

REPAIR SERVICE INSTRUCTIONS — CALIBRATION

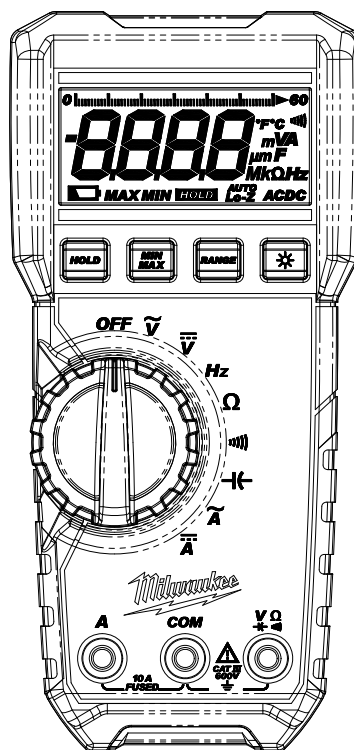
2216-20 Light Commercial Digital Multimeter

Environmental Condition

Perform all calibration at an ambient temperature of $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ / $73.4^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$ and relative humidity of 80% - allow the digital multimeter to sit at this temperature for a minimum of 30 minutes before proceeding.



REPAIR SERVICE INSTRUCTIONS Calibration



MILWAUKEE ELECTRIC TOOL CORPORATION

13135 WEST LISBON ROAD • BROOKFIELD, WISCONSIN 53005-2550 • USA

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Introduction

Warning

To avoid shock or injury, do not perform the verification tests or calibration procedures described in the manual unless you are qualified to do so.

The information provided in this document is for the use of qualified personnel only.

Caution

The 2216-20 contain parts that can be damaged by static discharge.

Follow the standard practices for handling static sensitive devices.

Precautions and Safety Information

Use the Meter only as described in the Users Manual. If you do not do so, the protection provided by the Meter may be impaired. Read the “Safety Information” page before servicing this product.

In this manual, a  Warning identifies conditions and actions that pose hazard (s) to the user; a

Caution identifies conditions and actions that may damage the Meter or the test instruments.

The Symbols

The symbols used on the Meter and in this manual are explained in Table 1.

Table A. The Symbols

Symbol	Meaning
~	Alternating signal
≡	Direct signal
CAT III	IEC overvoltage Category III
	Refer to the manual, Important information.
	Take appropriate precautions. Hazardous voltage may be present.
	Battery
	Earth ground
	Fuse
	Double insulated
	Do not discard this product or throw away.

SAFETY

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use the product only as specified.

⚠ WARNING: These statements identify conditions or practices that could result in personal injury or loss of life.

CAUTION: These statements identify conditions or practices that could result in damage to the equipment or other property.

Specific precautions

Use proper Fuse. To avoid fire hazard, use only the fuse type and rating specified for this product, 10A / 600V Fast-acting (Cat. No. 22-89-0300). For fuse replacement, it is recommended to return the tool to a factory Service/Sales Support Branch or authorized service station.

Do not operate without covers. To avoid personal injury, do not apply any voltage or current to the product without covers in place.

Electric overload. Never apply a voltage to a connector on the product that is outside the range specified for that connector.

Avoid electric shock. To avoid injury or loss of life, do not connect or disconnect probes or test leads while they are connected to a voltage source.

Do not operate in wet/damp conditions. To avoid electric shock, do not operate this product in wet or damp conditions.

SPECIFICATIONS

All specifications are warranted unless noted typical and apply to the 2216-20 DMM.

Stated accuracies are at 23°C±5°C at than 80% relative humidity and without the battery indicator displayed.

General specifications

Characteristics	Description
Display count	6000 counts
Numeric update rate	3 times / sec
Polarity display	Automatic
Overrange display	Display "OL" when the reading exceeds range by 10%
Low voltage indicator	 is indicated
Automatic power-off time	20 minutes
Power source	1.5V * 2 IEC LR6 or AA size
Maximum input voltage	600V CAT III between V and COM
Maximum floating voltage	600V CAT III between any terminal and earth ground
Maximum input current	10A between A and COM
Maximum open circuit Voltage (current inputs)	600V between A and COM
Overload protection A connector	10A, 600V, Fast action fuse
V connector	V~, V $\overline{\text{---}}$, $\overline{\text{---}}$, $\overline{\text{---}}$, Hz
Temperature Coefficient	0.1×(Spec. Accuracy) / °C, <18°C or >28°C
Battery Life	30 hours typical (alkaline)

Measurement Characteristics

Accuracy is $\pm(\% \text{ reading} + \text{number of digits})$ at $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$, less than 80% R.H.

Temperature coefficient: $0.1 * (\text{Specified accuracy})/^{\circ}\text{C}$, $< 18^{\circ}\text{C}$, $> 28^{\circ}\text{C}$

(1) DC Voltage

Range	Resolution	Accuracy
600.0mV	0.1mV	$\pm(0.5\% \text{ reading} + 2 \text{ digits})$
6.000V	0.001V	
60.00V	0.01V	
600.0V	0.1V	

Input Impedance: 10M Ω

Response Time: < 1.5 sec.

Overload Protection: AC/DC 720V for 10 second.

(2) AC Voltage

Range	Resolution	Accuracy (Sine Wave)
600.0mV *	0.1mV	$\pm(1\% \text{ reading} + 3 \text{ digits})$ for 45Hz ~ 500Hz
6.000V	0.001V	
60.00V	0.01V	$\pm(2\% \text{ reading} + 3 \text{ digits})$ for 500Hz ~ 1kHz
600.0V	0.1V	

* LCD displays 0.0mV when measuring < 4.0mV.

Input Impedance: 10M Ω // less than 100pF

Frequency Response: 45 ~ 1kHz (Sine Wave)

AC Conversion Type: RMS sensing, RMS indication

Additional Accuracy by Crest Factor (C.F.): Add 6.0% for C.F. 1.0 ~ 2.0.

Add 7.0% for C.F. 2.0 ~ 2.5.

Add 9.0% for C.F. 2.5 ~ 3.0.

Max. Crest Factor: 1.6 for 6600 ~ 5000 digits

2.0 for 5000 ~ 3000 digits

3.0 for 3000 ~ 0 digits

Response Time: < 2 sec. when the LCD reading is bigger than 1000 digits in each range.

Overload Protection: AC/DC 720V for 10 second.

(3) DC Current

Range	Resolution	Accuracy
6.000A	0.001A	$\pm(1\% \text{ reading} + 3 \text{ digits})$
10.00A	0.01A	

Response Time: < 1.5 sec.

Maximum measurement time: 5 minutes at 10A with at least 20 minutes rest time.

Overload Protection: AC/DC 20A for 10 second.

(4) AC Current

Range	Resolution	Accuracy (Sine Wave)
6.000A *	0.001A	$\pm(1.5\% \text{ reading} + 3 \text{ digits})$
10.00A	0.01A	

* LCD displays 0.000A when measuring < 0.040A.

Frequency Response: 45 ~ 500Hz (Sine Wave)

AC Conversion Type: RMS sensing, RMS indication

Additional Accuracy by Crest Factor (C.F.): Same as ACV.

Max. Crest Factor: Same as ACV.

Response Time of AC Input: < 2 sec. when the LCD reading is bigger than 1000 digits in each range.

Maximum measurement time: 5 minutes at 10A with at least 20 minutes rest time.

Overload Protection: AC/DC 20A for 10 second.

(5) Resistance

Range	Resolution	Accuracy
600.0 Ω	0.1 Ω	$\pm(1\% \text{ reading} + 5 \text{ digits})$
6.000k Ω	0.001k Ω	
60.00k Ω	0.01k Ω	
600.0k Ω	0.1k Ω	
6.000M Ω	0.001M Ω	
40.00M Ω *	0.01M Ω	$\pm(2\% \text{ reading} + 5 \text{ digits})$

* There is a little rolling less then ± 50 digits when measuring > 10.00 M Ω .

Open Circuit Voltage: Approx. 0.6V

Response Time: < 1.5 sec.

Overload Protection: AC/DC 600V for 10 second.

(6) Continuity

Range	Resolution	Accuracy
600.0Ω	0.1Ω	±(1% reading + 5 digits)

Open Circuit Voltage: Approx. 0.6V

Continuity: Built-in buzzer sounds when measured resistance is less than 30Ω and sounds off when measured resistance is more than 200Ω, Between 30Ω to 200Ω the buzzer maybe sound or off either.

Continuity Indicator: 2.7KHz Tone Buzzer

Response Time of Buzzer: < 500 μ sec.

Response Time of LCD reading: < 1.5 sec.

Overload Protection: AC/DC 600V for 10 second.

(7) Capacitance

Range	Resolution	Accuracy
100.0μF	0.01μF	±(1.9% reading + 2 digits)
1000μF	1μF	

Response Time when measuring 1000μF: < 2.5 sec.

Overload Protection: AC/DC 600V for 10 second.

(8) Frequency

Range	Resolution	Min. Sensitivity	Accuracy
100.00Hz	0.01Hz	> 10.0Vp-p	±(0.1% reading + 2 digits)
1000.0Hz	0.1Hz	> 10.0Vp-p	
10.000kHz	0.001Hz	> 10.0Vp-p	
50.00kHz	0.01Hz	> 10.0Vp-p	

Max. Sensitivity: 600V rms

Response Time: < 1.2 sec. when measuring bigger than 2.00Hz signal.

Overload Protection: AC/DC 720V for 10 second.

(9) Over-range Indication

Display "OL" or "-OL" when the reading exceeds 10% of the full scale except the full scale is 10000 counts.

(10) Rotary Switch

In order to prevent a "0" reading, the contacts about the input signal must be made properly before the contact of the function selection.

(11) Auto Power Off

The meter automatically turns the power off after powering up and no operation for 20 ± 5 minutes.
To power up, turn the knob back to OFF first.

(12) Measuring Rate: 3 times/sec.

(13) Fuse: 10A/600V Fast Action Fuse

(14) Battery: Alkaline 1.5V Battery * 2

(15) Low Battery Voltage: $2.3V \pm 0.1V$

(16) Backlight

The meter automatically turns the backlight off after lighting up and no operation for 10 ± 1 minutes.

(17) Battery life (ALKALINE):

Approx. 26 hours with backlight on.
Approx. 360 hours with backlight off.

(18) Overvoltage Category

IEC 61010-1 600V CAT. III

(19) Operating Temperature

$-10^{\circ}\text{C} \sim 30^{\circ}\text{C}$, $\leq 80\%\text{RH}$
 $30^{\circ}\text{C} \sim 40^{\circ}\text{C}$, $\leq 75\%\text{RH}$
 $40^{\circ}\text{C} \sim 50^{\circ}\text{C}$, $\leq 45\%\text{RH}$

(20) Storage Temperature

$-40^{\circ}\text{C} \sim +60^{\circ}\text{C}$, $0 \sim 80\%\text{RH}$ (No batteries)

Physical and Environmental Characteristics

Characteristics	Description
Dimensions (H×W×D)	170mm×80mm×57mm
Weight (with battery)	0.3Kg
Environmental characteristics	Description
Temperature operating	-10 to +50°C
Non-Operating	-40 to +60°C
Humidity (operating)	<80% R.H.
Altitude Operating	2,000M (6560 ft.)
Non-Operating	12,300M (40354 ft.)
Vibration & shock Operating	MIL-PRF-28800F for Class 2 Instrument
Indoor Use	Indoor Use

Certifications and compliances

Safety	Designed to IEC61010-1, UL61010-1 and CSA specifications
Input rating	Category III 600V.
Over voltage category	CAT III : Distribution level mains, fixed installation.
	CAT II : Local level mains, appliances, portable equipment
	CAT I : Signal level, special equipment or parts of equipment, telecommunication, electronics.
Pollution Degree 2	Do not operate in environments where conductive Pollutants may be present.

Required Equipment

Required equipment is listed in Table B. If the recommended models are not available, equipment with equivalent specifications may be used.

Repairs or servicing should be performed only by qualified personnel.

Table B. Required Equipment

Equipment	Required Characteristics	Recommended Model
Calibrator	AC Voltage Range: 0 ~ 750V AC Accuracy: $\pm 0.07\%$ (Basic) Frequency Range: 40 ~ 1kHz Accuracy: $\pm 2\%$ DC Voltage Range: 0 ~ 1000V DC Accuracy: $\pm 0.006\%$ (Basic) Current Range: 0 ~ 20A Accuracy: AC (40Hz to 1kHz): $\pm 0.08\%$ (Basic) DC: $\pm 0.02\%$ (Basic) Frequency Source: 0.5Hz ~ 100kHz Accuracy: $\pm 0.001\%$ Amplitude: 0.5V p-p ~ 600V p-p Accuracy: $\pm 5\%$ Resistance Range: 1Ω ~ $100M\Omega$ Accuracy: $\pm 0.03\%$ (Basic) Capacitance Range: 0.1 μ F ~ 1100 μ F Accuracy: $\pm 0.10\%$ (Basic)	Fluke 5500 or Wavetek 9100 Calibrator or equipment

Basic Maintenance

⚠Warning

To avoid shock, remove the test leads and any input signals before opening the case or replacing the battery or fuses.

Opening the Meter Case

Caution

To avoid unintentional shock circuit, always place the uncovered Meter assembly on a protective surface. When the case of the Meter is open, circuit connections are exposed.

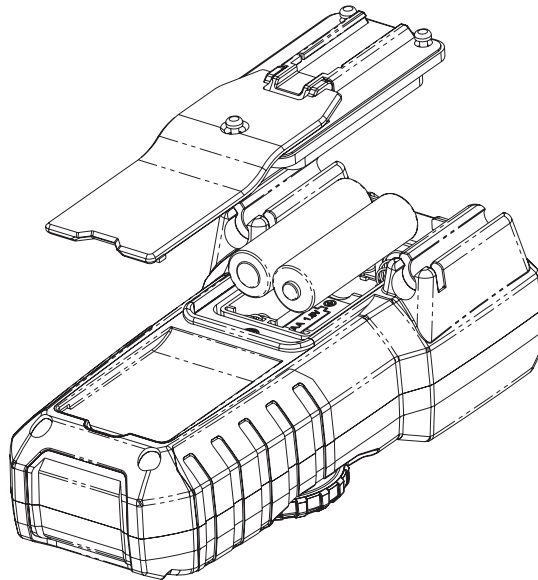
To open the Meter case, refer to Figure 1 and do the following:

1. Disconnect test leads from any live source, turn rotary switch to OFF, and remove the test leads from the front terminals.
2. Remove the battery door by using a flat-blade screwdriver to turn the battery door screws turn counter-clockwise.
3. The bottom case is secured to the top case by four screws. Using a phillips-head screwdriver to remove the four screws.

Replacing the Battery

The meter is powered by 2 AA 1.5V batteries.

To replace the battery, refer to Figure



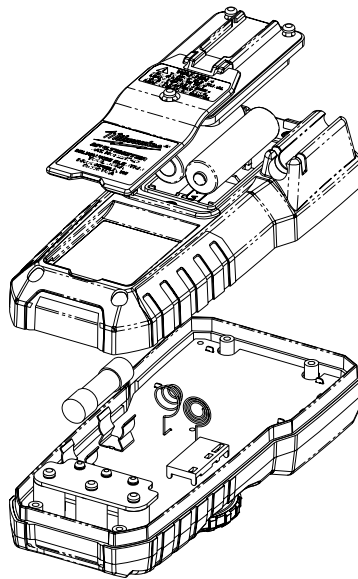
Testing Fuses

To test the internal fuses of the meter.

1. Turn the rotary selector switch to the Ω position.
2. To test FS1, plug a test lead into V Ω Hz input terminal, and touch the probe to the A input terminal. The display should indicate between 0.0 to 0.2 Ω . (Bussmann KTK-10 recommended). If display reads higher than 0.2 Ω , replace the fuse.

Fuse Replacement

Refer to the following figure to replace fuse:



Use only a fuse with the amperage, interrupt, voltage, and speed rating specified.
Fuse rating : 10A , 600V, Fast

Replacing Fuses

⚠ Warning

To avoid electrical shock, remove the test leads and any input signals before replacing the battery or fuses. To prevent damage or injury, INSTALL ONLY quick acting fuses with the following Amp/Volt current interrupt rating :

Fuse : 10A, 600V, FAST.

Cleaning

⚠ Warning

To avoid electrical shock or damage to the Meter, never allow water inside the case. To avoid damaging the Meter's housing, never apply solvents to the Meter.

Performance Tests

The following performance tests verify the complete operability of the Meter and check the accuracy of each Meter function against the Meter's specifications.

Accuracy specifications are valid for a period of one year after calibration, when measured at an operating temperature of 18°C to 28°C and at a maximum of 80% relative humidity.

To perform the following tests, it is not necessary to open the case, no Adjustments are necessary. Merely make the required connections, apply the designated inputs, and determine if the reading on the Meter display falls within the acceptable range indicated.

If the Meter fails any of these tests, it needs calibration adjustment or repair.

Testing the Display

Rotate the dial from the "OFF" position to any other position. Check the LCD display segments when all segments are displayed. Compare the display with the example in Figure 2.

LCD Graphics 2216-20



Figure 2 Display Test

Testing the Voltage Function

To verify accuracy in the AC and DC voltage ranges, do the following:

1. Turn the rotary switch to “**V~**” position.
2. Connect the Calibrator to the **VΩ** and **COM** inputs on the Meter.
3. Set the Calibrator for the voltage and frequency from step 1 to 12 in Table 1.
4. Compare the reading on the Meter display with the display reading shown in Table 1.
5. If the display reading falls outside of the range shown in Table 1, the Meter does not meet specification.

Table 1 AC Voltage Test:

Step	Input	Frequency	Reading
1	500mV	50Hz	494.7 to 505.3
2	500mV	500Hz	494.7 to 505.3
3	500mV	1kHz	489.7 to 510.3
4	5.000V	50Hz	4.947 to 5.053
5	5.000V	500Hz	4.947 to 5.053
6	5.000V	1kHz	4.897 to 5.103
7	50.00V	50Hz	49.47 to 50.53
8	50.00V	500Hz	49.47 to 50.53
9	50.00V	1kHz	48.97 to 51.03
10	500.0V	50Hz	494.7 to 505.3
11	500.0V	500Hz	494.7 to 505.3
12	500.0V	1kHz	489.7 to 510.3

6. Turn the rotary switch to “**V---**” position.
7. Set the calibration for the voltage from step 1 to 4 in Table 2.
8. Compare the reading on the Meter display with the display reading shown in Table 2.
9. If the display reading falls outside of the range shown in Table 2, the meter does not meet specification.

Table 2 DC Voltage Test:

Step	Input	Reading
1	500mV	497.3 to 502.7
2	5.000V	4.973 to 5.027
3	50.00V	49.73 to 50.27
4	500.0V	497.3 to 502.7

Testing the Resistance Function

To verify the accuracy of the resistance function, do the following:

1. Connect the Calibrator to **VΩHz** and **COM** on the Meter.
2. Turn the rotary switch to Ω .
3. Apply the inputs for step 1-6 in Table 3.
4. Compare the Meter display readings to the display readings in Table 3.
5. If the display reading falls outside of the range shown in Table 3, the Meter does not meet specification.

Table 3 Resistance Test :

Step	Source	Reading
1	560.0	553.9 to 566.1
2	5.600k	5.539k to 5.661k
3	56.00k	55.39k to 56.61k
4	560.0k	553.9k to 566.1k
5	5.600M	5.539M to 5.661M
6	36.00M	35.44M to 36.56M

* Lead resistance on the 400 Ω range is not included in error.

Testing the Capacitance Function

The Meter measures capacitance by charging the capacitor with a known Direct current, measuring the resultant voltage, and calculating the capacitance. If the same capacitance is measured on an impedance bridge, a different reading may result. This variance is likely to be Greater at higher frequencies.

To verify the accuracy of the capacitance measuring function, do the Following:

1. Apply the Capacitor to the **VΩHz** and **COM** inputs on the Meter. For steps 1-4 in Table 4.
2. Turn the rotary switch to $\text{—}| \text{—}$.
3. Compare the reading on the Meter display to the reading in Table 4.
4. If the display reading falls outside of the range shown in Table 4, the Meter does not meet specification.

Table 4 Capacitance Test :

Step	Source	Reading
1	3.6uF	3.3uF to 3.9uF
2	80.0uF	78.3uF to 81.7uF
3	320uF	312uF to 328uF
4	1000uF	979uF to 1021uF

Testing the Ampere Function

To verify the accuracy of AC current measurement functions, do the following:

1. Connect the Calibrator to the **A** and **COM** inputs on the Meter.
2. Turn the rotary switch to A~.
3. Apply the inputs for steps 1-4 in Table 5.
4. For each input, compare the readings on the Meter display to the reading in Table 5.
5. If the display reading falls outside of the range shown in the Table 5, the meter does not meet specification.

Table 5 AC Current Test:

Step	Source	Frequency	Reading
1	5.000A	50Hz	4.922A to 5.078A
2	5.000A	500Hz	4.922A to 5.078A
3	10.00A	50Hz	9.82A to 10.18A
4	10.00A	500Hz	9.82A to 10.18A

6. Turn the rotary switch to A=.
7. Apply the inputs for steps 1-4 in Table 6.
8. For each input, compare the reading on the Meter display to the reading in Table 6.
9. If the display reading falls outside of the range shown in Table 6, the meter does not meet specification.

Table 6 DC Current Test:

Step	Source	Reading
1	5.000A	4.922A to 5.078A
2	5.000A	4.922A to 5.078A
3	10.00A	9.82A to 10.18A
4	10.00A	9.82A to 10.18A

Testing the Frequency Function

To verify the accuracy of the Meter's frequency function, do the following:

1. Connect the Calibrator to the **VΩ** and **COM** inputs on the Meter.
Note: The accuracy of the Calibrator's frequency function must be appropriate for the specified accuracy of the Meter.
2. Set the rotary switch to Hz.
3. Set Function Generator for the square wave voltage and frequency for steps 1-7 of Table 7.
4. Compare the reading on the Meter display with the display reading shown in Table 7.
5. If the display reading falls outside of the range shown in Table 7, the Meter does not meet specification.

Table 7 Frequency Test:

Step	Source	Level	Waveform	Reading
1	8.0Vp-p	2.00Hz	Square Wave	1.98Hz to 2.02Hz
2	8.0Vp-p	80.00Hz	Square Wave	79.90Hz to 80.10Hz
3	8.0Vp-p	800.0Hz	Square Wave	799.0Hz to 801.0Hz
4	8.0Vp-p	8.000kHz	Square Wave	7.990kHz to 8.010kHz
5	10.0Vp-p	50.00kHz	Square Wave	49.93kHz to 50.07kHz
6	230.0Vp-p	10.00Hz	Sine Wave	9.97Hz to 10.03Hz
7	230.0Vp-p	100.0Hz	Sine Wave	49.93kHz to 50.07kHz

Calibration Procedure

Recalibrate the meter:

It is recommended that the meter may be calibrated once year. Use the following procedure to calibrate the meter.

Environmental Condition

1. Perform calibration at an ambient temperature and relative humidity ($23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $\text{R.H.} \leq 80\%$).
Allow the instrument to sit at this temperature for at least thirty minutes.

Calibration Procedure

(A) Open the bottom case

1. Disconnect the test leads from any circuit under test and turn off the meter.
2. Loosen the screw from the bottom case.
3. Remove the bottom case.
4. Supply 3V to the meter.

(B) DCV Calibration (VR2)

1. Rotate the rotary switch to DCV Function.
2. Connect the output of a DCV calibrator to V and COM input terminals of the meter.
3. Output DCV 4.000V from the calibrator.
4. Adjust VR2 until the display shows $4.000\text{V} \pm 0.001\text{V}$.
5. Turn off the output of the calibrator and disconnect the meter from the calibrator.

(C) ACV Calibration (VR3)

1. Rotate the rotary switch to ACV Function.
2. Connect the output of an ACV calibrator to V and COM input terminals of the meter.
3. Output ACV 4.000V @ 60Hz from the calibrator.
4. Adjust VR3 until the display shows $4.015\text{V} \pm 0.001\text{V}$.
5. Turn off the output of the calibrator and disconnect the meter from the calibrator.

(D) DCV mV Calibration (VR4)

1. Rotate the rotary switch to DCV Function.
2. Connect the output of a DCV calibrator to V and COM input terminals of the meter.
3. Output DCV 400.0mV from the calibrator.
4. Adjust VR4 until the display shows $400.0\text{mV} \pm 0.1\text{mV}$.
5. Turn off the output of the calibrator and disconnect the meter from the calibrator.

(E) DCA Calibration (VR7)

1. Rotate the rotary switch to DCA Function.
2. Connect the output of a DCA calibrator to V and COM input terminals of the meter.
3. Output DCA 5.000A from the calibrator.
4. Adjust VR7 until the display shows $5.000A \pm 0.001A$.
5. Turn off the output of the calibrator and disconnect the meter from the calibrator.

(F) Resistance (6k Ω Range) Calibration (VR6)

1. Rotate the rotary switch to the resistance function.
2. Connect the output of a resistance calibrator to V and COM input terminals of the meter.
3. Output resistance 5.000k Ω from the calibrator.
4. Adjust the VR6 until the display shows $5.000k\Omega \pm 1\Omega$.
5. Turn off the output of the calibrator and disconnect the meter from the calibrator.

(G) Capacitance Calibration (VR1)

1. Rotate the rotary switch to Capacitance Function.
2. Connect the output of a capacitance calibrator to V and COM input terminals of the meter.
3. Output capacitance 100.0 μ F from the calibrator.
4. Adjust VR1 until the display shows $100.0 \mu F \pm 0.1 \mu F$.
5. Turn off the output of the calibrator and disconnect the meter from the calibrator.

(H) Assemble the bottom case

1. Assemble the bottom case.
2. Tighten the screw.