ANALOG MULTIMETER KIT

MODEL M-1250K

Assembly and Instruction Manual

Elenco™ Electronics, Inc.

Revised 2003 REV-D

753070

PARTS LIST

If you are a student, and any parts are missing or damaged, please see instructor or bookstore.
If you purchased this meter kit from a distributor, catalog, etc., please contact Elenco™ Electronics (address/phone/e-mail is at the back of this manual) for additional assistance, if needed.

RESISTORS

Qty.	Symbol	Value	Color Code	Part #
☐ 1	R10	.04Ω	Shunt Wire	100269
☐ 1	R9	.97Ω 1% 1/2W	black-white-violet-silver-brown	109731
☐ 1	R27	4.5Ω 1% 1/4W	yellow-green-black-silver-brown	114530
☐ 1	R11	10Ω 1% 1/4W	brown-black-black-gold-brown	121030
☐ 1	R22	18.5Ω 1% 1/4W	brown-gray-green-gold-brown	121832
☐ 1	R12	102Ω 1% 1/4W	brown-black-red-black-brown	131034
☐ 1	R21	200Ω 1% 1/4W	red-black-black-black-brown	132030
☐ 1	R7	240Ω 1% 1/4W	red-yellow-black-black-brown	132430
☐ 1	R20	2.08kΩ 1% 1/4W	red-black-gray-brown-brown	142034
☐ 1	R13	3kΩ 1% 1/4W	orange-black-black-brown-brown	143033
☐ 1	R6	5kΩ 1% 1/4W	green-black-black-brown-brown	145030
☐ 1	R31	5.6kΩ 1% 1/4W	green-blue-black-brown-brown	145630
☐ 1	R32	8.2kΩ 1% 1/4W	gray-red-black-brown-brown	148230
☐ 1	R25	18kΩ 1% 1/4W	brown-gray-black-red-brown	151830
☐ 2	R35, R36	24kΩ 1% 1/4W	red-yellow-black-red-brown	152430
☐ 1	R26	31kΩ 1% 1/4W	orange-brown-black-red-brown	153130
☐ 1	R19	34kΩ 1% 1/4W	orange-yellow-black-red-brown	153430
☐ 1	R5	40kΩ 1% 1/4W	yellow-black-black-red-brown	154030
☐ 1	R23	44kΩ 1% 1/4W	yellow-yellow-black-red-brown	154430
☐ 1	R17	83.3kΩ 1% 1/4W	gray-orange-orange-red-brown	158330
☐ 1	R34	100kΩ 1% 1/4W	brown-black-black-orange-brown	161030
☐ 1	R4	150kΩ 1% 1/4W	brown-green-black-orange-brown	161533
☐ 1	R33	165kΩ 1% 1/4W	brown-blue-green-orange-brown	161630
☐ 1	R18	195kΩ 1% 1/4W	brown-white-green-orange-brown	161930
☐ 1	R30	260kΩ 1% 1/4W	red-blue-black-orange-brown	162630
☐ 1	R16	360kΩ 1% 1/4W	orange-blue-black-orange-brown	163630
☐ 1	R3	800kΩ 1% 1/4W	gray-black-black-orange-brown	168030
☐ 1	R29	820kΩ 1% 1/4W	gray-red-black-orange-brown	168230
☐ 1	R15	1.8MΩ 1% 1/2W	brown-gray-black-yellow-brown	171831
☐ 1	R28	3MΩ 1% 1/2W	orange-black-black-yellow-brown	173031
☐ 1	R2	4MΩ 1% 1/2W	yellow-black-black-yellow-brown	174031
☐ 1	R14	6.75MΩ 1% 1/2W	blue-violet-green-yellow-brown	176731
☐ 1	R1	15MΩ 1% 1/2W	brown-green-black-green-brown	181531
☐ 1	R24	10kΩ Potentiometer		191508
☐ 1	R8	680Ω Potentiometer		191660

*** NOTE:** All fixed resistors are 1% tolerance (last stripe, brown). In some cases, resistors with a .5% tolerance (last stripe, green) may be used in place of the 1% resistors.

CAPACITORS AND INDUCTORS

Qty.	Symbol	Value	Marking	Part #
☐ 1	C4	.001μF Discap	(102)	231036
☐ 1	C3	.047μF Discap	(473)	234710
☐ 1	C1	.047μF, 400V Mylar	(473)	245028
☐ 1	L1	57.4mH	Coil	455577

Note: C2 is not used.

SEMICONDUCTORS

Qty.	Symbol	Value	Description	Part #
☐ 2	D1, D2	2CZ	Diode	314148
☐ 1	Q2	A1015	Transistor	321015
☐ 2	Q1, Q3	C1815	Transistor	321815

MISCELLANEOUS

Qty.	Description	Part #
☐ 1	PC Board	516001
☐ 1	Fuse 0.5A, 250V	533004
☐ 2	1.5V Battery	590001
☐ 1	9V Battery	590009
☐ 1	Buzzer	595225
* ☐ 1	Selector Knob	622011
☐ 1	Zero Adjust Knob	622013
☐ 1	Case Bottom	623213
☐ 1	Top Cover Assembly	623116
☐ 1	Buzzer Case Top	623117
☐ 1	Buzzer Case Bottom	623214
* ☐ 1	Selector Wiper	622014
* ☐ 1	Selector Base	622021
☐ 1	Screw M4 x 10	642309
☐ 1	Rubber Strip M-1250	662016
☐ 2	Fuse Clip	663060
☐ 4	Input Sockets M-1250	664003
☐ 6	Transistor Socket M-1250	664004
* ☐ 1	Ball Bearing	666401
* ☐ 1	Selector Spring	680020
☐ 1	Battery Clip Double	680027
☐ 2	Battery Clip Single	680028
☐ 1	Battery Snap	680029
☐ 2	Wire 30AGW Stranded, 90mm (3.5”) Red	828220
☐ 1	Wire 30AGW Stranded, 90mm (3.5”) Green	828250
☐ 1	Wire 30AGW Stranded, 65mm (2.5”) Violet	828270
☐ 2	Wire 30AGW Stranded, 90mm (3.5”) White	828290
☐ 1	Wire 27AGW Bare 65mm (2.55”) or two 25.4mm (1”) wires	83J400
☐ 1	Solder Tube	9ST4
☐ 1	Test Lead Set	9TL11

*** These parts are part of the main rotary switch assembly. This may come preassembled by the factory.**

Specifications

Measurement	Ranges	Accuracy	Remarks
DC Voltage (DCV)	All ranges 1,000V	±3% FS ±5% FS	Input impedance 20kΩ/V
DCV Null Meter	0 - ±5V 0 - ±25V	±5% FS	Zero centering meter type input impedance 40kΩ/V
DC Current	50µA - 2.5mA - 25mA - 250mA (50µA at the DC 0.1V position) 10A	±3% FS ±5% FS	Terminal Voltage drop: 250mV 100mV 50µA
AC Voltage	0 - 10V - 50V - 250V 1,000V	±4% FS ±5% FS	Input impedance 9kΩ/V
AF Output (dB)	–10dB ~ +22dB (AC10V) ~ +62dB 0dB/0.775V (1mW through 600Ω impedance circuit)		Input impedance 9kΩ/V for output terminal.
Resistance	All ranges	±3% of arc	Internal batteries: (2) 1.5V “AA”, (1) 9V
Buzzer	Conduct indicator (buzzer is emitted at 20Ω or less.)		Same Ω range, Power supply optional.
Battery Test (BATT)	GOOD – ? – BAD Color Coded Scale		Load current 250mA
Leakage Current (Iceo) (LI)	0 - 150µA at X1k range 0 - 15mA at X10k range 0 - 1.5mA at X100 range 0 - 15mA at X1 range		Current across terminals.
Terminal to Terminal Voltage (LV)	Common to each Ω range 3V - 0V (Reverse of LI scale)		Voltage applied across terminal while Ω is measured.
DC Current Amplification Factor (h_{FE})	Transistor h_{FE}: 0 - 1000 (in x 10Ω range)		Insert h_{FE} terminal (on scale) directly.
Size - 6 x 3 7/8 x 1 1/2 inches Weight - 0.62 pounds			

CONSTRUCTION

Introduction

Assembly of your M-1250 Analog Multimeter Kit will prove to be an exciting project and give you much satisfaction and personal achievement. If you have experience in soldering and wiring techniques, then you should have no problem with the assembly of this kit. Care must be given to identifying the proper components and in good soldering habits. Above all, take your time and follow these easy step-by-step instructions. Remember, “An ounce of prevention is worth a pound of cure”. Avoid making mistakes and no problems will occur.

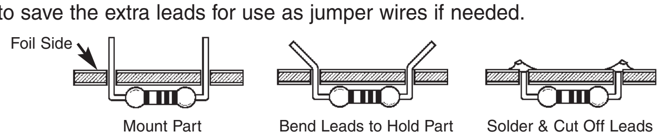
CAUTION: WEAR SAFETY GLASSES WHEN ASSEMBLING THIS KIT.

Safety Procedures

- Wear eye protection when soldering.
- Locate soldering iron in an area where you do not have to go around it or reach over it.
- **Do not hold solder in your mouth.** Solder contains lead and is a toxic substance. Wash your hands thoroughly after handling solder.
- Be sure that there is adequate ventilation present.

Assemble Components

In all of the following assembly steps, the components must be installed on the top side of the PC board unless otherwise indicated. The top legend shows where each component goes. The leads pass through the corresponding holes and the board is turned to solder the component leads on the foil side. Solder immediately unless the pad is adjacent to another hole which will interfere with the placement of the other component. Cut excessive leads with a diagonal cutter. Then, place a check mark in the box provided next to each step to indicate that the step is completed. Be sure to save the extra leads for use as jumper wires if needed.



☑ Rx - 100Ω 5% 1/4W Resistor (brown-black-brown-gold)

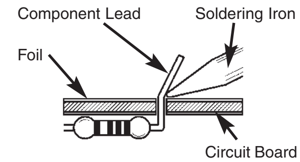
Soldering

The most important factor in assembling your Analog Multimeter is good soldering techniques. Using the proper soldering iron is of prime importance. A small pencil type soldering iron of 25 - 40 watts is recommended. **The tip of the iron must be kept clean at all times and well tinned.** Many areas on the PC board are close together and care must be given not to form solder shorts. Size and care of the tip will eliminate problems.

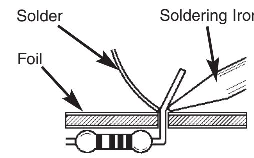
For a good soldering job, the areas being soldered must be heated sufficiently so that the solder flows freely. Apply the solder simultaneously to the component lead and the component pad on the PC board so that good solder flow will occur. Be sure that the lead extends through the solder smoothly indicating a good solder joint. **Use only rosin core solder of 60/40 alloy.**

DO NOT USE ACID CORE SOLDER! Do not blob the solder over the lead because this can result in a cold solder joint.

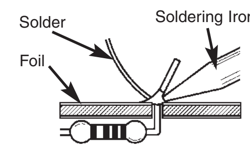
1. Solder all components from the copper foil side only. Push the soldering iron tip against both the lead and the circuit board foil.



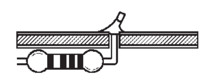
2. First apply a small amount of solder to the iron tip. This allows the heat to leave the iron and onto the foil. Immediately apply solder to the opposite side of the connection, away from the iron. Allow the heated component and the circuit foil to melt the solder.



3. Allow the solder to flow around the connection. Then, remove the solder and the iron and let the connection cool. The solder should have flowed smoothly and not lump around the wire lead.

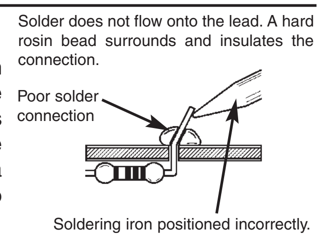


4. Here is what a good solder connection looks like. Cut off excess leads.



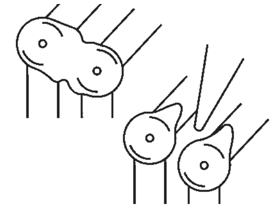
Example 1

Poor solder connections occur when the lead is not heated sufficiently. The solder will not flow onto the lead as shown. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.



Example 2

A solder bridge occurs when solder runs between circuit paths and creates a short circuit. This is usually caused by using too much solder. To correct this, simply drag your soldering iron across the solder bridge as shown.



IDENTIFYING RESISTOR VALUES

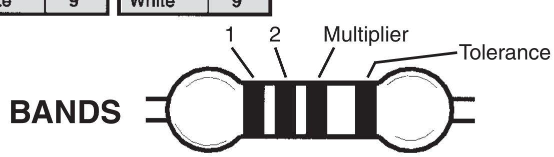
Use the following information as a guide in properly identifying the value of resistors.

BAND 1 1st Digit	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

BAND 2 2nd Digit	
Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

Multiplier	
Color	Multiplier
Black	1
Brown	10
Red	100
Orange	1,000
Yellow	10,000
Green	100,000
Blue	1,000,000
Silver	0.01
Gold	0.1

Resistance Tolerance	
Color	Tolerance
Silver	±10%
Gold	±5%
Brown	±1%
Red	±2%
Orange	±3%
Green	±.5%
Blue	±.25%
Violet	±.1%

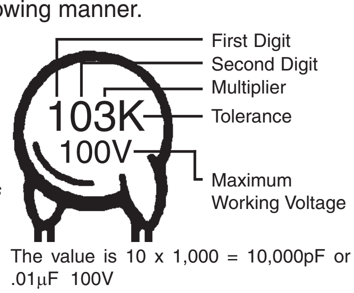


IDENTIFYING CAPACITOR VALUES

Capacitors will be identified by their capacitance value in pF (picofarads), nF (nanofarads), or μF (microfarads). Most capacitors will have their actual value printed on them. Some capacitors may have their value printed in the following manner.

The letter M indicates a tolerance of ±20%
The letter K indicates a tolerance of ±10%
The letter J indicates a tolerance of ±5%

Note: *The letter “R” may be used at times to signify a decimal point; as in 3R3 = 3.3*



The value is 10 x 1,000 = 10,000pF or .01μF 100V

Multiplier	For the No.	0	1	2	3	4	5	8	9
	Multiply By	1	10	100	1k	10k	100k	.01	0.1

ASSEMBLE COMPONENTS TO THE PC BOARD

After each step, put a check in the box located next to the step that you have completed.

☐ Place the PC board on a table with the copper side facing up and insert the four input sockets into the PC board holes as shown in Figure A. **Note that there is a lip on one end of the input socket.** Solder the input sockets to the PC board as shown in Figure A. Apply enough heat to allow the solder to flow around the input socket.

☐ Insert the six transistor sockets into the PC board as shown in Figure 1 and then solder into place.

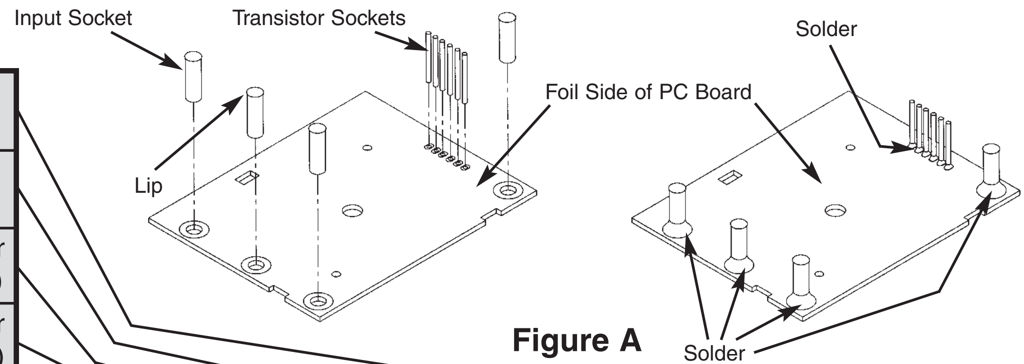


Figure A

- ☐ L1 - 57.4mH Coil (see Figure B)
- ☐ Q3 - C1815 Transistor (see Figure C)
- ☐ R34 - 100kΩ 1% 1/4W Resistor (brown-black-black-orange-brown)
- ☐ R33 - 165kΩ 1% 1/4W Resistor (brown-blue-green-orange-brown)
- ☐ R25 - 18kΩ 1% 1/4W Resistor (brown-gray-black-red-brown)
- ☐ R14 - 6.75MΩ 1% 1/2W Resistor (blue-violet-green-yellow-brown)
- ☐ R15 - 1.8MΩ 1% 1/2W Resistor (brown-gray-black-yellow-brown)
- ☐ R16 - 360kΩ 1% 1/4W Resistor (orange-blue-black-orange-brown)
- ☐ D2 - 2CZ Diode (see Figure D)
- ☐ R18 - 195kΩ 1% 1/4W Resistor (brown-white-green-orange-brown)
- ☐ R35 - 24kΩ 1% 1/4W Resistor (red-yellow-black-red-brown)
- ☐ R23 - 44kΩ 1% 1/4W Resistor (yellow-yellow-black-red-brown)
- ☐ R19 - 34kΩ 1% 1/4W Resistor (orange-yellow-black-red-brown)
- ☐ R20 - 2.08kΩ 1% 1/4W Resistor (red-black-gray-brown-brown)
- ☐ R36 - 24kΩ 1% 1/4W Resistor (red-yellow-black-red-brown)
- ☐ R17 - 83.3kΩ 1% 1/4W Resistor (gray-orange-orange-red-brown)
- ☐ R21 - 200Ω 1% 1/4W Resistor (red-black-black-black-brown)
- ☐ R31 - 5.6kΩ 1% 1/4W Resistor (green-blue-black-brown-brown)
- ☐ R32 - 8.2kΩ 1% 1/4W Resistor (gray-red-black-brown-brown)

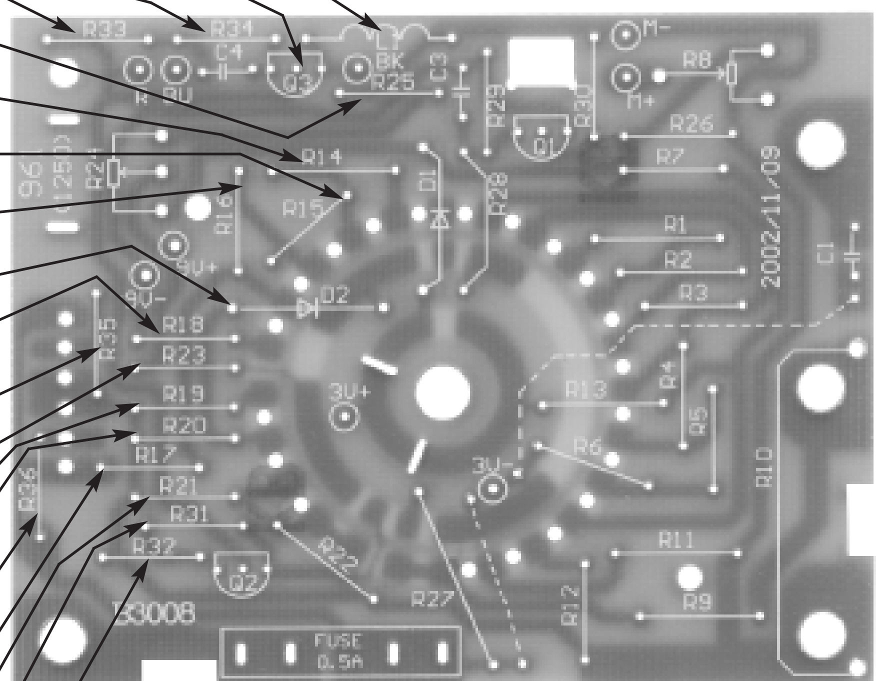
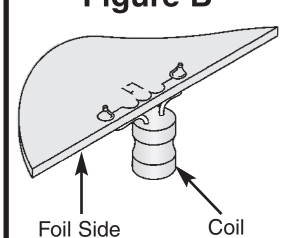


Figure B



Solder the coil to the foil side of the PC board.

Figure C

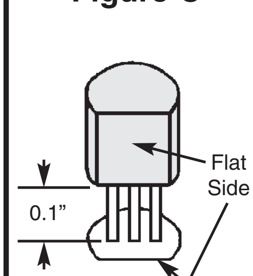
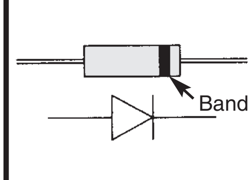


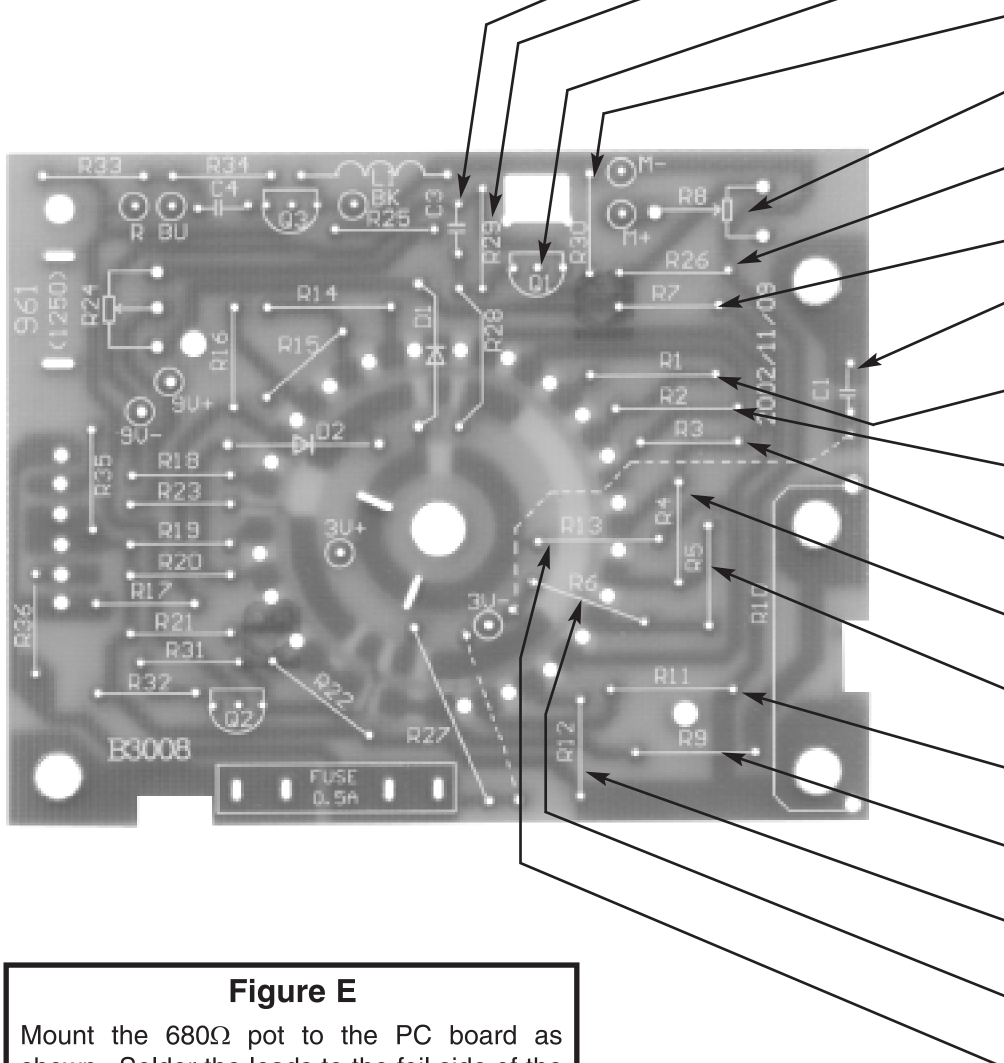
Figure D



Diodes have polarity. Mount them with the band as shown on the top legend.

ASSEMBLE COMPONENTS TO THE PC BOARD

After each step, put a check in the box located next to the step that you have completed.



- ☐ C3 - .047μF Discap (473)
- ☐ R29 - 820kΩ 1% 1/4W Resistor (gray-red-black-orange-brown)
- ☐ Q1 - C1815 Transistor (see Figure C)
- ☐ R30 - 260kΩ 1% 1/4W Resistor (red-blue-black-orange-brown)
- ☐ R8 - 680Ω Potentiometer (see Figure E)
- ☐ R26 - 31kΩ 1% 1/4W Resistor (orange-brown-black-red-brown)
- ☐ R7 - 240Ω 1% 1/4W Resistor (red-yellow-black-black-brown)
- ☐ C1 - .047μF 400V (473) Mylar Cap. (see Figure F)
- ☐ R1 - 15MΩ 1% 1/2W Resistor (brown-green-black-green-brown)
- ☐ R2 - 4MΩ 1% 1/2W Resistor (yellow-black-black-yellow-brown)
- ☐ R3 - 800kΩ 1% 1/4W Resistor (gray-black-black-orange-brown)
- ☐ R4 - 150kΩ 1% 1/4W Resistor (brown-green-black-orange-brown)
- ☐ R5 - 40kΩ 1% 1/4W Resistor (yellow-black-black-red-brown)
- ☐ R11 - 10Ω 1% 1/4W Resistor (brown-black-black-gold-brown)
- ☐ R9 - .97Ω 1% 1/2W Resistor (black-white-violet-silver-brown)
- ☐ R12 - 102Ω 1% 1/4W Resistor (brown-black-red-black-brown)
- ☐ R6 - 5kΩ 1% 1/4W Resistor (green-black-black-brown-brown)
- ☐ R13 - 3kΩ 1% 1/4W Resistor (orange-black-black-brown-brown)

Figure E

Mount the 680Ω pot to the PC board as shown. Solder the leads to the foil side of the PC board.

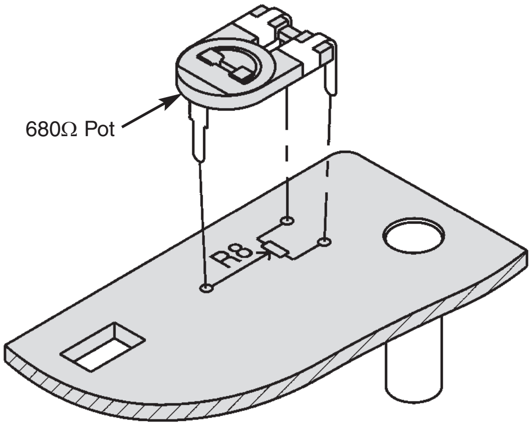
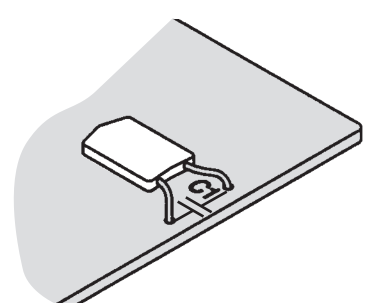


Figure F

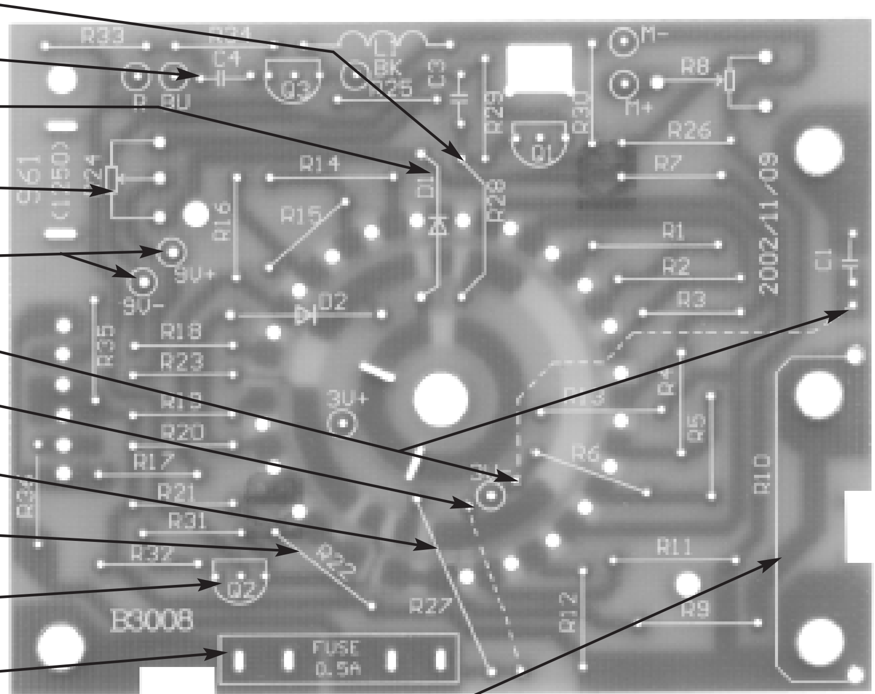
Mount and bend the mylar capacitor as shown. Solder and cut off the excess leads.



ASSEMBLE COMPONENTS TO THE PC BOARD

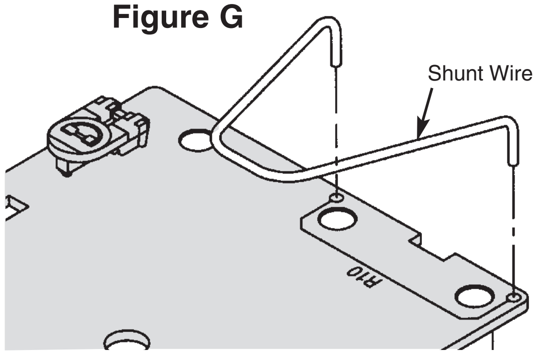
After each step, put a check in the box located next to the step that you have completed.

- ☐ R28 - 3MΩ 1% 1/2W Resistor (orange-black-black-yellow-brown)
- ☐ C4 - .001μF (102) Capacitor
- ☐ D1 - 2CZ Diode (see Figure D)
- ☐ R24 - 10kΩ Potentiometer (see Figure H)
- ☐ 9V Battery Snap (see Figure I)
- ☐ 2.5” Violet Wire (tin both ends)
- ☐ Jumper Wire (see Figure J)
- ☐ R27 - 4.5Ω 1% 1/4W Resistor (yellow-green-black-silver-brown)
- ☐ R22 - 18.5Ω 1% 1/4W Resistor (brown-gray-green-gold-brown)
- ☐ Q2 - A1015 Transistor (see Figure C)
- ☐ F1 - Fuse Clips, Fuse 0.5A (see Figure K)
- ☐ R10 - .04Ω Shunt Wire (see Figure G)



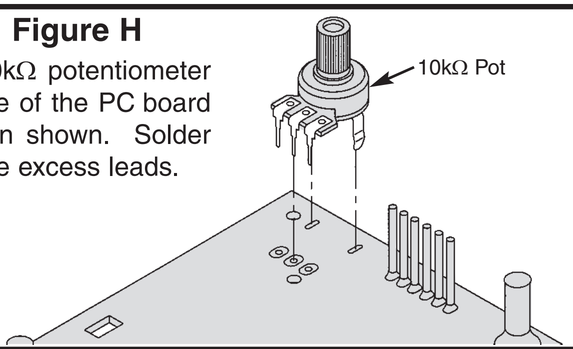
☐ **Figure G**

Mount the shunt wire in the location shown. Give about 1/8” clearance from the PC board. Solder into place.



☐ **Figure H**

Mount the 10kΩ potentiometer to the foil side of the PC board in the location shown. Solder and cut off the excess leads.

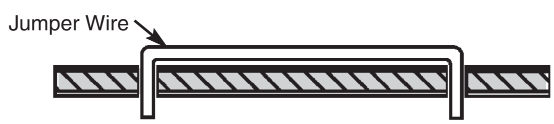


☐ **Figure I**

Solder the battery snap wires as follows:
Red wire to 9V+
Black wire to 9V–

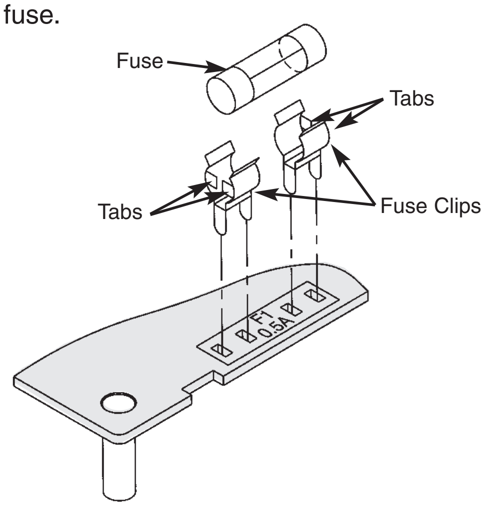
☐ **Figure J**

Use the 65mm bare wire (27AGW) as a jumper wire and mount it flush against the PC board as shown.



☐ **Figure K**

Mount the fuse clips to the location shown on the PC board. Make sure that the tabs are in the direction shown below. Solder and **cut off the excess leads**. Insert the fuse.



ASSEMBLE THE BUZZER

☐ Tin the buzzer in the three locations shown in Figure La.

☐ Tin both ends of the 3.5” red, white, and green wires as shown in Figure Lb.

☐ Solder the red, white, and green wires to the buzzer (see Figure Lc).

☐ Place the buzzer into the holder and snap together (see Figure M).

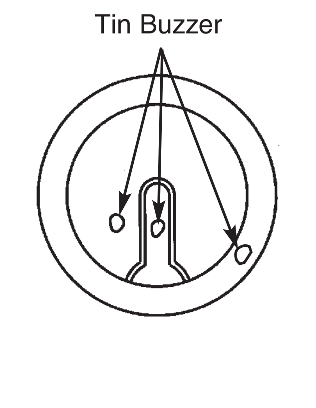


Figure La

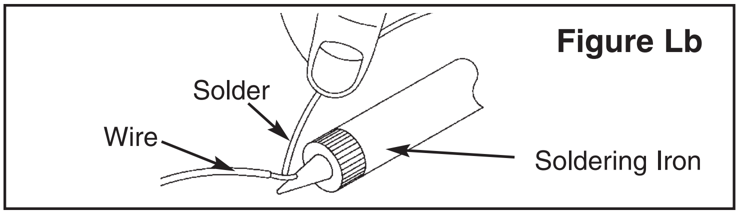


Figure Lb

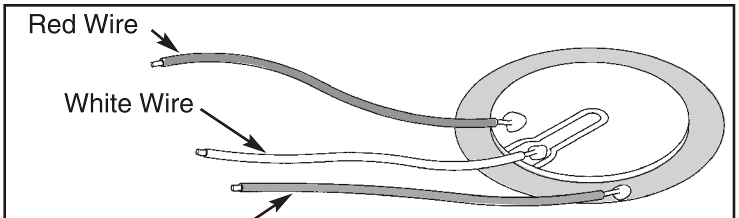


Figure Lc

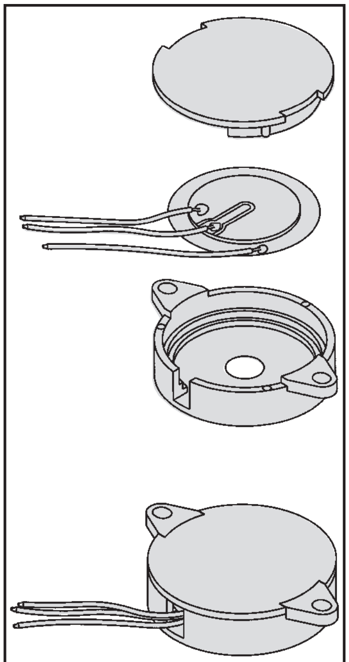


Figure M

SOLDER BUZZER AND BATTERY CLIP WIRES TO PC BOARD

☐ Solder the red buzzer wire to point R on the PC board.

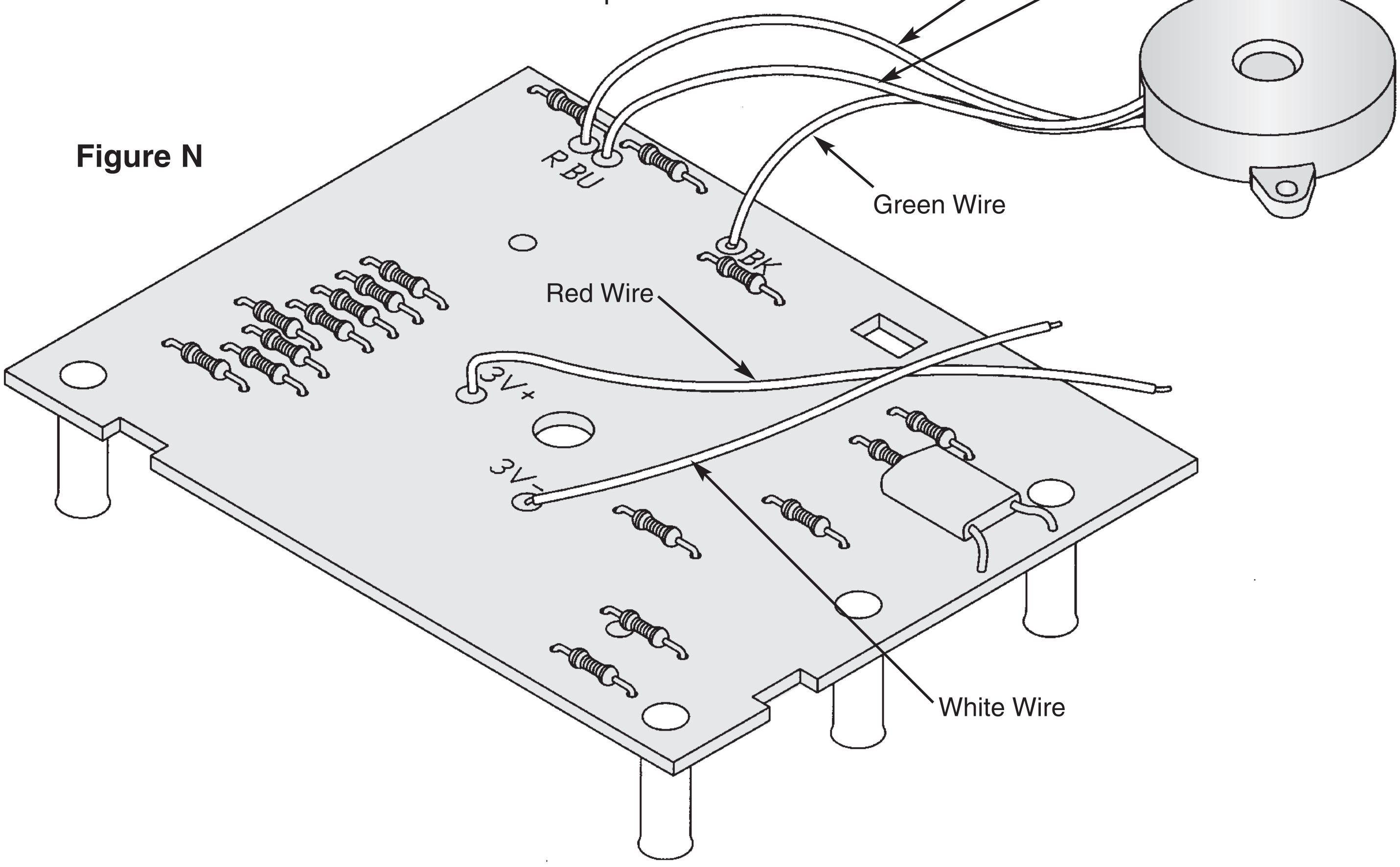
☐ Solder the white buzzer wire to point BU on the PC board.

☐ Solder the green buzzer wire to point BK on the PC board.

☐ Tin both ends of the 3.5” red wire and solder to point 3V+ on the PC board.

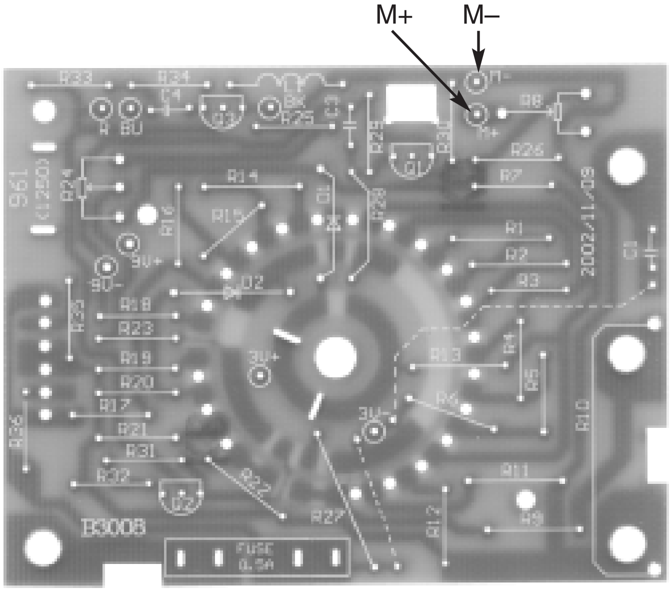
☐ Tin both ends of the white wire and solder to point 3V– on the PC board.

Figure N



SOLDER METER MOVEMENT WIRES TO PC BOARD

☐ Tin the ends of the meter wires. Solder the red meter wire to M+ and the black wire to M– on the foil side of the PC board (see Figure O).



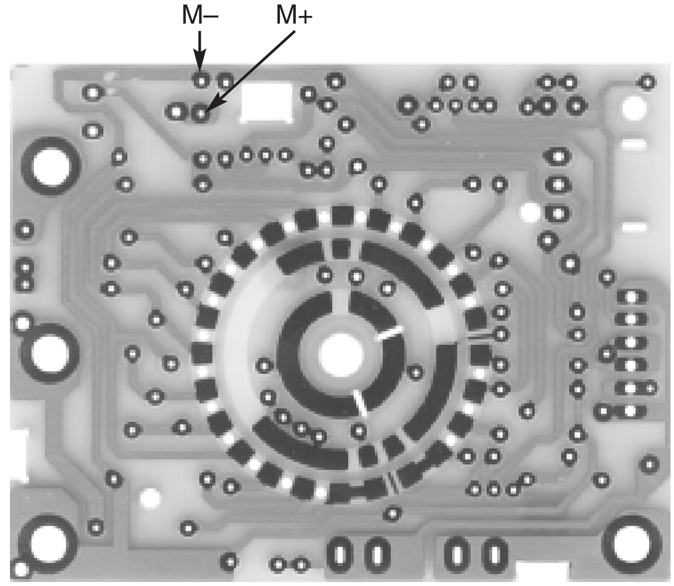
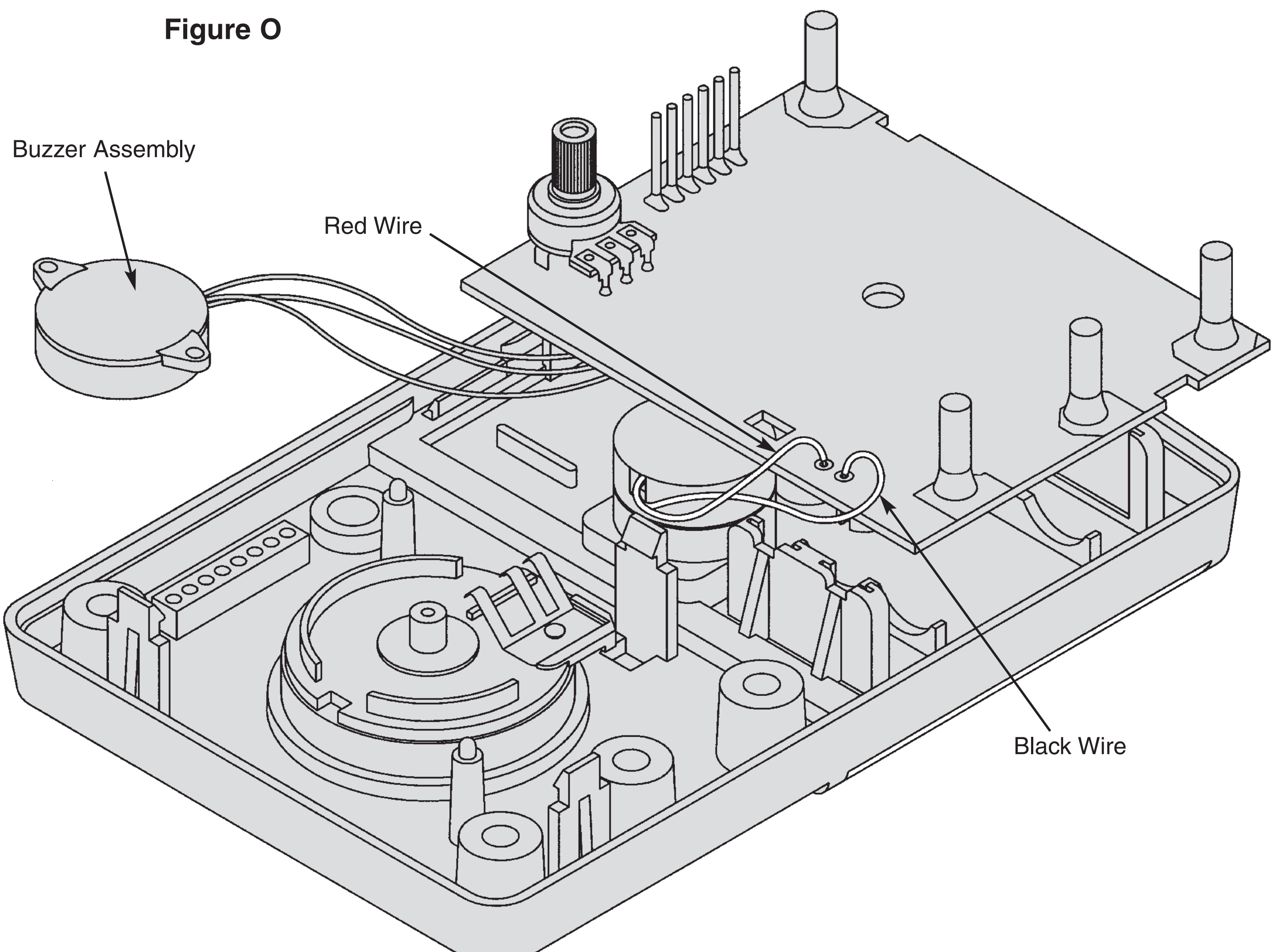


Figure O



INSTALL BATTERY CLIPS

- ☐ Install the PC board into the case (see Figure P).
- ☐ Align the buzzer holder over the two posts and press it down in place (see Figure P).
- ☐ Install the two single and one double battery clip as shown in Figure P.
- ☐ Solder the red and white wires from the PC board locations 3V+ and 3V– to the single battery contacts (see Figure Q).

Figure P

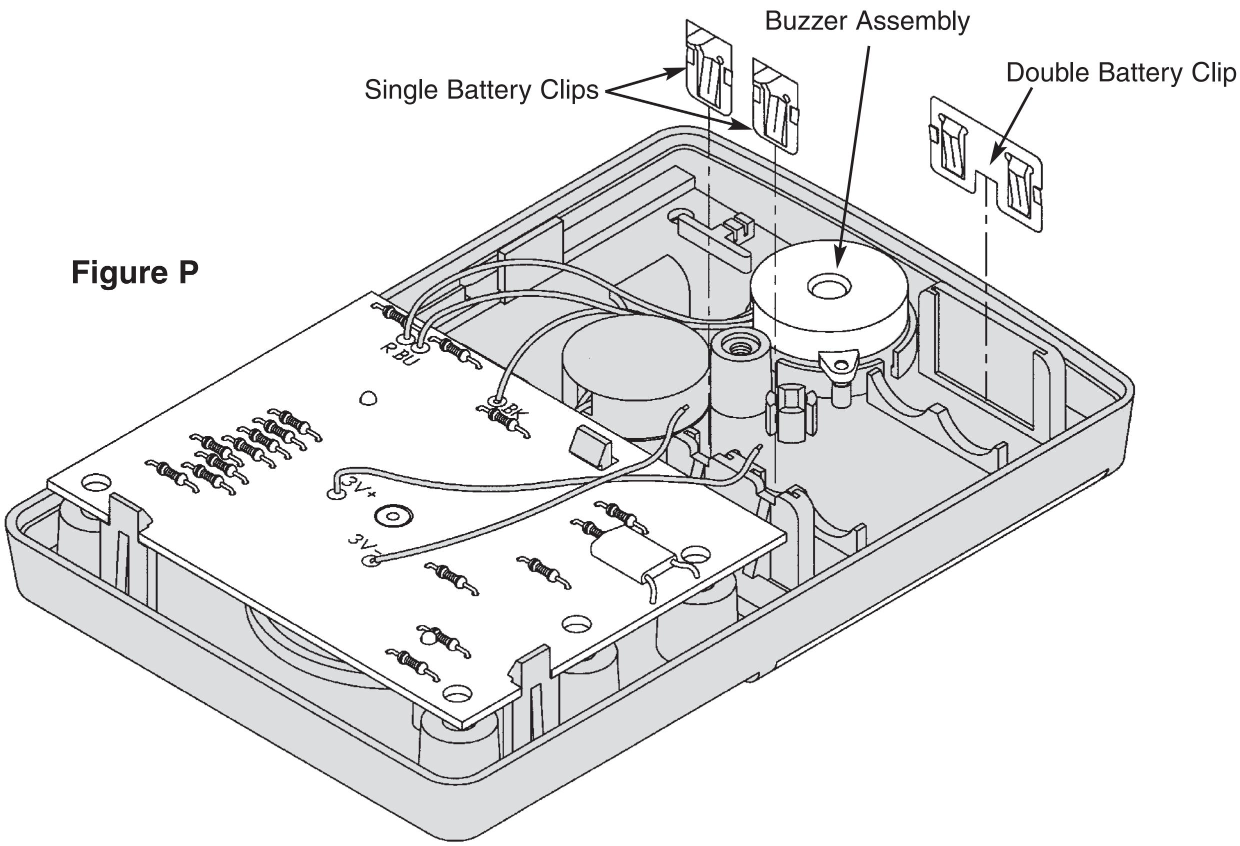
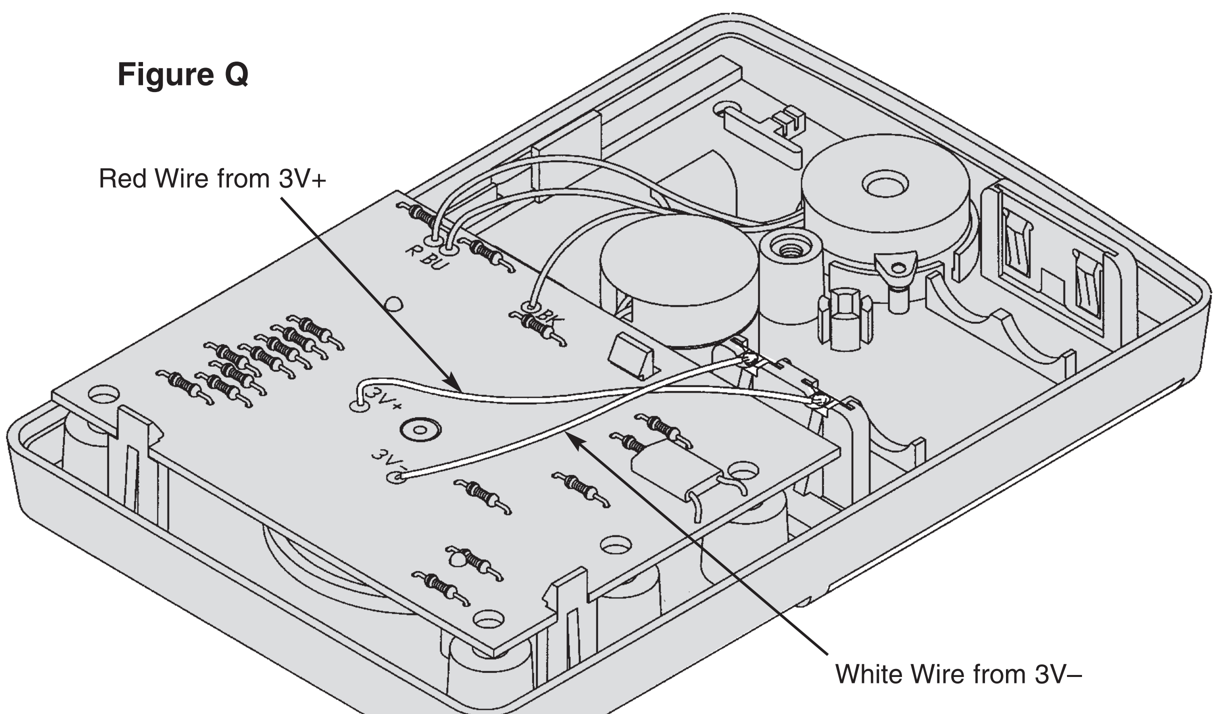


Figure Q



CALIBRATION

Batteries

Install the following parts:

1. Install the 9V and the two 1.5V (AA) batteries as shown in Figure 1. Be sure to observe the polarity markings on the bottom of the battery compartment.
2. Place the thumb wheel knob onto the 0Ω ADJ pot located at the lower right side of the meter dial.

Meter Calibration (See Operating and Testing the Multimeter Section for meter operating instructions).

1. Before starting tests, set the meter needle to zero . The zero adjust screw is located on the meter face next to the base of the needle. With no test leads connected, slowly turn this screw until the needle points to zero on the 0-10 scale immediately below the meter mirror.
2. Obtain a voltage source of 0.4V as measured by an accurate voltmeter. The circuit of Figure 2 will work fine.
3. Set the range switch to 0.5VDC.
4. Connect the test leads as shown in Figure 2.
5. Adjust R8 for a reading of 0.4V (40 on 50 scale) on the M-1250 meter.

If a DC power supply or an accurate voltmeter is not available, then use a fresh 1.5V battery and adjust R6 to read 1.55V on the 2.5V scale (155 on 250V scale).

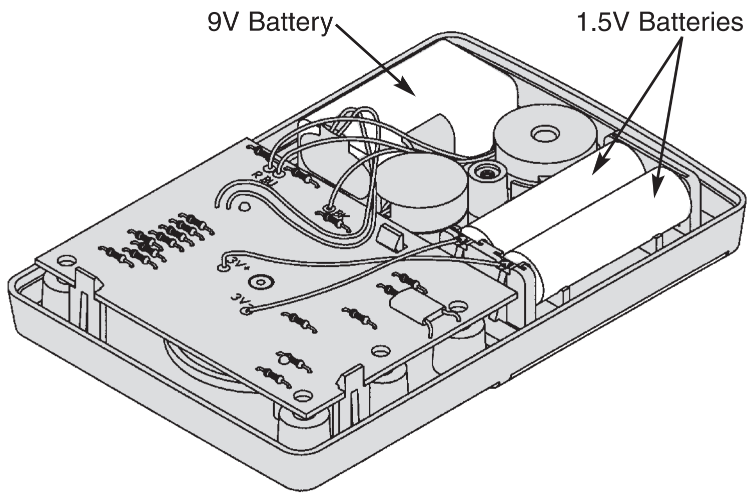


Figure 1

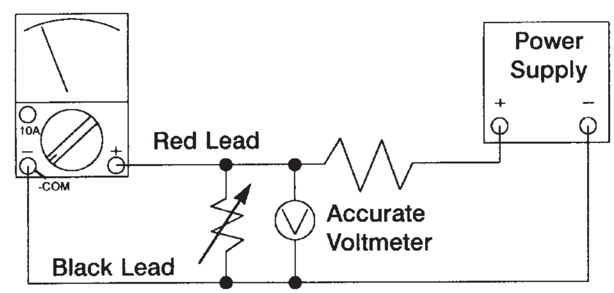


Figure 2

Shunt Wire Calibration

To calibrate the shunt wire, you will need a 5A current source like a 5V power supply and a 1Ω 25 watt resistor. If a 5A source is not available, you can use a lower current (2A). If no supply is available, it is not important to do this test. Set the range switch to 250A/10A position and connect the red and black test leads as shown in Figure 3. Read the current on the 0-10 scale immediately below the meter mirror. If the meter reads high, resolder the shunt wire so that there is less wire between the two mounting holes (move the shunt wire closer to the PC board). If the meter reads low, resolder the shunt wire so that there is more wire between the two mounting holes (move the shunt wire away from the PC board).

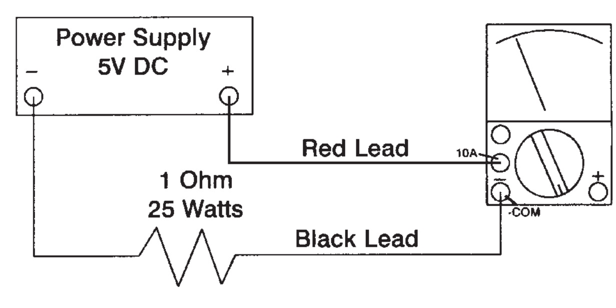


Figure 3

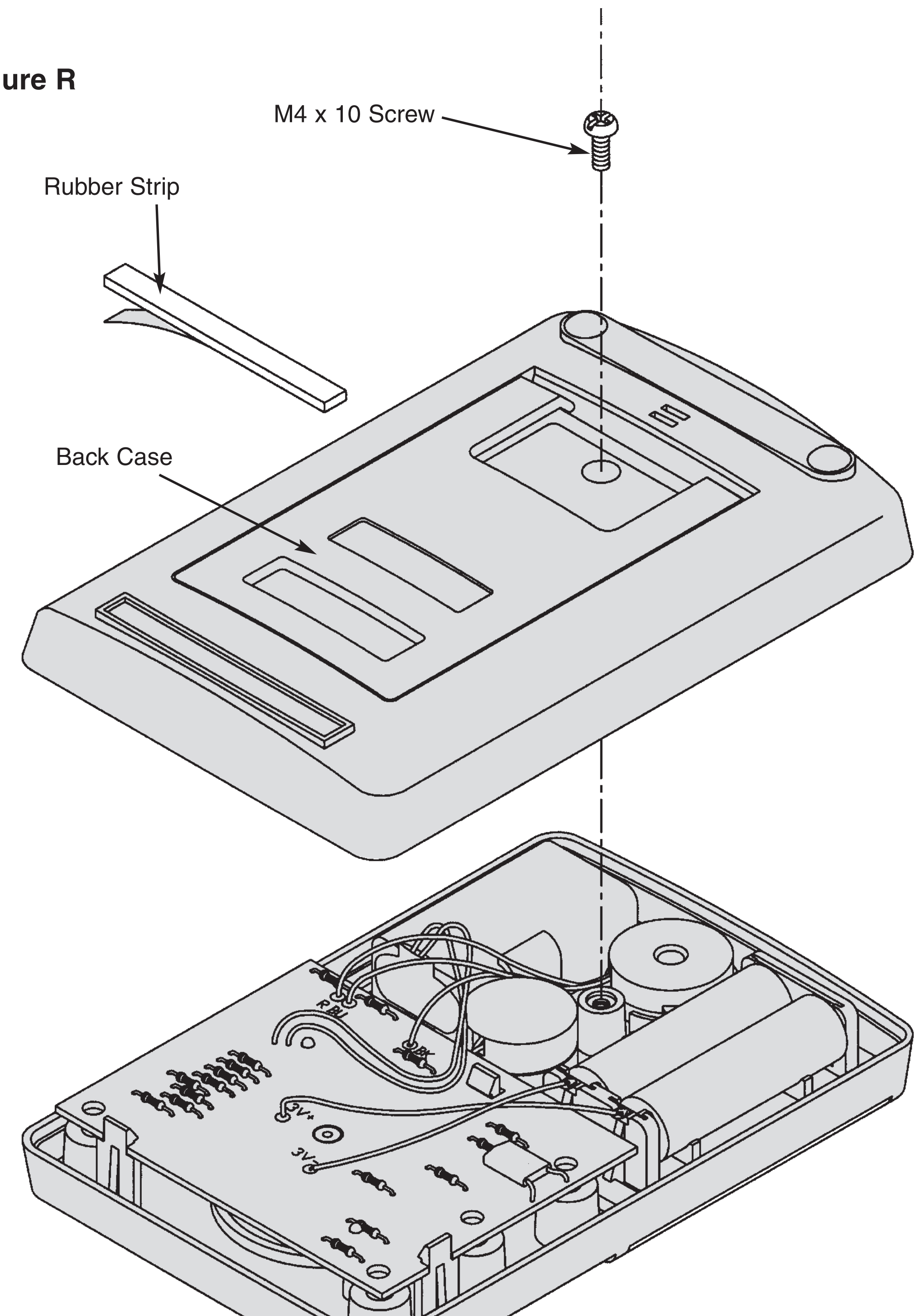
INSTALL BACK COVER AND 0Ω ADJ KNOB

☐ Remove the backing on the rubber strip and attach it to the bottom case as shown in Figure R.

☐ Install the bottom case and mount into place with an M4 x 10 screw as shown in Figure R.

☐ Place the 0Ω ADJ knob onto the front of the unit on the upper right of the panel.

Figure R



TROUBLESHOOTING CHART

This chart lists the condition and possible causes of several malfunctions. If a particular part is mentioned as a possible cause, check that part to see if it was installed correctly. Also, check that part and the parts connected to it for good solder connections.

PROBLEM	POSSIBLE CAUSE
No DC voltage reading Refer to Figure 2 for a better understanding of how the meter works.	1. Check for open fuse. 2. Check resistors R1 - R8, R13 for correct values and good solder connections. 3. Check that the PC board is seated properly and that the three board clamps are engaged. 4. Check the meter movement. Unsolder the red wire from the meter movement to the PC board. Place a 75kΩ resistor between the red wire and the positive side of a 1.5V battery. Connect the negative side of the battery to the black wire from the meter movement. The meter should read a little over half scale.
Wrong meter readings	1. Check resistors R1 - R7, R13, R24 & R25 for correct values and good solder connections.
No AC voltage reading Refer to Figure 3 for a better understanding of how the meter works.	1. Check for open fuse. 2. Check diodes D1, D2 for opens and shorts. 3. Check resistors R8, R14 - R17 for correct values and good solder connections.
No DC current reading Refer to Figure 4 for a better understanding of how the meter works.	1. Check for open fuse. 2. Check resistors R7 - R13 for correct values and good solder connections.
Ohms Refer to Figure 5 for a better understanding of how the meter works.	1. If meter cannot be zeroed: A. Check for open fuse. B. Check for weak or improperly installed batteries. C. Check that the battery snap and battery contacts are installed correctly. D. Check resistors R23 - R25 for correct value and good solder connections. 2. If meter does not read correctly: A. Check R18 - R25 for correct value and good solder connections.
No h_{FE} reading Refer to Figure 6 for a better understanding of how the meter works.	1. Check resistors R21, R23 - R25, R35, and R36.
Buzzer not working.	1. Check the following components: R31 - R34, Q2, Q3, C4, L1, and the fuse for correct values and good solder connections.
Null not working.	1. Check the following components: R3 - R6, R28 - R30, Q1, and C3 for correct values and good solder connections.

OPERATING AND TESTING THE MULTIMETER

CAUTION: When measuring an unknown voltage or current, always start with the range switch set to the highest scale. Then, if necessary, move the range switch down until the meter reads in the middle or right half of the dial.

Checking your multimeter for proper operation is fairly easy. Of prime importance is knowing which scale is read for each setting of the range switch. DC voltage is read on the dial immediately below the meter mirror. This dial is marked with three scales with full scale readings of 10, 50 and 250. The 0-10 scale is used for DC voltage ranges of .1, 10 and 1000VDC. The 0-50 scale is used for DC voltage ranges of .5 and 50VDC and the 0-250 scale is used for DC voltage ranges of 2.5 and 250VDC. The readings taken on these scales must be multiplied by the proper scale factor. For example, when the range switch is in 2.5VDC, a full scale reading on the 0-250 scale is actually 2.5 volts. You should therefore multiply your reading by .01 (move the decimal point 2 places to the left). DCmA are read using the same three scales as DC volts.

AC volts are read on the red dial marked ACV using the same 0-10, 0-50 and 0-250 scales as used for DC volts. AC volts may also be read in decibels using the dB scale. The reference voltage (0dB) for the dB scale is .775 volts. This voltage across 600 ohms dissipates 1mW of power. When dBs are read with the range switch at 10ACV, the dB scale is read directly to 22dB. With the range switch at 50ACV add 14dB. With the range switch at 250ACV add 28dB and at 1000ACV add 40dB. The maximum dB readable is 22 + 40 = 62 (dB) measured on the 1000ACV scale.

Ohms are read on the top scale. Multiply the reading by the appropriate factor 1, 10, 1k or 10k as indicated by the range switch.

If you are new to reading analog meter scales, assemble and try the Dial Scale Reading Exercise included with this kit.

Before starting tests, set the meter needle to zero . The zero adjust screw is located on the meter face next to the base of the needle. With no test leads connected, slowly turn this screw until the needle points to zero on the 0-10 scale immediately below the meter mirror. We will now test each meter function. If the meter should fail to perform as indicated, refer to the troubleshooting section for assistance.

DC Voltage Test

1) Plug the red test lead into the positive (+) socket, and the black lead into the –COM socket.
2) Set the range switch to 2.5VDC.
3) Connect the red lead to the positive side of a 1.5V battery (you may remove and use one of the 1.5V batteries from the meter). Connect the black lead to the negative side of the battery. The meter should read about 150 on the 0-250 scale. Move the decimal point 2 places to the left to obtain 1.5VDC.
4) Set the range switch to 10VDC. The meter should read 1.5 on the 0-10 volt scale.
5) Set the range switch to 50VDC. The meter should move about 1 1/2 small divisions on the 0-50 volt scale.

Ohms Test

CAUTION: When measuring ohms, be sure that there is no voltage across the circuit being tested.

1) Plug the red test lead into the positive (+) socket, and the black lead into the –COM socket.
2) If you removed the 1.5 volt battery from the multimeter for the DC voltage test, replace it now.
3) Set the range selector switch to X1.
4) Short the test leads together and adjust the 0Ω ADJ pot for a zero reading on the ohms (top) scale.
5) Connect the test leads to a known resistor between 1 and 100 ohms and observe the meter reading. Multiply by the scale factor to obtain the resistance.
6) Set the range switch to X10 and repeat steps 4 and 5 using a 10 to 1k ohm resistor.
7) Set the range switch to X100 and repeat steps 4 and 5 using a 1k to 10k ohm resistor.
8) Set the range switch to X1k and repeat steps 4 and 5 using a 10k to 100k ohm resistor.
9) Set the range switch to X10k and repeat steps 4 and 5 using a 100k to 1M ohm resistor.

AC Voltage Test

In reading AC voltage, it is necessary to obtain a known source of AC. A 12 volt transformer is preferred. If one is not available, use the 120VAC line.

CAUTION: Be very careful when working with 120VAC. Be sure that the range switch is in the 250 or 1000VAC position before connecting the test leads to 120VAC.

1) Plug the red test lead into the + socket, and the black lead into the –COM socket.
2) Set the range switch to the appropriate ACV position. Touch the test leads to the power source and observe the meter reading. Then, multiply by the appropriate scale factor.

DC Current Test

The DC current circuit is protected by a 0.5 amp fuse. **Be sure that the test current is below this level.** Obtain a 68kΩ resistor and a 1.5 volt battery (you may again use one of the 1.5V meter batteries).
Proceed as follows:

1) Plug the red test lead into the + socket and the black lead into the –COM socket.
2) Set the range switch to the 50μ ADC position.
3) Connect the 68kΩ resistor to the positive side of the battery. Connect the red test lead to the other side of the resistor. Connect the black test lead to the negative side of the battery. The meter should read about 22 on the 0-50 scale. This converts directly to 22μA.
4) Set the range switch to the 2.5mADC position. Repeat step 3 using a 1kΩ resistor. The meter should read about 150 on the 0-250 scale. Move the decimal point two places to the left to obtain 1.5mADC.
5) Check the remaining scales using a power supply and suitable resistors.
6) See Calibration Section for 10 amp range.

h_{FE} Test

The h_{FE} of a transistor is read using the six small input sockets. To measure the h_{FE} (beta) of an NPN transistor, proceed as follows.

1) If you removed the 1.5 volt battery from the multimeter, replace it now.
2) Set the range switch to the ohms X10 position.
3) Adjust the 0ΩADJ pot for a zero reading on the ohms scale.
4) Insert the transistor into the NPN section.
5) Read the h_{FE} of the transistor on the blue h_{FE} scale immediately below the BATT (1.5V) scale.
8) To measure a PNP transistor, insert the transistor into the PNP section.

Transistor Leakage Test (Iceo)

1) Plug the red test lead into the P (+) and the black test lead in into N (–COM) sockets.
2) Set the range switch to the ohm X10 (15mA) position for small size transistors, for X1 (150mA) position for large size transistors.
3) Adjust the 0Ω ADJ for a zero reading on the ohms scale.
4) Connect the transistor as follows:

   NPN Connect the test lead from the P terminal to the EMITTER (E) of the transistor.
   Connect the test lead from the N terminal to the COLLECTOR (C) of the transistor.

   PNP Connect the test lead from the P terminal to the COLLECTOR (C) of the transistor.
   Connect the test lead from the N terminal to the EMITTER (E) of the transistor.

5) Read the leakage current on the Iceo scale. If you are on the 150mA scale, move the decimal point one place to the right.

Battery Test

1. Set the range switch to the BATT position.
3. Plug the red test lead into the positive (+) socket and the black test lead into the –COM socket.
3. Connect 1.5V battery to the test leads and read the scale.

Good battery: The pointer stays within the GOOD (BLUE) range.
Low battery: The pointer stays within the ? range. The battery may be only good for low current equipment.
Bad battery: The pointer stays within the BAD (RED) range.

Buzzer Test

1. Set the range switch to the BUZZ position.
2. The buzzer will sound if there are 20Ω or less across the leads.

DCV (NULL) Test

1. Set the range switch to either the ± 5 or ±25 scale in the DCV (NULL) position.
2. Adjust the 0Ω ADJ pot for a zero center position
3. Plug the red test lead into the positive (+) socket and the black test lead into the –COM socket.
4. Connect voltage to the test leads and read the voltage.

Output Jack Test (allows measurement of AC voltage when superimposed on a DC voltage.)

1. Plug the red lead into the OUTPUT socket and the black lead into –COM.
2. Set the range switch to the appropriate ACV position. Touch the test leads to the power source and observe the reading. Then, multiply by the appropriate scale factor.

Diode Tests

The diode forward current I_f and reverse current I_r are read LI scale. To check a diode in the forward direction proceed as follows:

1) Plug the red test lead into the + socket and the black lead into the –COM socket.
2) Select the approximate forward current desired 150μA, 1.5mA, 15mA or 150mA and set the range switch to this position (blue markings in ohms range).
3) Short the test leads together and adjust the 0ΩADJ pot for a zero reading on the ohms (top) scale.
4) Connect the red test lead to the cathode (striped end) of the diode and the black test lead to the anode of the diode.
5) Read the forward current on the LI scale. The voltage drop across the diode is shown on the LV scale immediately below the LI scale.

THEORY OF OPERATION

Introduction

Your multimeter is of professional quality using 1% precision resistors throughout the design. The accuracy at full scale reading will be within 3% of full scale DC voltage or current (1,000V - 5%, 10A - 5%) and 4% of full scale (for 1,000V - 5%) AC voltage. The accuracy of the ohms measurement is 3% of arc.

On the DC volts range, the loading impedance of the meter is 20,000 ohms per volt. This means that if the range switch is on the 250V position, the loading to the circuit under test will be 20,000 x 250 = 5MΩ.

The input loading of the meter is a very important factor to be considered when measuring the voltage of a high resistance circuit. Take the example where two 1MΩ resistors are connected in series across a 9V battery. The voltage at the junction of the resistors will be 4.5V. When measured on the 10V scale, the input loading will be about 200kΩ (20,000 ohms/volt times 10V). The voltage at the junction will therefore drop to 1.28V and the meter will read this voltage. If the meter is switched to the 50V position, the loading will be 1MΩ and the meter will read 3V. For reasonably accurate measurement, the circuit under test should have an impedance of less than 100kΩ or you should use the higher ranges. The loading on the 250V and 1,000V ranges will be 5MΩ and 20MΩ respectively, but it will be hard to read 4.5V on these ranges.

DC Voltage Measurement

Figure 4 shows a simplified diagram of the DC voltage measuring circuit. Here resistors are switched in series with the meter to provide the desired ranges.

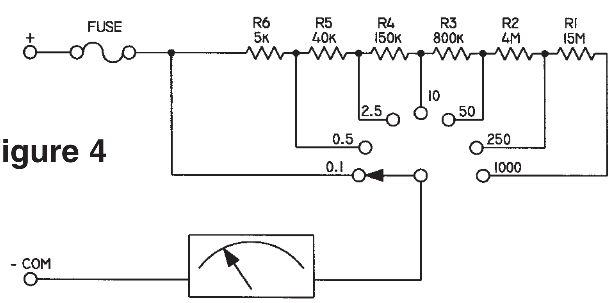
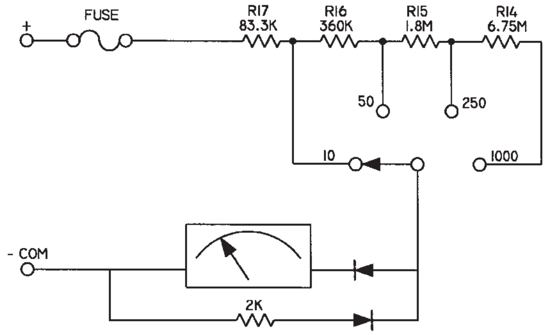


Figure 4

AC Voltage Measurement

Figure 5 shows a simplified diagram of the AC voltage measuring circuit. Two diodes are added to the series resistors to rectify the AC voltage. The input impedance on the AC voltage ranges is 9kΩ per volt. On the 250VAC range, the input impedance is therefore 2MΩ.

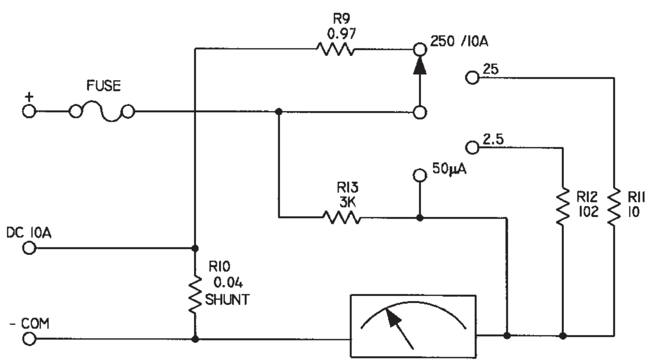
Figure 5



DC Current Measurement

Figure 6 shows a simplified diagram of the DC current measuring circuit. Here the resistors are placed across the meter to shunt the current. On the 50μA range, the current is fed directly to the meter and the voltage drop across the meter at full scale deflection is .1 volt. On all of the other ranges, the full scale voltage drop across the meter is .25 volts. A .5 amp fuse is added to the circuit for protection against overload.

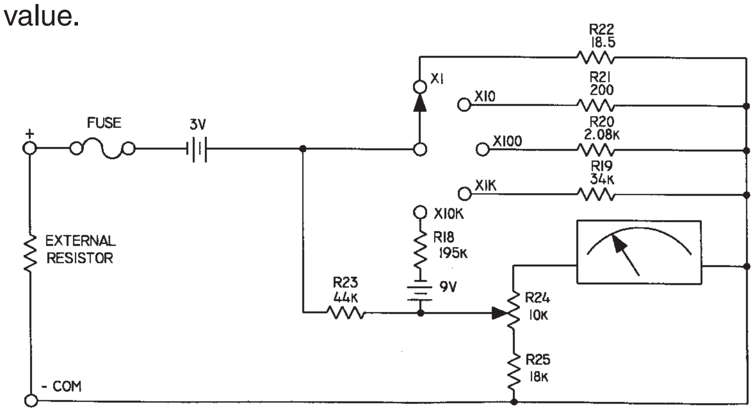
Figure 6



Resistance Measurement

Figure 7 shows a simplified diagram of the resistance measuring circuit. Here a known 1% resistor, in parallel with the meter and the zero adjust resistors, is compared to the external resistor in a series circuit. The current is supplied by the 3V battery on the X1, X10 and X1k ranges. On the X10k range, a 9V battery is placed in series with the 3V battery to supply more current to the series circuit. To calibrate the ohms circuit, the external resistor is made zero ohms by shorting the test leads together. This places the full battery voltage across the internal resistors. The current in the meter is adjusted to full scale deflection, or zero reading on the dial. When an external resistor is made equal to the internal resistance, the meter will deflect to half scale and the dial marking will show its value.

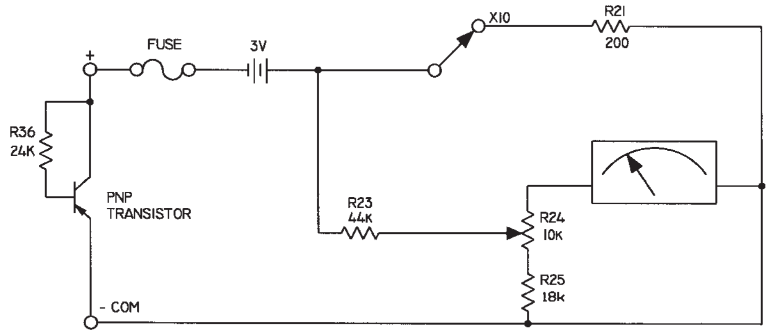
Figure 7



hFE Measurement

Figure 8 shows a simplified diagram of the hFE measuring circuit for PNP transistor. Here the range switch is in the X10 ohms position and the transistor circuit takes the place of the external resistor in the ohms measurement. The higher the hFE of the transistor, the more current flows in the external circuit and the lower the effective resistance. The meter reads this resistance and the hFE of the transistor may be read on the hFE scale.

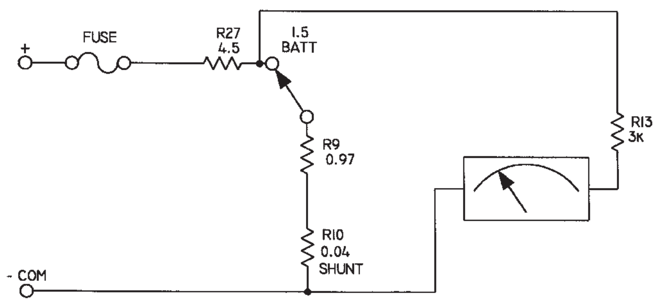
Figure 8



Battery Test

Figure 9 shows a simplified diagram of the battery measuring circuit. The battery voltage is measured under a 0.25A load.

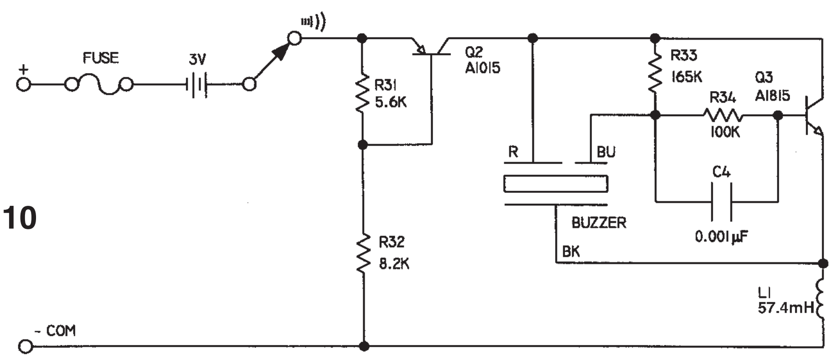
Figure 9



Buzzer Test

Figure 10 shows a simplified diagram of the audio continuity circuit. When a 20Ω load or less is place across the terminals, transistor Q3 conducts and allows Q3 to oscillate.

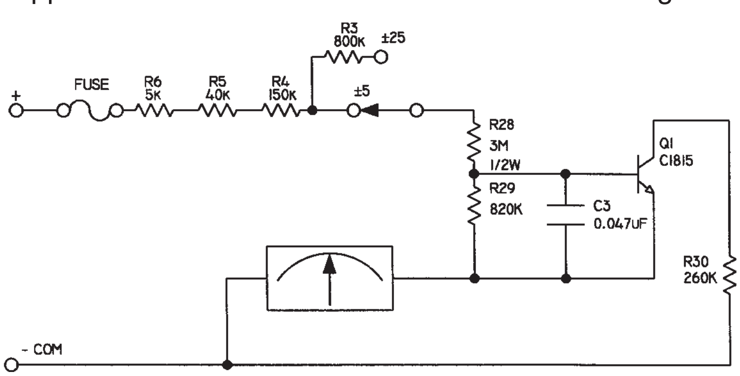
Figure 10



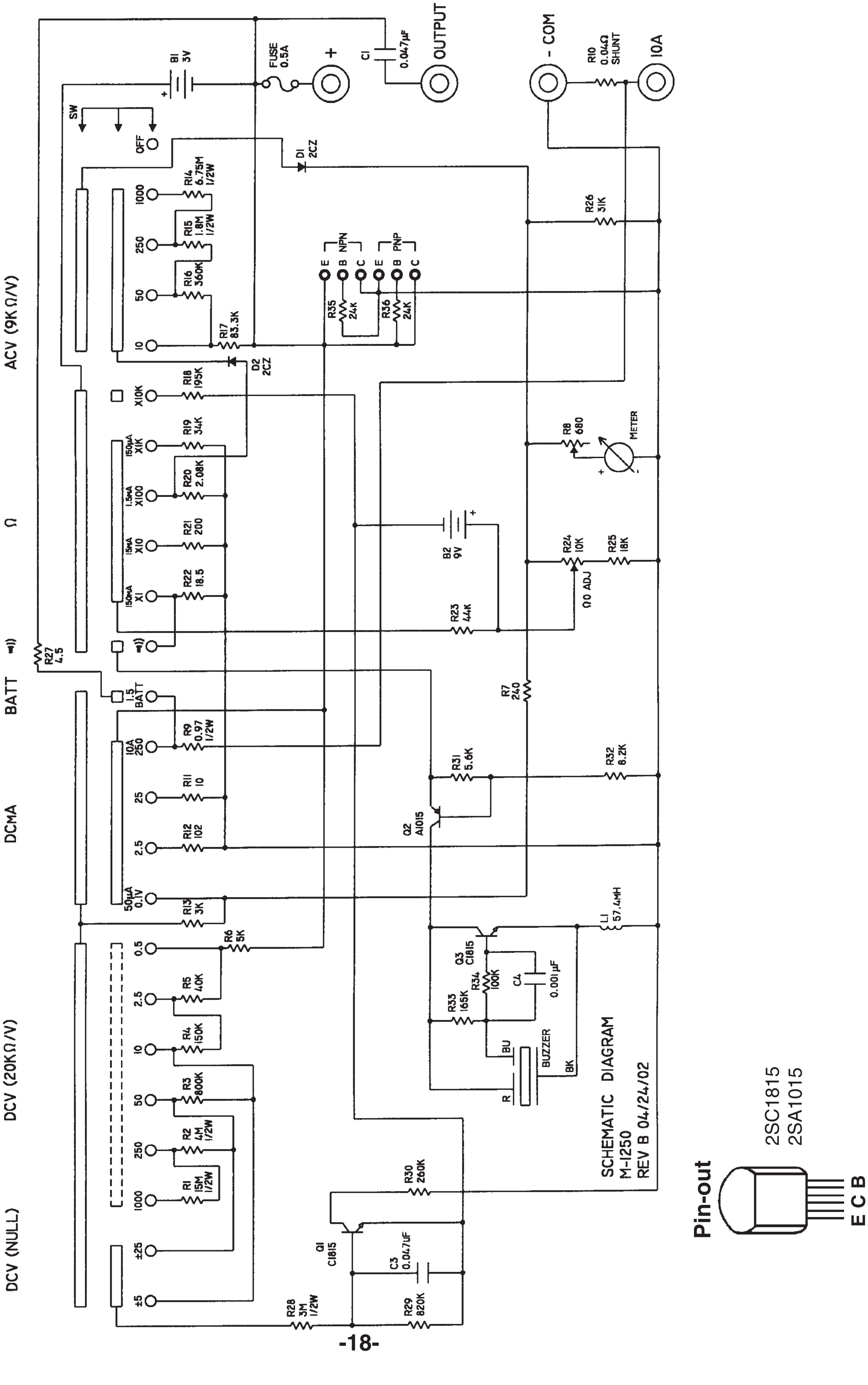
DC NULL Test

Figure 11 shows a simplified diagram of the DCV (NULL) circuit. The meter is set to 0 on the DCV (NULL) scale. Positive or negative voltage applied to the terminals causes the meter to swing in either direction.

Figure 11



SCHEMATIC DIAGRAM M-1250K



Elenco™ Electronics, Inc.
150 W. Carpenter Avenue
Wheeling, IL 60090
(847) 541-3800
http://www.elenco.com
e-mail: elenco@elenco.com