# THE KNIGHT VTVM


**ALLIED RADIO**
CORPORATION
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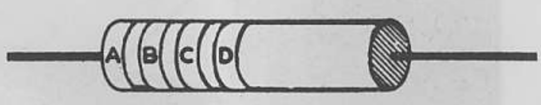
750009-9M-AP-556

# HOW TO READ COLOR CODE ON RESISTORS AND CONDENSERS

All carbon resistors are produced and color-coded under standards set by the RTMA (Radio and Television Manufacturers' Association). Under these standards the user is assured of a wide range of values and of a universal color-coding system that permits easy identification of any carbon resistor. To determine the value of a resistor, hold it with the colored bands reading from the left end, as illustrated, and refer to the chart.

| BAND A | | BAND B | | BAND C | | BAND D | |
|---|---|---|---|---|---|---|---|
| Color | Value | Color | Value | Color | Decimal Multiplier | Color | Tolerance |
| Black | 0 | Black | 0 | Black | 0 | None | ± 20% |
| Brown | 1 | Brown | 1 | Brown | X10 | Silver | ± 10% |
| Red | 2 | Red | 2 | Red | X100 | Gold | ± 5% |
| Orange | 3 | Orange | 3 | Orange | X1,000 | | |
| Yellow | 4 | Yellow | 4 | Yellow | X10,000 | | |
| Green | 5 | Green | 5 | Green | X100,000 | | |
| Blue | 6 | Blue | 6 | Blue | X 1 Million | | |
| Violet | 7 | Violet | 7 | Violet | X 10 Million | | |
| Grey | 8 | Grey | 8 | Gold | ÷ 10 | | |
| White | 9 | White | 9 | Silver | ÷ 100 | | |




The first band (A) shows the first figure of the resistor value, the second band (B) shows the second figure, the third band (C) indicates the number of zeros to add. The fourth band (D), which is not included on all resistors, merely indicates tolerance: silver for ± (plus or minus) 10%, gold for ± 5%. If the (D) band is omitted, the tolerance is ± 20%.

Here is an example: Band A yellow, band B violet, band C yellow, band D silver = (4) (7) (X10,000) (±10%) or 470,000 ohms, ± 10% tolerance.

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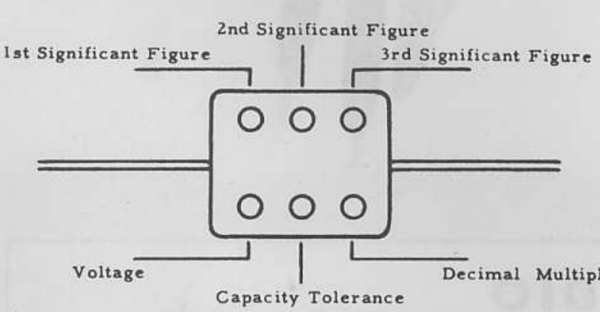
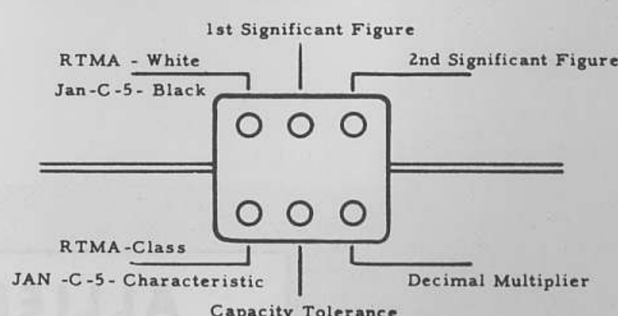
Mica condensers are frequently color-coded. The colored dots have the same figure meaning as for resistors (that is, black is 0, brown is 1, etc.) but there are three systems for reading the complete values.

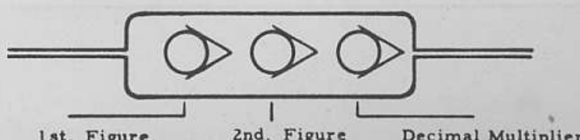
## OLD RMA SIX DOT SYSTEM




## RTMA PROPOSED AND JAN-C-5




## THREE DOT SYSTEM



## SPECIFICATIONS

**DC Voltmeter:**

| | |
|---|---|
| Ranges | 1.5, 5, 15, 50, 150, 500, and 1500 volts full scale. |
| Input Resistance | 11 Megohms (1 Megohm in probe) on all ranges. |
| Circuit | Push-Pull balanced bridge with 12AU7 twin triode. |
| Accuracy | ±3% full scale. |

**AC Voltmeter:**

| | |
|---|---|
| RMS Ranges | 1.5, 5, 15, 50, 150, 500, 1500 volts full scale. |
| Accuracy | ±5% full scale. |
| Peak-to-Peak Ranges | 4, 14, 40, 140, 400, 1400, 4000 volts. |

**Ohmmeter:**

| | |
|---|---|
| Ranges | Center scale at 10 with multipliers × 1, × 10, × 100, × 1000, × 10K, × 100K, × 1Meg. |

| | |
|---|---|
| **Meter:** | 4½" 200 μA movement. |
| **Multipliers:** | 1% precision type. |
| **Printed Circuit:** | Copper etched on laminated phenolic. |
| **Tube Complement:** | 12AU7, twin triode meter bridge.<br>6AL5, twin diode full wave rectifier. |
| **Power Supply:** | 105-125 volts, 50-60 cycles AC. |
| **Battery:** | 1.5 volt "C" battery. |

## HOW TO BUILD THE KNIGHT VTVM

Your KNIGHT VTVM uses a printed circuit which assures you that the VTVM will be an accurate, reliable test instrument regardless of age. A sheet of copper is bonded to a sheet of phenolic. When the wiring pattern has been determined, the unused portion of the copper sheet is etched off leaving an exact duplication of the engineering prototype. Exact duplication is one of the greatest advantages of printed circuits, and prevents variation in wiring and performance from instrument to instrument.

Your KNIGHT VTVM is all electronic. That is, the bridge circuit is used for every measurement of DC voltage, resistance, and AC voltage after rectification by the full-wave rectifier.

The meter employed is an extremely stable, sensitive 200 microampere movement. The multipliers are 1% precision type. Overall accuracy of the DC functions is ±3% of full scale reading, and ±5% on AC functions. A wide choice of measurements is provided giving you seven ranges on DC, AC, and resistance. Both RMS and peak-to-peak AC voltages may be measured.

Your KNIGHT VTVM, through the use of the printed circuit, saves a great deal of tedious wiring, assures you of a finished instrument which compares closely to the original engineering model, and provides you with an instrument worth many times its low cost.

Before starting to build your KNIGHT VTVM, check each part against the Parts List on page 23. If you are unable to identify some of the parts by sight, locate them on the pictorial diagrams. Capacitor and resistor values, if not printed on the part, can be found with the aid of the color code chart.

Hardware is listed in the last part of the Parts List. To keep our kits at the lowest possible price, we frequently weigh hardware rather than to count it. Therefore, do not be concerned if more nuts and machine screws, for example, are supplied than are specified in the Parts List.

The only tools required for building your KNIGHT VTVM are: Long-nose pliers, diagonal cutters, screwdriver, set-screw driver, and a 50-watt soldering iron. You may want to use a larger iron for soldering the contacts other than the printed circuit, but DO NOT USE AN IRON LARGER THAN 50 WATTS FOR MAKING THE SOLDER CONNECTIONS ON THE PRINTED CIRCUIT. A good set of tools is listed at the end of the Parts List.

Study the pictorial diagrams and note how the parts are mounted. These pictorial diagrams show the actual location of all parts and wiring. The schematic diagram shows how the parts are connected electrically and is helpful in understanding how the circuits work.

The step-by-step instructions were prepared by a skilled technician while he was actually building the KNIGHT VTVM. Therefore, they are the best and fastest way of assembling this instrument. We suggest that you read through the instructions before building the VTVM. This will enable you to familiarize yourself with the procedure and avoid possible errors. We invite you to use the blank parentheses, ( ), before each step to check it off after you have completed it.

Each step is clearly illustrated on an accompanying line drawing. Some builders prefer to "cross out" each wire and component on the drawings with a colored pencil after it is installed. While an excellent way to avoid mistakes, and highly recommended by us, this procedure results in drawings that are difficult to reuse. For this reason each wiring view is reproduced on a separate, folded sheet of paper.

You are now ready to build your KNIGHT VTVM.

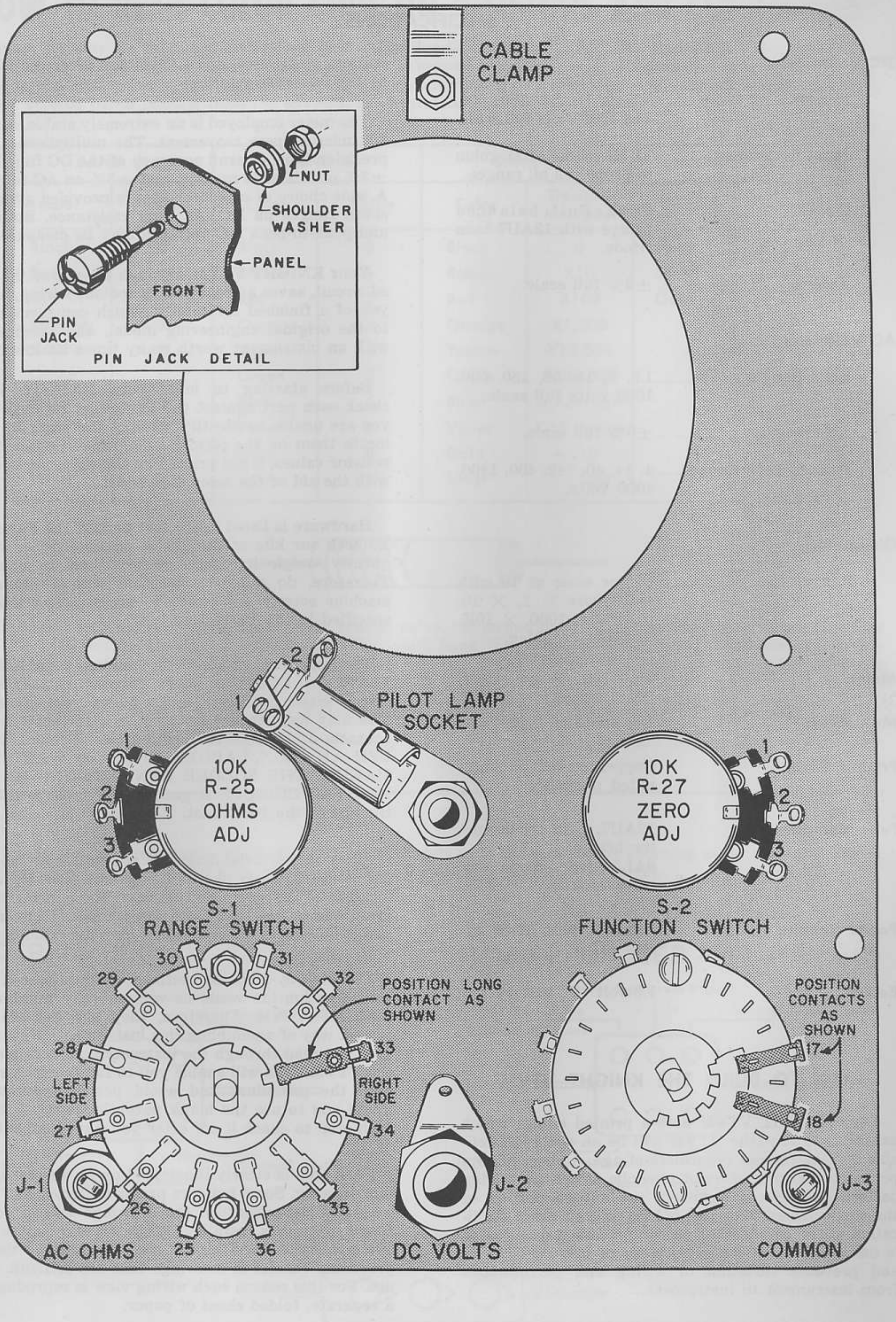



FIGURE 1. MOUNTING THE PARTS ON THE PANEL

# MOUNTING THE PARTS ON THE PANEL

Before you begin mounting the parts, place a pad or a soft cloth on your work table to protect the finish on the front panel.

### SEE FIGURES 1 AND 2

( ) Insert the short flat head screw through the hole in the top center of the panel. Place an external lockwasher over the screw. Next put one of the cable clamps over the screw. Now, put on an internal lockwasher and tighten a nut over it very securely. See Figure 2.

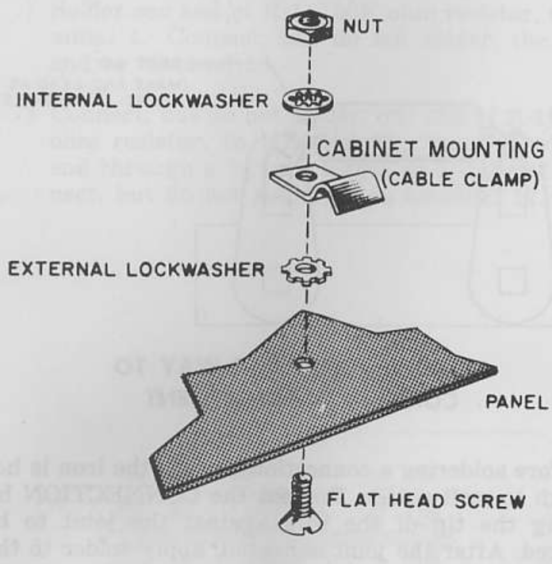



**FIGURE 2. HOW TO ASSEMBLE THE CABINET CLAMP**

( ) Mount R-25, 10K ohms OHMS ADJUST potentiometer, in the large hole in the left center of the panel. Use two nuts to mount this control as shown in Figure 3.

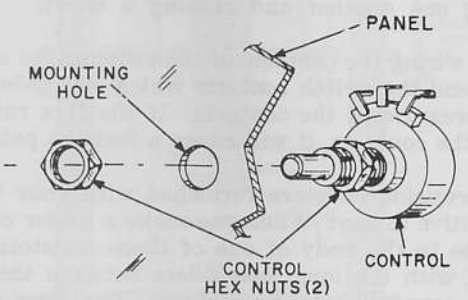



**FIGURE 3. HOW TO MOUNT A CONTROL**

( ) Mount R-27, 10K ohm ZERO ADJUST potentiometer, in the large hole in the right center of the panel, in the same manner.

( ) Mount the pilot light socket between R-25 and R-27. The bracket must be positioned as shown in Figure 1.

( ) Mount J-1, the red pin jack, in the lower left corner of the panel. Use a **shouldered fiber washer** on the **inside of the panel** to insulate the jack from the panel. Now, tighten a nut against the washer. Refer to the pin jack detail in the upper left corner of Figure 1.

( ) Mount J-3, the black pin jack, in the lower right corner of the panel in the same manner.

( ) Mount J-2, the chassis connector in the large hole in the lower center of the panel. This connector is supplied with a shouldered fiber washer. Take this washer off and throw it away. Place the flat fiber washer over the small threaded end of the connector. Scrape the paint from around this hole on the rear of the panel. Insert the small threaded end through the hole in the panel. Place the solder lug and the flat metal washer on the connector and tighten the nut securely. See Figure 4.

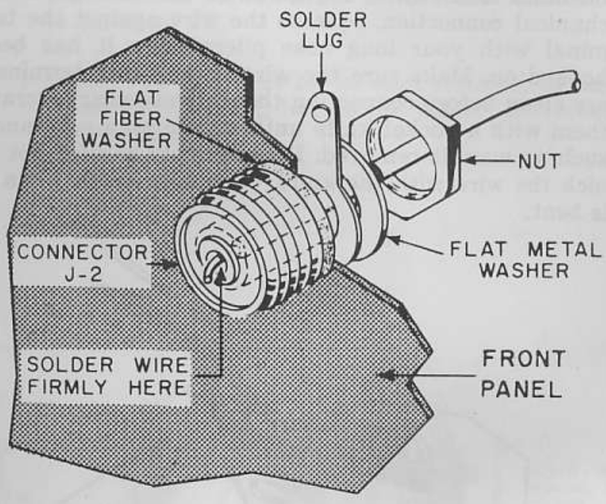



**FIGURE 4. HOW TO MOUNT THE CHASSIS CONNECTOR**

( ) Mount S-1, the long triple wafer RANGE switch in the hole in the lower left corner of the panel. The long contact on the end wafer must be positioned as shown in Figure 1. The blank space on the wafer near the shaft end must be toward J-1. Use a large nut and a lockwasher on the inside of the panel. Fasten it securely with another large nut. Place a large knob on the shaft. Be sure the line on the knob lines up exactly with the printed dots on the panel. If not, rotate S-1 so the scale on the panel and the line on the knob correspond.

( ) Mount S-2, the other triple wafer FUNCTION switch, in the other hole on the right of the panel. Use another large nut and lockwasher inside the panel. Use a large nut outside the panel. Again place a knob on the shaft and be sure that the line on the knob lines up with the scale on the panel.

You have finished mounting the parts on the panel until after the switches are wired.

# WIRING AND SOLDERING HINTS

How well a piece of electronic equipment works often depends on the quality of workmanship used in its construction. It is for this reason that the following suggestions are made. These hints are mainly for the beginner, however, even experienced persons may benefit from a brief review.

The insulated wire furnished with this kit is cut to length and the ends are stripped. Each different colored wire is a different length, therefore, be sure to use the color specified in each of the wiring steps.

A long piece of bare wire is included. Whenever it is necessary to use some of it, the exact length of the piece required is given.

The flexible tubing supplied is called "spaghetti". Spaghetti is used to cover the bare end leads of some of the components and portions of some of the bare wires when there is danger they will touch other bare wires or the chassis.

The proper way to connect a wire or lead to a solder terminal is shown in Figure 5. To insure a good mechanical connection, squeeze the wire against the terminal with your long nose pliers after it has been hooked on. Make sure the wires, leads, and terminals are clean before connecting them. If necessary, scrape them with a pocket knife until any foreign substance, such as wax, is removed. Be extremely careful not to nick the wire with the knife, or it may break when it is bent.

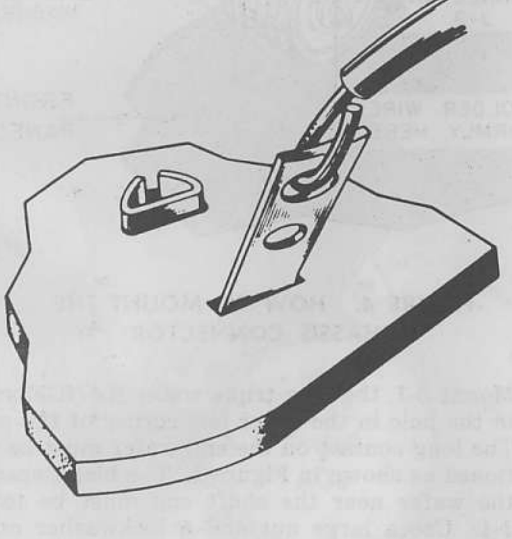


**FIGURE 5. HOW TO CONNECT A WIRE TO A TERMINAL**

Unless otherwise stated, all the leads on the resistors, capacitors, and transformer should be as short as possible. Figure 6 illustrates the best way to connect a component. As shown, the end leads should be pulled through the terminals so that the parts are tightly mounted. After a lead is pulled through a terminal, bend it around the terminal and cut off the excess wire.

## USE ONLY ROSIN CORE SOLDER

**IF YOU ARE IN DOUBT ABOUT THE SOLDER YOU MAY ALREADY HAVE, WE RECOMMEND THAT YOU OBTAIN A NEW ROLL PLAINLY MARKED: "ROSIN CORE SOLDER". KITS WIRED WITH ACID CORE SOLDER OR ACID FLUX WILL CORRODE AND WILL NOT WORK LONG. SUCH KITS ARE NOT ELIGIBLE FOR REPAIR OR SERVICE.**

Before soldering, the tip of your soldering iron must be properly tinned. To do this, clean the surfaces of the tip with steel wool, or a fine file, until the bright copper surface is exposed. Plug the iron in and allow it to heat until it melts solder. Apply solder to the tip until it is well covered with a thin coat. Wipe off the excess solder with a rag. The tip should now be "shiny". Re-tin the tip whenever it becomes covered with a layer of scale (flakes of gray matter).

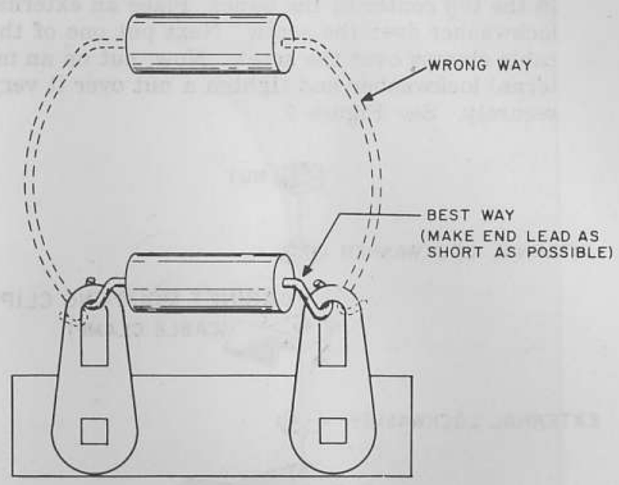



**FIGURE 6. THE BEST WAY TO CONNECT A COMPONENT**

Before soldering a connection be sure the iron is hot enough to melt solder. Preheat the CONNECTION by holding the tip of the iron against the joint to be soldered. After the joint is heated, apply solder to **the joint**, NOT to the iron tip. Use only enough solder to fill the crevices and cover all of the wires and the terminal. Do not solder any connection until all wires have been connected to it.

After you have soldered a connection, push any insulation or spaghetti as close to the connection as possible. This will prevent close connections from touching one another and causing a short.

When wiring the contacts of the switches, be careful not to bend the switch contacts which will reduce the spring pressure of the contacts. If the flux runs out around the contacts, it will cause a leakage path.

The precision resistors furnished with your VTVM are sensitive to heat. When you make a solder connection close to the body of one of these resistors, hold the lead with the long nose pliers between the body and the connection to be soldered. The jaws of the pliers will conduct the heat away from the body of the resistor.

You are now ready to begin wiring your KNIGHT VTVM. As you are wiring, we would like you to keep the following in mind: Do your best to position the parts as shown in the wiring diagrams, and, above all, USE ONLY ROSIN CORE SOLDER.

## WIRING SWITCH S-1

S-1 is the three wafer switch in the lower left corner of the panel. The open space between two of the terminals, on the wafer nearer the shaft end, is used as the reference point for numbering the terminals.

**SEE FIGURE 7.**

( ) Connect, but do not solder, one end of R-2, 320K ohm resistor, to terminal 1 of S-1. Connect, but do not solder, the other end to terminal 4 of S-1. Position R-2 as shown in Figure 7.

( ) Connect, but do not solder, one end of R-3, 900K ohm, 1 watt, resistor, to terminal 1. Connect, but do not solder, the other end to terminal 6. Position R-3 as shown in Figure 7.

( ) Solder one end of a 2 inch bare wire to terminal 1. Insert the other end through a 1¼ inch length of spaghetti. Solder it to terminal 5.

( ) Solder one end of R-1, 150K ohm resistor, to terminal 4. Connect, but do not solder, the other end to terminal 13.

( ) Connect, but do not solder, one end of R-16, 10K ohm resistor, to terminal 13. Insert the other end through a ½ inch length of spaghetti. Connect, but do not solder, it to terminal 17.

( ) Connect, but do not solder, one end of R-20, 90K ohm resistor, to terminal 14. Connect, but do not solder, the other end to terminal 25.

( ) Connect, but do not solder, one end of a 2 inch bare wire to terminal 14. Solder the other end to terminal 26.

( ) Solder one end of R-21, 9K ohm resistor to terminal 14. Connect, but do not solder, the other end to terminal 27.

( ) Connect, but do not solder, one end of R-22, 900 ohm resistor, to terminal 16. Solder the other end to terminal 27.

( ) Connect, but do not solder, one end of a 2 inch bare wire to terminal 16. Solder the other end to terminal 28.

( ) Solder one end of R-23, 90 ohm resistor, to terminal 16. Connect, but do not solder, the other end to terminal 29.

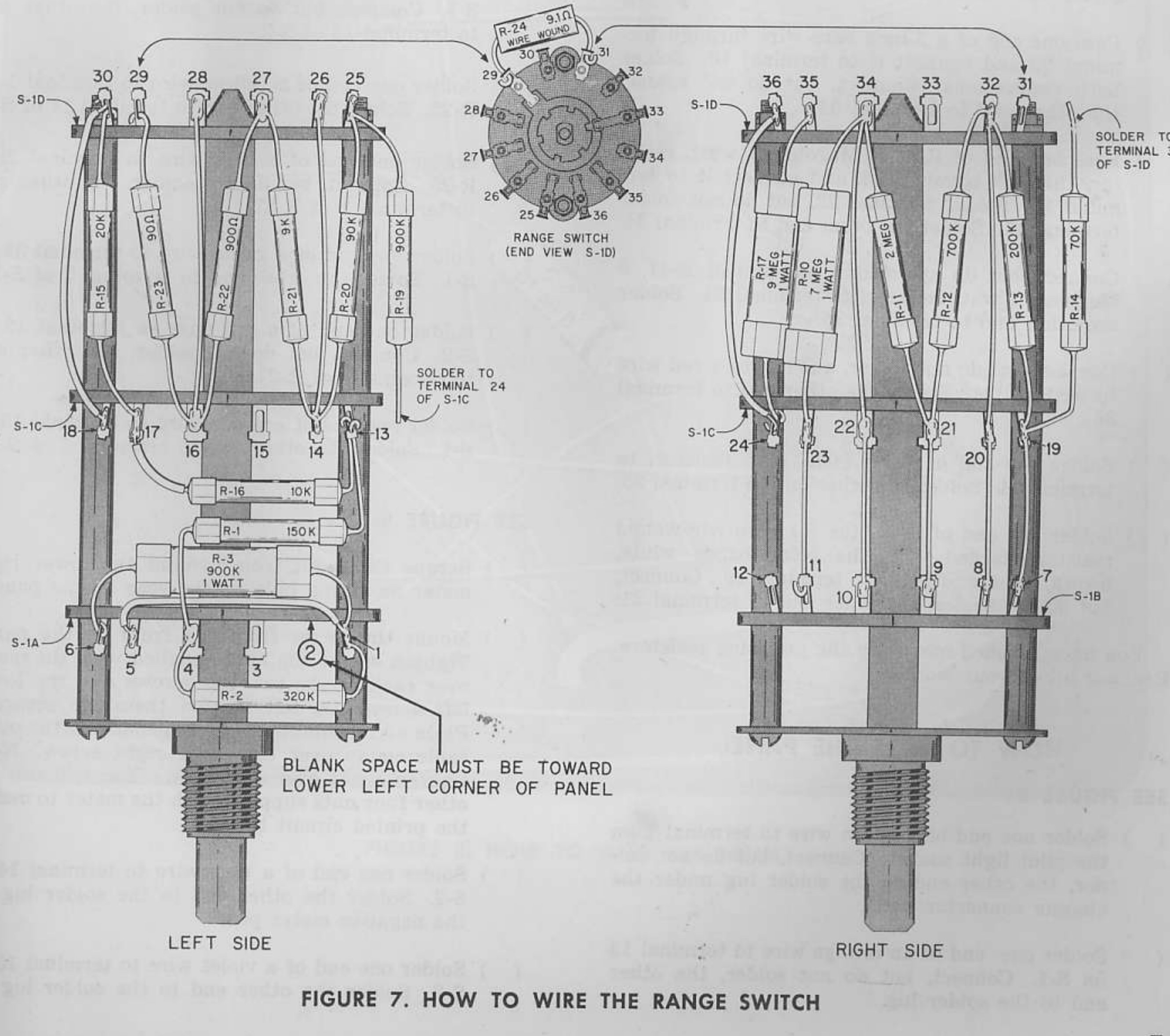



**FIGURE 7. HOW TO WIRE THE RANGE SWITCH**

( ) Solder one end of R-15, 20K ohm resistor, to terminal 17. Connect, but do not solder, the other end to terminal 30.

( ) Solder one end of a 2 inch red wire to terminal 18. Connect, but do not solder, the other end to terminal 30.

( ) Pass one end of R-14, 70K ohm resistor through terminal 19 and connect it to terminal 7. Solder terminal 7, but do not solder terminal 19. Solder the other end of R-14 to terminal 30.

( ) Solder one end of R-13, 200K ohm resistor, to terminal 19. Connect, but do not solder, the other end to terminal 32.

( ) Pass one end of a 3 inch bare wire through terminal 20 and connect it to terminal 8. Solder both terminals 8 and 20. Connect, but do not solder, the other end to terminal 32.

( ) Connect, but do not solder, one end of R-12, 700K ohm resistor, to terminal 21. Solder the other end to terminal 32.

( ) Pass one end of R-11, 2 Megohm resistor, through terminal 21 and connect it to terminal 9. Solder both connections. Connect, but do not solder, the other end to terminal 34.

( ) Pass one end of a 3 inch bare wire through terminal 22 and connect it to terminal 10. Solder both connections. Connect, but do not solder, the other end to terminal 34.

( ) Pass one end of R-10, 7 Megohm, 1 watt, resistor, through terminal 23, and connect it to terminal 11. Solder terminal 23, but do not solder terminal 11. Solder the other end to terminal 34.

( ) Connect, but do not solder, one end of R-17, 9 Megohm, 1 watt resistor, to terminal 24. Solder the other end to terminal 35.

( ) Connect, but do not solder, one end of a red wire to terminal 24. Solder the other end to terminal 36.

( ) Solder one end of R-19, 900K ohm resistor, to terminal 24. Solder the other end to terminal 25.

( ) Solder one end of R-24, the 9.1 ohm wirewound resistor marked with the color bands white, brown, gold, and gold, to terminal 29. Connect, but do not solder, the other end to terminal 31.

You have finished mounting the precision resistors. Recheck all of your work.

## HOW TO WIRE THE PANEL

### SEE FIGURE 8.

( ) Solder one end of a green wire to terminal 1 on the pilot light socket. Connect, but do not solder, the other end to the solder lug under the chassis connector nut.

( ) Solder one end of an orange wire to terminal 13 on S-1. Connect, but do not solder, the other end to the solder lug.

( ) Solder one end of another orange wire to the terminal on J-3, the common jack. Solder the other end to the solder lug.

( ) Pass one end of a red wire through the chassis connector. Solder it to the eyelet in the center of the connector. Insert the other end through a 1½ inch length of the large spaghetti. Force the spaghetti down against the soldered eyelet connection. Solder the other end of the red wire to terminal 1 of S-2.

( ) Insert each end lead of C-2, .01 MFD paper capacitor, through a 1½ inch length of small spaghetti. Solder the lead from the banded end to terminal 9 of S-2. Solder the other lead to terminal 6 of S-1. Position C-2 between J-2 and S-2A.

( ) Solder one end of a red wire to terminal 11 of S-1. Solder the other end to terminal 2 of S-2.

( ) Solder one end of a yellow wire to terminal 12 of S-1. Solder the other end to terminal 6 of S-2.

( ) Insert a green wire through a 4½ inch length of the large spaghetti. Solder one end to J-1. Solder the other end to terminal 8 of S-2.

( ) Solder one end of a green wire to terminal 3 of S-1. Connect, but do not solder, the other end to terminal 15 of S-2.

( ) Solder one end of a yellow wire to terminal 1 of R-25. Solder the other end to terminal 11 of S-2.

( ) Solder one end of a blue wire to terminal 2 of R-25. Connect, but do not solder, the other end to terminal 1 of R-27.

( ) Solder one end of a green wire to terminal 33 of S-1. Solder the other end to terminal 7 of S-2.

( ) Solder one end of a red wire to terminal 12 of S-2. Connect, but do not solder, the other end to terminal 3 of R-27.

( ) Solder one end of a green wire to terminal 15 of S-1. Solder the other end to terminal 4 of S-2.

### SEE FIGURE 9.

( ) Scrape the paint from around the lower right meter mounting hole on the rear of the panel.

( ) Mount the meter from the front of the panel. Tighten one of the nuts supplied with the meter over each of the two top screws and the lower left screw. Do not tighten them too securely. Place an internal tooth lockwasher and the other cable clamp over the lower right screw. Now, tighten a nut over the screw. You will use the other four nuts supplied with the meter to mount the printed circuit board.

( ) Solder one end of a blue wire to terminal 14 of S-2. Solder the other end to the solder lug on the negative meter post.

( ) Solder one end of a violet wire to terminal 10 of S-2. Solder the other end to the solder lug on the positive meter post.

( ) Solder one end of another violet wire to terminal 2 of the pilot light socket. The other end will be connected to the printed circuit later.

( ) Insert the pilot lamp into its socket.

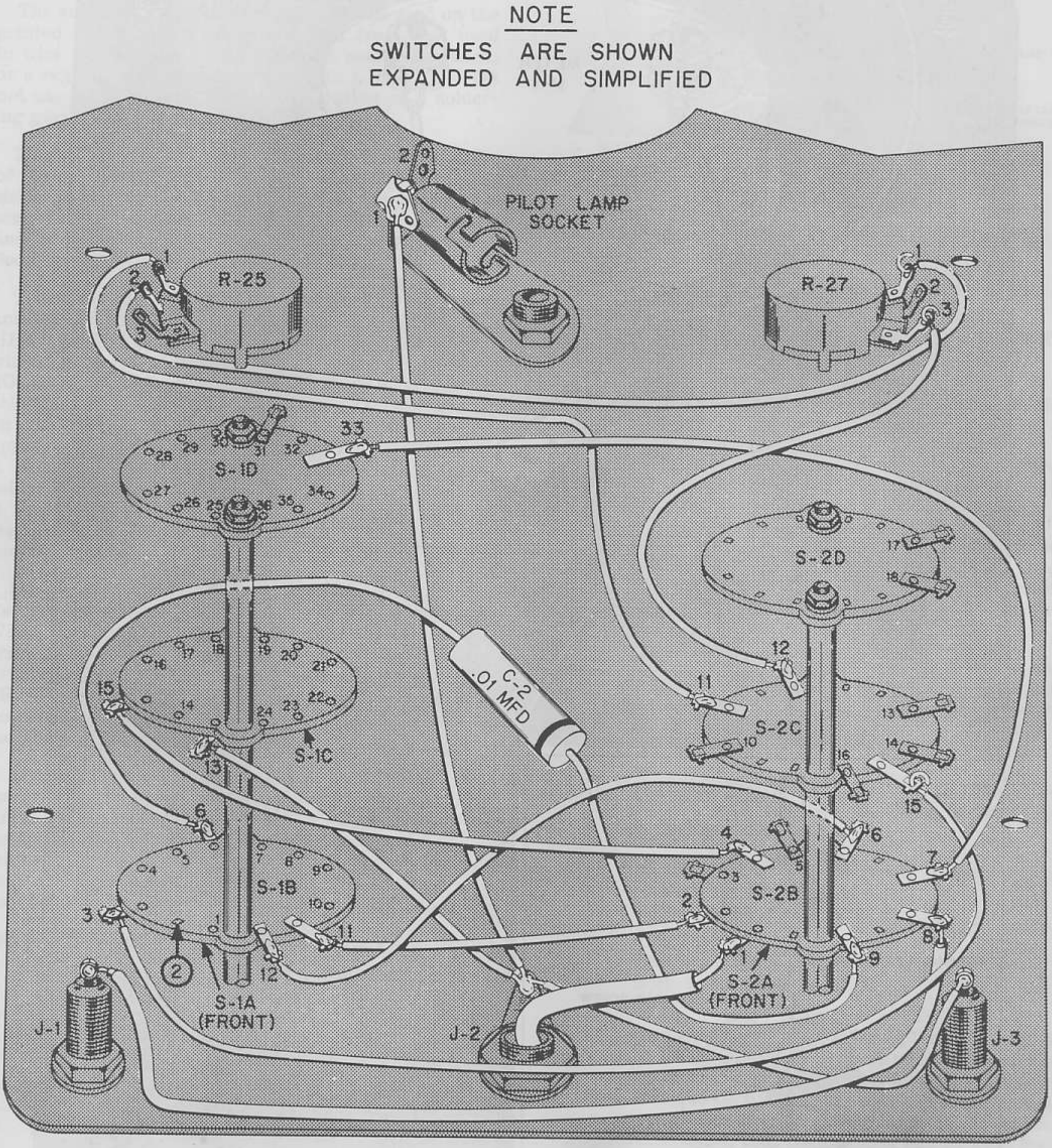



**FIGURE 8. HOW TO WIRE THE PANEL**

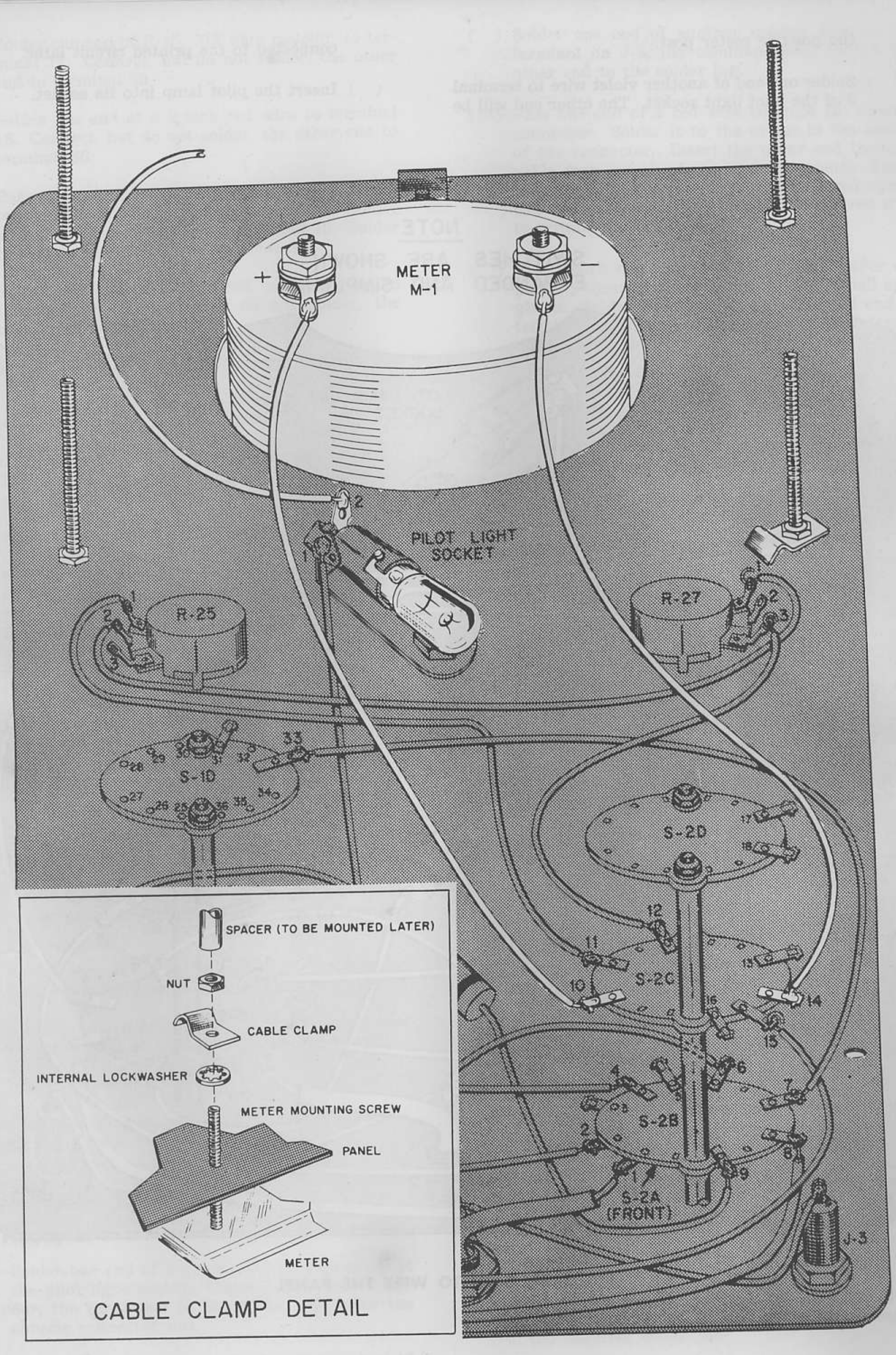



**FIGURE 9. HOW TO MOUNT AND WIRE THE METER**

# ASSEMBLING THE PRINTED CIRCUIT BOARD

You are ready to mount the parts on the printed circuit board. Handle the board gently. Examine it. One side shows the outline and value of each part to be mounted. That is, the capacitors, resistors, the transformer, the battery, etc., are pictured in their exact locations.

The soldering technique which MUST be used on the printed circuit is somewhat different from that used to wire the switches. Use a 50-watt soldering pencil, or a regular type soldering iron with a small tip. Do not use an iron of higher wattage rating or a soldering gun.

Mount the components on the board. Bend the leads of the resistors at right angles to the body of the resistor so the resistors will lay flat on the board. Insert the leads through the proper holes in the board and bend them to hold the part firmly in position. See Figure 10.

Touch the connection to be soldered with the solder and the iron AT THE SAME TIME. DO NOT PREHEAT the connection. This may damage the printed wiring pattern. REMOVE THE IRON AND THE SOLDER as soon as the flux from the core of the solder flows out around the connection. The solder on the connection should have a shiny, "silvery" appearance. If the connection has a dull appearance, it is a cold solder joint. Using more solder, again solder the connection. Do not use so much solder that it flows off the printed wiring onto the board. This may cause an intermittent, or a short, between connection points.

Before you solder the pins of the tube sockets to the printed wiring, insert the tubes in the socket. When you solder the pins of the tube sockets to the printed wiring, touch the soldering iron and the solder to the pin of the tube socket, and NOT TO THE PRINTED WIRING PATTERN. When the solder flows down onto the printed wiring REMOVE both the solder and the iron.

After you have soldered all of the connections on the printed board, but before you put in the cable, examine the printed wiring side of the board closely. If the flux from the core of the solder has flowed off the printed wiring pattern onto the board, remove it with denatured alcohol. This condition, if not corrected, may cause a leakage path.

**SEE FIGURE 11.**

( ) Mount the 9-pin miniature socket for V-2, the 12AU7, from the screened side of the board. This socket can be mounted only one way. Line up the notch in the socket with the half-moon shaped notch in the board. Put the12AU7 in the socket. Solder one end of a ¾ inch bare wire to pin 1. Solder the other end to pin 6. Solder all pins to the board.

( ) Mount the 7-pin miniature socket for V-1, the 6AL5. Put the 6AL5 in the socket. Solder all pins.

( ) Mount R-34, 10,000 ohms AC Balance potentiometer, from the screened side of the board. The three terminals must be toward the left edge of the board. Bend the two large, flat terminals out slightly so the potentiometer is held firmly.

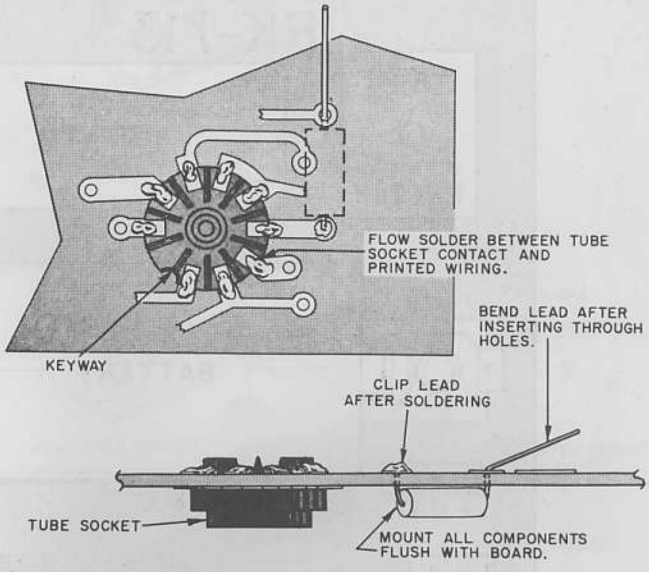



**FIGURE 10. HOW TO MOUNT AND SOLDER PARTS ON THE PRINTED CIRCUIT BOARD.**

Solder each terminal and also the two large flat terminals.

( ) Mount R-29, 10,000 ohms DC Calibration potentiometer in the same manner. Solder the large flat terminals and the two small terminals.

( ) Mount R-26, 10,000 ohms AC Calibration potentiometer in the same manner with the three terminals toward the terminals of R-29. Solder the three terminals which go into the printed wiring.

( ) Mount CR-1, the rectifier, by inserting the two terminals through the holes in the upper left corner of the board. The positive side must be toward the right. Bend the two terminals slightly to hold CR-1 firmly. Solder both terminals.

( ) Mount C-6, the 20 MFD, 150V electrolytic filter capacitor, with the "+" end next to the rectifier. Solder both leads.

( ) Trim the leads of T-1, the power transformer to the following lengths:

The black lead toward the upper right corner to 1½″.
The other black lead to 6″.
Both green leads to 1½″.
Both red leads to 2″.

Remove the insulation from ¼″ of the end of each lead. Hold the lead with pliers close to the body of the transformer as you remove the insulation so that you do not tear the lead through the wrapping around the winding of the transformer. Now, coat the stripped end of each lead with solder.

Mount T-1 with the red and green leads toward the center of the board. Use a machine screw through each mounting tab of T-1, **through a flat fiber washer,** and through the board. Tighten a nut over each screw.

( ) Insert the short black lead into the hole marked Black Pri. in the upper right corner of the board.

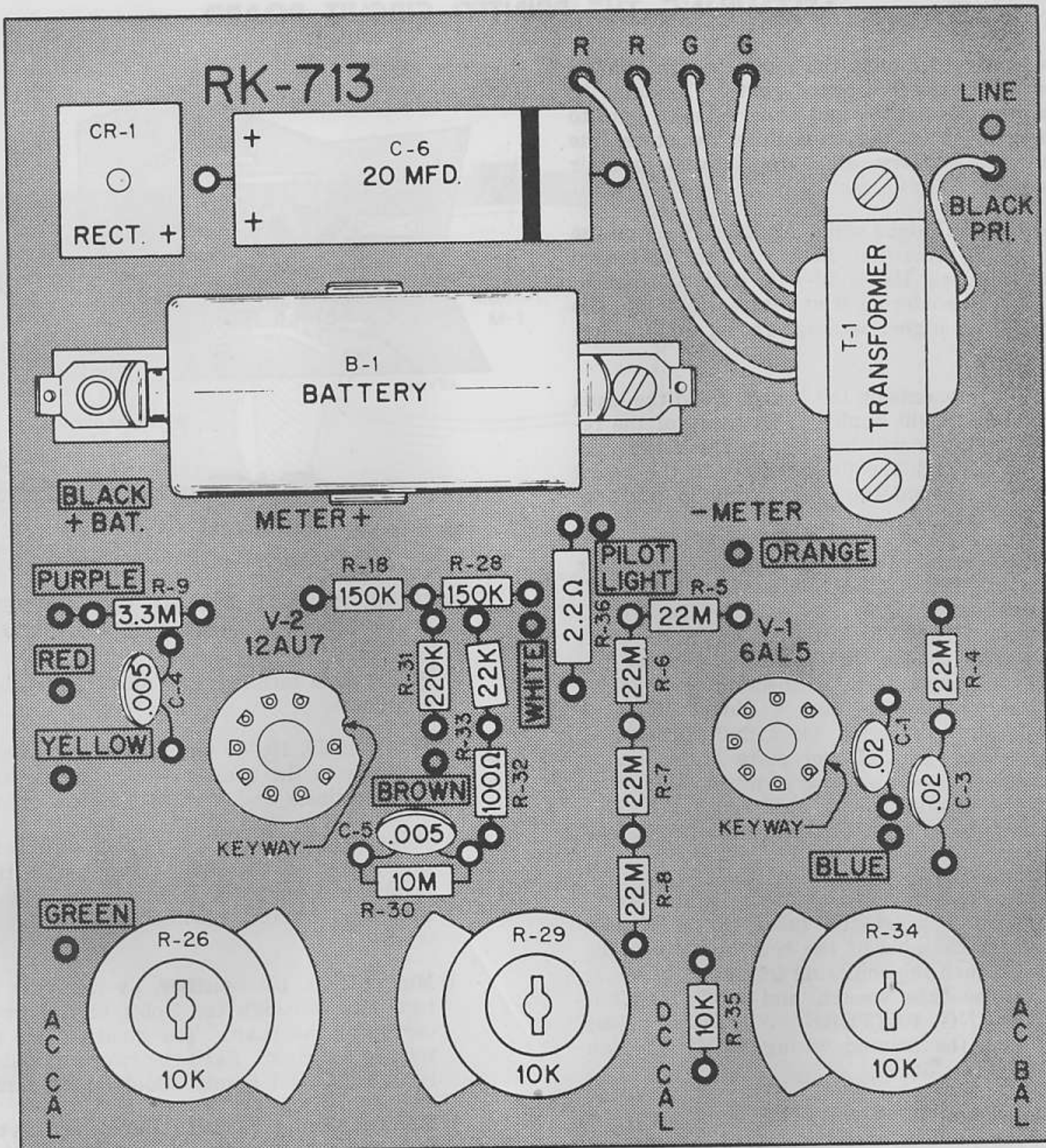



**FIGURE 11. MOUNTING THE PARTS ON THE PRINTED CIRCUIT BOARD**

Bend it slightly so it will stay in position and solder it. The other black lead will be connected later.

( ) Insert the green leads into the holes marked G. Bend them slightly. Solder them.

( ) Insert the red leads into the two holes marked R. Bend them slightly. Solder both.

**SEE FIGURES 11 AND 12.**

( ) Mount the battery bracket as shown in Figure 12. Insert a machine screw through the battery retaining clip through the center hole in the battery bracket, through a flat fiber washer, and through the hole in the printed circuit board. Tighten a nut onto the screw. Use the thin screw through the hole in the end of the bracket near T-1, and through the circuit board. Place a small flat metal washer over the screw on the printed wiring side of the board and tighten a nut over the screw.

You are now ready to mount the resistors and capacitors on the printed circuit board.

( ) Mount R-9, 3.3 Megohm resistor (orange, orange, green) as shown in Figure 11.

( ) Mount C-4, .005 MFD disc capacitor.

( ) Mount R-18, 150K ohm resistor (brown, green, yellow).

( ) Mount R-28, 150K ohm resistor (brown, green, yellow).

( ) Mount R-33, 22K ohm resistor (red, red, orange).

( ) Mount R-31, 220K ohm resistor (red, red, yellow).

( ) Mount R-32, 100 ohm resistor (brown, black, brown).

( ) Mount C-5, .005 MFD disc capacitor.

( ) Mount R-30, 10 Megohm resistor (brown, black, blue).

( ) Mount R-36, 2.2 ohm resistor (red, red, gold, silver).

( ) Mount R-5, 22 Megohm resistor (red, red, blue).

( ) Mount R-6, 22 Megohm resistor (red, red, blue).

( ) Mount R-7, 22 Megohm resistor (red, red, blue).

( ) Mount R-8, 22 Megohm resistor (red, red, blue).

( ) Mount R-35, 10K ohm resistor (brown, black, orange).

( ) Mount C-1, .02 MFD disc capacitor.

( ) Mount R-4, 22 Megohm resistor (red, red, blue).

( ) Mount C-3, .02 MFD disc capacitor. Note that the leads of this capacitor must be positioned so that they clear the hole for mounting the printed circuit to the panel.

( ) Turn the circuit board over and solder each connection. Remember to use a small iron and the rosin-core solder supplied. REMOVE THE FLUX if it flows out around the soldered connections. Cut off each end lead close to the soldered connection.

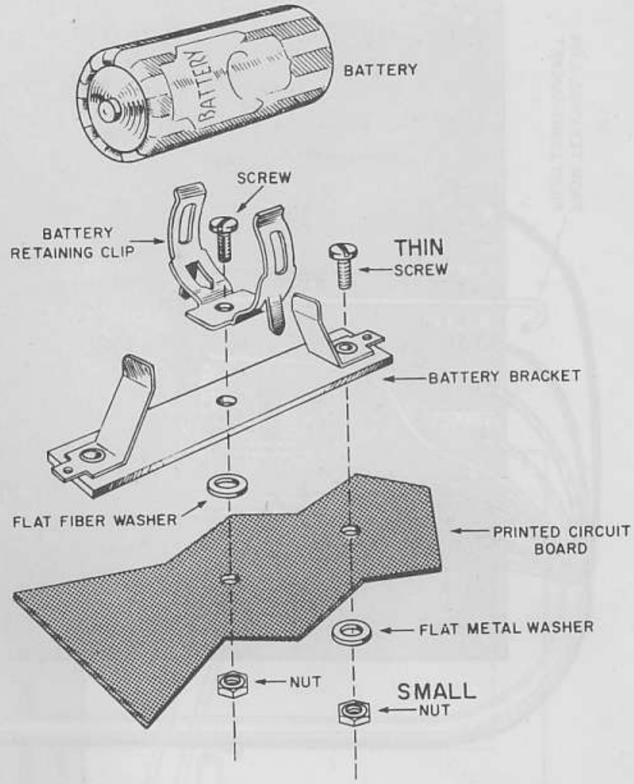



**FIGURE 12. MOUNTING THE BATTERY**

## FINAL WIRING

You are now ready to prepare the cable and do the final wiring on your VTVM.

**SEE FIGURE 13.**

( ) Carefully remove 4½ inches of the outer insulation from one end of the cable. Be very careful not to cut the insulation of any of the wires. Now, trim the wires to the following lengths:

| | |
|---|---|
| Orange: | Leave it the full 4½ inches. |
| Green: | 1″ |
| Yellow: | 1″ |
| Red: | 1½″ |
| Violet: | 1¾″ |
| Black: | 2¾″ |
| Brown: | 2¼″ |
| White: | 3½″ |
| Blue: | 4¼″ |

Remove ¼ inch of insulation from the end of each wire. Coat each end with solder.

( ) Solder the black wire to the terminal on the battery bracket marked + Bat. This wire does not go through the printed circuit board.

( ) Insert each of the other wires into the hole in the board marked with the corresponding color. Solder each on the printed wiring side of the board.

( ) Remove 3¾″ of the outer insulation from the other end of the cable. Trim each wire as follows:

| | |
|---|---|
| Red: | Leave it the full 3¾″ |
| White: | 2¾″ |
| Brown: | 2½″ |
| Violet: | 1½″ |
| Yellow: | 2¾″ |
| Blue: | 3″ |
| Green: | 3¾″ |
| Orange: | 2″ |
| Black: | 3″ |

Remove ¼″ of insulation from the end of each wire. Coat each end with solder.

( ) Solder the violet wire to terminal 5 of S-2.

( ) Solder the brown wire to terminal 3 of R-27.

( ) Solder the white wire to terminal 2 of R-27.

( ) Solder the red wire to terminal 1 of R-27.

( ) Solder the yellow wire to terminal 13 of S-2.

( ) Solder the blue wire to terminal 15 of S-2.

( ) Solder the green wire to terminal 16 of S-2.

( ) Solder the orange wire to terminal 3 of S-2.

( ) Solder the black wire to terminal 31 of S-1.

( ) Solder the violet wire from terminal 2 of the pilot light socket to PILOT LIGHT on the printed circuit board. Bring this wire over the screened side of the board.

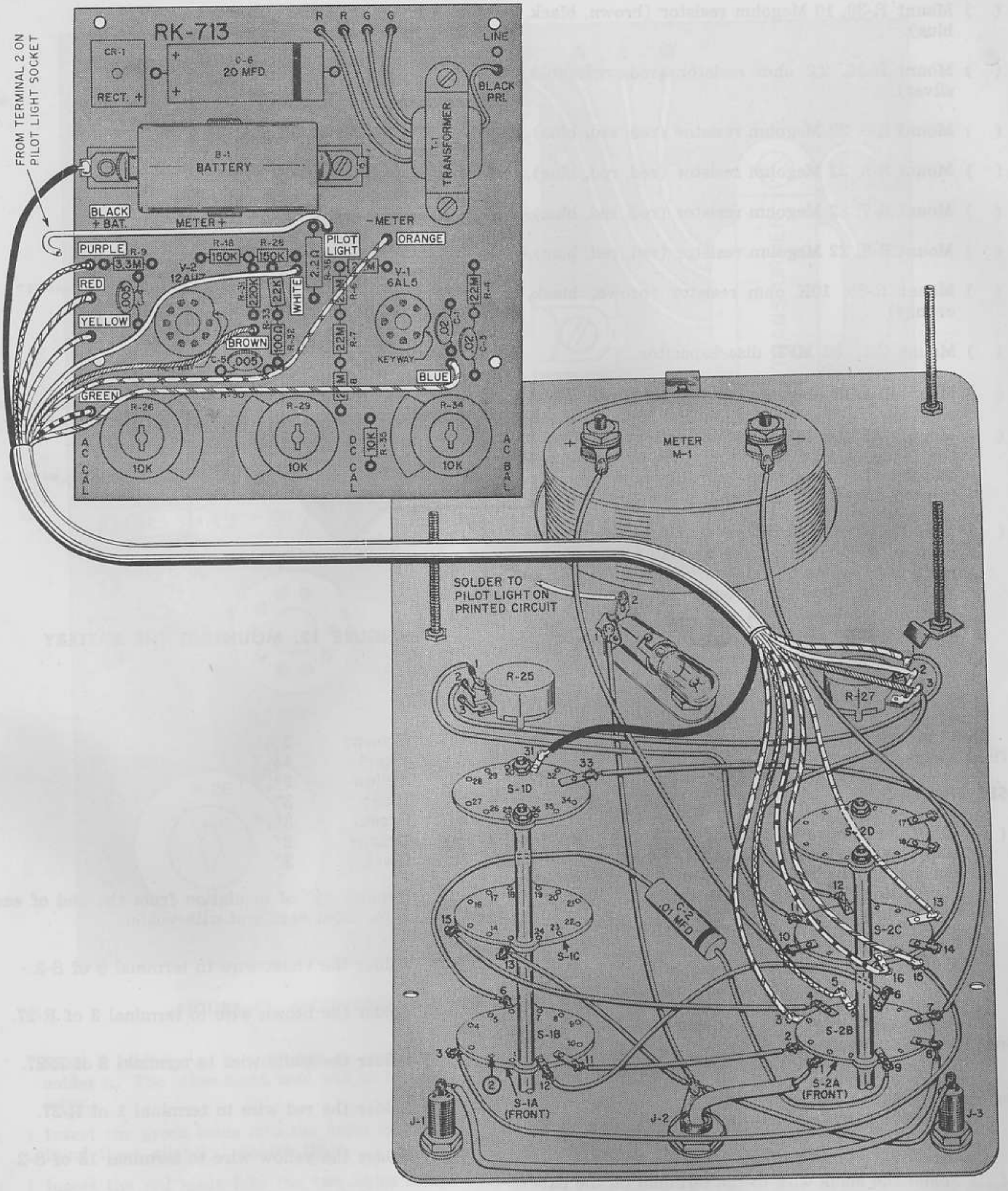


FIGURE 13. HOW TO CONNECT THE CABLE

SEE FIGURE 14.

( ) Slide the bare ends of the line cord under the cable clamp mounted on the lower right meter mounting screw. Tie a knot in the cord 5″ from the bare ends. Split the cord back to the knot. Solder one section to the printed circuit board at the point marked "Line". Cut 2½″ off the other section. Solder it to terminal 17 of S-2.

( ) Solder the other black transformer lead to terminal 18 of S-2.

( ) Put one of the spacers over each of the meter mounting screws.

( ) Place the printed circuit on the meter mounting screws. Secure it with the 4 split washers and 4 nuts.

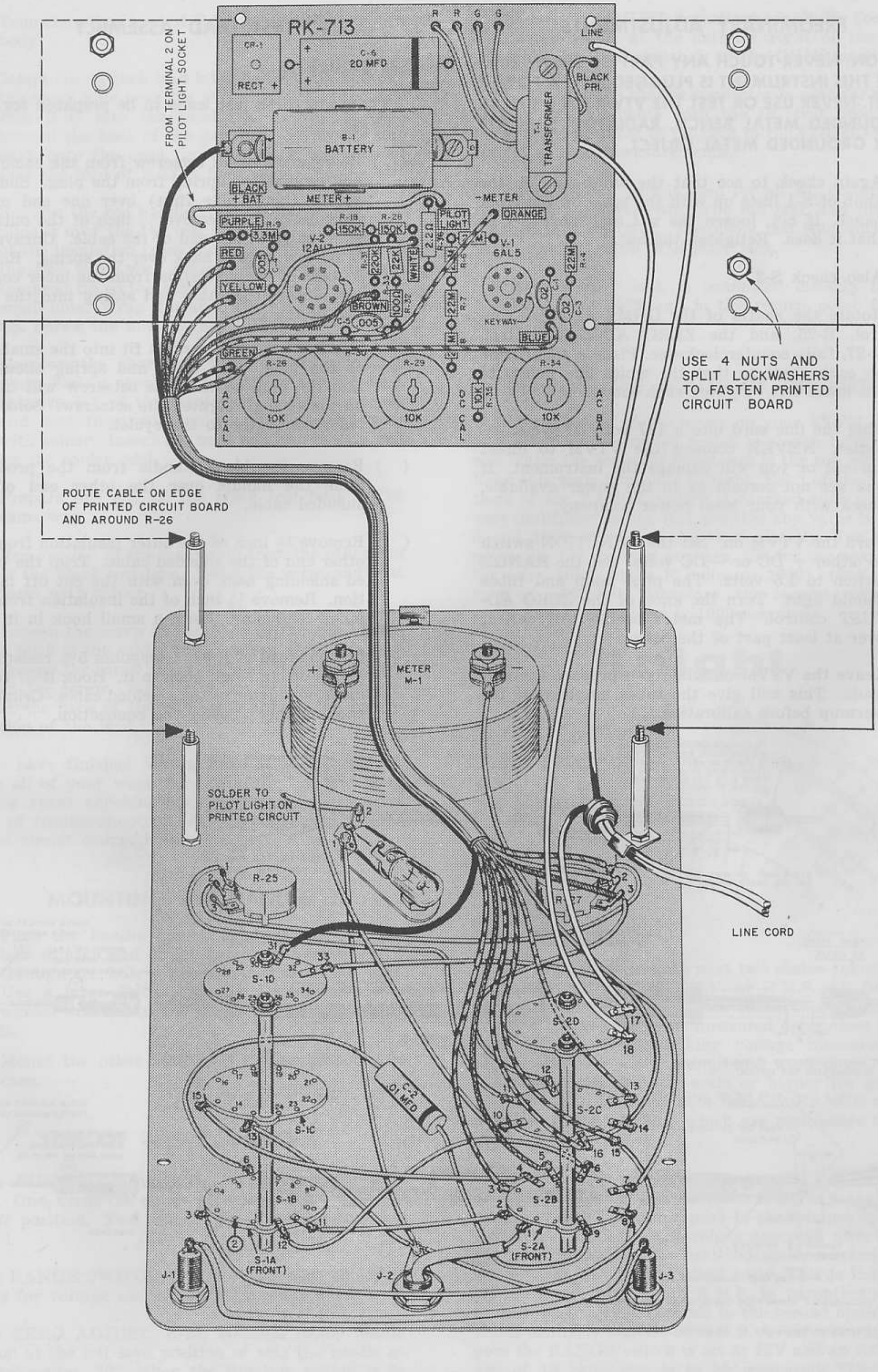



FIGURE 14. HOW TO MOUNT THE PRINTED CIRCUIT BOARD

## PRELIMINARY ADJUSTMENTS

**CAUTION: NEVER TOUCH ANY PART OF THE WIRING WHILE THIS INSTRUMENT IS PLUGGED INTO A POWER OUTLET. NEVER USE OR TEST THE VTVM ON OR NEAR A GROUNDED METAL BENCH, RADIATOR, SINK, OR OTHER GROUNDED METAL OBJECT.**

( ) Again check to see that the white line on the knob of S-1 lines up with the scale on the front panel. If not, loosen the nut and move S-1 so that it does. Retighten the nut.

( ) Also check S-2.

( ) Rotate the shafts of the OHMS ADJUST control, R-25, and the ZERO ADJUST control, R-27, fully counterclockwise. Place a small knob on each shaft so that the white line points to the lower left. Tighten each set screw.

( ) Plug the line cord into a 117 volt, 60 cycle, AC outlet. NEVER connect the VTVM to direct current or you will damage the instrument. If you are not certain as to the power available, check with your local power company.

( ) Turn the VTVM on. Set the FUNCTION switch to either + DC or —DC volts. Set the RANGE switch to 1.5 volts. The pilot lamp and tubes should light. Turn the knob of the ZERO ADJUST control. The meter needle will deflect over at least part of the scale.

( ) Leave the VTVM on while you prepare the test leads. This will give the tubes ample time for warmup before calibration.

## TEST LEAD ASSEMBLY

**SEE FIGURE 15.**

There are three test leads to be prepared for your VTVM.

( ) Remove the small setscrew from the cable plug and remove the spring from the plug. Slide the spring (large hole first) over one end of the shielded cable. Remove ½ inch of the outer insulation from one end of the cable. Unravel the braid and bend it back over the spring. Remove ⅛ inch of the insulation from the inner conductor. Insert the cable and spring into the open end of the plug.

The inner conductor must fit into the small hole of the plug. The braid and spring should fit into the plug so that the setscrew will tighten on the spring. Tighten the setscrew. Solder the inner conductor to the eyelet.

( ) Remove the black handle from the prod tip. Slide the handle over the other end of the shielded cable.

( ) Remove ½ inch of the outer insulation from the other end of the shielded cable. Trim the braided shielding back even with the cut off insulation. Remove ¼ inch of the insulation from the inner conductor. Form a small hook in it.

( ) Cut one lead of R-37, 1 megohm 5% resistor, to ¼". Form a small hook in it. Hook R-37 to the inner conductor of the shielded cable. Crimp the two together. Solder the connection.

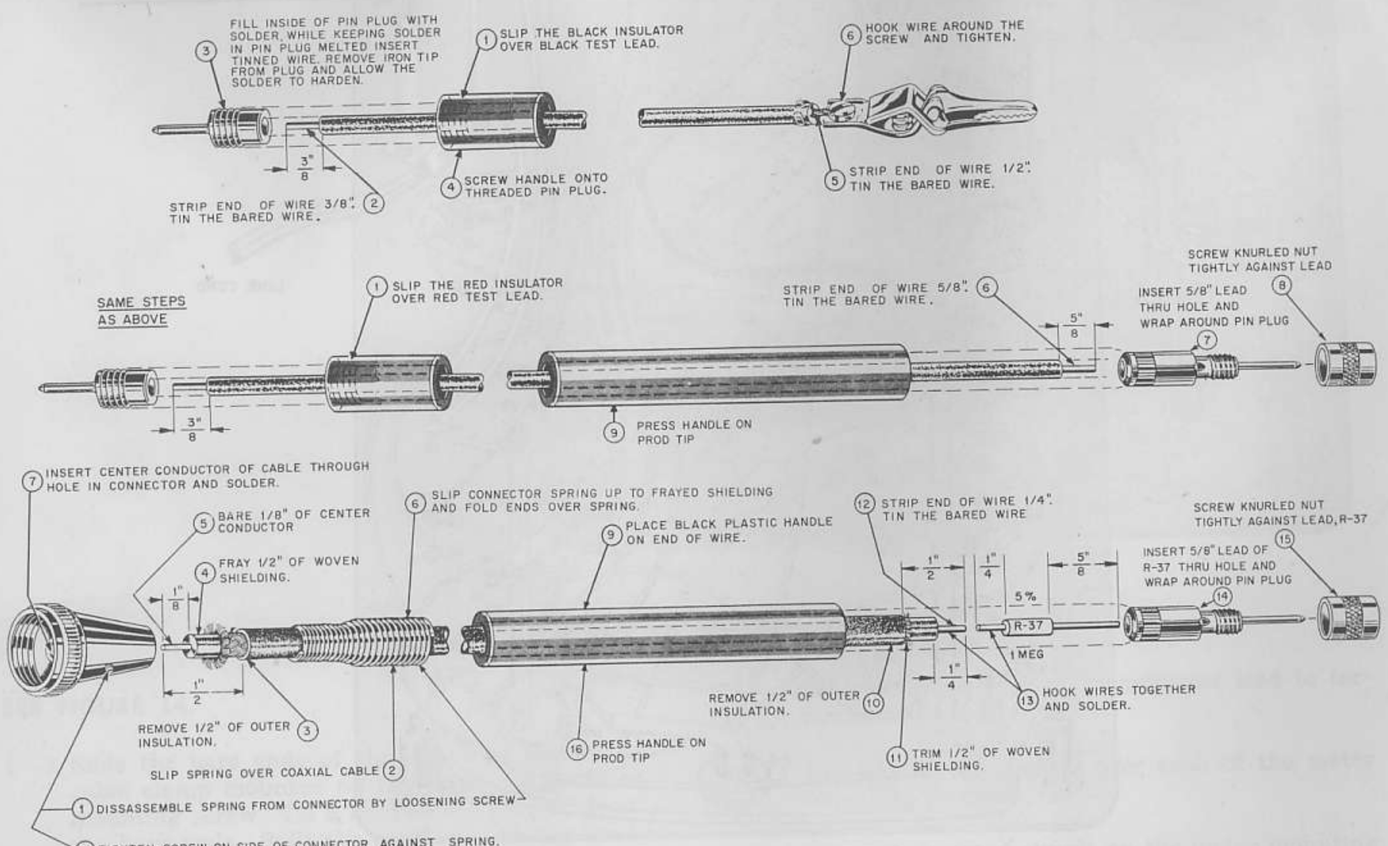



**FIGURE 15. HOW TO ASSEMBLE THE TEST LEADS**

( ) Trim the other lead of R-37 to 5/8 inch from the body.

( ) Insert the 5/8 inch lead into the prod tip and out the small hole near the threads on the prod tip. Pull R-37 into the prod tip. Wrap the lead around the base of the prod tip. Screw the nut back onto the prod tip. Tighten it securely so that the lead of R-37 is held very firmly.

( ) Remove the red handle from the other prod tip. Slide it over the red test lead wire. Remove 5/8″ of the insulation from one end of the wire. Coat the fine wires with solder. Insert the end into the prod tip so the bared end comes through the small hole. Wrap it around the base of the prod tip. Screw the nut on very tightly.

( ) Unscrew the short red insulator from the tip plug. Slide it over the other end of the red wire. Remove 3/8″ of the insulation. Twist the wires and coat them with solder. Fill the tip plug with solder. Insert the bare end into the tip and let the solder cool.

( ) Prepare one end of the black test lead in the same way.

( ) Remove 1/2″ of the insulation from the other end of the black test lead. Twist the wires and coat them with solder.

( ) Loosen the screw at the back of the clip. Form a hook in the solder coated wires. Hook the wire around the screw in a clockwise direction. Tighten the screw. Now, bend the two small prongs at the back of the clip down around the insulation of the lead.

You have finished wiring your KNIGHT VTVM. Check all of your work very carefully. A few extra minutes spent checking your instrument may save hours of trouble-shooting. Be especially sure all the printed circuit connections are shiny.

## MOUNTING THE HANDLE

( ) Push the handle mounting studs through the hole in each end of the handle. Insert the stud through the hole in the meter case on one side. Use a large flat metal washer, a shakeproof washer and one of the larger hex nuts to fasten it.

( ) Mount the other stud in the other side of the case.

## USE OF THE CONTROLS

The FUNCTION SWITCH, S-2, serves two purposes. One, turns the power off when the switch is in the off position. Two, selects the operating function desired.

The RANGE SWITCH, S-1, provides wide choice of ranges for voltage and resistance measurements.

The ZERO ADJUST, R-27, controls meter needle position at the left zero position or sets the needle at the zero-center, "0", when the function switch is in VOLTS position.

The OHMS ADJUST potentiometer, R-25, positions the meter needle at the extreme right of the scale when the function switch is in the OHMS position.

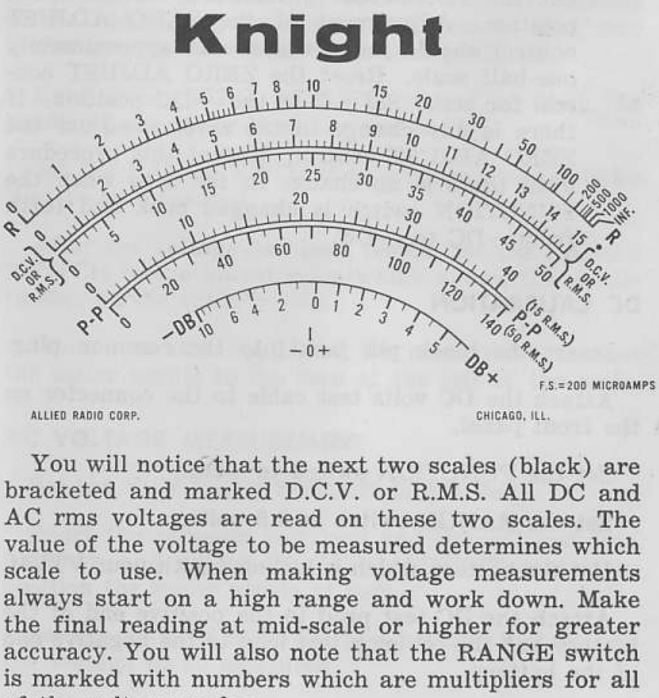
The DC VOLTS chassis connector is used for all DC voltage measurements with the DC test prod. The black test lead must be plugged in the COMMON jack for all of these measurements.

The AC-OHMS jack is used for all AC voltage and resistance measurements. The red test lead must be plugged into this jack. The black test lead must also be plugged into the COMMON jack.

The COMMON jack is connected directly to the panel of the VTVM and is the return point for all measurements.

## READING THE SCALES OF THE METER

Study the face of the meter on your VTVM. A reproduction of the meter scales is shown below. You will notice the scale for resistance is the top red scale. Read this scale from left to right. Each of the 7 positions of the RANGE switch is marked with a resistance multiplier. In the Rx1 position any value between 0 and 1000 ohms may be read directly. Ten is the multiplier for the next position, 100 for the next, 1000 the next, 10K (where K indicates 1000), 100K and 1 meg or 1,000,000. Therefore, the largest resistance which can be measured is 1000 megohms.




You will notice that the next two scales (black) are bracketed and marked D.C.V. or R.M.S. All DC and AC rms voltages are read on these two scales. The value of the voltage to be measured determines which scale to use. When making voltage measurements always start on a high range and work down. Make the final reading at mid-scale or higher for greater accuracy. You will also note that the RANGE switch is marked with numbers which are multipliers for all of the voltage scales.

The next two scales (red) are marked P-P, or peak-to-peak. The peak value of a sine wave is 1.414 times the rms value. Therefore, peak-to-peak values are 2.83 times rms. Peak-to-peak values are read directly on the two red scales. The first red scale, marked 0-40, corresponds to the first black scale. This is indicated on the meter face by 15 R.M.S. in parenthesis. The second red scale corresponds to the second black scale and is similarly marked 50 R.M.S. As an example, suppose the RANGE switch is set at 15V and an AC voltage of 10 volts rms is to be measured. The meter needle will stop at 10 on the rms scale. At the same time you can read the peak-to-peak value of the sine wave on the corresponding P-P scale, or 28.3 volts. No calculations are necessary to convert rms to peak-to-peak or vice versa. Greater accuracy is assured as well as saving you time. Peak-to-peak voltages are used for waveform measurements such as are encountered in television service work.

The use of the decibel scale and zero center are explained in the section of this manual "USING YOUR VTVM".

## CALIBRATION

Before you calibrate your VTVM, be sure the meter needle is at zero on the left side of the scale.

( ) Turn the instrument off. If the needle is not at zero, remove the screw above the pilot light. Use a scriber, or comparable instrument, to move the zero-adjustment lever either right or left as required to bring the meter needle to zero.

**CAUTION: Be very careful that you do not insert the scriber too deep. If this is done the pointer spring will be damaged. The standard RETMA warranty does not cover such damage.**

Replace the screw. Turn the instrument on again.

( ) Set the FUNCTION switch, S-2, to the +DC position. Adjustment of the ZERO ADJUST control should move the needle approximately one-half scale. Reset the ZERO ADJUST control for zero. Set S-2 to the —DC position. If there is any change in the zero, re-adjust the ZERO ADJUST control. Repeat this procedure until there is no change in the zero when the FUNCTION switch is changed back and forth from +DC to —DC.

### DC CALIBRATION

Insert the black pin jack into the common plug.

Attach the DC volts test cable to the connector on the front panel.

Set the FUNCTION switch to +DC.

Set the RANGE switch to 1.5 volts.

Use the battery which is included with your VTVM.

Attach the DC test prod to the positive end of the battery and the common test lead to the negative end of the battery.

Adjust R-29, the DC calibrate control on the printed circuit board, so that the needle of the meter rests exactly over the red dot at the extreme right edge of the scale.

Set the FUNCTION switch to —DC.

Connect the test leads to the battery in opposite polarity.

There should be no change in the position of the needle over the red dot. If there is, adjust the DC calibrate control until there is no change when switching back and forth from +DC to —DC.

### AC CALIBRATION

Set the FUNCTION switch to AC volts.

Insert the AC-OHMS pin jack into the red pin plug.

Let the leads hang free. DO NOT hold them to eliminate any hum pickup.

Set the RANGE switch to 1.5 volts.

Adjust R-34, the AC Balance Control on the printed circuit board, so that the meter needle reads exactly zero on the left side of the scale.

Set the RANGE switch to 15 volts.

Touch the AC-OHMS test prod to the green lead of T-1, which is not grounded.

The common test prod is already grounded to complete the circuit.

Adjust R-26, the AC Calibrate Control on the printed circuit board, for 6.3 volts.

You also can make this adjustment by measuring the voltage between the two connections of the line cord.

Set the RANGE switch to 150 volts.

Adjust the AC Calibrate Control for 117 volts.

### OHMS CALIBRATION

Turn off the VTVM.

Install the battery on the printed circuit board.

Turn the VTVM on.

Set the FUNCTION switch to ohms.

Adjust R-25 for full scale.

Touch the AC-OHMS and COMMON test leads together. The meter needle should indicate zero ohms.

## FINAL ASSEMBLY

( ) Install the meter in the case so that the clamp at the top of the panel hooks against the inside of the flange in the case.

( ) Use the two self-tapping screws through the holes in the panel. Tighten them into the holes in the case.

## HOW THE KNIGHT VTVM WORKS

### SEE FIGURE 16.

The KNIGHT VTVM utilizes the basic principle of a vacuum tube which is: A tube can amplify without taking power from the voltage source applied to its grid. This instrument is extremely sensitive and stable because every measurement is made electronically.

A sensitive 200 microampere meter is the indicating component. The meter is in the cathode circuit of the 12AU7 twin triode tube, V-2. R-27, the zero adjust control, balances the two sections of the tube so that there is no indication on the meter due to both sections of the control being equal when there is no applied voltage. When a voltage to be measured is fed into the grid of V-2, this balance is upset and the voltage can be read directly on the meter. The test voltage and the meter indicating current are directly proportional, so that the meter is calibrated directly. The meter is protected, because as stated before, the voltage to be measured is applied to the tube rather than the meter.

The test voltage applied to the tube is a maximum of 3 volts. Higher test voltages are reduced through the voltage divider with a total resistance of 10 megohms. The DC test prod includes a 1 megohm resistance in addition. The high input impedance of the VTVM enables you to make measurements in most circuits without disturbing the circuits.

When the instrument is used for making AC measurements, the 6AL5 tube, V-1, acts as a full wave rectifier. The output of this tube is directly proportional to the AC voltage to be measured. The DC output is fed through the voltage divider network the same as for DC measurements and is indicated in exactly the same way.

On the 500 and 1500 volt scales for AC measurements, the voltage to be measured is reduced through R-3 and R-2 before it is applied to V-1. This feature protects V-1 and all following circuitry since voltages greater than 150 volts are not applied to the tube.

The AC scales are calibrated in both RMS and peak-to-peak values.

The AC balance control provides proper meter indication for the applied AC voltage by cancelling out the contact potential between elements of V-1. The contact potential is cancelled out by the bucking voltage provided by the AC balance control. This control permits changing from AC to DC without re-adjusting the zero of the meter.

A 1.5 volt battery is connected through a series of multipliers and the unknown resistance to be measured creating a voltage divider across the battery. Part of the resulting battery voltage is applied to the 12AU7 causing a deflection in the meter. For these measurements the meter is calibrated in ohms.

There are two accessory probes which will make your KNIGHT VTVM an even more versatile instrument. One is the high-voltage probe which extends the range of the instrument to 50,000 volts, when on the 500 volt scale.

The other probe is the high-frequency probe. This probe further permits work in RF circuits up to 250 megacycles, yielding a direct reading in RMS volts.

The stock number of each probe is listed at the end of the Parts List.

## USING YOUR VTVM

**CAUTION: NEVER TOUCH ANY PART OF THE WIRING WHILE THE INSTRUMENT IS PLUGGED INTO AN AC OUTLET. Do not use the VTVM on a grounded metal bench, radiator, or other grounded object.**

Remove the power from the equipment under test before you attach the test leads. If this cannot be done, use SPECIAL CARE not to touch grounded objects. Use only one hand at a time. Grasp the test prods on the handles, never on the metal tips. Stand on a well insulated floor.

It is a good policy to discharge filter capacitors before test leads are attached.

### DC VOLTAGE MEASUREMENTS

Set the FUNCTION SWITCH to + or — DC volts as required.

Set the RANGE SWITCH to a range higher than the voltage to be measured.

Connect the common test lead.

Touch or connect the DC test prod to the high side of the voltage to be measured.

Reset the RANGE SWITCH to a scale where a reading will be obtained at almost full scale.

Read the DC voltage directly.

### ZERO-CENTER INDICATION

This is a useful feature of the instrument since both the positive and negative DC voltages may be observed without changing the setting of the FUNCTION SWITCH.

Set the FUNCTION SWITCH to +DC or —DC volts, whichever gives zero centering of the meter needle. Either position may be used. The two sections of the 12AU7 may be slightly different so that zero center may not be obtained in both positions.

Rotate the ZERO ADJUST control so that the needle of the meter is at the center "0".

Set the RANGE SWITCH to a range at least twice that to be measured.

After the voltage has been tested, set the RANGE SWITCH to the lowest scale which allows the needle to stay on the scale.

When you have completed the measurement, reset the meter needle to the zero at the left of the scale.

### AC VOLTAGE MEASUREMENT

Set the FUNCTION SWITCH to AC Volts.

Short the common test lead and the AC test lead together, and adjust the ZERO ADJUST control to position the meter needle at zero.

Set the RANGE SWITCH to a position higher than the voltage to be measured.

Connect the common lead to the ground side of the circuit.

Touch the AC-OHMS test lead to the hot side of the circuit.

Reset the RANGE SWITCH for a scale which will give an indication near full scale.

Since the human body picks up AC when near an AC circuit, the sensitivity of the KNIGHT VTVM causes the instrument to indicate this. Therefore, do not hold both test leads when making AC measurements.

## RESISTANCE MEASUREMENTS

Set the FUNCTION SWITCH to ohms.

Set the RANGE SWITCH for the proper value.

Connect the common test lead to one side of the resistor to be measured.

Set the OHMS ADJUST Control so that the meter reads exactly full scale.

Touch the AC-OHMS test prod to the other side of the resistor.

Read the resistance on the ohms scale and multiply by the multiplier indicated by the setting of the RANGE SWITCH.

The instrument must be plugged into an AC power outlet when making resistance measurements as all indications are through the electronic meter circuit. Do not leave the FUNCTION SWITCH in the ohms position when you have completed the resistance measurements as this may greatly shorten the life of the battery.

## DECIBEL MEASUREMENTS

A unit known as the "bel" was adopted as a unit of measurement for sound since the human ear does not respond to volume of sound in proportion to signal strength. The bel is more clearly equivalent to human ratios. The measurement is usually given in 1/10 of a bel which is known as a decibel. The KNIGHT VTVM db scale uses a standard of 1 milliwatt into a 600 ohm line as zero decibels. This corresponds to .774 volts AC on the 0-1.5 volt scale. Using this figure, the AC ranges may be converted to db by the following chart:

| AC VOLTS SCALE | DECIBEL SCALE |
|---|---|
| 0-1.5 volts | Read db directly |
| 0-5 volts | Add 10 db to the reading |
| 0-15 volts | Add 20 db to the reading |
| 0-50 volts | Add 30 db to the reading |
| 0-150 volts | Add 40 db to the reading |
| 0-500 volts | Add 50 db to the reading |
| 0-1500 volts | Add 60 db to the reading |

For example, when measuring the gain of an amplifier, if the input reading is +4.5 db on the 1.5 volt range and the output reading is —5.5 db on the 500 volt range, the correct reading would be 50 plus 4.5 minus 5.5 or 49 db, which is the algebraic sum.

The decibel is a power or voltage ratio and may be used as such without specifying the reference level. Since this is true, a fidelity curve may be run by feeding in a signal of variable frequency but constant amplitude. At the reference frequency, adjust the input to give a convenient indication (zero db) on the VTVM connected to the output. The output variation may be read directly in db above and below the specified reference level as the input frequency is varied.

However, when measuring complex AC wave shapes, such as ripple, hum, distorted and square waves, the indication is 35% peak-to-peak.

## SPECIAL APPLICATIONS

OSCILLATOR GRID-BIAS MEASUREMENTS. Set the FUNCTION SWITCH to DC. Select a suitable range. Make comparative voltage readings on each band of a multi-band receiver and rotate the main tuning capacitor through each band while measuring the bias.

AVC-VOLTAGE MEASUREMENTS. Make this measurement at the diode-load resistor, along the AVC bus, or at the grids of the controlled tubes.

OUTPUT INDICATION. Set the FUNCTION SWITCH for DC. Make the measurement with the test prod connected to the load resistor of the second detector in AM and TV receivers while adjusting the components for optimum output. Connect the test prod to the limiter load resistor for an FM receiver.

BIAS-CELL VOLTAGE MEASUREMENTS. The low scales of 0-1.5 and 0-5 volts make small voltages easy and convenient to read when bias voltages are critical.

DETECTION OF GASSY TUBES. If a tube is gassy and does not show up on a tube tester, the bias voltage will have an abnormal value when checked in an RC-coupled circuit.

# SERVICE HINTS

If you have followed all of the instructions and diagrams carefully, your KNIGHT VTVM should operate properly.

If it does not, recheck all of the wiring carefully. Most difficulties are the result of a wiring error. Often it is helpful to have someone else check the wiring, preferably someone with radio-TV or amateur experience.

Be sure that the shouldered fiber washer is on the inside of the panel on the AC-OHMS jack so that the jack is insulated from the panel. If this jack is not insulated from the panel, the house fuse will blow if you use your house line for calibrating on AC volts; and the needle will deflect fully to the right on OHMS indicating a short.

If a tube does not light, and you are absolutely certain the wiring on its socket is correct, its heater is open. Replace it with another of the same type.

If the tubes light and the instrument still does not operate properly, check each position of the FUNCTION switch and the RANGE switch. Determine if all functions are inoperative, or only one or two.

If the instrument operates satisfactorily on DC volts and not on AC volts, the 6AL5 tube and its associated circuitry are at fault. If the meter will not zero on AC, check R-34.

If the instrument does not operate on the 500 and 1500 volt AC scales, check R-2 and R-3. If the instrument fails to operate on either AC or DC voltages, check the string of multipliers R-10, R-11, R-12, R-13, R-14, R-15, and R-16.

If the instrument fails to function properly on OHMS, first check the battery. If this is satisfactory, check the string of multipliers R-17, R-19, R-20, R-21, R-22, R-23, and R-24.

If the instrument is erratic in operation, that is varying deflection to the right on +DC volts, varying deflection to the left on —DC volts, and a "wavy" deflection on AC, the bond between the board and the tube socket pins has probably been broken. Using more solder, again solder the connections.

Should there be no operation whatsoever, check the "D" wafer section of S-2. If this is OK, check the transformer. If the transformer is OK, check the rectifier. If all of the power supply components are satisfactory, the problem is in the 12AU7 or its associated circuitry.

## VOLTAGE CHART

All measurements made with vacuum tube voltmeter from pin indicated to panel ground. FUNCTION SWITCH in AC Volts position. RANGE SWITCH in 1.5 volt position.

| | PIN | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TUBE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 6AL5 | * | * | 5.4AC | 0 | 0 | NC | - | | |
| 12AU7 | 77.0 | 0 | 3.5 | 0 | 0 | 77.0 | 0 | 3.5 | 5.4AC |

* Non-significant voltages. NC – Not connected.

## RESISTANCE CHART

All measurements made with vacuum tube voltmeter from pin indicated to panel ground. FUNCTION SWITCH in off position.

| | PIN | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TUBE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 6AL5 | * | * | 1 | 0 | 0 | NC | 110M | | |
| 12AU7 | 20K | * | 85K | 0 | 0 | 20K | 10M | 85K | 1 |

All values indicate ohms. *-Infinite. K equals 1000. M equals 1,000,000. NC – Not connected.

## ALLIED'S SERVICE FACILITIES

If the kit still does not operate properly, we recommend the following:

Please write our Kit Department giving stock number and date of purchase of the kit. Also, describe fully what appears to be wrong. Details as to which controls or sections of the circuit do not function properly will help us analyze the problem. We may be able to determine a wiring error or a defective part.

This wired KNIGHT kit may be returned for inspection within 1 year after purchase for a special service charge of $3.00. However, if the meter movement must be replaced because of burnout or other abuse another $11.40* will be charged. Parts within the standard RETMA 90-day warranty period will be replaced without charge for the parts. A charge will be made for parts damaged in construction or because of a wiring error, or for parts which are beyond the 90-day warranty period. After the one year period, service charges, plus cost of parts are based on the length of time required to repair the unit.

**PLEASE NOTE: KITS WIRED WITH ACID CORE SOLDER OR ACID FLUX ARE NOT ELIGIBLE FOR REPAIR OR SERVICE AND WOULD HAVE TO BE RETURNED NOT REPAIRED AT YOUR EXPENSE.**

Allied's service facilities are primarily for inspection and trouble-shooting. Kits not completely wired, which require extensive work, will be returned collect with a letter of explanation.

If, for any reason, you desire to ship your VTVM, it is extremely important that you unsolder the six connections on the power transformer, remove the two nuts and screws, and lift the transformer from the printed circuit board. Wrap the transformer separately and pack it outside the case of the VTVM. This will assure no damage to the printed circuit board during shipment. Re-installation is a simple job since the board does not have to be removed for this operation.

If you return this kit, pack it well. To prevent damage in shipment, use a large enough carton so that cushioning material can be placed around the instrument. Cushion it well and tightly. Mark it: FRAGILE —DELICATE ELECTRONIC INSTRUMENT. Send the kit prepaid and insured. We will return the repaired kit to you C.O.D. as soon as repairs are completed. If you wish to save C.O.D. fees, your advance remittance may be enclosed for standard repair charges plus transportation costs. Any excess remittance will be refunded.

## ALLIED'S GUARANTEE ON KNIGHT KITS

The designs and components selected for KNIGHT kits represent over a quarter of a century of experience in kit development. KNIGHT kits are easy to assemble even for the beginner. Instructions are complete, panels are drilled, the chassis is punched and formed, and every last part is included as listed.

Allied extends these firm guarantees on KNIGHT kits:

> We guarantee that the circuits on all KNIGHT kits have been carefully engineered and tested.
>
> We guarantee that only high-quality components are supplied. All parts are covered by the standard RETMA 90-day warranty. Any faulty components will be replaced prepaid and without charge if reported to us within the warranty period. We reserve the right to request the return of defective parts.

If your kit was shipped by parcel post and is received in a damaged condition, please write us at once describing the state in which the shipment was received. If your kit was part of a Railway Express shipment that was damaged in transit, please notify the Railway Express agent at once and then write us.

Allied Radio cannot accept responsibility or liability for injury or damage sustained in the assembly or operation of the kit.

The efficiently engineered KNIGHT kits are moderately priced. When you buy a KNIGHT kit you get the best in design, quality, and value. Recommend KNIGHT kits to your friends.

*** Subject to change without notice.**

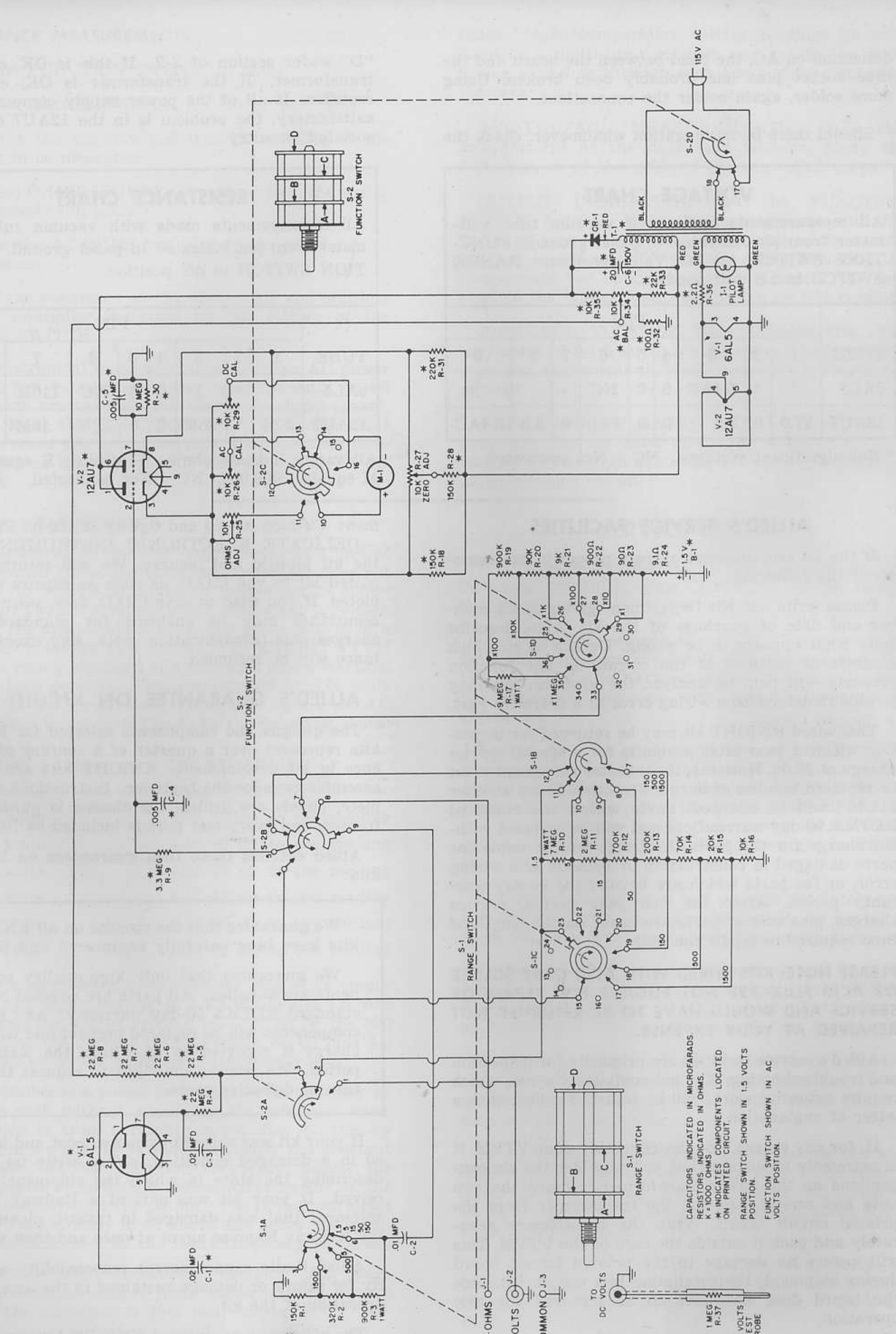



FIGURE 16. SCHEMATIC DIAGRAM, KNIGHT VTVM

# THE KNIGHT VTVM PARTS LIST

| Symbol Number | Description | Allied Part No. |
|---|---|---|
| C-1 | Capacitor, Disc, .02 MFD 600V | 12L229 |
| C-2 | Capacitor, Molded Tubular, .01 MFD 1600V | 258015 |
| C-3 | Capacitor, Disc, .02 MFD 600V | 12L229 |
| C-4 | Capacitor, Disc, .005 MFD 600V | 12L200 |
| C-5 | Capacitor, Disc, .005 MFD 600V | 12L200 |
| C-6 | Capacitor, Tubular Electrolytic, 20 MFD 150V | RK-280 |

**Note: When ordering resistors, give complete description and part number.**

| Symbol Number | Description | Allied Part No. |
|---|---|---|
| R-1 | Resistor, 150K - ½W, ±1% | 1M490 |
| R-2 | Resistor, 320K - ½W, ±1% | RK-750 |
| R-3 | Resistor, 900K - ½W, ±1% | RK-746 |
| R-4 | Resistor, 22 Megohm, ½W, ±10% | 2M040 |
| R-5 | Resistor, 22 Megohm, ½W, ±10% | 2M040 |
| R-6 | Resistor, 22 Megohm, ½W, ±10% | 2M040 |
| R-7 | Resistor, 22 Megohm, ½W, ±10% | 2M040 |
| R-8 | Resistor, 22 Megohm, ½W, ±10% | 2M040 |
| R-9 | Resistor, 3.3 Megohm, ½W, ±10% | 2M040 |
| R-10 | Resistor, 7 Megohm, 1W, ±1% | RK-745 |
| R-11 | Resistor, 2 Megohm, ½W, ±1% | 1M490 |
| R-12 | Resistor, 700K, ½W, ±1% | RK-749 |
| R-13 | Resistor, 200K - ½W, ±1% | 1M490 |
| R-14 | Resistor, 70K - ½W, ±1% | RK-752 |
| R-15 | Resistor, 20K - ½W, ±1% | 1M490 |
| R-16 | Resistor, 10K - ½W, ±1% | 1M490 |
| R-17 | Resistor, 9 Megohm, 1W, ±1% | RK-744 |
| R-18 | Resistor, 150K - ½W, ±10% | 2M040 |
| R-19 | Resistor, 900K - ½W, ±1% | RK-748 |
| R-20 | Resistor, 90K - ½W, ±1% | RK-751 |
| R-21 | Resistor, 9K - ½W, ±1% | RK-755 |
| R-22 | Resistor, 900 ohm, ½W, ±1% | RK-756 |
| R-23 | Resistor, 90 ohm, ½W, ±1% | RK-757 |
| R-24 | Resistor, 9.1 ohm, ½W, 5% Wirewound | 1M065 |
| R-25 | Potentiometer, 10K ohm, Carbon Pot, Linear Taper | 29M356 |
| R-26 | Potentiometer, 10K ohm, Carbon Pot, Linear Taper | 390113 |
| R-27 | Potentiometer, 10K ohm, Carbon Pot, Linear Taper | 29M356 |
| R-28 | Resistor, 150K - ½W, ±10% | 2M040 |
| R-29 | Potentiometer, 10K ohm, Carbon Pot, Linear Taper | 390113 |
| R-30 | Resistor, 10 Megohm, ½W, ±10% | 2M040 |
| R-31 | Resistor, 220K - ½W, ±10% | 2M040 |
| R-32 | Resistor, 100 ohm, ½W, 20% Carbon | 1M065 |
| R-33 | Resistor, 22K - ½W, ±10% | 2M040 |
| R-34 | Potentiometer, 10K ohm, Carbon Pot, Linear Taper | 390113 |
| R-35 | Resistor, 10K - ½W, ±10% | 2M040 |
| R-36 | Resistor, 2.2 ohm, ½W, 5% Wirewound | 1M065 |
| R-37 | Resistor, 1 Megohm, ½W, ±5% | 2M045 |
| S-1 | Switch, Range, 3 Section, 7 Position | RK-734 |
| S-2 | Switch, Function, 3 Section, 5 Position | RK-735 |
| T-1 | Transformer, Power | RK-583 |
| V-1 | Tube, 6AL5 | 6AL5 |
| V-2 | Tube, 12AU7 | 12AU7 |
| I-1 | Pilot Bulb, #47 | 52E312 |
| J-1 | Jack, Insulated Red Tip | 502211 |
| J-2 | Cable Connector, Chassis Mtg. | RK-610 |
| J-3 | Jack, Insulated Black Tip | 502212 |
| M-1 | Meter, 200 μAmp. | RK-708 |
| CR-1 | Rectifier, Selenium, 50 MA. | 4A631 |
| B-1 | Battery, Type 1 Size "C" | 53J029 |

## ACCESSORIES YOU MAY WANT

| Allied Stock No. | Description |
|---|---|
| 83F126 | High-Voltage Probe |
| 83F127 | RF Probe |

| Description | Quantity | Allied Part No. |
|---|---|---|
| Assembly, Pilot Light | 1 | RK-643 |
| Battery Clip Board | 1 | RK-732 |
| Cable, 9 Conductor | 11" | 803003 |
| Cable, Shielded | 48" | 803001 |
| Case | 1 | 700003 |
| Circuit Board, Printed Wiring | 1 | RK-713 |
| Clamp, Cable | 2 | 532001 |
| Clip, Alligator | 1 | RK-612 |
| Clip, Battery Retaining | 1 | RK-658 |
| Connector, Cable | 1 | RK-611 |
| Control Nut, Hex, ⅜" | 8 | RK-357 |
| Cord, Line | 1 | 49T211 |
| Instruction Manual | 1 | 750009 |
| Knob, ¾" Dia. | 2 | RK-377 |
| Knob, 1" Dia. | 2 | RK-378 |
| Leather Handle, Black | 1 | 920001 |
| Nut, 4-36 Hex | 2 | RK-10 |
| Nut, 6-32 Hex | 3 | RK-62 |
| Nut, 10-32 Hex | 2 | RK-537 |
| Panel | 1 | 462204 |
| Plug, Insulated Black Tip | 1 | 502112 |
| Plug, Insulated Red Tip | 1 | 502111 |
| Prod, Black Test | 1 | 880002 |
| Prod, Red Test | 1 | 880001 |
| Screw, 4-36 x ⅜" B.H. | 1 | RK-9 |
| Screw, 4-36 x ¼" Flat Head | 1 | 563232 |
| Screw, 6-32 x ¼" B.H. | 3 | RK-279 |
| Screw, #4 Pan Head, Self Tap | 2 | RK-390 |
| Sleeve, 1⅜" Long Spacer | 4 | 470007 |
| Socket, 7-pin Printed Circuit Miniature | 1 | 501671 |
| Socket, 9-pin Printed Circuit Miniature | 1 | 501691 |
| Solder, rosin core | 48" | RK-438 |
| Spaghetti, Small | 7" | RK-436 |
| Spaghetti, Large | 7" | RK-495 |
| Studs, Handle Mtg. | 2 | RK-542 |
| Washer, Fiber, Flat #6 | 3 | RK-282 |
| Washer, #6 Flat Steel | 1 | 580200 |
| Washer, #10 Flat Steel | 2 | 580501 |
| Washer, ⅜" Lock | 2 | 43N331 |
| Washer, External Tooth #6 Lock | 1 | RK-71 |
| Washer, Internal Tooth #6 Lock | 2 | 582300 |
| Washer, Internal Tooth #10 Lock | 2 | RK-538 |
| Wire, Red Hookup, 2" | 5 | RK-448 |
| Wire, Orange Hookup, 3" | 2 | RK-449 |
| Wire, Yellow Hookup, 4" | 2 | RK-450 |
| Wire, Green Hookup, 5" | 5 | RK-451 |
| Wire, Blue Hookup, 6" | 2 | RK-452 |
| Wire, Violet Hookup, 7" | 2 | RK-453 |
| Wire, #20 Bare Hookup | 13" | RK-473 |
| Wire, Rubber Covered Black Test Lead | 48" | RK-782 |
| Wire, Rubber Covered Red Test Lead | 48" | RK-783 |

## TOOLS YOU MAY NEED

| Allied Stock No. | Description | Price* |
|---|---|---|
| 46N593 | Pencil type soldering iron | $1.06 |
| 46N401 | 6" long nose pliers | 2.50 |
| 45N795 | 8" screwdriver | .60 |
| 46N403 | 6" diagonal cutters | 2.50 |
| 43N831 | Set-screw driver | .24 |

*** All Prices Subject To Change Without Notice.**