

***mA-2000***  
*DC / TRUE RMS AC*  
*NON-CONTACT MILLIAMMETER*

## **Instruction Manual**

Manual UN-01-237  
Item 359929  
April, 1999  
Rev. A  
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*This symbol appears on the instrument and probe.  
It refers the operator to additional information  
contained in this instruction manual, also identified  
by the same symbol.*

## **NOTICE:**

**See Pages 3-1 and 3-2  
for SAFETY  
instructions prior to first use !**



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# Section 1

## Introduction

### DESCRIPTION

The *mA-2000* is a battery-powered, clamp-on instrument that measures dc and ac current as low as 1 mA and as high as 2000 mA, at frequencies up to 100 kHz. The *mA-2000* consists of a palm-sized meter and a detachable probe. The probe clamps around the conductor to be measured. There is no need to disconnect the conductor or make physical contact with the circuit being measured. The current-carrying conductor is surrounded by a magnetic field that is proportional to the amount of current that is flowing through it. The probe senses the magnetic field and provides a signal to the meter. The meter then translates this signal into a milliamp current value.

The probe features a unique aperture mechanism that retracts easily and closes smoothly. The probe can accommodate conductors up to 5.3 mm (0.21 in.) in diameter.

The meter operates on two standard 9 volt alkaline batteries or can be operated with an ac adapter. Two ranges can be selected (199.9 mA or 1999 mA full scale) in addition to three modes of measurement; dc, low-frequency ac or high-frequency ac. The meter contains a 3 ½ digit display that provides dc and true rms ac readings. In addition, an analog output provides a 1 mV / mA voltage signal proportional to the current being measured. This output can be connected to a voltmeter, oscilloscope or recorder.

The meter, probe and accessories are protected between use by a sturdy carrying case.

## **INTRODUCTION**

### **APPLICATIONS**

- Diagnosis and general maintenance of 4 - 20 mA process control loops.
- Troubleshooting of low-to-medium current devices in automobiles, such as lamps, relays, motors and communications lines.
- Detection of leakage current in battery operated devices.
- Monitoring charge current in battery charging systems.
- Testing of low level signal lines in electronic equipment.
- Monitoring serial communications bit streams (RS-232).

## Section 2 Specifications

### ELECTRICAL

**Range / Resolution: (displayed reading)**

**LOW (200 mA):** 0.1 to 199.9 mA dc or rms ac  
**HIGH (2000 mA):** 1 to 1999 mA dc or ac peak

**Accuracy:** (% of reading,  $\pm 3$  counts for the displayed reading or  $\pm 0.15\%$  of range for the analog output. Meter zeroed prior to measurement in DC or AC-LOW mode.)

**dc:** 1%  
**ac low:** 2%  
**ac high (200 Hz- 400 Hz):** 4%  
**ac high (400 Hz- 40 kHz):** 2%  
**ac high (40 kHz - 100 kHz):** 3%

**Repeatability:** 0.5% of reading,  $\pm 3$  counts for the displayed reading or  $\pm 0.15\%$  of range for the analog output.

**Output noise:** less than 100  $\mu\text{V}$  rms

Table 2-1 mA-2000 Specifications

**Frequency Range: (displayed reading)**

**dc:** 0 Hz  
**ac low:** 10 Hz to 200 Hz  
**ac high:** 200 Hz to 100 kHz

**Frequency Range: (analog output)**

**dc:** 0 Hz to 200 Hz  
**ac low:** 0 Hz to 200 Hz  
**ac high:** 200 Hz to 100 kHz

**Frequency response: (-3 dB point)**

**ac low:** 400 Hz  
**ac high:** 250 kHz

**Rise Time:**

**ac low:** 750  $\mu$ s.  
**ac high:** 1  $\mu$ s.

**Analog output scaling:** 1 mV / mA

**Analog output load:** 10 k $\Omega$  min, 100 pF max.

**Current • Frequency Limit:** 80 A • kHz maximum

**Probe Inductance:** less than 1  $\mu$ H

Table 2-1 mA-2000 Specifications (cont.)

### **GENERAL**

<b>Battery Type:</b>	9 Vdc alkaline (NEDA 1640A) (two required)
<b>Battery Life:</b>	15 hours typical (based on equal usage of all three modes: DC, AC-LOW and AC-HIGH).
<b>Auxiliary Power:</b>	15 to 18 Vdc, 100 mA minimum. (Certified for the country of use)
<b>Auxiliary Power Connector:</b>	2.5 mm, center post is positive (+) polarity.
<b>Analog Output Connector:</b>	BNC
<b>Probe aperture size:</b>	5.3 mm (0.21 in.)
<b>Probe dimensions:</b>	
<b>Length:</b>	15.9 cm (6.25 in.)
<b>Diameter:</b>	3.0 cm (1.2 in.)
<b>Meter dimensions:</b>	
<b>Length:</b>	13.2 cm (5.2 in.)
<b>Width:</b>	13.5 cm (5.3 in.)
<b>Height:</b>	3.8 cm (1.5 in.)
<b>Weight:</b>	
<b>Probe/Cable:</b>	178.6 g (6.3 oz)
<b>Meter w/batteries:</b>	357.2 g (12.6 oz)
<b>Shipping:</b>	1.758 kg (3 lb., 14 oz.)

Table 2-1 mA-2000 Specifications (cont.)

**Safety:** IEC 1010 Cat.2 (300 volt), Pollution Degree 2  
Standards: EN61010-1/1993  
EN61010-1 A2/1995  
EN61010-2-032/1995

**EMC :** RF Immunity: EN50140:1993  
IEC 1000-4-3:1995

ESD Immunity IEC 801-2:1991  
IEC 1000-4-2:1995

Radiated & Conducted Emission:  
EN55011:1991

**Temperature coefficient:** 0.01% / °C

**Operating temperature range:** 0 to +50 °C (+32 to +122 °F)

**Storage temperature range:** -25 to +70 °C (-13 to +158 °F)

**Reference Condition:** This instrument is designed to comply with IEC1010-1, Installation Category II, 300V, Pollution Degree 2 and is for use with conductors having a suitable insulation. This instrument is designed to be safe at least under the following conditions:

- Indoor use;
- Altitude up to 2000 m;
- Temperature 0 to 50 °C
- Maximum relative humidity 80% for temperatures up to 31°C decreasing linearly to 50% relative humidity at 40°C.

Table 2-1 mA-2000 Specifications (cont.)



# Section 3

## Operating Instructions

### OPERATOR SAFETY



*This symbol appears on the instrument and probe. It refers the operator to additional information contained in this instruction manual, also identified by the same symbol.*

The following safety rules must be followed during the operation and servicing of the mA-2000. Strict adherence to these rules is essential for safe operation. F.W.Bell assumes no liability for failure to comply with these rules.



*Do not clamp around conductors with voltages equal to or exceeding 300 V dc or rms ac.*

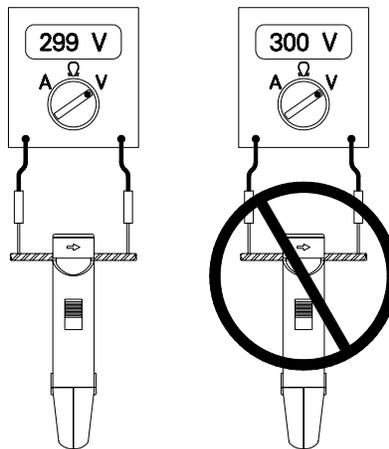


Fig. 3-1  
Conductor Voltage Limit Warning

## OPERATING INSTRUCTIONS



*Do not clamp the probe around bare conductors. Conductor must have a suitable insulation.*

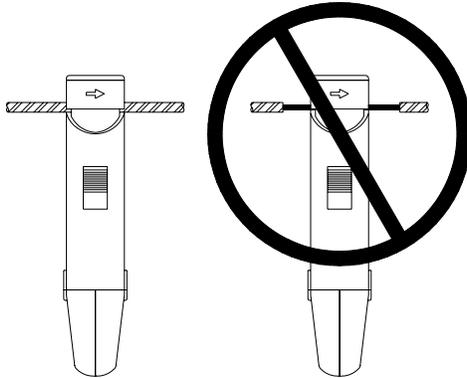


Fig. 3-2  
Bare Conductor Warning



*Do not connect the auxiliary power connector to an ac power source. Do not exceed 18 Vdc. Do not reverse the polarity. Use only AC power supply certified for country of use.*

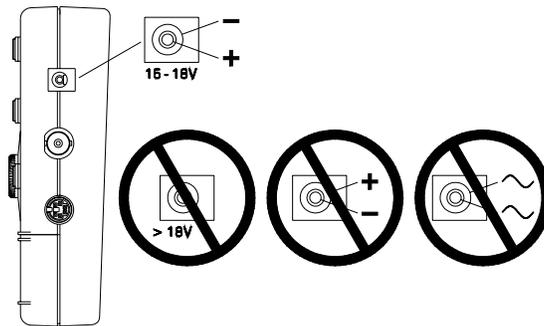


Fig. 3-3  
Auxiliary Power Connector Warnings

# OPERATING INSTRUCTIONS

## OPERATING FEATURES

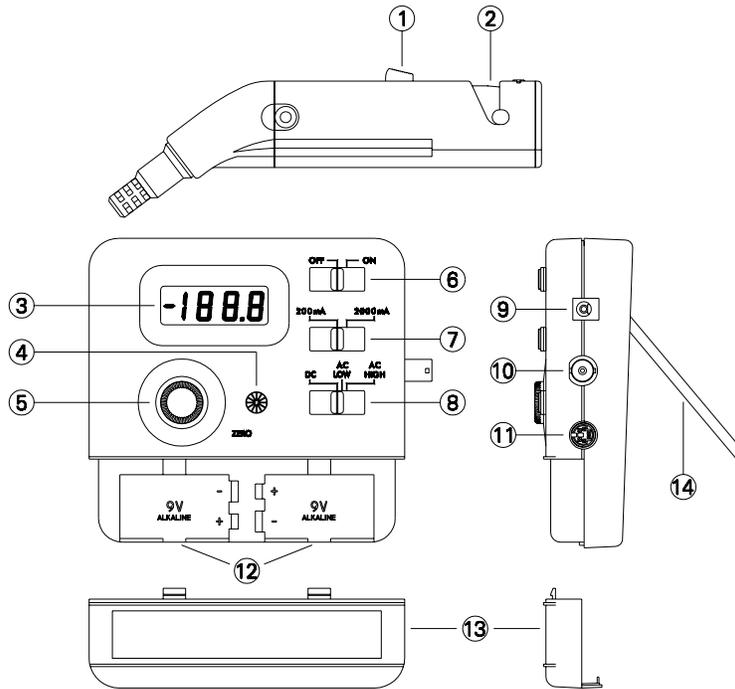


Fig. 3-4  
Product Features

- (1) **Aperture trigger.** When the trigger is pulled back the aperture (2) opens. When the trigger is released the aperture will close slowly. *Do not force the aperture closed by pushing on the trigger or damage may occur.*
- (2) **Probe aperture.** The aperture can accommodate up to 5.33 mm (0.21 inch) diameter conductors. The aperture is opened by pulling back on the trigger (1). It is important that the aperture be free of contaminants that might prevent the aperture from fully closing, otherwise the earth's magnetic field may affect instrument accuracy.

## OPERATING INSTRUCTIONS

Use only isopropyl alcohol and a cotton swab to clean the aperture area. **Never** use a sharp instrument or a stiff brush to clean the aperture or damage will occur !

- (3) **Display.** LCD containing 3 ½ digits of numeric information and the LOW BAT annunciator. In all modes the value displayed is in milliamps; dc current in the DC mode and true rms ac current in the AC-LOW and AC-HIGH modes.
- (4) **Coarse zero adjust control.** With the aperture closed and no current flowing through the aperture, this control is adjusted so that the displayed reading is as close to zero as possible.
- (5) **Fine zero adjust control.** With the aperture closed and no current flowing through the aperture, this control is adjusted so that the displayed reading is zero. If this is not possible readjust the coarse zero control **(4)**.
- (6) **Power switch.** Sliding the switch to the “ON” position turns the meter on.
- (7) **Range switch.** The range switch affects the displayed reading only. Sliding the switch to the “200 mA” position results in a measurement range of 0.0 - 199.9 mA. Sliding the switch to the “2000 mA” position results in a measurement range of 0 - 1999 mA. The analog output is not affected by the range switch and always provides an output of 1 mV / mA.

## OPERATING INSTRUCTIONS

- (8) **DC/AC-LOW/AC-HIGH switch.** This three-position switch selects the type of current to be measured. It affects both the displayed reading and the analog output, although differently.

Sliding the switch to the “DC” position allows for the display of dc current. The analog output will contain both the dc component and any ac component up to frequencies of 200 Hz.

Sliding the switch to the “AC-LOW” position allows for the display of rms ac current in the frequency range of 10 Hz to 200 Hz. The analog output will contain both the dc component and any ac component up to frequencies of 200 Hz.

Sliding the switch to the “AC-HIGH” position allows for the display of rms ac current in the frequency range of 200 Hz to 100 kHz. The analog output will contain any ac component in the same frequency range.

- (9) **Auxiliary power connector.** This is an industry-standard, 2.5 mm, dc power connector. The *mA-2000* will accept a dc voltage in the range of 15 - 18 Vdc at 100 mA minimum current. The center pin is positive (+). The internal batteries are disconnected when using this connector.



*Do not connect the auxiliary power connector to an ac power source. Do not exceed 18 Vdc. Do not reverse the polarity.*

- (10) **Analog output connector.** A voltage signal representative of the current being measured is available

## OPERATING INSTRUCTIONS

at this BNC connector. Calibration is set to 1 mV / mA.  
Minimum load is 10 k $\Omega$ .

- (11) **Probe connector.** The clamp-on probe plugs into this connector and locks in place. To disconnect, pull on the body of the plug, *not the cable!*
- (12) **Batteries.** Install two 9-V alkaline batteries (NEDA-1640A) in the positions shown. The connections are polarized to prevent accidental battery reversal. It is suggested that *both* batteries be replaced at the same time with new batteries.
- (13) **Battery compartment door.** This cover slides off as shown in Figure 3-4.
- (14) **Meter stand.** This retractable stand allows the meter to be viewed when placed on a horizontal surface. A notch in the stand allows the meter to be mounted to a vertical surface.

# OPERATING INSTRUCTIONS

## MEASUREMENT PROCEDURES

### Instrument Preparation

1) With the power switch in the "OFF" position, remove the battery compartment door by pressing down at the two points shown in Figure 3-5 and sliding the door off. Install two 9V alkaline batteries. Install the battery compartment door.

NOTE: Batteries are not required if using an ac adapter.

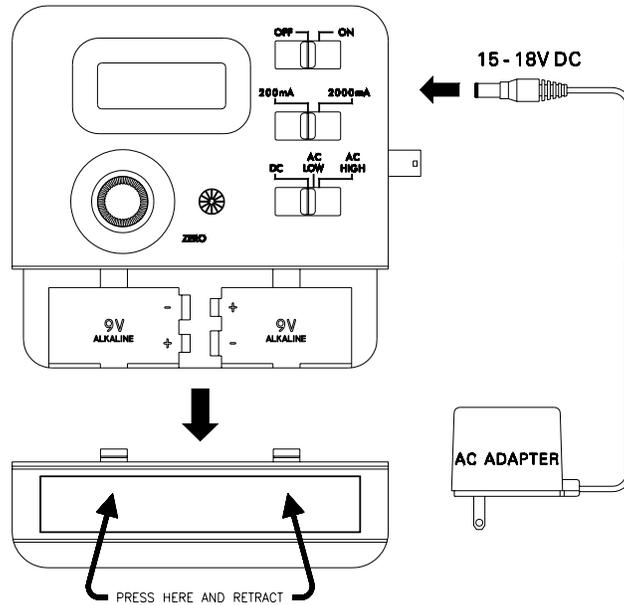


Fig. 3-5  
Battery Installation and AC Adapter Connection

2) Connect the probe by matching the keyway on the probe's connector to that of the mating socket in the meter. Push the connector in until it locks in place.

## OPERATING INSTRUCTIONS

**NOTE:** The probe and meter are calibrated together. Probes are not interchangeable. If the probe has to be replaced the meter must be recalibrated with the new probe.

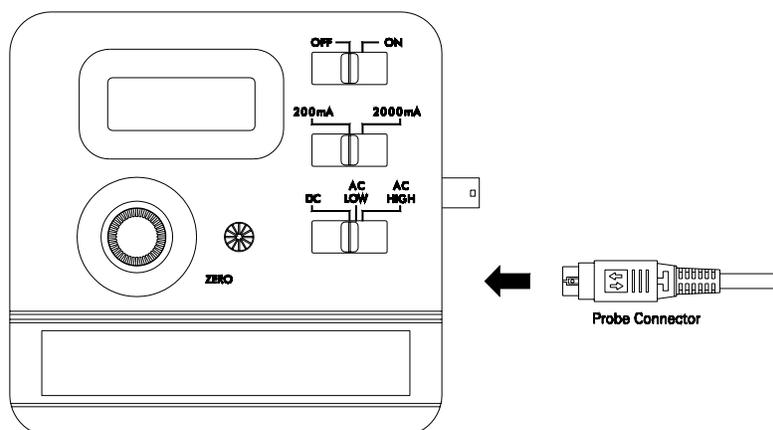


Fig. 3-6  
Probe Connection

3) Slide the power switch to the “ON” position and allow the probe to settle for a few seconds.

### DC Current Measurements

Initially the probe and meter may contain magnetic and electrical offsets that will be displayed as an actual current reading. This “false” reading must be removed to obtain a true current reading. This process is called “zeroing” and should be performed as follows, referring to Figure 3-7:

- 1) Slide the DC/AC-LOW/AC-HIGH switch to “DC”.
- 2) Select the desired range, either “200 mA” or “2000 mA”.

## OPERATING INSTRUCTIONS

- 3) Open and close the aperture one time. Do not clamp around the conductor to be measured. Stay away from sources of high magnetic fields.
- 4) Using the smaller coarse “zero” knob adjust the reading as close to zero as possible.
- 5) Using the larger fine “zero” knob adjust the reading to zero. Readjust the coarse knob if this is not possible.
- 6) Pull back the trigger and clamp onto the conductor to be measured. Release the trigger and allow the aperture to fully close before taking a reading. **Once the aperture closes do not push the trigger or drop or bump the probe against any other object. Any mechanical stress or shock can cause a dc offset and thus an error in the reading.**

**NOTE:** When the meter is first turned on the aperture should be opened and closed at least once before zeroing.

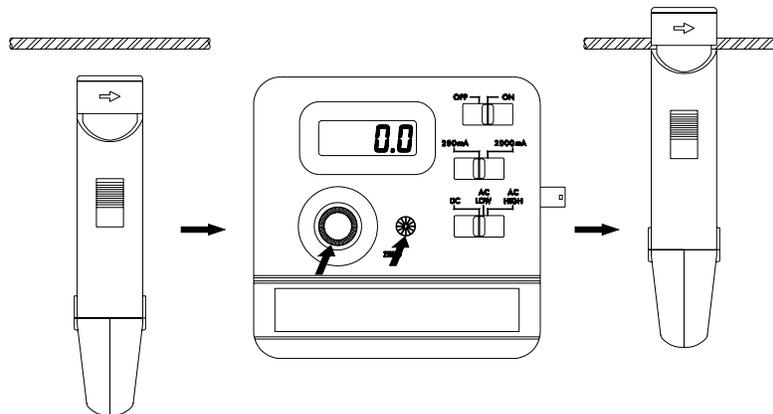


Fig. 3-7  
DC Zeroing Process

## OPERATING INSTRUCTIONS

If the reading appears as a "1", the current level exceeds the selected range of the meter. Select the "2000 mA" range and repeat Steps 3-6 above. If already on the "2000 mA" range the current exceeds the measurement range of this instrument.

An arrow appears on the probe near the aperture. If the reading is positive the current is flowing in the direction of the arrow. If negative the current is flowing in the opposite direction.

A voltmeter or oscilloscope can be connected to the analog output connector. The output is a voltage proportional to the current being measured and is scaled to 1 mV / mA, regardless of the range switch setting. This signal will contain the dc level as well as any ac components up to 200 Hz. The coarse and fine "zero" adjustments also affect the dc level of the analog output.

### Low Frequency AC Current Measurements

To measure ac current in the frequency range of 10 Hz to 200 Hz, select the "AC-LOW" setting and select the desired range ("200 mA" or "2000 mA"). Clamp around the conductor. The displayed readings will be the true rms values of the ac current. The coarse and fine "zero" adjustments have no effect on the displayed readings.

A voltmeter or oscilloscope can be connected to the analog output connector. The output is a voltage proportional to the current being measured and is scaled to 1 mV / mA, regardless of the range switch setting. This signal will contain the dc level as well as any ac components up to 200 Hz. Since the coarse and fine "zero" adjustments affect the dc level of the analog output, the meter must be zeroed. This procedure is described in the previous section entitled "DC Current Measurement", Steps 3-6.

## OPERATING INSTRUCTIONS

### High Frequency AC Current Measurements

To measure ac current in the frequency range of 200 Hz to 100 kHz, select the “AC-HIGH” setting and select the desired range (“200 mA” or “2000 mA”). Clamp around the conductor. The displayed readings will be the true rms values of the ac current. The coarse and fine “zero” adjustments have no effect on the displayed readings.

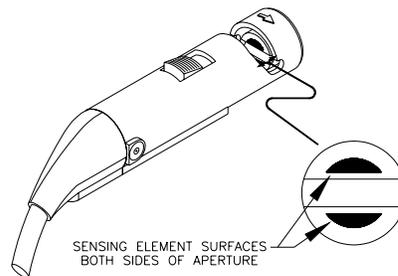
A voltmeter or oscilloscope can be connected to the analog output connector. The output is a voltage proportional to the current being measured and is scaled to 1 mV / mA, regardless of the range switch setting. This signal will contain only ac components from 200 Hz to 100 kHz. The coarse and fine “zero” adjustments have no effect on the analog output.



*Prolonged operation under conditions in which the product of the current and frequency exceeds 80 A•kHz can cause permanent damage to the probe !*

### Measurement Hints

- It is important that the aperture be free of contaminants that might prevent the aperture from fully closing, otherwise the earth’s magnetic field may affect instrument accuracy. Use only isopropyl alcohol and a cotton swab to clean the sensing element surfaces. **Never** use a sharp instrument or a stiff brush to clean the aperture or damage will occur !



## OPERATING INSTRUCTIONS

- In the “DC” current mode the process of “zeroing” the meter is vital for accurate measurements. The meter should be zeroed each time prior to clamping on to the conductor. Check the zero point often. When the meter is first turned on the aperture should be opened and closed at least one time before zeroing.
- Once the aperture closes, do not push the trigger or drop or bump the probe against any other object. Any mechanical shock or stress can cause a dc offset and thus an error in the reading. If this happens, remove the probe from the conductor, zero the meter and repeat the measurement.
- Whenever possible, allow current to flow through the conductor before clamping the probe around the conductor. In the “DC” current mode, sudden large changes in the dc current, or current exceeding the range of the instrument, can induce an offset that will affect the accuracy of the meter, or could cause the meter to overrange. Examples include motor or lamp circuits, where inrush currents far exceed the normal operating current. If this occurs, open and close the probe aperture and rezero the meter, or allow the inrush to occur and then clamp the probe around the conductor.
- The sensitivity of the measurement can be increased by wrapping several turns of the same conductor through the aperture. The turns must be circulating in the same direction. The actual current can be calculated by dividing the reading by the number of turns. For instance, suppose there are 8 turns and the reading is 3.2 mA. The actual current flow is

$$3.2 \text{ mA} / 8 = 0.4 \text{ mA}$$

- If the conductor being measured is too large, the aperture will not fully close and the reading will be inaccurate.

## OPERATING INSTRUCTIONS

- A common mistake made when using clamp-on probes is attempting to measure dual conductors carrying current in opposite directions (i.e. - a lamp cord). Each conductor produces a magnetic field, but the fields oppose one another for a net magnetic field of zero. It is necessary to split the conductor pair and make the measurement on one conductor only.
- When the LO BAT annunciator appears readings may not be accurate. Either use an ac adapter (see the Specifications section for voltage ratings) or replace *both* batteries at the same time. Replacing only one battery will not damage the unit, but will reduce the normal life of the new battery.

## GENERAL MAINTENANCE

- Use only isopropyl alcohol and a cotton swab to clean the aperture area. ***Never use a sharp instrument or a stiff brush to clean the aperture or damage will occur !***

### WARNING !

**The probe is a precision instrument with no serviceable parts and no adjustment points. Under no circumstances attempt to disassemble the probe !**

- Gently clean the display and case with a soft, dry cloth (**do not use chemicals !**).
- If the meter is to be idle for an extended period of time, remove the batteries. Battery corrosion can damage the meter.

## Section 4

# Warranty

F.W. Bell warrants each instrument of its manufacture to be free of defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to replace any defective parts thereof. This warranty covers instruments which, within one year after delivery to the original purchaser, shall be returned with transportation charges prepaid by the original purchaser, and which upon examination shall disclose to the manufacturer's satisfaction to be defective. If it is determined that the defect has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost after submitting an estimate to the purchaser.

F.W. Bell reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

THE ABOVE WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED AND ALL OTHER OBLIGATIONS AND LIABILITIES ON THE PART OF F.W. BELL, AND NO PERSON INCLUDING ANY DISTRIBUTOR, AGENT OR REPRESENTATIVE OF F.W. BELL IS AUTHORIZED TO ASSUME FOR F.W. BELL ANY LIABILITY ON ITS BEHALF OR ITS NAME, EXCEPT TO REFER THE PURCHASER TO THIS WARRANTY. THE ABOVE EXPRESS WARRANTY IS THE ONLY WARRANTY MADE BY F.W. BELL. F.W. BELL DOES NOT MAKE AND EXPRESSLY DISCLAIMS ANY OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED, INCLUDING WITHOUT LIMITING THE FOREGOING, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ARISING BY STATUE OR OTHERWISE IN LAW OR FROM A COURSE OF DEALING OR USAGE OR TRADE. THE EXPRESS WARRANTY STATED ABOVE IS MADE IN LIEU OF ALL LIABILITIES FOR DAMAGES, INCLUDING BUT NOT LIMITED TO CONSEQUENTIAL DAMAGES, LOST PROFITS OR THE LIKE ARISING OUT OF OR IN CONNECTION WITH THE SALE, DELIVERY, USE OR PERFORMANCE OF THE GOODS. IN NO EVENT WILL F.W. BELL BE LIABLE FOR SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES EVEN IF F.W. BELL HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

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