PRICE $1.00

Assembling and Using your

CONAR

Vacuum Tube Voltmeter

Model 211

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The purpose of this book is to tell you how to get maximum value from this CONAR product. Please read these instructions carefully and follow them faithfully. Then you can rely on the dependable service of CONAR quality.

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WARRANTY

All CONAR products carry a 90-day Electronics Industries Association warranty. CONAR will replace at no charge any parts or components which are found defective during the warranty period, provided such defects are not the result of misuse or accident.

There are four conditions under which you may have to write to us about this CONAR product:

(1) It arrives damaged. We ship some items by parcel post, others by express. In a parcel post shipment, if any part is broken on arrival, we will replace it without charge, if you return it to us. However, for damage in express shipments, the Railway Express Agency is responsible. If you find any damage to an express shipment, contact the Express Agency and ask for an Inspection Report. They will fill the report and give you a copy, which you are to send to us. We cannot replace damaged parts until we receive this report.

(2) Parts are missing. If anything is missing, and you find no substitute or other instructions after carefully examining the packing for small items, write us a letter explaining.

(3) A part has a defect. DEFECTIVE MATERIAL MUST BE RETURNED BEFORE A REPLACEMENT CAN BE MADE. TWO THINGS MUST BE WITH EVERY PACKAGE YOU RETURN TO US: (1) Your name and address, (2) Your reason for returning it. You may enclose a letter in the package, if you mark the package "first class letter enclosed". Such a package requires a stamp in addition to the regular parcel post charge. Unless examination shows an obvious defect, write first, and tell us why you think the part is defective. Some other part may be causing the trouble.

(4) You lose or damage parts. Parts listed in this manual may be ordered directly from CONAR, 3939 Wisconsin Ave., Washington, D.C., 20016. When ordering parts, please be sure to give the following information:

1. The part number.
2. The part name.
3. The type and model number of the product in which the part is used.

CONAR INSTRUMENTS DIVISION OF NATIONAL RADIO INSTITUTE, WASHINGTON, D.C. 20016

211-A-1266 1966 EDITION Litho in U.S.A.

CONAR
Vacuum Tube Voltmeter
ASSEMBLING THE MODEL 211 VTVM

If you have purchased your VTVM already assembled, turn to page 28 for instructions on operating it.

You have purchased one of the finest service type Vacuum Tube Voltmeters on the market. This instrument is an improved version of a VTVM that has satisfied the needs of tens of thousands of users. For you to get this same satisfaction it is necessary that you carefully follow the assembly instructions. Remember that this instrument will give you daily service for many years. It is worthwhile for you to take a little extra time to do a really fine job of assembly.

CHECKING YOUR PARTS

Check the parts that you have received against those listed in the parts list. Use the photo in Fig. 1 to identify the parts in your kit with the parts listed in the parts list. If any part appears to be missing, look for a substitute. If you find no substitute or if any part is damaged in shipment, follow the instructions on the inside of the front cover for obtaining a replacement. After you have checked your parts, be sure to read the assembly hints before starting to build your VTVM.

TOOLS

Ordinary servicing tools are all that you need to assemble this kit. The minimum tools required are a medium sized screwdriver, a 1/8” bade screwdriver, long nose pliers, diagonal cutters, a knife for stripping insulation, and a soldering iron or soldering gun. We recommend a small pencil type soldering iron rated at 35 to 65 watts. The following tools are helpful but not absolutely necessary: a set of hex nut drivers, a Phillips head screwdriver, and a wire stripper. You can

buy a complete set of high-quality tools from CONAR at considerable savings.

ASSEMBLY HINTS

1. Follow the instructions. Follow the step-by-step instructions in the order that they are given. Check off each step as soon as you finish it by placing a check mark in the space provided. Do not attempt to skip around or leave out any steps, or to build from the schematic diagram, even though you may be entirely capable of doing so.

We suggest you read over the entire instruction manual before you start construction. Before performing any step of the instructions, read the step clear through to make sure you understand what is to be done. After performing the step make sure you did what the step called for and then check off that step.

2. Do a first-class soldering job. Use a clean hot iron at all times. Be sure to apply enough heat to avoid rosin joints. The solder should melt when you touch it to the wires of the joint. If you buy more solder locally, make certain that the box is marked RADIO ROSIN-CORE SOLDER. 60/40 solder is satisfactory. Do NOT USE ACID-CORE SOLDER OR PASTE FLUX. If you use either of these, you will ruin your VTVM beyond repair.

Soldering should be no problem if you use a small pencil iron (between 35 and 65 watts). The object of the small iron is not to keep the heat at a low value, but to make it easy to get the iron tip into tight corners. A larger soldering iron can, of course, also be used.

Pre-tinning of leads makes soldering easy. Just pass the leads back and forth over the iron tip while allowing a little solder to melt on the tip. This gives a thin solder coating on the lead and solder will "take" easily when you make the connections in the circuit. In general, this treatment is required only on resistor leads.

In most cases not more than three leads are soldered to a single terminal. This makes it easy to get the solder to "take" not only on the terminals, but also on all of the leads. If there are more than three leads attached to a lug, it may be necessary to turn the work so that the iron tip can be held against the bottom lead. After the soldered joint has cooled, wiggle each wire. If the wire moves in the joint when wiggled, resolder it, let it cool, and check again.

When soldering to the switch terminals, hold the switch so that solder will not run down the switch lugs and ruin the switch contacts. When you have made secure connections to a point, clip off all excess lead lengths.

CAUTION: When tinning and soldering the leads for these resistors, be sure to hold the lead with a pair of pliers between the body of the resistor and the point where the iron is in contact with the lead. EXCESS HEAT WILL CAUSE SOME RESISTORS TO CHANGE THEOR VALUE. In soldering the switch contacts, use enough heat to melt the solder and allow it to run freely to all parts of the joint. Make sure that solder does not run into switch contacts.

Poor soldering is the greatest single cause of trouble in kit construction. If you have not had considerable experience in soldering, take a little time to practice soldering before you start construction.

3. Position all parts and wires as shown in the illustrations: All leads are to be short with the parts and leads positioned as shown. Space is limited, but by following the directions all the way through the manual, you will have no trouble. In some cases, resistors are mounted an adjacent lugs of a terminal strip. To get a neat fit, bend the resistor leads at right angles to the body of the resistor as shown in Fig. 2A. Next, use your fingers to bend the lead nearest the first color code band back along the resistor body as far as the first band close to the body of the resistor, and then straight down as shown in Fig.

2B. The spacing between the resistor leads will be exactly right to fit into the holes in the terminal strip lugs, as shown in Fig. 2C. Do not grasp or squeeze the resistor body with pliers as this will break the resistor. When connecting more than one component to a terminal strip, make sure the leads do not come in contact with each other. An example of this is shown in Fig. 2D.

The color codes for identifying the values of resistors and capacitors are shown inside the back cover of this manual.

Be sure to use the length of wire specified in each case. Strip off 1/4" of insulation from each end of the hookup wire. It is seldom necessary to take off more than 1/4" of insulation unless the end goes through one terminal to another one. If you remove too much insulation you may cause shorts to other wires or parts. Excess lead length between the part and soldered connections may result in short circuits. On the other hand, do not pull insulated leads so tight that sharp edges of the chassis will cut through the insulation and produce shorts. In some cases, insulation known as spaghetti is slipped over part leads to avoid a short circuit. You will be instructed when to use it.

When a lockwasher is used, it is to be directly under the nut unless otherwise indicated. When tightening nuts over lockwashers, tighten the nut until the lockwasher is squeezed closed. The spring tension of the lockwasher will then prevent the nut from backing off.

The drawings and photographs in this manual are selected to make the kit assembly easy. Use Figs. 3 and 4 to identify the holes in the panel. Use Figs. 5 and 6 to identify the holes in the chassis. Figs. 7 and 8 identify all the terminal numbers used in the instructions. Other pictorial diagrams

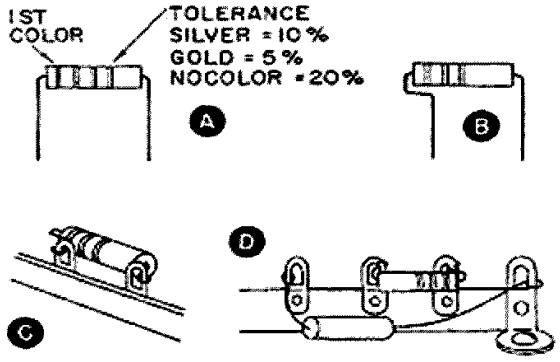


Figure 2 - How to bend resistor leads so the part can be easily mounted.

show the placement of parts and details of construction steps. Study the figures carefully. It will help you understand the assembly instructions.

WIRING THE RANGE SWITCH

To make the wiring of the range switch easier, you will wire the switch before mounting it. In this way, you can work out in the open instead of in a tight corner under the chassis. You will use the chassis as a convenient mount to hold the switch upright while you work on it. You will need the following parts:

One chassis
One front panel
Two 1/4", 6-32 screws.
Two 6-32 nuts.
One rubber grommet.
One range switch (6-position, double-pole).
One 10K-ohm, 1% 1W resistor.
One 30K-ohm, 1% 1W resistor.
One 60K-ohm, 1% 1W resistor.

One 300K-ohm, 1% 1W resistor.
One 600K-ohm, 1% 1W resistor.
One 3-megohm, 1% 1W resistor.
One 10-ohm, 5% 1W resistor (brown-black-black-gold).
One 100-ohm, 5% 1W resistor (brown-black-brown-gold).
One 10K-ohm, 5% 1W resistor (brown-black-orange-gold).
One 100K-ohm, 5% 1W resistor (brown-black-yellow-gold).
One 1-megohm, 5% 1W resistor (brown-black-green-gold).
One 10-megohm, 5% 1W resistor (brown-black-blue-gold).

When you have gathered these parts together, proceed with the following steps. When wiring the resistors to the switch terminals keep the leads short and the body of the resistor close to the terminals. However, do not let the body of a resistor touch other resistors, terminals or the metallic part of the switch. Use Figs. 11 and 12 to see how to position and wire the resistors. Before performing a step, read through the entire step to be sure you understand it. Check off each step as soon as you finish it, so you won't skip any.

( ) Install a rubber grommet in hole L in the chassis. See Fig, 5 for the location of hole L. To install a grommet, squeeze the grommet between your thumb and forefinger, and force the grommet part-way through the chassis hole. Continue working the grommet into the hole until it is completely in place. Lift up the grommet lips on both sides of the chassis until the lips lie flat.

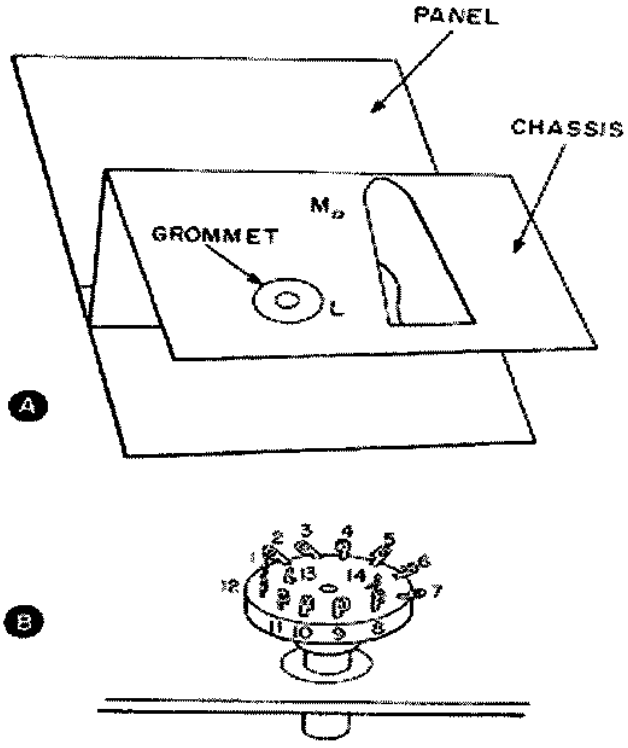


Figure 9 – How to support the range switch for easy wiring.

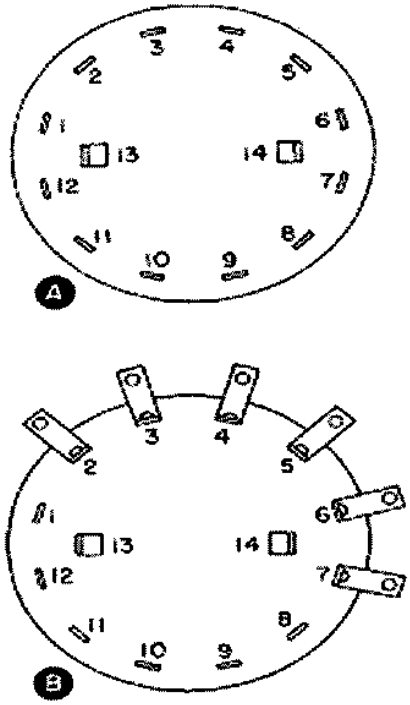


Figure 10 – (A) Arrangement of terminals before bending; (B) Position of the bent terminals in relation to terminals 13 and 14.

( ) Temporarily attach the front panel to the chassis. Insert a 1/4", 6-32 screw from the front of the panel through hole X in the panel and corresponding to hole

A in the chassis. Attach a 6-32 nut and draw nut finger tight. Insert a 1/4", 6-32 screw from the front, through hole U in the panel and corresponding to hole B in the chassis. Attach a 6-32 nut and draw the nut finger tight.

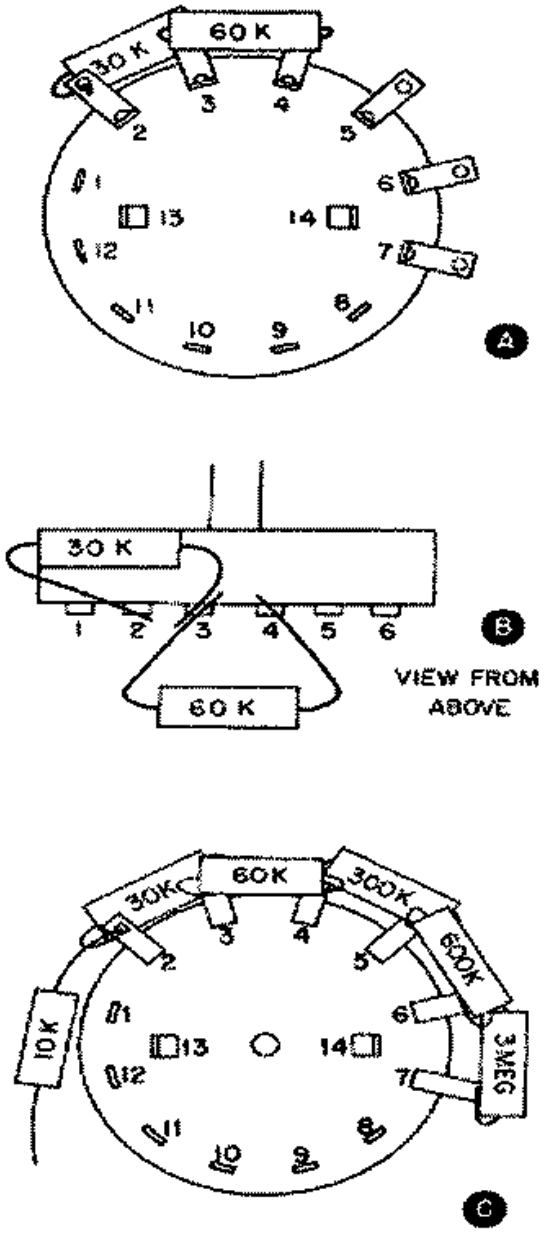


Figure 11 - (A) and (B) How to position the resistors in the range switch terminals; (C) Placement of the resistors connected to terminals 2, 3, 4, 5, 6, and 7.

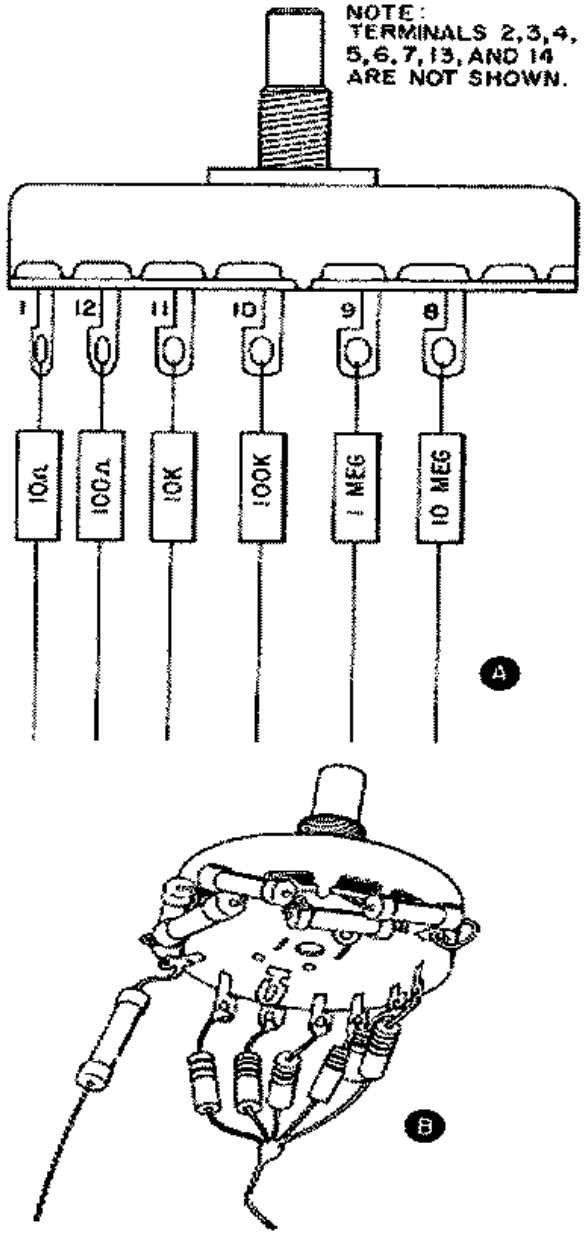


Figure 12 - (A) How to position the resistors that are attached to terminals 1, 12, 11, 10, 9, and 8. (B) The completed range switch.

Lay the panel face down on a soft piece of cloth to protect the panel. Be careful not to set the panel on a rough surface or you may scratch the fine finish of the panel.

( ) Insert the shaft of the range switch through the grommet in hole L as far as the threaded portion. Fig. 9 shows the position of the switch which is in an upright position so that it is easy to work on. The switch may be easily rotated to any position.

( ) Position the range switch as shown in Fig. 10A. Notice that the terminal numbers shown in the figure do not appear on the switch. You can position the switch either of two ways and it will be like it is shown in Fig 10A. Either way is permissible. Only after you bend down the proper terminals will the terminal numbers, shown in Fig. 10B, apply to your switch. Bend down terminals 2, 3, 4, 5, 6, and 7. Bend these terminals out nearly flat, but do not bend them too far as they can touch the metal part of the switch. Position the resistors on the range switch in Fig. 11.

( ) Connect a 30K-ohm, 1% resistor between terminals 2 and 3 on the range switch.

( ) Connect a 60K-ohm, 1% resistor from terminal 3 to terminal 4. Solder terminal 3.

( ) Connect a 300K-ohm, 1% resistor from terminal 4 to terminal 5. Solder terminal 4.

( ) Connect a 600K-ohm. 1% resistor from terminal 5 to terminal 6. Solder terminal 5.

( ) Connect a 3-megohm. 1% resistor from terminal 6 to terminal 7. Solder terminal 6.

( ) Shorten one lead of a 10K-ohm, 1% resistor to 3/4" length. Connect this lead to terminal 2 of the range switch. Leave the other end free as shown in Fig. 11C. Solder terminal 2.

( ) Shorten one lead of a 10-ohm, 5% resistor to 1/2" length. Connect this lead of the resistor to terminal 1 on the range switch. Leave the other end free. See Fig. 12A. Solder terminal 1.

( ) Shorten one end of a 100-ohm, 5% resistor to 1/2" length. Connect this lead to terminal 12 of the switch. Leave the other end free. Solder terminal 12.

( ) Shorten one lead of a 10K-ohm, 5% resistor to 1/2" length. Connect this end of the resistor to terminal 11. Leave the other end free. Solder terminal 11.

( ) Shorten one lead of a 100K-ohm, 5% resistor to 1/2" length. Connect this lead to terminal 10 of the switch. Leave the other end free. Solder terminal 10.

( ) Shorten one lead of a 1-megohm, 5% resistor to a 1/2" length. Connect this lead to terminal 9 of the switch. Leave the other end free. Solder terminal 9.

( ) Shorten one lead of a 10-megohm, 5% resistor to 1/2" length. Connect this lead to terminal 8 of the switch. Leave the other end free. Solder terminal 8.

Now check your switch against Fig. 12A for the appearance of the resistors connected to terminals 1, 12, 11, 10, 9, and 8. Make sure that each terminal has the proper resistor soldered to it. Terminals 1 through 12 on the switch should now all be soldered except terminal 7. The next step is to connect together the long, free leads of the resistors soldered to terminals 8. 9. 10, 11, 12, and 1, as shown in Fig. 12B. To do this, proceed with the following instructions:

( ) Straighten the free lead on the 10K-ohm resistor connected to terminal 11. Hook the free lead of the 100K-ohm resistor, which is connected to terminal 12, around the long free lead of the 10K-ohm resistor. This hook should be about 1/4" from the body of the 10K-ohm resistor. Cut off the excess lead from the 100K-ohm resistor. Solder the connection.

( ) Hook the free lead of the 10-ohm resistor, which is connected to terminal 1, around the long free lead on the 10K-ohm resistor. Squeeze the hook tight and cut off the excess lead from the 10K-ohm resistor. Solder the connection.

( ) Hook the free lead of the 100K-ohm resistor, which is connected to terminal 10, around the long free lead on the 10K-ohm resistor. Squeeze the hook tight and cut off the excess lead. Solder the connection.

( ) Hook the free lead of the 1-megohm resistor, which is connected to terminal 9, around the long free lead on the 10K-ohm resistor. Squeeze the hook tight and cut off the excess lead. Solder the connection.

( ) Hook the free lead of the 10-megohm resistor, which is connected to terminal 8, around the long free lead of the 10K-ohm resistor. Squeeze the hook tight and cut off the excess lead. Solder the connection.

Your wired switch should look like the drawing in Fig. 12B. This completes the wiring of the range switch. Remove the switch from the grommet and set the wired switch to one side. Leave the grommet installed in hole L.

WIRING THE FUNCTION SWITCH

You will wire the 5-position, 3-deck function switch before mounting it in the chassis to make the wiring easier. Support the switch in the grommet in hole L in the chassis in the same manner as you did the range switch. In this way the function switch is supported upright and will be easier to wire.

You must follow the instructions for wiring this switch very carefully because it is easy to mistake the location of a terminal. Study the method of terminal numbering so that you can locate the proper terminals. Each time before performing an operation, reread the instructions for that step to be sure that you understand what is to be done. Work very carefully because the leads are to be cut so the parts will fit into small spaces. If you make a mistake and cut the wrong lead or get a part connected to the wrong terminals, you will have much difficulty in getting your instrument to work.

Use special care when soldering to the terminals of the switch. Be careful not to get any solder onto the switch contacts or the switch will short out or work improperly.

Study Fig. 13 to see how the switch is numbered. Notice that the numbers do not appear on the switch. You must use the red dot that is painted on a spacer of the switch to locate the terminals. The switch

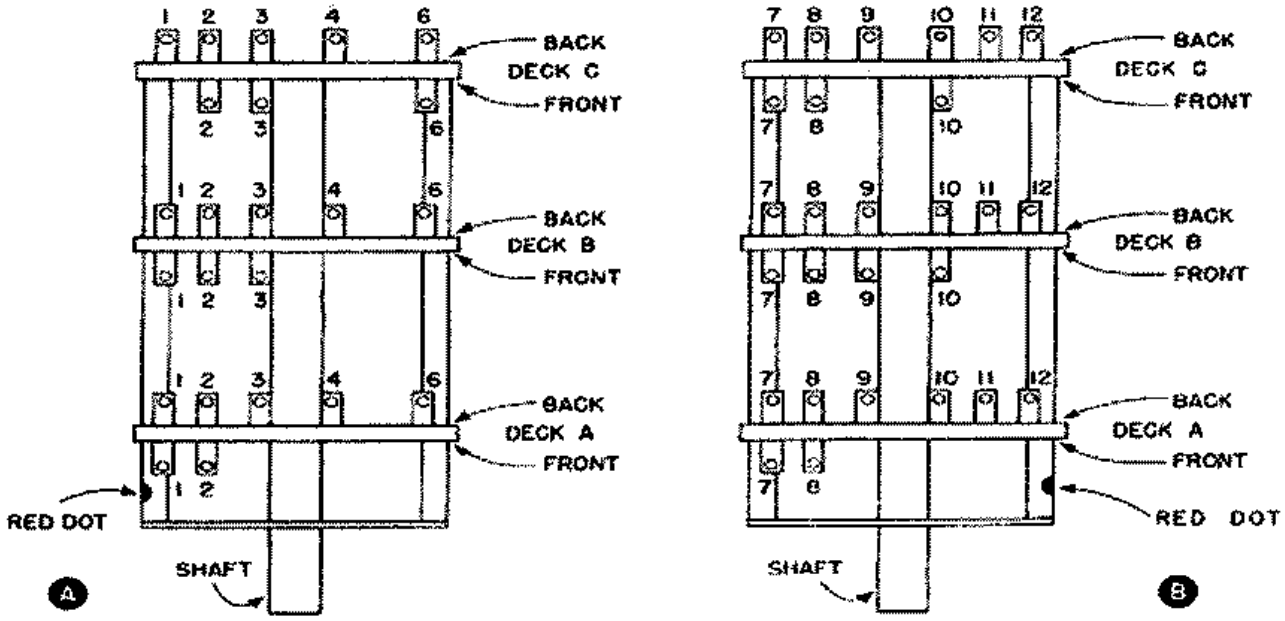


Figure 13 - Two views of the on-off function switch with the terminals identified.

consists of deck A, deck B, and deck C. Each deck of the switch has contacts on the front and the back. Notice that the front of the switch is the shaft end of the switch. Looking at the shaft end of the switch, the contacts are numbered 1 through 12 from the red dot in a clockwise direction. When you look at the back of one of the decks, the switch terminals are numbered 1 through 12 from the red dot in a counterclockwise direction. When you are sure you understand the terminal numbering system, proceed with wiring deck A of the switch.

Wiring Deck A

Since no wires or parts are connected to the front of deck A, all of the wiring steps will refer to the back of deck A. For wiring deck A, you will need assorted hookup wire. Use Fig. 14 for placement of wires.

( ) Connect a 1-3/4" blue wire from terminal 2 to terminal 9. Solder terminal 9.

( ) Connect a 7" blue wire to terminal 2. Leave the other end free. Solder terminal 2.

( ) Connect a 1-3/4" green wire from terminal 3 to terminal 8. Solder terminal 8.

( ) Connect a 3" green lead to terminal 3. Leave the other end free. Solder terminal 3.

( ) Connect a 2" black lead to terminal 4. Leave the other end free. Solder terminal 4.

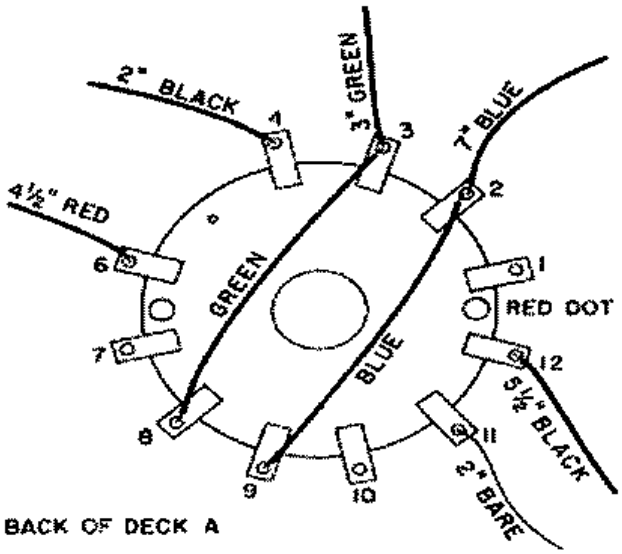


Figure 14 - Wiring of deck A.

( ) Connect a 4-1/2” red lead to terminal 6. Leave the other end free. Solder terminal 6.

( ) Insert a 2” bare wire through the hole in terminal 11, back of deck a from the front of the switch. Push the wire through terminal 11, back of deck B, and through terminal 11, back of deck C. Now bend a hook at terminal11, back of deck A; cut off the excess wire and solder terminal 11, back of deck A. The position of this bare wire is shown in Fig. 16.

( ) Connect a 5-1/2” black wire to terminal 12 on the back of deck A. Leave the other end free. Solder terminal 12.

This completes the wiring of deck A and you should now check your work carefully against the following check list. Check each terminal of the switch as you count around the switch. This will help you to identify each terminal. Check off each terminal on the check-off list.

Back of Deck A

1. Terminal 1 should have no connections. …….
2. Terminal 2 should have two blue leads soldered to it. …….
3. Terminal 3 should have two green leads soldered to it. …….
4. Terminal 4 should have a black lead soldered to it. …….
5. There is no terminal 5 on deck A. …….
6. Terminal 6 should have a red lead soldered to it. …….
7. Terminal 7 should have no connections. …….
8. Terminal 8 should have a green lead soldered to it. …….
9. Terminal 9 should have a blue lead soldered to it. …….
10. Terminal 10 should have no connections. …….
11. Terminal 11 should have a bare wire soldered to it. …….
12. Terminal 12 should have a black lead soldered to it. …….

Wiring Deck B

Refer to Figs. 15 and 16 for the placement of the resistor and the wires that are connected to deck B of the switch. You will need the following:

One 1.5-megohm 5% 1W resistor (brown-green-green-silver)
Assorted hookup wire

Now proceed with the following steps.

( ) Connect a 4-1/2” blue wire to terminal 3 on the front of deck B. Leave the other end free. Solder terminal 3.

( ) Connect a 5” red wire to terminal 4 on the back of deck B. Leave the other end free.

( ) Connect a 1” bare wire from terminal 4 on the back of deck B to terminal 4 on the back of deck C as shown in Fig. 16B. Cut off the excess wire. Solder terminal 4 on the back of deck B and on the back of deck C.

( ) Connect a 1.5-megohm resistor from terminal 12 on the back of deck B to terminal 10 on the front of deck C. Place the body of the resistor inside the switch so it does not touch the bare wire above it. See Fig. 16A for placement of the resistor. Cut off the excess wire. Solder terminal 12 on the back of deck B and terminal 10 on the front of deck C.

This completes the wiring of deck B. Now check your work using the following check-off lists.

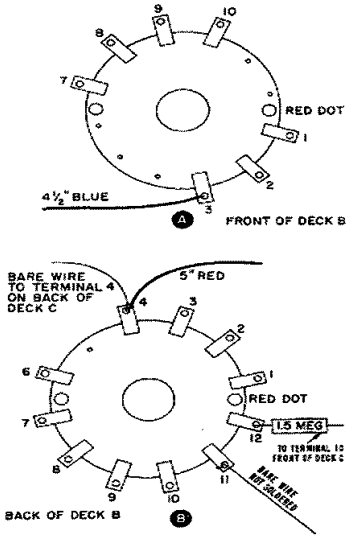


Figure 15 - (A) Wiring on front of deck B; (B) Wiring on back of deck B.

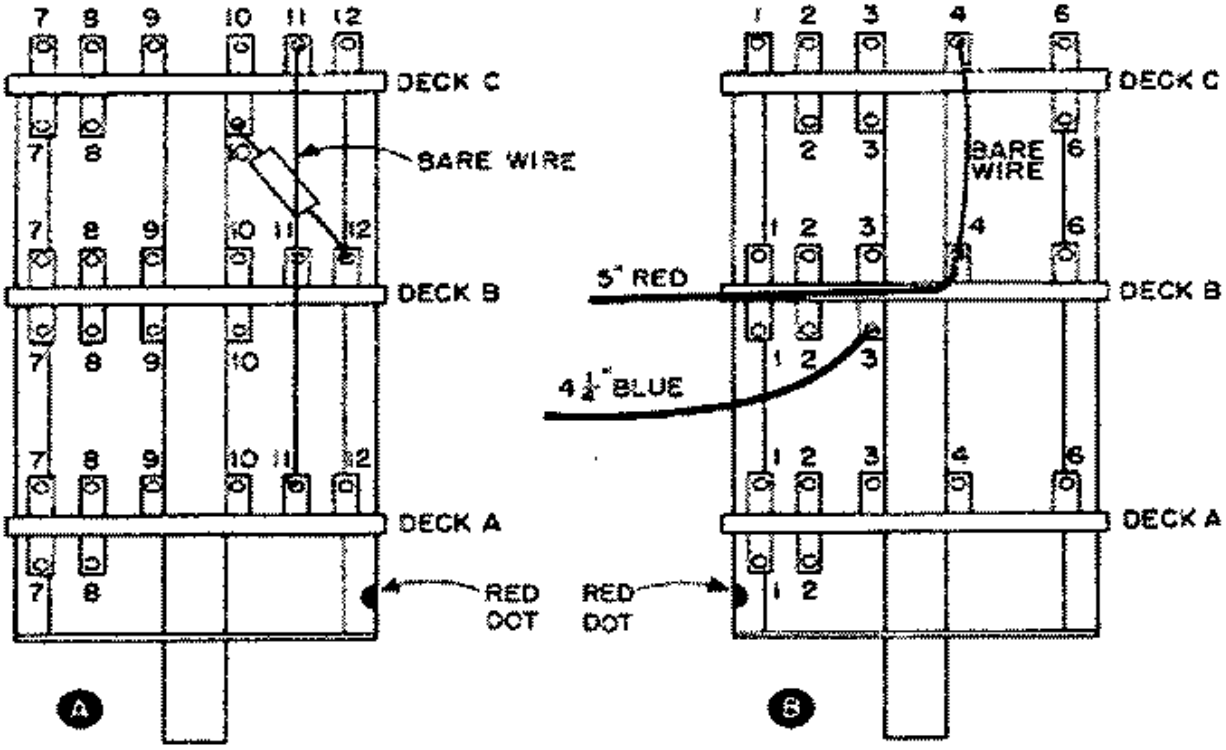


Figure 16 - Side view showing the wiring on deck B.

Front of Deck B

1. Terminal 1 should have no connections. .....
2. Terminal 2 should have no connections. .....
3. Terminal 3 should have a 4-1/2” length of blue hookup wire soldered to it. .....
4. There is no terminal 4. .....
5. There is no terminal 5. .....

6. There is no terminal 6. …….
7. Terminal 7 should have no connections. …….
8. Terminal 8 should have no connections. …….
9. Terminal 9 should have no connections. …….
10. Terminal 10 should have no connections. …….
11. There is no terminal 11. …….
12. There is no terminal 12. …….

Back of Deck B

1. Terminal 1 should have no connections. …….
2. Terminal 2 should have no connections. …….
3. Terminal 3 should have no connections. …….
4. Terminal 4 should have a 5” length of red wire and also a bare wire which connects to terminal 4 back of deck C, soldered to it. …….
5. There is no terminal 5 …….
6. Terminal 6 should have no connections. …….
7. Terminal 7 should have no connections. …….
8. Terminal 8 should have no connections. …….
9. Terminal 9 should have no connections. …….
10. Terminal 10 should have no connections. …….
11. Terminal 11 should have a bare wire fed through the hole but not soldered. …….
12. Terminal 12 should have one lead of a 1.5-megohm resistor soldered to it. …….

Wiring Deck C

The first wiring on deck C will consist of installing two resistors on the front of deck C. Refer to Fig. 17 for the placement of these resistors.

Next, you will wire two capacitors and a resistor on the back of deck C. Refer to Fig. 19 for the placement of these parts. You will need the following parts:

Two 0.01-µF 1kV disc capacitors.
Two 8.2-megohm, 1% 1W resistors.
One 10-megohm, 1% 1W resistor.
2” spaghetti insulation.
Assorted hookup wire.

When you have definitely located the correct terminals on your switch, proceed with the following steps.

( ) Connect one lead of an 8.2-megohm, 1% resistor to terminal 3 on the front of deck C. Connect the other lead to terminal 7 on the front of deck C. See Fig. 17 for placement of the resistor. Cut off the excess wire. Solder terminals 3 and 7.

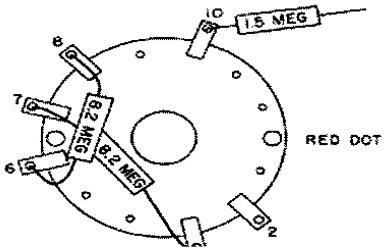


Figure 17 - Placement of parts on the front of deck C.

( ) Connect one lead of an 8.2-megohm, 1% resistor to terminal 6 on the front of deck C. Connect the other lead to terminal 8. Position the resistor as shown in Fig. 17. Solder terminals 6 and 8 on the front of deck C.

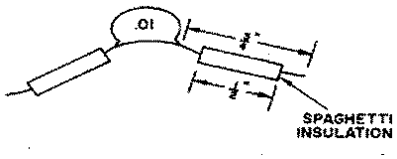


Figure 18 - Preparing the 0.01-µF capacitors for the back of deck C.

This completes the wiring on the front of deck C. Make sure the bodies of the 8.2-megohm resistors are not touching each other or the shaft of the switch. Before proceeding with the wiring on the back of deck C, prepare the two 0.01-µF disc capacitors as shown in Fig. 18. Shorten the leads of the two capacitors to 3/4" length. Slip a 1/2" length of tubular spaghetti insulation over each lead. This insulation prevents the capacitor leads from shorting against other leads. Now proceed with wiring the back of deck C.

( ) Connect one end of a 0.01-µF disc capacitor to terminal 1 on the back of deck C. Connect the other end of this capacitor to terminal 8 on the back of deck C. Position the capacitor as shown in Fig. 19. Solder terminal 1 on the back of deck C.

( ) Connect one end of a 10-megohm, 1% resistor to terminal 6 on the back of deck C. Connect the other end to terminal 9 on the back of deck C. Position the resistor as shown in Fig, 19.

( ) Connect one end of the other 0.01-µF disc capacitor to terminal 6, back of deck C. Connect the other end of the capacitor to terminal 11, back of deck C. Position the capacitor as shown in Fig. 19. Solder terminal 6, back of deck C.

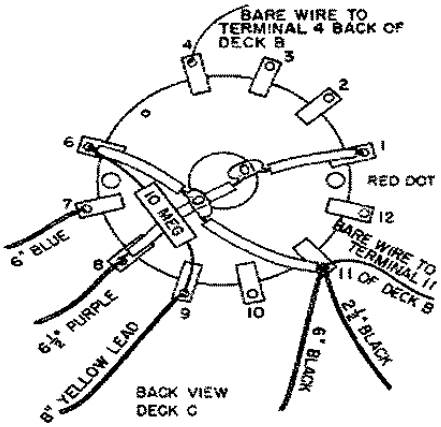


Figure 19 - Wiring on back of deck C.

( ) Connect a 6” blue lead to terminal 7, back of deck C. Leave the other end free. Solder the terminal.

( ) Connect a 6-1/21” purple wire to terminal 8, back of deck C. Leave the other end free. Solder the terminal.

( ) Connect an 8” yellow lead to terminal 9, back of deck C. Leave the other end free. Solder the terminal.

( ) Connect a 2-1/2” black lead to terminal 11, back of deck C. Leave the other end free. Solder the terminal.

( ) Connect a 6” black lead to terminal 11, back of deck C. Leave the other end free. Solder the terminal.

This completes the wiring on the back of deck C. Now check the front and back of deck C with the following check-off lists.

Front of Deck C

1. There is no terminal 1. …….

2. Terminal 2 should have no connections. …….
3. Terminal 3 should have one lead of an 8.2-megohm resistor soldered to it. …….
4. There is no terminal 4. …….
5. There is no terminal 5. …….
6. Terminal 6 should have one lead of an 8.2-megohm resistor soldered to it. …….
7. Terminal 7 should have one lead of an 8.2-megohm resistor soldered to it. …….
8. Terminal 8 should have one lead of an 8.2-megohm resistor soldered to it. …….
9. There is no terminal 9. …….
10. Terminal 10 should have one lead of a 1.5-megohm resistor soldered to it. …….
11. There is no terminal 11. …….
12. There is no terminal 12. …….

Back of Deck C

1. Terminal 1 should have one lead of a 0.01-µF ceramic disc capacitor soldered to it. …….
2. Terminal 2 should have no connections. …….
3. Terminal 3 should have no connections. …….
4. Terminal 4 should have a bare wire soldered to it. …….
5. There is no terminal 5. …….
6. Terminal 6 should have one lead of a 10-megohm resistor and one lead of a 0.01-µF capacitor soldered to it. …….
7. Terminal 7 should have a 6” length of blue wire soldered to it. …….
8. Terminal 8 should have a 6-1/2” length of purple wire and one lead of a 0.01-µF capacitor soldered to it. …….
9. Terminal 9 should have one lead of a 10-megohm resistor and an 8” length of yellow wire soldered to it. …….
10. Terminal 10 should have no connections. …….
11. Terminal 11 should have one lead of a 0.0-µF ceramic disc capacitor, a bare wire, a 6” length of black wire, and a 2-1/2” length of black wire soldered to it. …….
12. Terminal 12 should have no connections. …….

This completes the wiring of the function switch. Remove the switch from the grommet and set the wired switch to one side until you are instructed to install it in the instrument. Leave the grommet installed in hole L.

Remove the front panel from the chassis by removing the 1/4", 6-32 screws from holes X and U. Protect the panel with clean cloth or paper and set it to one side while you work on the chassis.

MOUNTING HARDWARE ON THE CHASSIS

The next thing you are to do is to mount many of the parts on the chassis. Use Figs. 5 and 6 to identify the holes in the chassis. Use Figs. 7 and 8 for the terminal numbers. Use Figs. 20 and 21 for the placement of parts. You will need the following parts:

One chassis with rubber grommet in hole L.

One 7-pin miniature socket.
One 9-pin miniature socket.
Two 3K-ohm linear-taper potentiometers with plastic shafts, lockwashers, and nuts.
One 1-lug terminal strip with mounting foot on left.
One 5-lug terminal strip with mounting lug on right.
One power transformer with dual secondary windings.
Three 1/4”, 6-32 screws.
Three 6-32 nuts.
Four 1/4", 4-40 screws.
Four 4-40 nuts.
Three No. 6 lockwashers.

When you have gathered these parts, proceed with the following steps:

( ) Install the 7-pin socket at hole K from the bottom of the chassis. Position the socket so the pins are located as shown in Fig. 7. Insert a 1/4", 4-40 screw from the top of the chassis through hole K_1. Attach a 4-40 nut.

( ) Insert a 1/4", 4-40 screw from the top of the chassis through hole K_2. Attach a 4-40 nut. Now tighten both screws.

( ) Install the 9-pin socket at hole F from the bottom of the chassis. Position the socket so the pins are located as shown in Fig. 7. Insert a 1/4", 4-40 screw from the top of the chassis through hole F_1. Attach a 4-40 nut.

( ) Insert a 1/4", 4-40 screw from the top of the chassis through hole F_2. Attach a 4-40 nut. Now tighten both screws.

( ) Use a screwdriver to bend down the four unused solder lugs on the mounting ring of the 9-pin socket. By bending these solder lugs down against the chassis, they will be out of your way when you wire the socket.

( ) Prepare the power transformer by shortening the leads. Use a ruler to measure each lead to the specified length. This will assure an easy fit when you connect the leads in the circuit. Cut the leads to the following lengths: two black leads, 4” each; one green lead, 3-1/4”; one green lead, 4-1/2”; one red lead, 7”; one red lead, 3”. Now strip off about 1/4" insulation from the end of each lead. Notice that the leads are stranded wire. Be careful not to cut or nick any of the strands when you strip the insulation.

( ) Install the power transformer on top of the chassis at holes H and I. Position the transformer so the black leads extend through cutout E. The red and green leads are toward the rear of the chassis. Push the two green leads through hole J. Leave the red leads on top of the chassis as shown in Fig. 8. Insert a 1/4", 6-32 screw from the top of the chassis through the hole in the transformer mounting foot and through hole H in the chassis. Attach a No. 6 lockwasher and a 6-32 nut.

( ) Insert a 1/4", 6-32 screw through the other mounting foot and through hole I in the chassis. Attach a No. 6 lockwasher and a 6-32 nut. Now tighten both screws.

( ) Insert a 1/4", 6-32 screw through the mounting foot of the 5-lug terminal strip. Position the 5-lug terminal strip on top of the chassis as shown in Figs. 8 and 21. The terminals are numbered 35, 36, 37, 38, and 39. Extend the screw through hole G from the top of the chassis. Now slip the mounting foot of a 1-lug terminal strip (mounting foot on left) over the screw in hole G on the bottom of the chassis. Position the 1-lug terminal strip as shown in Figs. 7 and 20. This is terminal 21. Attach a No. 6 lockwasher and a 6-32 nut. Tighten the nut.

( ) Slip a control lockwasher over the shaft of a 3K-ohm potentiometer (with plastic shaft). Insert the shaft through hole D from the underside of the chassis. Position the potentiometer as shown in Fig. 20. The terminals of the potentiometer are marked 15, 16, and 17. Attach a control nut over the shaft and tighten the nut.

( ) Slip a control lockwasher over the shaft of the other 3K-ohm potentiometer (with plastic shaft). Insert the shaft through hole C from the underside of the chassis. Position the potentiometer as shown in Fig. 20. The terminals of the potentiometer are marked 18, 19, and 20. Attach a control nut over the shaft and tighten the nut.

This completes the mounting of hardware on the chassis. Carefully examine each part that you have mounted. Make sure that each part is mounted as shown in Figs. 20 and 21.

WIRING THE CHASSIS

You are now ready to begin wiring your instrument. Read through each step before starting it. Use Figs.20 and 21 to see how to place the parts and position the wires. Check off each step as you finish it. You will need the following parts:

One chassis, with hardware mounted.
One 0.01-µF 1kV disc capacitor.
Two 22K-ohm 10% 1/2W resistors (red-red-orange).
One 18K-ohm 10% 1/2W resistor (brown-grey-orange).
Assorted hookup wire.

When you have gathered these parts proceed with the following instructions:

( ) Connect the 3-1/2” green lead coming from hole J from the transformer to pin 3 of V_1.

( ) Connect the 4-1/2” green lead from the transformer to Pin 7 of V_1. Position the lead as shown in Fig. 20.

( ) Connect a 3-1/2” black lead from pin 3 of V_1 to pin 9 of V_2. Solder pin 3 of V_1 and pin 9 of V_2.

( ) Connect a 1-1/2" bare wire from pin 4 of V_1, through the center shield of V_1, and through pin 6 and pin 7 of V_1. Solder pin 4 and pin 6 of V_1.

( ) Connect a 2" red lead to pin 2 of V_2. Leave the other end free.

( ) Connect a 2" green wire from pin 7 of V_1 to pin 5 of V_2. Solder pin 7 of V_1.

( ) Connect a 1-1/2" bare wire from pin 7 of V_2 through the center shield of V_2 and through pin 4 and pin 5 of V_2. Cut off any excess lead. Solder pin 4 and pin 5 of V_2.

( ) Connect a 9" red lead to pin 1 of V_2. Route the lead through cutout E to the top of the chassis and leave the other end free.

( ) Connect a 2-1/4" red lead from pin 1 of V_2 to pin 6 of V_2. Route the lead around the base of the socket. Solder pins 1 and 6 of V_2.

( ) Connect a 7" green wire to pin 2 of V_2. Leave the other end free.

( ) Connect a 0.01-µF disc capacitor between pin 2 of V_2 and the center shield of V_2. Shorten the capacitor leads as necessary. Solder pin 2 of V_2.

( ) Connect a 6" brown lead to the center shield of V_2. Route the lead through cutout E in the chassis and leave the other end free. Solder the center shield of V_2. Make sure all leads connected to the center shield are soldered.

( ) Connect a 4-1/2" blue lead from pin 8 of V_2 to terminal 17. Route this lead next to the chassis and around the potentiometer. Solder pin 8 of V_2.

( ) Connect a 6" orange lead to pin 3 of V_2 and leave the other end free.

( ) Connect a 1-1/2" orange lead from pin 3 of V_2 to terminal 15. Solder pin 3 of V_2.

( ) Twist an orange lead, a green lead, and a blue lead together. Measure off 4-1/2" of this twisted lead and cut it off. At one end, connect the orange lead to terminal 15, the green lead to terminal 16, and the blue lead to terminal 17. Let the other ends of the three twisted leads extend through cutout E in the chassis. Solder terminals 15 and 16.

( ) Connect a 2" blue lead from terminal 17 to terminal 19. Solder terminal 17.

( ) Connect one of the black transformer leads that extends through cutout E to terminal 21.

( ) On top of the chassis, connect the 3" red transformer lead to terminal 39.

( ) Connect the green lead of the three twisted leads to terminal 37.

( ) Connect the orange lead of the three twisted leads to terminal 36.

( ) Connect the blue lead of the three twisted leads to terminal 35.

( ) Connect a 22K-ohm resistor (red-red-orange) from terminal 35 to terminal 38. Solder terminal 35.

( ) Connect a 22K-ohm resistor (red-red-orange) from terminal 36 to terminal 39.

( ) Connect an 18K-ohm resistor (brown-grey-orange) from terminal 37 to terminal 38. Solder terminal 37.

This completes the pre-assembly wiring of your chassis. Check your work with Figs. 20 and 21.

SECURING THE FRONT PANEL OF THE CHASSIS BY MOUNTING THR METER

You will need the following:

One chassis, wired.
One front panel.
One 0-1mA meter with mounting hardware. The mounting hardware consists of four No. 6 split-ring lockwashers and four 6-32 nuts. You will find these items packed in the box with the meter.

When you have gathered these parts, proceed with the following steps using Figs. 3 and 4 as a guide.

( ) Your meter may have been shipped with a wire jumper connected between the meter terminals. This jumper provides additional damping to protect the meter movement during shipment. Remove and discard the wire jumper.

( ) Position the meter on the front panel so the four meter mounting studs extend through holes S, N, X, and U and so the round portion of the meter case extends through hole V.

( ) Attach a No. 6 lockwasher and a 6-32 nut to the studs at holes S and N. Tighten the nuts. Be very careful not to over-tighten these nuts as it is easy to crack the plastic meter case. You will know when you have the nuts tight enough by observing the split-ring washer. Tighten the nut until the split-ring lockwasher is squeezed flat. Any additional tightening will put excessive pressure on the plastic and can cause the meter case to crack near the studs.

( ) Position the front panel against the front of the chassis. See Fig. 5 for identifying holes in the chassis. Position the panel so the meter mounting stud at hole X in the panel lines up with hole A in the chassis and the stud at hole U in the panel lines up with hole B in the chassis. Notice that the plastic shafts on the potentiometers at holes C and D in the chassis extend through holes Z and Y in the front panel.

( ) Attach a No. 6 lockwasher and a 6-32 nut to the studs at holes A and B of the chassis. Again, be careful not to over-tighten these nuts.

MOUNTING PARTS ON THE FRONT PANEL

You will need the following:

Two 3K-ohm linear-taper potentiometers with short metal shafts, lockwashers and nuts.
One 1-lug terminal strip with mounting foot on right.
One 160V 0.65A selenium rectifier.
One pre-wired range switch, with lockwasher and nut.
One pre-wired function switch, with lockwasher and nut.
Two control knobs.
Two control flat washers.
Two 1/4", 6-32 screws.
Two No. 6 lockwashers.
Two 6-32 nuts.

When you have gathered these parts, proceed with the following steps:

( ) Slip a control lockwasher over the shaft of a 3K-ohm potentiometer (short metal shaft). Install this potentiometer at hole Q, see Figs. 3 and 4, in the panel. Position the terminals as shown in Figs. 8 and 25. Secure the potentiometer with a control nut.

( ) Slip a control lockwasher over the shaft of the other 3K-ohm potentiometer (short metal shaft). Install this potentiometer at hole P in the front panel. Position the terminals as shown in Figs. 8 and 25. Secure the potentiometer with a control nut.

( ) Install the 1-lug terminal strip at hole O in the front panel. Insert a 1/4", 6-32 screw through hole O from the top of the panel. Attach the mounting foot of the 1-lug terminal strip, then a No. 6 lockwasher and a 6-32 nut. Position the terminal strip (terminal 32) as shown in Figs. 8 and 25. Tighten the nut.

( ) Insert a 6-32, 1/4" screw through hole R from the top of the panel. Attach the selenium rectifier to this screw so the screw extends through the hole in the rectifier mounting clip. Attach a No. 6 lockwasher and a 6-32 nut. Position the selenium rectifier as shown in Fig. 25. Tighten the nut.

Note: Terminal 24 is the positive terminal of the selenium rectifier. This is the terminal closest to the panel. Refer to Fig. 25 when making connections to terminals 24 and 25 of the selenium rectifier.

( ) Slip a control lockwasher over the shaft of the pre-wired range switch. Insert the shaft of the range switch through hole BB from the rear of the panel. Position the switch so the terminals are located as shown in Fig. & and Fig. 24. Attach a flat control washer and a control nut. Tighten the nut.

( ) Attach a control knob to the shaft of the range switch. With the switch turned fully counterclockwise, position the knob so that the white line points to 3V on the panel. Tighten the knob set screw.

( ) Slip a control lockwasher over the shaft of the pre-wired function switch. Insert the shaft of the function switch through hole CC from the rear of the panel. Position the switch as shown in Figs. 7

and 24. Be sure the red dot is toward the center of the instrument. Attach a flat control washer and a control nut. Tighten the nut.

( ) Attach a control knob to the shaft of the function switch. Position the knob so that the set screw lines up with the flat area on the shaft. Tighten the knob set screw. With the switch turned fully counterclockwise, the white line on the knob will point to "OFF".

FINAL WIRING AND PARTS INSTALLATION

You will need the following:

One 12BH7 vacuum tube.
One 6X4 vacuum tube.
Two 51K-ohm 5% 1W resistors (green-brown-orange).
One 20-µF 150V electrolytic capacitor.
One line cord.
One 36" flexible ground lead.
One alligator clip with black insulator.
One assembled test probe with coaxial cable and red insulator.
One 1.5-volt size "D" dry cell or alkaline cell.
Assorted hookup wire.

When you have gathered these parts proceed with the following steps. Refer to Figs. 7 and 8 to locate terminals. Refer to Figs. 24 and 25 for parts placement and lead location.

( ) Connect the black lead that extends from the transformer through cutout E to terminal 6 on the back of deck B of the function switch. Solder terminal 6.

( ) Connect the 6" black lead from terminal 11 on the back of deck C of the function switch to the center shield of V_1. Solder the center shield of V_1.

( ) Connect the free end of the single wire from the cluster of resistors on the range switch to pin 2 of V_1. Solder pin 2 of V_1.

( ) Connect the free end of the 6" blue lead from terminal 7, back of deck C, to terminal 7 on the range switch. Solder terminal 7 on the range switch.

( ) Connect the free end of the 6-1/2" purple lead from terminal 8 on the back of deck C to pin 1 of V_1. Solder pin 1 of V_1.

( ) Connect the free end of the 10K-ohm, 1% resistor from terminal 2 of the range switch to pin 7 of V_2. Solder pin 7 of V_2.

( ) Connect the free end of the 2” black lead from terminal 4 on the back of deck A of the function switch to terminal 20. See Fig. 7. Solder terminal 20.

( ) Connect the free end of the 3” green lead from terminal 3 on the back of deck A of the function switch to terminal 19. Solder terminal 19.

( ) Connect the free end of the 7” green wire from pin 2 of V_2 to terminal 10 on the back of deck C of the function switch. Solder terminal 10 on the back of deck C.

( ) Connect the free end of the 6” orange lead from pin 3 of V_2 to terminal 10 on the back of deck A of the function switch. Solder terminal 10 on the back of deck A.

( ) Connect the free end of the 5” red lead from terminal 4 on the back of deck B of the function switch to terminal 13. Solder terminal 13.

( ) Connect the free end of the 4-1/4” blue lead from terminal 3 on the front of deck B of the function switch to terminal 14. Solder terminal 14.

( ) Locate the 8” yellow lead from terminal 9 on the back of deck C of the function switch. Push the free end of this lead up through cutout E in the chassis and connect the free lead to terminal 27. See Fig.8. Solder terminal 27.

( ) Connect the 7” red lead from the power transformer to terminal 25. Do not confuse with terminal 24. The side of the rectifier case next to terminal 25 is unmarked. Solder terminal 25.

( ) Connect the free end of the 4-1/2” red lead from terminal 6 on the back of deck A of the function switch to terminal 33 which is the + terminal of the meter. See Fig. 8. Solder terminal 33. Be careful not to touch the plastic meter case with the hot soldering iron.

( ) Connect the free end of the 5-1/2” black lead from terminal 12 on the rear of deck A of the function switch to terminal 34. Route the lead through cutout E in the chassis. Solder terminal 34.

( ) Connect the free end of the 6” brown lead from the center shield of V_2 to terminal 28. This lead extends up through cutout E in the chassis.

( ) Locate the 7” blue wire on terminal 2 on the back of deck A of the function switch. Route the free end of this lead up through cutout E in the chassis. Connect the lead to terminal 30. Solder terminal 30.

( ) Connect the free end of the 9” red lead from pin 1 of V_2 to terminal 24. This lead extends up through cutout E in the chassis. Do not confuse terminal 24 with terminal 25. The side of the rectifier case (not necessarily visible) next to terminal 24 has a + mark or red dot. Terminal 25 is unmarked.

( ) Connect a 51K-ohm resistor (green-brown-orange) from terminal 24 to terminal 26. Solder terminal 26.

( ) Connect a 51K-ohm resistor (green-brown-orange) from terminal 28 to terminal 32. Solder terminal 28.

( ) Connect a 6” purple lead from terminal 32 to terminal 38.

( ) Connect a 5” orange lead from terminal 31 to terminal 36. Solder terminal 31 and 36.

( ) Connect the lead on the positive end of the 20-µF capacitor to terminal 24. Position the capacitor as shown in Fig. 25. Be sure to observe the polarity marking on the capacitor. Solder terminal 24.

( ) Connect the negative lead of the 20-µF capacitor to terminal 32. Solder terminal 32.

( ) Run a bare wire between terminals 38 and 39. Solder terminals 38 and 39. Make sure that all wires connected to these terminals are well soldered.

( ) Insert the prepared end of the test probe cable through the metal grommet in hole EE from the front of the panel. Connect the center lead of this coaxial cable to terminal 12 of the rear of deck C of the function switch. See Fig. 22 for details of the coaxial cable and how the cable is connected to the switch. Solder terminal 12, rear of deck C.

( ) Solder the tinned end of the braided shield of the coaxial cable to the bare wire that extends from terminal 11 on deck C to terminal 11 on deck B of the function switch. Also solder terminal 11 on deck B.

( ) Insert one end of the 36” black flexible ground lead through hole FF from the front of the panel. Solder this lead to the bare wire that extends from terminal 11 on the B deck to terminal 11 on the A deck of the function switch.

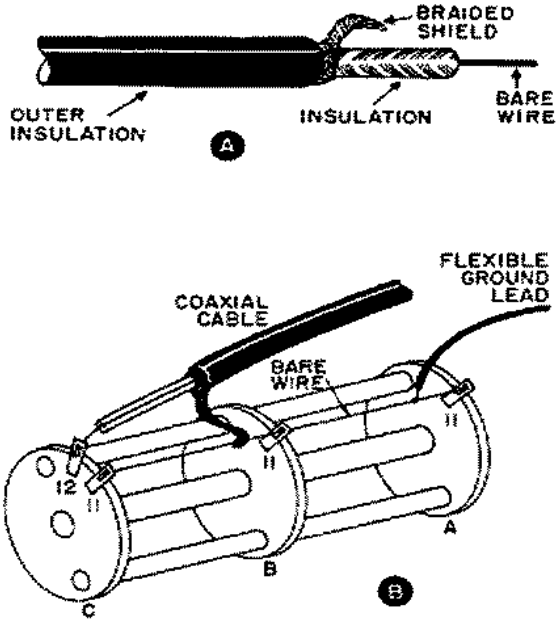


Figure 22 - (A) Prepared end of the coaxial cable. (B) Connections to the function switch.

( ) Slip the alligator clip over the free end of the black flexible ground lead. Push the bare end of the wire under the small loop in the clip and solder the connection. See Fig. 23.

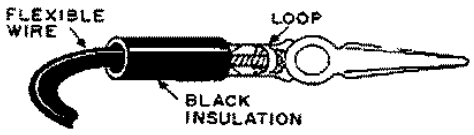


Figure 23 - How to attach the flexible wire to the alligator clip.

( ) Tin a spot on the center of the bottom of the 1.5-volt “D”-type dry cell. It may be necessary to file or sandpaper the spot lightly before attempting to tin it. Use plenty of heat and be sure the solder “wets” the spot. Add a small gob of solder to the tinned spot so it will be easy to a lead later.

( ) Insert the dry cell in the curved battery clip under the chassis. Position the cell so the positive terminal (raised center terminal) is toward the edge of the chassis. This is terminal 22 in Fig. 7.

( ) Solder the free end of the 2" red lead from pin 2 of V1 to the positive terminal, terminal 22, of the dry cell.

( ) Solder the free end of the 2-1/2" black wire from terminal 11 on the back of deck C of the function switch to the tinned spot on the negative end of the dry cell. This is terminal 23 in Fig. 7.

( ) Insert the end of the line cord through the grommet in hole L from then back of the chassis. Tie an overhand knot about 3" from the end of the cord. Pull the cord so the knot is pulled up against the rubber grommet.

( ) Connect one lead of the line cord to terminal 21. Solder terminal 21.

( ) Connect the other lead of the line cord to terminal 10 on the rear of deck B of the function switch. Solder the terminal.

( ) Install the 6X4 tube in the 7-pin socket, V_1.

( ) Install the 12BH7 tube in the 9-pin socket, V_2.

This completes the wiring and parts installation of your instrument. Carefully check your work. Examine the position of each part to make sure that it is in the proper location and is not touching some other part. Examine the soldered connections to make sure that they are well soldered. Take particular notice of the resistors and the solder connections around the range switch. Make sure that the body of the 1% resistors are not touching other wires or other resistors or the metal portion of the switch. If these resistors touch, they can cause undesirable leakage to other portions of the instrument. Look for loose solder that may have melted and run down onto the connections or into the switch. You will not install the instrument into the case until after you have tested and calibrated the completed instrument.

ASSEMBLING THE HIGH VOLTAGE PROBE

If you have purchased a high voltage probe with your VTVM, you will need to assemble it. Your high voltage probe has three sections, the red probe tip, the multiplier resistor fitted with spring, and the black handle threaded at one end. To assemble the high voltage probe, proceed with the following instructions:

( ) Insert spring end of multiplier into threaded end of black handle.

( ) Slip red barrel over end of multiplier and screw it into black handle. Do not force – the red and black barrels do not fit flush.

This completes the probe assembly. If you pull the spring off the multiplier before assembly, do not be alarmed – no damage has been done. Just slip the spring (either end) into the threaded end of the black handle and insert either end of the multiplier after the spring. Screw on the red probe tip as directed above.

TESTING AND CALIBRATING THE COMPLETED INSTRUMENT

Calibrate your VTVM before installing it in the case since you have access to the calibration potentiometers and the 1.5-volt cell. Ordinarily you will only have to recalibrate when you renew the 1.5-volt cell. This cell will usually last from six months to one year.

The first step in calibrating your meter is to make sure the pointer reads zero when the instrument is turned "OFF". Set the meter upright on a flat surface. Observe that the pointer lines up with the zero mark on the left-hand edge of the scale. If it does not, you will have to reset the mechanical zero of the meter before proceeding with the electrical calibration.

Reset the mechanical zero of the meter with a screwdriver as shown in the photo in Fig. 26. Rotate the plastic screw in the center of the meter face until the meter pointer is exactly on zero. Be sure you are looking directly at the meter face to observe the pointer. If you observe the meter from an angle, there will be an error caused by parallax. When you have the pointer set at mechanical zero, you are ready for the electrical calibration.

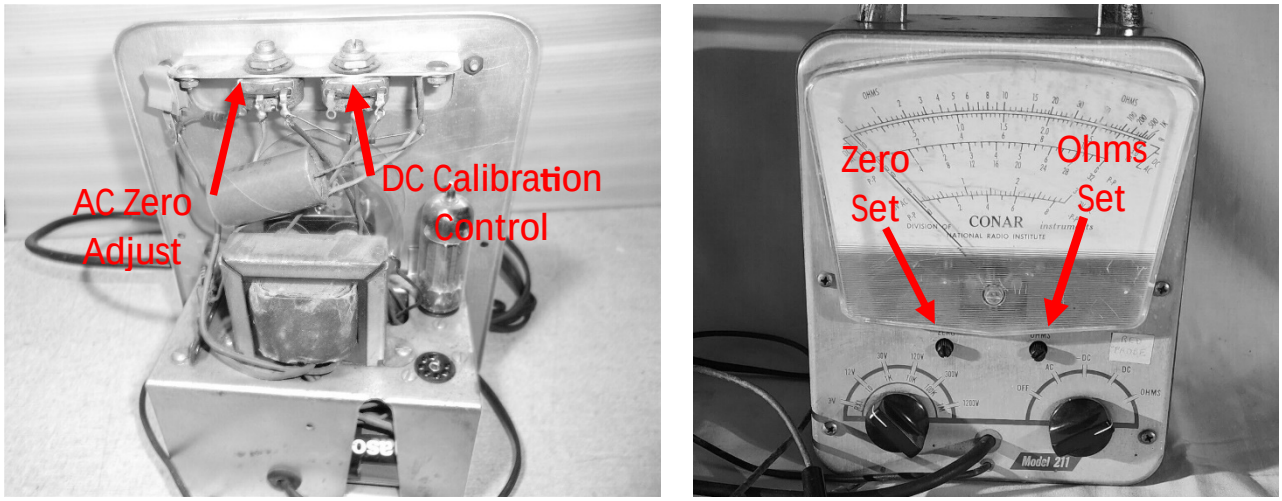


Figure 27 - Location of the calibration and adjustment potentiometers.

Plug the line cord into a 115-volt 60-cycle AC electrical outlet. DO NOT PLUG THE INSTRUMENT INTO A DC SUPPLY. If you do, serious damage to your instrument will result. Rotate the function switch to +DC and the range switch to the 3V position. The meter pointer will probably move up or down scale after the tubes warm up for about 30 seconds. You should observe that the filaments in the tubes light up. Let the instrument warm up for about five minutes.

CAUTION: Dangerous voltages exist in the instrument. Use extreme care whenever the instrument is out of its case and plugged into an AC outlet. Be careful not to touch the exposed wiring and terminals.

After the instrument has warmed up, proceed with the following calibration steps. You can locate the calibration potentiometers from the photo in Fig. 27.

With the function switch at +DC and the range switch at 3V, set the pointer to read zero using the ZERO SET on the front panel. Touch the probe of the VTVM to the positive terminal, terminal 22, of the 1.5-volt cell. See Fig. 28. Be careful not to touch the probe to any other leads or terminals. Adjust the AC-DC calibration control

until the meter pointer reads exactly 1.5 volts on the 3-volt scale. The AC-DC calibration control is the 3K-ohm potentiometer mounted in hole P of the panel. This is the control on your left when you look over the top of the instrument from the front. See the photos in Fig. 27. Remove the probe from the positive terminal of the 1.5-volt cell and see if the meter pointer goes back to zero. If not, adjust the ZERO SET until it does go to zero. Again, touch the positive terminal of the cell and readjust the calibration control for a 1.5-volt reading. It may be necessary to repeat these adjustments several times until the meter reads accurately for both the zero and the 1.5-volt readings.

Switch the function switch to -DC. The pointer may move a slight amount up or down scale from zero. If it moves only one division or less, it is considered satisfactory. If it moves off zero more than one division on the 3-volt scale, turn the instrument off and reset the mechanical zero of the pointer as previously explained. Then repeat the above electrical calibration steps.

Switch the function switch to AC and clip the ground lead to the tip of the probe. Rotate the AC calibration control until the pointer reads zero. The AC calibration control is the 3K-ohm potentiometer mounted to hole Q of the panel. This is the control on your right when you look over the top of the instrument from the front. See the photo in Fig. 27.

When you separate the ground lead and the probe, the meter pointer will probably move upscale. This is normal. A small amount of AC is picked up by the probe and since the VTVM is very sensitive on the 3-volt scale, it responds to the small pick-up voltage. If you touch the probe with your finger, the meter will read off scale because your body acts as an antenna that picks up a sizable AC voltage. The fact that the meter does not read zero due to AC pickup will not affect the Accuracy of your readings. When the VTVM is connected to a circuit for taking an AC voltage reading, the pickup voltage will not affect the reading.

Switch the function switch to OHMS. With the ground lead clipped to the tip of the probe, the meter will read a fraction of one ohm. This reading is normal and is due to the resistance of the coaxial cable and the ground lead. Unclip the ground lead from the probe tip. Adjust the OHMS SET adjustment on the front of the panel Until the meter reads infinity (last mark on the right-hand end of the ohms scale).

This completes the calibration of your VTVM. The 12BH7 tube that you receive with your VTVM has been aged and tested for proper operation in this circuit. Therefore, your VTVM will stay in calibration. If you ever have to replace the 12BH7 tube with one that has not been aged, the calibration will have to be checked after the new tube has been operated for about 48 hours. Or you can purchase an aged and tested tube from CONAR. Normally, you can expect the tubes to last five years or more.

Any time you replace the 1.5-volt cell you should go through the complete calibration procedure. As mentioned before, you can expect six months to one year or more of service from a cell depending on the amount you use the ohmmeter section of your VTVM. A weak cell will show up first on the R X 1 ohms scale. The ohms readings will be low. If you suspect the cell is weak, compare the voltage of the cell in the VTVM with the voltage of a new 1.5-volt size “D” cell. Replace as necessary.

The initial calibration given above must be carried out in the order that the steps are given. After the calibration is completed and the instrument is installed in the cabinet, the ZERO SET and the OHMS SET are the only two adjustments that may need resetting. Remember to adjust the ZERO SET with the function switch

on +DC and the range switch on 3V. Reset the OHMS SET with the function switch on OHMS and the range switch on the range that you are using.

IN CASE OF TROUBLE

Your VTVM will probably work all right when you have completed the assembly. However, if it does not or if you cannot calibrate it properly, check the following:

1. Make sure you are plugged into as good electrical outlet. Try a lamp in the same socket. If the lamp lights, the outlet is good. Try spreading the prongs slightly on the power plug of your VTVM to be sure that they will make contact in the outlet.

2. Unplug your VTVM and check the soldered connections. Make sure that every wire in every connection is well soldered. Check to make sure that the wires or terminals in the connections are not touching some OTHER WIRE OR PART. Check to see that the bodies of the resistors around the range switch are not touching each other or other wires in the switch assembly.

3. If one of the tubes fails to light, remove it and test the tube in a tube tester.

4. Check to make sure you have not made a wiring error. Go back through the instructions and make sure that you have performed each step correctly.

If you locate a defective part, write us giving the part number and the name of the part. We will furnish a replacement. Do not send the defective part to us unless instructed to do so. Do bot disassemble the defective part as this may void the warranty.

If you have a defect in your VTVM that you cannot find yourself, use our free CONAR Consultation Service. Write us explaining your difficulty in detail. Do the tubes light? Does the instrument work only on some functions? Which ones? How does it act? What steps in the calibration can't you perform? The more information you can give us, the better chance we have of giving you the necessary information to get your VTVM operating properly.

If you cannot repair your VTVM yourself, you can return it to CONAR for repair. If it is necessary to do this, we will make a service charge of $5.00 plus the cost of any parts that may have been damaged due to wiring errors. If you send your VTVM to us for repair, proceed as follows:

1. Write to us that it is on the way, and explain the nature of your difficulty.
2. Enclose your remittance for the $5.00 service charge with your letter. Use a check or money order; do not send cash.
3. Pack the VTVM in a sturdy carton. Protect the instrument by filling the extra space with crushed newspapers.
4. Send it to us b y prepaid express or insured parcel post. We will return your instrument express collect or insured parcel post.

INSTALLING THE INSTRUMENT IN THE CABINET

You will need the following parts:

One cabinet.
One handle with mounting screws.
Four No. 6 Phillips head self-tapping screws.
One No. 6 hex head self-tapping screw.

Before you install the VTVM in the cabinet, mount the handle on the top of the cabinet. Unplug the VTVM from the power outlet. Thread the AC line cord inside the cabinet and then out through the large hole in the back of the cabinet. Slip the chassis into the cabinet while pulling the line cord out the back. Line up the

four screw holes in the edge of the panel with the screw holes in the cabinet. Insert the four No. 6 Phillips head self-tapping screws in the four screw holes in the front panel. These screws tap their own threads as they are screwed into the holes in the cabinet. Start all four screws before completely tightening them. Insert one No. 6 hex head self-tapping screw in the screw hole in the back of the cabinet. A little finger pressure on the line cord may be necessary to cause the hole in the chassis to line up with the hole in the cabinet. Tighten the screw.

OPERATING THE CONAR MODEL 211 VTVM

Your CONAR Model 211 VTVM can be used to measure AC voltages, DC voltages, and resistances. The operating controls are conveniently arranged for simple switching from one function to another. Only one set of test leads are used to take the readings on all functions. The readings are indicated on an easy-to-read 6" meter. The scale on the meter that indicates the correct reading depends on the function selected and the setting of the range switch. A detailed discussion of the use of the scales is included in these operating instructions. A few minutes spent in studying these operating instructions will be repaid in easier and more pleasant use of this fine instrument.

OPERATING CONTROLS

The two operating controls are the ON-OFF Function Switch and the Range Switch. Two other seldom used controls are accessible on the front panel. These are the ZERO SET and the OHMS SET. In addition, there is a screwdriver adjustment on the face of the meter. This adjustment is used for setting the mechanical zero of the meter needle. Do not touch this adjustment unless the need for adjustment has been determined after a careful study of the calibration instructions given elsewhere in this manual.

The On-Off Function Switch. This control is a pointer knob located in the lower right-hand corner of the front panel. The switch has five positions marked OFF, AC, -DC, +DC and OHMS. In the OFF position, the switch opens the line from the external AC supply and the instrument is completely de-energized. In any position other than OFF, the AC line is connected to the internal power supply transformer and the instrument is "ON" or energized.

In the AC position, the VTVM is set up to measure AC voltages that are applied to the test leads. The VTVM will respond to AC voltages of any frequency or waveform. However, the AC scales are calibrated to indicate RMS voltages of sine waves. The P-P scales are calibrated to read peak-to-peak values of sine waves. This should be considered when taking AC readings of irregular waveforms.

In the -DC position, the VTVM is set up to measure DC voltages that are applied to the test leads in such a way that the voltage at the test probe is negative with respect to the ground clip lead. This is simply a convenient position so that you do not have to interchange test leads when going from taking positive voltage readings to taking negative voltage readings.

In the +DC position, the VTVM is set up to measure voltages that are applied to the test leads in such a manner that the voltage at the test probe is positive with respect to the ground clip lead.

In the OHMS position, a 1.5-volt cell is switched into the test lead circuit and the instrument is set up to measure the resistance of components that are connected between the test probe and the ground clip lead.

The Range Selector Switch. This control is a pointer knob located in the lower left-hand corner of the front panel. This 6-position switch has two markings for each position – one for volts and one for ohms. These markings are arranged in two concentric arcs. The readings on the outside arc are 3V, 12V, 30V, 120V, 300V, and 1200V. These voltage ranges apply to the AC, -DC, and +DC functions. The meter will deflect full-scale when a voltage equal to the selected markings on the arc is applied to the test leads. Thus, the position of the range switch indicates the full-scale value of the appropriate scale.

The six markings on the inside arc of the range switch are for ohms. The markings indicate the multiplying factor for the ohms reading. The R X 1 position indicates that the resistance of the component connected between the test leads is that value which is indicated on the OHMS scale of the meter. The 10K position indicates that the ohmmeter reading should be multiplied by 10 to give the correct value of resistance being measured. Likewise, the 1K position indicates a multiplying factor of 1,000, the 10K position indicates a multiplying factor of 10,000, the 100K position indicates a multiplying factor of 100,000 and the 1M position indicates a multiplying factor of 1,000,000.

Zero Set. This control is located just below the meter on the left of center on the front panel. The control is used to set the pointer on zero electrically when the Function Switch is set at +DC and the Range Switch is set at 3V. Do not use this control to zero the meter when the operating controls are in any other position. This adjustment should be made only when the instrument has been warmed up for at least five minutes. The adjustment has to be made only on infrequent occasions.

Ohms Set. This control is located just below the meter to the right of center on the front panel. It is used to set the meter to infinity on the ohms scale when the Function Switch is set to OHMS and the Range Switch is set to the desired range. The test leads should not be in contact with each other. This adjustment needs to be made only infrequently.

THE METER SCALES

The scales on your CONAR Model 211 VTVM are divided into five graduated arcs. Most of these graduated arcs are read in several different ways giving an effective total of 24 scales. Let's examine each scale carefully.

Ohms Scale. The top scale is marked OHMS and is graduated left to right from zero to infinity. The small marks between zero and one are each 0.2 ohm. Likewise, the small marks between 1 and 2 and between 2 and 3 are also 0.2 of an ohm markings. The small mark between 3 and 4 indicates 0.5 ohm. A 0.5-ohm marking is also placed between 4 and 5, between 5 and 6, between 6 and 7, between 7 and 8, and between 8 and the large un-numbered line that indicates 9 ohms. There are no marks between 9 ohms and 10 ohms.

The short marks between 10 ohms and 15 ohms are each 1 ohm. Likewise, the short marks between 15 and 20 are each 1 ohm. The value of the short marks between 20 and 30 are each 2 ohms. The value of the short marks between 30 and 50 are each 5 ohms. The value of the short marks between 50 and 100 are each 10 ohms. The short mark between 100 and 200 indicates 150 ohms. The short marks between 200 and 500 are each 100 ohms. The short mark between 500 and 1K indicates 750 ohms. The last mark on the right-hand end of the ohms scale indicates infinite resistance and is labeled ∞.

Use the ohms scale only when the Function Switch is set at OHMS. The Range Switch may be set at any one of its positions. In the R X 1 position, the ohms scale is read directly. In the (R X) 10 position indication, the meter reading must be multiplied by 10. For example, if the meter points to 20 and the range switch is on the RX10 position, the correct reading is 200 ohms.

In the 1K position, the meter indication must be multiplied by 1,000. For example, if the meter pointer indicates 20 and the range switch is in the1K position, the correct reading is 20,000 ohms.

In the (R X) 10K position, the meter indication must be multiplied by 10,000 and a meter indication of 20 would be read as 200,000 ohms.

In the (R X) 1M position the meter indication must be multiplied by 1,000,000 and a meter indication of 20 would be read as 20 megohms (20,000,000 ohms).

AC or DC Voltage Scales. The second scale from the top is labeled AC-DC. This single set of graduations has two sets of numbers. The 0-3 set of numbers is used when the range switch is set to 3V, 30V, or 300V. Only DC is read on the 0-3 scale. There is a separate red scale for reading 0-3V AC. However, both AC and DC are read on the 30V and 300V scales. The 0-12 set of numbers is used when the range switch is set to 12V, 120V, or 1200V. These scales are used for both AC and DC.

Do not attempt to measure AC voltages over 600 volts.

P-P Scale (black). The black scale labeled P-P is used to read peak-to-peak voltage readings. The readings will be accurate only when the waveform of the AC voltage is essentially a pure sine wave. The scale has two sets of markings, 0-8 and 0-32. The 0-8 scale is used when the range switch is set to 30V or 300V. The peak-to-peak readings are from 0 to 80 volts read on the 0 to 8 volts black P-P scale with the range selector set at 30V. The peak-to-peak readings are from 0 to 800 volts read on the 0-8 black P-P scale with the range switch set at 300V.

The 0-32 black P-P scale is used when the range switch is set to 12V, 120V, or 1200V. The peak-to-peak readings are from zero to 32 volts on the black P-P scale when the Range Switch is on 12V. The peak-to-peak readings are from 0 to 320 volts on the 0-32 black P-P scale when the Range Switch is set on 120V. The peak-to-peak readings are from 0 to 3200 volts on the 0-32 black P-P scale when the range selector is set on 1200V.

CAUTION: You should not attempt to measure AC voltage above 600 volts RMS. This gives a peak-to-peak reading of over 1600 volts.

3V AC Scale (Red). The re8d scale graduated from 0 to 3 is used for reading AC voltages smaller than 3 volts. When using this scale, the function switch is set at AC and the range switch is set at 3V.

P-P Scale (Red). The red scale, labeled P-P and graduated from 0-8 is used to indicate the peak-to-peak values of AC voltages between 0 and 8 volts peak-to-peak. When using this scale, the function switch is set at AC and the range switch is set at 3V.

USING YOUR VTVM

Plug the line cord of the VTVM into a 115-volt, 60-cycle AC electrical outlet. DO NOT PLUG THE INSTRUMENT INTO A DC SUPPLY. If you do, serious damage to your instrument will result.

Rotate the function switch to +DC and the range switch to 3V. The meter pointer will probably move up or down scale from zero as the tubes warm up. Let the instrument warm up for at least five minutes.

After the instrument is warmed up, set the pointer exactly on zero using the ZERO SET. Now switch the function switch to OHMS. The meter pointer will move toward the high end of the scale. Adjust to OHMS SET so that the pointer reads infinity – the last mark on the right side of the OHMS scale.

Your instrument is now adjusted and ready for taking measurements in any of the function positions.

The meter movement in your VTVM is almost burn-out proof. That is, if you momentarily apply 300 volts to the test leads with the range switch ono 3V, for example, the meter will not burn out. However, the meter pointer will peg off-scale. Repeated mis-use of the meter in this manner can damage the meter.
Be careful not to apply voltage to the test leads with the function switch set at OHMS. The applied voltage will be dropped across the precision multiplying resistors on the range switch. If the range switch is on a low range, the large applied voltage will burn out a multiplying resistor. If it does not burn the resistor out, the resistor may overheat and change value. This will cause errors in your ohms reading on that range and the resistor will have to be replaced.

Your VTVM is designed for continuous operation. It is normal practice to tourn it on when you start working at your bench and leave it on all day. Then it is always warmed up and ready anytime you want to take a measurement.

HIGH VOLTAGE DC MEASUREMENTS

If you purchased the high voltage probe with your VTVM, you can measure DC voltages up to 30,000 volts.

WARNING

To avoid the possibility of a shock, the VTVM ground clip must ALWAYS be attached to the negative side of the voltage source you are to measure and you must hold the probe by its black end.

Insert the probe of your VTVM into the hollow handle of the high voltage probe so the VTVM probe tip is fully engaged. Attach the VTVM ground clip to the negative side of the receiver circuit. Set the function switch to +DC and the range switch to 1200 volts. Holding the high voltage probe so the round flanges are between your hand and the red tip, touch the tip of the probe to the voltage source.

Read the voltage on the 0-3 black scale and multiply your reading by 10,000. A reading of 3 is 30,000 volts, the maximum voltage which can be measured. A reading of 1.25 is 12,500 volts. A meter reading of 1.1 indicates 11,000 volts. Another way to read voltages is to ignore the decimal points on the scale and read in thousands of volts. Thus, a meter indication of 1.5 is 15 thousand volts.

Just remember when using the high voltage probe to set the range switch to 1200 volts and that the range of the VTVM is now 0-30,000 volts: read the 0-3 black scale. If you did not purchase a high voltage probe with your VTVM, they are available postpaid from CONAR for $5.50.

MAINTENANCE

Your CONAR Model 211 VTVM should give you years of service with only minor maintenance. The 1.5-volt type “D” dry cell will have to be replaced occasionally. It will last six months to a year or more depending on the amount you use the ohmmeter section of your VTVM. The first indication of a weak cell will be inaccurate readings on the low OHMS range. The readings will be low. With a very weak cell you will not be able to adjust the meter to infinity with the OHMS SET adjustment.

To replace the 1.5-volt cell, remove the instrument from the cabinet. Unplug the VTVM from the electrical outlet. Remove the four Phillips head screws from the front panel. Remove the single slotted hex head screw from the center of the back of the cabinet. This screw is located just above and to the right of the line cord hole. The instrument can now be taken out of the cabinet.

Unsolder the leads connected to each end of the 1.5-volt cell. Remove the cell from the battery clip. The cell is soldered in the circuit of your VTVM to assure a positive electrical connection. For this reason, it is important that you make good soldered connections to the new cell.

Before installing the new cell, tin a spot at each end of the cell. Use a file or sandpaper to clean the metal before tinning. Use enough heat to make sure that the solder takes to the metal. Deposit a little solder on the tinned spot so that it will be easy to connect a lead to it.

The new cell should be the type with a cardboard outer covering. If your new cell has a painted metal jacket, we suggest that you wrap the cell with tape or thin cardboard. If the metal case of the cell touches the chassis, it will cause electrical leakage and upset the operation of your VTVM.

Install the new cell in the battery clip with the positive terminal toward the edge of the chassis. Solder the red lead to the positive terminal and the black lead to the negative terminal.

When you replace the cell in your VTVM, you must recalibrate the instrument. Follow the instructions in the section entitled "Testing and Calibrating the Completed Instrument." You will find this section in the assembly instructions of this manual. In the same section you will find instructions about replacing the 12BH7 tube. If you find it necessary to replace this tube, refer to these instructions.

If your VTVM develops a defect, you can probably repair it yourself. Refer to the schematic diagram in Fig. 29. Use standard troubleshooting techniques to locate defective parts.

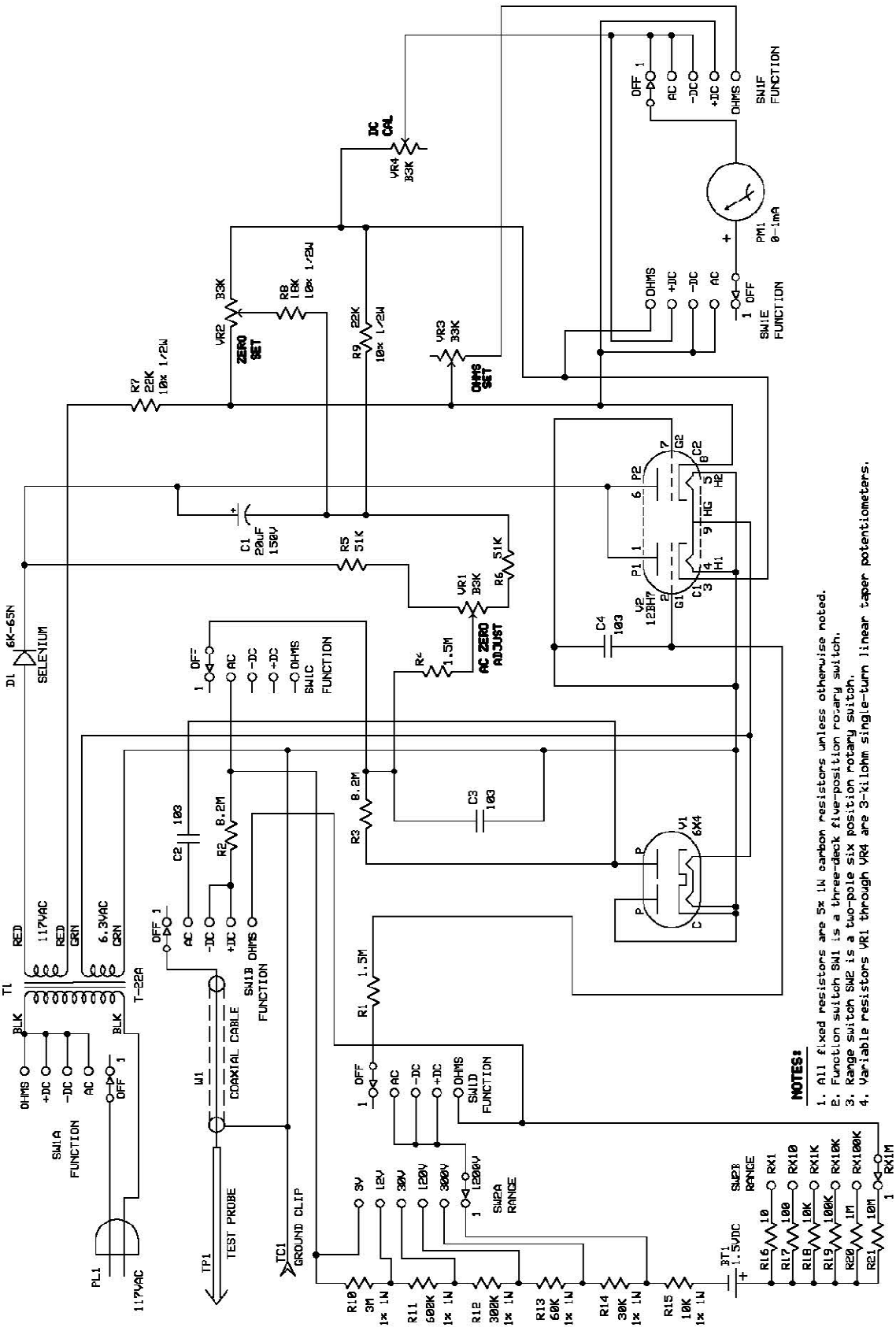
If your VTVM develops a defect that you cannot locate, you may use our free CONAR Consultation Service. Write us a letter explaining the exact nature of your trouble. Include the results of any tests that you have conducted in trying to locate the trouble. Try to give us enough information so we can analyze your trouble. We will try to send you the information necessary to get your VTVM back into operating condition.

If, after the warranty period has expired, a defect develops in your instrument that you are unable to repair yourself, you may return it for repair for which there is a minimum charge of $5.00 plus the cost of any parts. This minimum charge is necessary to cover the cost of handling, inspecting, and making minor repairs. If you return the instrument to us for repair, write us a letter informing us that the instrument is on the way and describe fully the difficulty you are having. Enclose the $5.00 minimum charge. Send check or money order. Do not send cash. Pack the instrument in a sturdy carton and fill the open spaces with shredded newspaper. Ship the instrument to us by prepaid express or insured parcel post. We will return your instrument express collect or insured parcel post.

PARTS LIST

Description	Value	Quantity
Chassis	211CH	1
Front Panel	211FP	1
Cabinet	211CAB	1
Handle	211HNDL	1
Screw, Slotted Truss Head	8-32 x 1/4”	2
Screw, Phillips-head Self-Tapping	#6 x 1/4"	4
Screw, Hex Head Self-Tapping	#6 x 1/4"	1
Machine Screw	6-32x 1/4"	7
Hex Nut	6-32	11
Lock Washer	#6	5
Split Lock Washer	#6	4
Machine Screw	4-40 x 1/4"	4
Hex Nut	4-40	4
Grommet, Rubber	1/4” ID x 5/8” OD x 3/8” Hole x 0.063” TH	1
Transformer, Power	TR-22A 10587 239702 115VAC x 6.3VAC/115VAC	1
Control Flat Washer	0.380” ID x 0.625” OD x 0.030 Thick	2
Control Knob, Brown Bakelite	1.125” OD x 0.25” shaft with white index line & set screw	2
Alligator Clip, Black Insulator	2” long x 0.375” jaw opening	1
Line Cord, Black, Non-Polarized	18 AWG x 48” long SPT/2	1
Test Lead Wire, Black	16 AWG Silicone Jacket x 36” long	1
Probe, Pre-Assembled, Red Insulator	RG-62/U Coaxial Cable x 36” long	1
Tube Socket	7-pin miniature	1
Tube Socket	9-pin miniature	1
Terminal Strip	1-lug, left foot	1
Terminal Strip	1-lug, right foot	1
Terminal Strip	5-lug, right foot	1
D’Arsonval Meter	0-1mA, 6” face, multiple scales	1
Vacuum Tube	6X4	1
Vacuum Tube	12BH7	1
Capacitor, Ceramic Disc	0.01µF 1kV	3
Capacitor, Axial Aluminum Electrolytic	20µF 150V	1
Alkaline Cell	1.5VDC Type “D”	1
Rectifier, Selenium	160V, 0.65A	1
Potentiometer, Internal	3KΩ Linear, short plastic shaft	2
Potentiometer, External	3KΩ Linear, short metal shaft	2
Switch, Function	5-position, 3-deck rotary	1
Switch, Range	6-position, 2-pole rotary	1
Resistor, Carbon	10Ω 5% 1W	1
Resistor, Carbon	100Ω 5% 1W	1
Resistor, Carbon	10KΩ 5% 1W	1
Resistor, Carbon	100KΩ 5% 1W	1
Resistor, Carbon	1MΩ5% 1W	1
Resistor, Carbon	10MΩ 5% 1W	1
Resistor, Carbon	10KΩ 1% 1W	1
Resistor, Carbon	30KΩ 1% 1W	1
Resistor, Carbon	60KΩ 1% 1W	1
Resistor, Carbon	300KΩ 1% 1W	1
Resistor, Carbon	600KΩ 1% 1W	1
Resistor, Carbon	3MΩ 1% 1W	1
Resistor, Carbon	51KΩ 5% 1W	2
Resistor, Carbon	1.5MΩ 10% 1W	1
Resistor, Carbon	8.2MΩ 1% 1W	2
Resistor, Carbon	10MΩ 1% 1W	1
Resistor, Carbon	22KΩ 10% 1/2W	2
Resistor, Carbon	18KΩ 10% 1/2W	1
Spaghetti Insulation	1/16” x 12” long	1
Hookup Wire	Black 22AWG Solid x 36” long	1

Hookup Wire	Brown 22AWG Solid x 36” long	1
Hookup Wire	Red 22AWG Solid x 36” long	1
Hookup Wire	Orange 22AWG Solid x 36” long	1
Hookup Wire	Yellow 22AWG Solid x 36” long	1
Hookup Wire	Green 22AWG Solid x 36” long	1
Hookup Wire	Blue 22AWG Solid x 36” long	1
Hookup Wire	Violet 22AWG Solid x 36” long	1



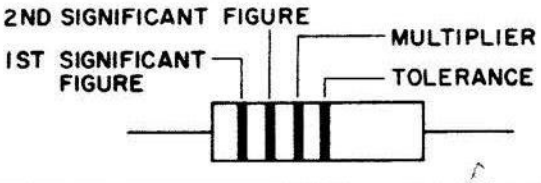
Schematic diagram of the CONAR Model 211 VTVM

RESISTOR AND CAPACITOR COLOR CODES

JAN and EIA stand for the two common color codes (Joint Army-Navy and Electronics Industries Association). The two codes are the same except as indicated. We have not indicated temperature coefficients or characteristics of capacitors, because they are not necessary for identifying your parts.

COLOR	SIG. FIG.	MULTIPLIER	RESIS.	TOLERANCE			
				CERAMIC CAPACITORS		MICA CAPACITORS	PAPER
				10 MMF OR LESS	OVER 10 MMF	(As below, or ± 1 mmf, whichever is larger)	CAP
Black	0	1		± 2.0 MMF	± 20%	± 20%	20%
Brown	1	10		± 1.0 MMF	± 1%	± 1%	
Red	2	100			± 2%	± 2%	
Orange	3	1000			± 2.5%	± 2.5%	
Yellow	4	10,000					
Green	5	100,000		± 0.5 MMF	± 5%	± 5% (EIA)	5%
Blue	6	1,000,000					
Violet	7	10,000,000					
Gray	8			± 0.25 MMF			
White	9			± 1.0 MMF	± 10%		10%
Gold		.1	± 5%			5% (JAN)	5%
Silver		.01	± 10%			10%	10%
No color			± 20%				20%

RESISTORS — RESISTANCE GIVEN IN OHMS

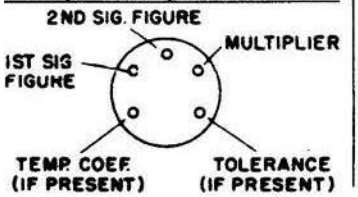


Black body = composition, non-insulated.
Colored body = composition, insulated.
Double width band for 1st sig. figure indicates wire-wound.

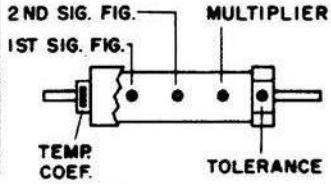
CAPACITORS — CAPACITY GIVEN IN MMF

CERAMIC

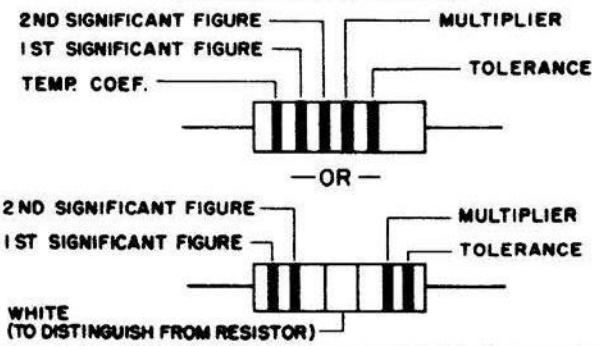
DISCS, BUTTON, OR FEED-THRU



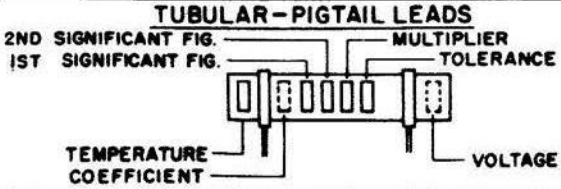
STAND-OFF



TUBULAR—AXIAL LEADS



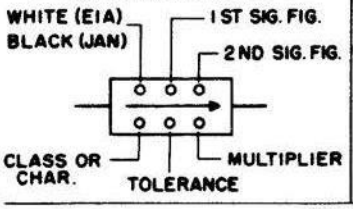
TUBULAR—PIGTAIL LEADS



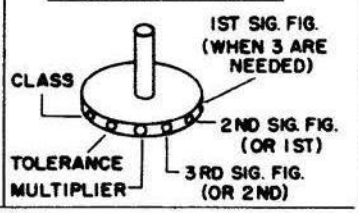
MICA

CLASS OR CHARACTERISTIC REFERS TO Q FACTOR, TEMPERATURE COEFFICIENT, AND PRODUCTION TEST REQUIREMENTS

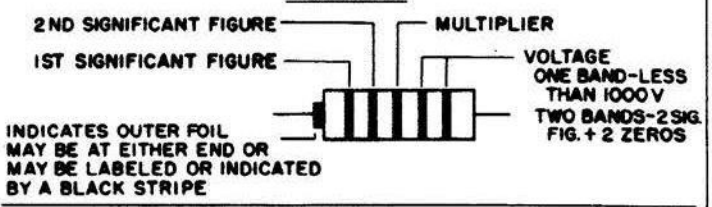
FLAT MOLDED



BUTTON SILVER

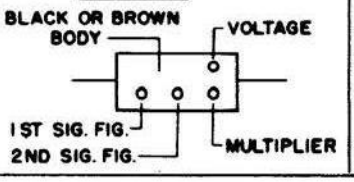


PAPER TUBULAR

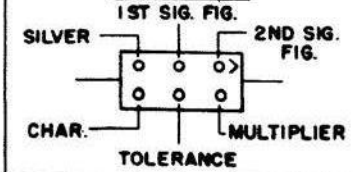


FLAT

EIA CODE



JAN CODE



USE THIS HANDY RULER FOR MEASURING LENGTHS OF WIRE