC.
7170 Manchester
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****MONTANA, BILLINGS 59102**
INDUSTRIAL ELECTRONICS & AUTOMATION COMPANY
2500 Grand Avenue
Tel. 406/656-1313

****NEBRASKA, LINCOLN 68508**
ELECTROMETRICS COMPANY
404 South 11th
Tel. 402/477-3434

*****NEW JERSEY, BELLEVILLE 07109**
MARSHALL INSTRUMENTS INC.
236 Washington Avenue
Tel. 201/751-1190

*****NEW JERSEY, SOUTH PLAINFIELD 07080**
BROWNELL-ELECTRO INC.
500 Hadley Road
Tel. 201/753-4600

*****NEW MEXICO, ALBUQUERQUE 87102**
☐ MISSOURI RESEARCH LAB, INC.
630 Haines Avenue NW
Tel. 505/243-6772

*****NEW YORK, CHADWICKS 13319**
MOHAWK COMMUNICATIONS
3500 Bleachery Place
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*****NEW YORK, CHADWICKS 13319**
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*****NEW YORK, ROCHESTER**
☐ ELECTRONIC INSTRUMENT COMPANY
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CONTRONICS, INC.
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HOUSTON LABORATORIES, INC.
536 No. Pennsylvania
Tel. 405/235-5469

***OKLAHOMA, TULSA 74120**
AGRA ENGINEERING COMPANY
527 S. Quaker Avenue
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*****OREGON, PORTLAND 97217**
☐ WESTCON, INC.
5101 N. Interstate
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☐ SUNSHINE SCIENTIFIC INSTRUMENTS INC.
1810 Grant Avenue
Tel. 215/673-5600

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620 Alpha Drive RIDC Pk.
Tel. 412/782-3770

*****PENNSYLVANIA, PITTSBURGH 15221**
☐ E.I.L. INSTRUMENTS, INC.
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☐ BROWNELL-ELECTRO INC.
1026 Acorn Drive
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3000 Monroe
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*****TEXAS, EL PASO 79901**
BORDER ELECTRONICS
1704 E. Paisano Drive
Tel. 915/532-2524

*****TEXAS, GARLAND 75040**
METERMASTER, INC.
2809 National Drive
Tel. 214/271-5671

*****TEXAS, HOUSTON 77006**
☐ ELECTRICAL INSTRUMENT METER COMPANY (EIMCO)
1424 Westheimer
Tel. 713/526-6871 & 72

*****TEXAS, HOUSTON 77023**
☐ METERS & INSTRUMENTS CORP.
6428 Gulf Freeway
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METER SERVICE & SUPPLY
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P.O. Box 2373
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BLACKS-INDUSTRIAL INC.
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*****WISCONSIN, MILWAUKEE 53202**
THE ELECTRO MECHANO COMPANY
241 East Erie Street
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† Regular Mail Delivery
†† UPS Delivery

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