PRICE $2.00

HEATH COMPANY · BENTON HARBOR, MICHIGAN

HEATHKIT®
ASSEMBLY MANUAL

HEATHKIT® by DAYSTROM

SERVICE BENCH VTVM

MODEL IM-10

RESISTOR AND CAPACITOR COLOR CODES

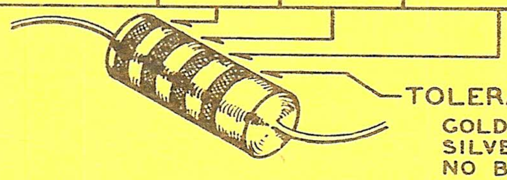
RESISTORS

The colored bands around the body of a color coded resistor represent its value in ohms. These colored bands are grouped toward one end of the resistor body. Starting with this end of the resistor, the first band represents the first digit of the resistance value; the second band represents the second digit; the third band represents the number by which the first two digits are multiplied. A fourth band of gold or silver represents a tolerance of ±5% or ±10% respectively. The absence of a fourth band indicates a tolerance of ±20%.

The physical size of a composition resistor is related to its wattage rating. Size increases progressively as the wattage rating is increased. The diameters of 1/2 watt, 1 watt and 2 watt resistors are approximately 1/8", 1/4" and 5/16", respectively.

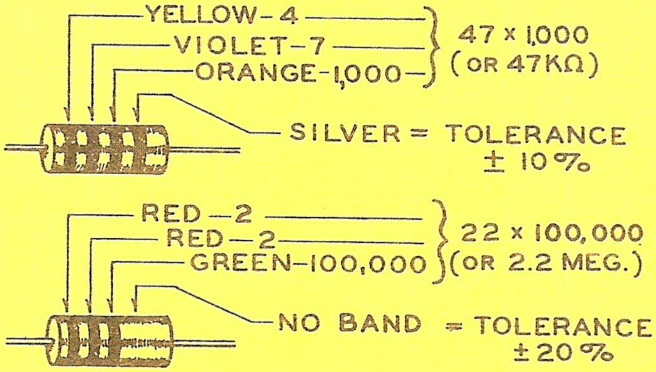
The color code chart and examples which follow provide the information required to identify color coded resistors.

COLOR	CODE 1ST DIGIT	2ND DIGIT	MULTIPLIER
BLACK	0	0	1
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
VIOLET	7	7	10,000,000
GRAY	8	8	100,000,000
WHITE	9	9	1,000,000,000
GOLD	-	-	.1
SILVER	-	-	.01



TOLERANCE
GOLD ±5%
SILVER ±10%
NO BAND ±20%

EXAMPLES

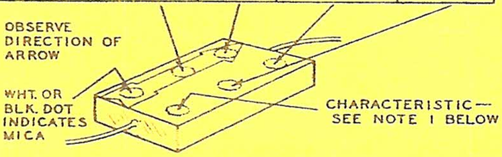


CAPACITORS

Generally, only mica and tubular ceramic capacitors, used in modern equipment, are color coded. The color codes differ somewhat among capacitor manufacturers, however the codes shown below apply to practically all of the mica and tubular ceramic capacitors that are in common use. These codes comply with EIA (Electronics Industries Association) Standards.

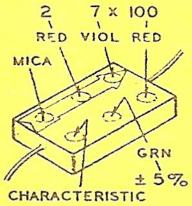
MICA

COLOR	CODE 1ST DIGIT	2ND DIGIT	MULTIPLIER	TOLER. %
BLACK	0	0	1	±20
BROWN	1	1	10	—
RED	2	2	100	± 2
ORANGE	3	3	1,000	± 3
YELLOW	4	4	10,000	—
GREEN	5	5	—	± 5
BLUE	6	6	—	—
VIOLET	7	7	—	—
GRAY	8	8	—	—
WHITE	9	9	—	—
GOLD	-	-	.1	—
SILVER	-	-	.01	± 10



(VALUE IN µµf—SEE NOTE 3 BELOW)

EXAMPLE

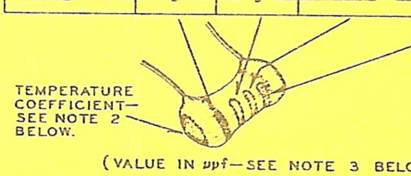


2,700µµf ±5%
OR .0027µfd

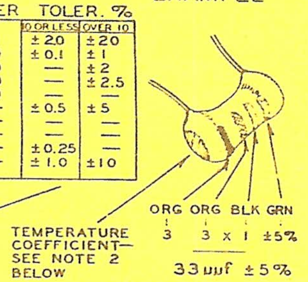
TUBULAR CERAMIC

Place the group of rings or dots to the left and read from left to right.

COLOR	CODE 1ST DIGIT	2ND DIGIT	MULTIPLIER	TOLER. % 10 OR LESS	TOLER. % OVER 10
BLACK	0	0	1	±2.0	±20
BROWN	1	1	10	±0.1	±1
RED	2	2	100	—	±2
ORANGE	3	3	1,000	—	±2.5
YELLOW	4	4	10,000	—	—
GREEN	5	5	—	±0.5	±5
BLUE	6	6	—	—	—
VIOLET	7	7	—	—	—
GRAY	8	8	—	±0.25	—
WHITE	9	9	—	±1.0	±10



EXAMPLE



33µµf ±5%

(VALUE IN µµf—SEE NOTE 3 BELOW)

NOTES:

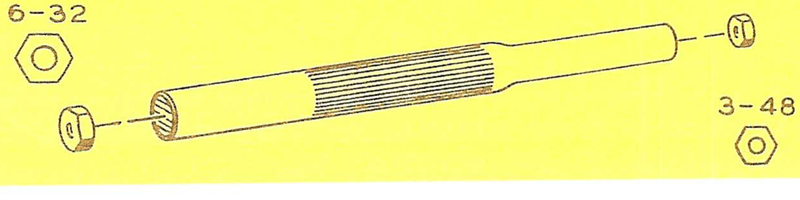
1. The characteristic of a mica capacitor is the temperature coefficient, drift capacitance and insulation resistance. This information is not usually needed to identify a capacitor but, if desired, it can be obtained by referring to EIA Standard, RS-153 (a Standard of Electronic Industries Association.)

2. The temperature coefficient of a capacitor is the predictable change in capacitance with temperature change and is expressed in parts per million per degree centigrade. Refer to EIA Standard, RS-198 (a Standard of Electronic Industries Association.)

3. The farad is the basic unit of capacitance, however capacitor values are generally expressed in terms of µfd (microfarad, .000001 farad) and µµf (micro-micro-farad, .000001 µfd); therefore, 1,000 µµf = .001 µfd, 1,000,000 µµf = 1µfd.

USING A PLASTIC NUT STARTER

A plastic nut starter offers a convenient method of starting the most used sizes: 3/16" and 1/4" (3-48 and 6-32). When the correct end is pushed down over a nut, the pliable tool conforms to the shape of the nut and the nut is gently held while it is being picked up and started on the screw. The tool should only be used to start the nut.



Assembly

and

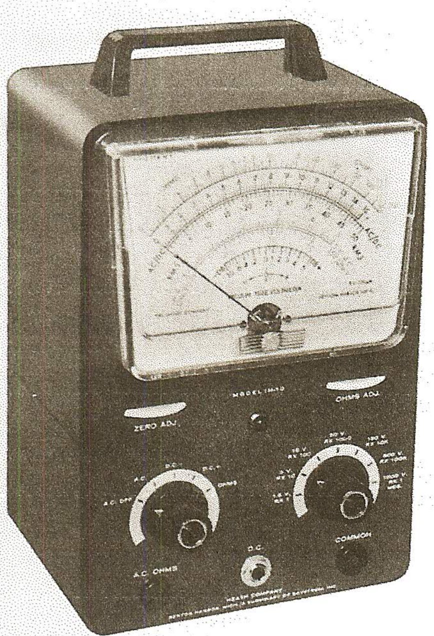
Operation

of the

HEATHKIT® by DAYSTROM

SERVICE BENCH VTVM

MODEL IM-10



HEATH COMPANY,

BENTON HARBOR,
MICHIGAN

a subsidiary of
DAYSTROM, INCORPORATED

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*Fold-out from page listed.

All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

10/13/61

SPECIFICATIONS

ELECTRONIC DC VOLTMETER

7 Ranges:	0-1.5, 5, 15, 50, 150, 500, 1500 volts full scale; up to 30,000 volts with accessory probe.
Input Resistance:	11 megohms (1 megohm in probe) on all ranges; 1100 megohms with accessory probe.
Circuit:	Balanced bridge (push-pull) using twin triode.
Accuracy:	± 3% of full scale.

ELECTRONIC AC VOLTMETER

7 Ranges:	0-1.5, 5, 15, 50, 150, 500, 1500 volts rms full scale. (0-1.5 and 5 volt ranges are read on separate scales.)
Input Resistance And Capacitance:	1 megohm shunted by 30 $\mu\mu$f (measured at input terminal).
Frequency Response:	± 1 db 25 cps to 1 mc (600 Ω source, referred to 60 cps).
Accuracy:	± 5% of full scale (at 60 cps).

ELECTRONIC OHMMETER

7 Ranges:	Scale with 10 Ω center X1, X10, X100, X1000, X10K, X100K, X1MEG. Measures .1 Ω to 1000 megohms with internal battery.
Meter:	6", 200 microampere movement. ±2% of full scale accuracy, polystyrene case.
Multipliers:	1% precision type.
Tubes-Diode:	1 - 12AU7 (twin-triode meter bridge) 1 - 6AL5 (twin diode AC rectifier) 1 - Selenium rectifier
Ohmmeter Battery:	1.5 volt, size "C" flashlight cell.
Cabinet Size:	9-1/2" high x 6-1/2" wide x 5" deep. Charcoal gray panel, feather gray cabinet.
Power Requirements:	105-125 volt, 50-60 cycle, 10 watts.

WEIGHT

Net:	5 lbs.
Shipping:	7 lbs.

INTRODUCTION

The HEATHKIT Model IM-10 Service Bench VTVM was designed for use by servicemen, engineers, and technicians, to make accurate voltage and resistance measurements. The large, easy-to-ready, multi-color meter scale makes the IM-10 a valuable instrument for applications requiring rapid, accurate measurements of electrical quantities. A separate scale for the low voltage AC ranges further increases the usefulness and accuracy of the IM-10.

This instrument employs vacuum tubes in all measurement functions to insure good sensitivity and stability. Precision resistors are used in the voltage dividing section to provide a high degree of accuracy. Thumbknobs are used for the ZERO and OHMS ADJust controls; this lessens the possibility that the user will inadvertently move these controls when operating the Range and Selector switches.

Due to the high input resistance of the IM-10 (11 megohms on DC and 1 megohm shunted by 30 $\mu\mu$f, on AC), the circuits in which voltage is being measured will not be significantly loaded by the VTVM. Most non-electronic voltmeters have a much lower input resistance and will load high impedance circuits, therefore, the indicated voltage will be less than the actual voltage.

CIRCUIT DESCRIPTION

The AC, OHMS and DC test leads of the IM-10 are connected to the Selector switch, which is used to choose the parts of the VTVM circuitry needed for any of the VTVM measurement functions. The COMMON test lead is connected to the ground circuit (case) of the VTVM.

With the Selector switch in the DC+ or DC- position, the voltage at the DC test probe is applied to the Range switch, which is effectively a series of precision resistors arranged as a voltage divider. Depending on the position of the Range switch, a portion of this DC voltage is picked off and applied to the input grid of the 12AU7 tube.

AC voltage is applied to the 6AL5 tube, (half-wave doubler circuit) where it is changed to a DC voltage that is proportional to the applied AC voltage. On the higher AC ranges, a voltage divider arrangement is used at the input of the 6AL5 stage to accurately divide the applied AC voltage so that the actual value of the voltage reaching the 6AL5 tube does not exceed the tube's rating.

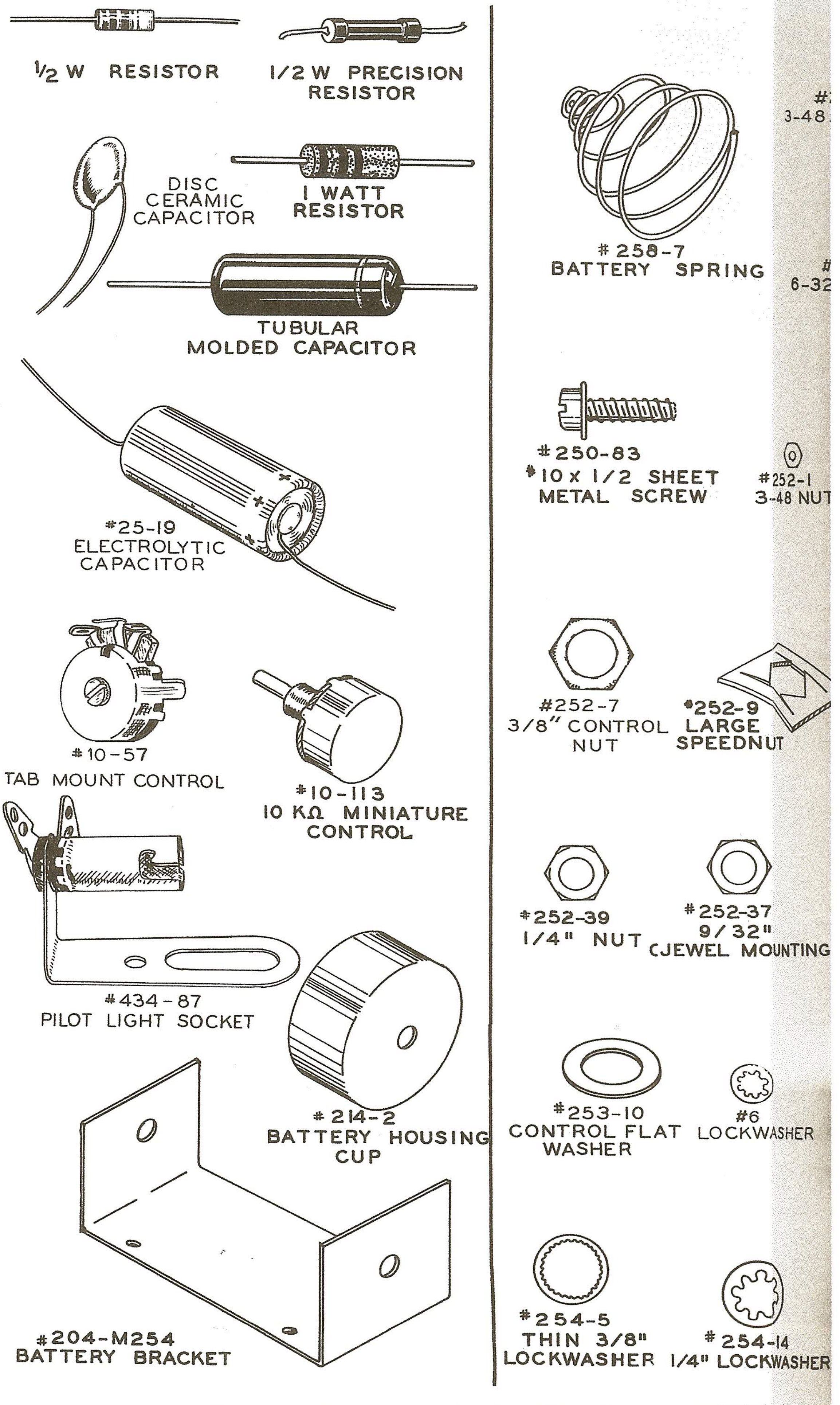
The DC voltage output of the 6AL5 stage is applied to the Range switch where it is handled as if a DC voltage were being measured. The AC Balance control is used to "buck-out" the small amount of contact potential developed in the 6AL5 tube. This eliminates residual readings on the two lowest AC ranges.

The ohmmeter section of the IM-10 uses a 1.5 volt battery which is connected in series with multiplier resistors on the Range switch and the resistance to be measured. The ratio between the ohmmeter multiplier resistors and the measured resistance determines how much of the ohmmeter battery voltage is applied to the input grid of the 12AU7 tube.

With zero voltage input to the 12AU7 balanced-bridge circuit, each of its triode sections draws the same amount of cathode current and, therefore, are at the same potential. Because the meter is connected between the cathodes of the 12AU7 tube, it will not deflect since both cathodes are at the same potential.

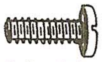
When a voltage from the Range switch (the result of measuring either voltage or resistance) is applied to one grid of the 12AU7 tube, one-half of this tube will draw more current than the other half and, thereby, provide a difference in cathode voltage between the two tube sections. This difference in cathode voltage is applied to the meter terminals, causing current to flow in the meter movement. This current, in turn, causes the meter pointer to indicate the value of the voltage or resistance being measured.

The maximum conduction characteristic of the 12AU7 tube, as used in the IM-10 circuit, is such that the voltage applied to the meter terminals is never large enough to damage the meter movement. However, if excessive voltage is applied the pointer may be bent as it hits against the stop. This is one of the primary advantages of VTVM circuitry in that the meter movement cannot be burned out by measuring a voltage that is higher than the Range switch setting. It is also possible to damage one of the resistors on the Range switch by measuring voltage with the Selector switch set to OHMS.



#204-M254
#254-5

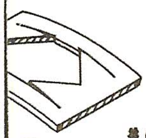
#250-49
3-48 x 1/4" BHMS



#250-89
6-32 x 3/8" BHMS

252-1
-48 NUT

#252-3
6-32 NUT

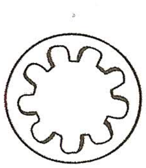


UT

#252-22
#6 SPEEDNUT

253-2
#6 SHOULDER
FIBER WASHER

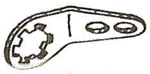
UNTING)



#254-4
3/8" CONTROL
LOCKWASHER

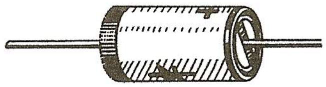
ASHER

-14



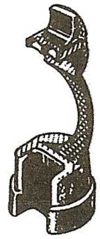
259-1
LOCKWASHER

260-1
ALLIGATOR
CLIP

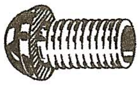


#57-22
SELENIUM
RECTIFIER

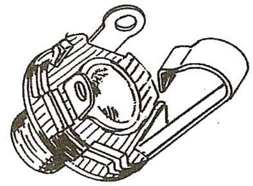
#70-5
BANANA PLUG
INSULATOR



#75-24
LINE CORD
STRAIN RELIEF



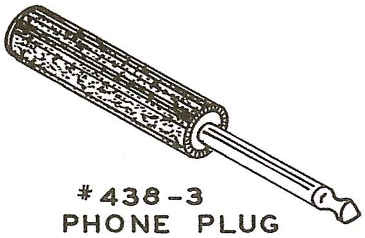
413-4
RED JEWEL



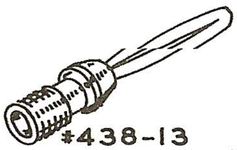
#436-1
PHONE JACK
(D.C.)

#436-2
BANANA JACK

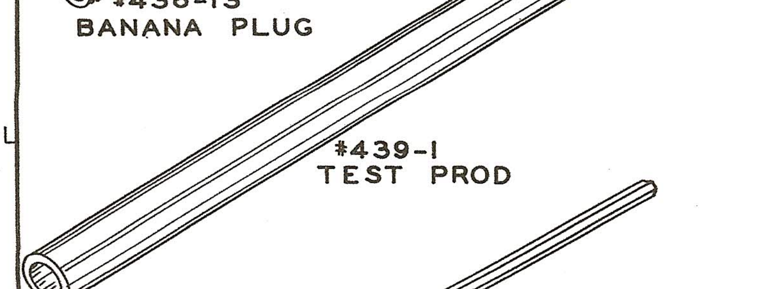
#437-1
BANANA JACK
INSERT



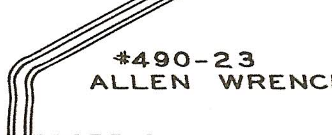
438-3
PHONE PLUG



#438-13
BANANA PLUG



#439-1
TEST PROD



#490-23
ALLEN WRENCH

#439-1
TEST PROD

The ZERO ADJust control is used to balance the cathode currents of the 12AU7 tube. Also, calibration controls for each of the VTVM functions are located in the 12AU7 cathode circuit. The correct calibration control is automatically switched in series with the meter by the Selector switch when the desired measurement function is chosen.

Switching for DC+ and DC- is accomplished by the Selector switch in the 12AU7 cathode circuit; the + and - meter terminals are simply reversed for DC- operation.

B+ and filament voltages are provided by a transformer-operated, selenium-rectifier power supply. The AC switch is a section of the Selector switch. A 1/4 ampere fuse electrically precedes the power transformer and is used to protect the IM-10.

CONSTRUCTION NOTES

This manual is supplied to assist you in every way to complete your kit with the least possible chance for error. The arrangement shown is the result of extensive experimentation and trial. If followed carefully, the result will be a stable instrument, operating at a high degree of dependability. We suggest that you retain the manual in your files for future reference, both in the use of the instrument and for its maintenance.

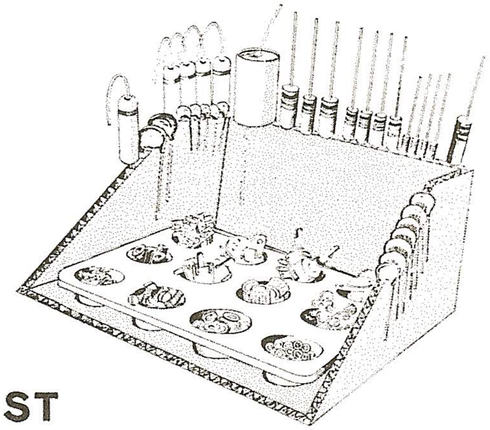
UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with the parts. Refer to the charts and other information on the inside covers of the manual to help you identify the components. If some shortage or parts damage is found in checking the Parts List, please read the REPLACEMENT section and supply the information called for therein. Include all inspection slips in your letter to us.

Resistors generally have a tolerance rating of 10% unless otherwise stated in the Parts List. Tolerances on capacitors are generally even greater. Limits of +100% and -20% are common for electrolytic capacitors.

We suggest that you do the following before work is started:

1. Lay out all parts so that they are readily available.
2. Provide yourself with good quality tools. Basic tool requirements consist of a screwdriver with a 1/4" blade; a small screwdriver with a 1/8" blade; long-nose pliers; wire cutters, preferably separate diagonal cutters; a pen knife or a tool for stripping insulation from wires; a soldering iron (or gun) and rosin core solder. A set of nut drivers and a nut starter, while not necessary, will aid extensively in construction of the kit.

Most kit builders find it helpful to separate the various parts into convenient categories. Muffin tins or molded egg cartons make convenient trays for small parts. Resistors and capacitors may be placed with their lead ends inserted in the edge of a piece of corrugated cardboard until they are needed. Values can be written on the cardboard next to each component. The illustration shows one method that may be used.



PARTS LIST

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-3	1	100 Ω 1/2 watt (brown-black-brown)
1-20	1	10 KΩ 1/2 watt (brown-black-orange)
1-23	1	27 KΩ 1/2 watt (red-violet-orange)
1-27	2	150 KΩ 1/2 watt (brown-green-yellow)
1-35	1	1 megohm 1/2 watt (brown-black-green)
1-38	1	3.3 megohm 1/2 watt (orange-orange-green)
1-40	1	10 megohm 1/2 watt (brown-black-blue)
1-70	6	22 megohm 1/2 watt (red-red-blue)
1-126	1	180 KΩ 1/2 watt (brown-gray-yellow)
2-24	1	90 Ω 1/2 watt precision
2-29	1	900 Ω 1/2 watt precision
2-35	1	9 KΩ 1/2 watt precision
2-39	1	21.62 KΩ 1/2 watt precision
2-40	1	68.38 KΩ 1/2 watt precision
2-41	1	90 KΩ 1/2 watt precision
2-42	1	216.2 KΩ 1/2 watt precision
2-45	1	683.8 KΩ 1/2 watt precision
2-48	1	9.1 Ω 1/2 watt 5% wirewound (white-brown-gold)
2-50	1	10 KΩ 1/2 watt precision
2-51	1	900 KΩ 1/2 watt precision
2-52	1	9 megohm 1/2 watt precision
2-86	1	150 KΩ 1/2 watt precision
2-123	1	800 KΩ precision
2-138	1	400 KΩ precision
Resistors (cont'd.)		
2-146	1	2.162 megohm 1/2 watt precision
2-147	1	6.838 megohm 1/2 watt precision
Capacitors		
21-27	2	.005 μfd disc ceramic
23-61	2	.05 μfd 400 volt tubular
23-91	1	.047 μfd 1600 volt tubular
25-19	1	20 μfd 150 volt electrolytic
Controls and Switches		
10-57	3	10 KΩ tab-mounting control
10-113	2	10 KΩ miniature control
63-79	1	Range Switch
63-80	1	Selector Switch
Tubes-Lamps		
411-25	1	12AU7 tube
411-40	1	6AL5 tube
412-1	1	#47 pilot lamp
Sockets-Knobs		
434-15	1	7-pin tube socket
434-16	1	9-pin tube socket
434-87	1	Pilot light socket
462-67	2	Skirted knob
462-91	2	Thumb knob
Wire-Grommets		
73-1	4	3/8" rubber grommets
89-1	1	Line cord
134-26	1	8 wire harness
134-28	1	4 wire harness
340-2	1	Length bare wire
341-1	1	Length black test lead
341-2	1	Length red test lead

PART No.	PARTS Per Kit	DESCRIPTION
Wire-Grommets (cont'd.)		
343-3	1	Length shielded test lead
344-1	1	Length hookup wire
346-6	1	Length 3/8" sleeving
Sheet Metal Parts		
90-110	1	Cabinet
200-M278F410	1	Chassis
203-215F395	1	Front panel
204-M254	1	Battery bracket
204-M352	1	Control mounting bracket
214-2	1	Battery housing cup
Hardware		
250-49	5	3-48 x 1/4" screw
250-83	2	#10 x 1/2 sheet metal screw
250-89	16	6-32 x 3/8" screw
252-1	5	3-48 nut
252-3	14	6-32 nut
252-7	3	3/8" control nut
252-9	2	Large speednut
252-22	2	#6 speednut
252-37	1	9/32" nut (for lamp jewel)
252-39	2	1/4" nut (control)
253-2	3	#6 fiber shoulder washer
253-10	3	3/8" flat washer
254-1	16	#6 lockwasher
254-4	2	3/8" control lockwasher, large
254-5	1	3/8" lockwasher, thin

PART No.	PARTS Per Kit	DESCRIPTION
Hardware (cont'd.)		
254-14	2	1/4" lockwasher
258-7	1	Battery spring
259-1	3	#6 solder lug
260-1	1	Alligator clip
Miscellaneous		
54-2	1	Power transformer
57-22	1	Selenium rectifier
70-5	1	Banana plug insulator, black
70-6	1	Banana plug insulator, red
75-24	1	Line cord strain relief
211-4	1	Handle
407-75	1	200 microampere meter
413-4	1	Pilot lamp jewel, red
418-1	1	* 1.55 V size "C" flashlight cell
421-19	1	1/4 ampere fuse
422-1	1	Fuse holder
431-10	1	3-lug terminal strip
431-11	2	5-lug terminal strip
431-14	2	2-lug terminal strip
436-1	1	Phone jack (DC)
436-2	1	Banana jack, black
436-3	1	Banana jack, red
437-1	2	Banana jack insert
438-3	1	Phone plug
438-13	2	Banana plug
439-1	1	Test probe, red
439-2	1	Test probe, black
490-23	1	Allen wrench
595-362	1	Manual

* A fresh size "C" flashlight cell will read 1.55 volts.

PROPER SOLDERING TECHNIQUES

Only a small percentage of HEATHKIT equipment purchasers find it necessary to return an instrument for factory service. Of these instruments, by far the largest portion malfunction due to poor or improper soldering.

If terminals are bright and clean and free of wax, frayed insulation and other foreign substances, no difficulty will be experienced in soldering. Correctly soldered connections are essential if the performance engineered into a kit is to be fully realized. If you are a beginner with no experience in soldering, a half hour's practice with some odd lengths of wire may be a worthwhile investment.

For most wiring, a 30 to 100 watt iron or its equivalent in a soldering gun is very satisfactory. A lower wattage iron than this may not heat the connection enough to flow the solder smoothly over the joint. Keep the iron tip clean and bright by wiping it from time to time with a cloth.

CHASSIS WIRING AND SOLDERING

1. Unless otherwise indicated, all wire used is the type with colored insulation (hookup wire); the size of the conductor is the same for all colors of hookup wires furnished with this kit. In preparing a length of hookup wire, 1/4" of insulation should be removed from

each end unless directed otherwise in the construction step.

2. To avoid breaking internal connections when stripping insulation from the leads of transformers or similar components, care should be taken not to pull directly on the lead. Instead, hold the lead with pliers while it is being stripped.

3. Leads on resistors, capacitors and similar components are generally much longer than they need to be to make the required connections. In these cases, the leads should be cut to proper length before the part is added to the chassis. In general, the leads should be just long enough to reach their terminating points.

5. Crimp or bend the lead (or leads) around the terminal to form a good joint without relying on solder for physical strength. If the wire is too large to allow bending or if the step states that the wire is not to be crimped, position the wire so that a good solder connection can still be made.

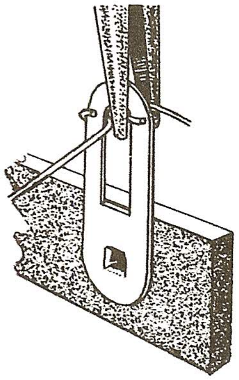
6. Position the work, if possible, so that gravity will help to keep the solder where you want it.

7. Place a flat side of the soldering iron tip against the joint to be soldered until it is heated sufficiently to melt the solder.

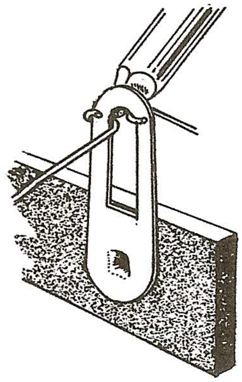
8. Then place the solder against the heated terminal and it will immediately flow over the joint; use only enough solder to thoroughly wet the junction. It is usually not necessary to fill the entire hole in the terminal with solder.

9. Remove the solder and then the iron from the completed junction. Use care not to move the leads until the solder is solidified.

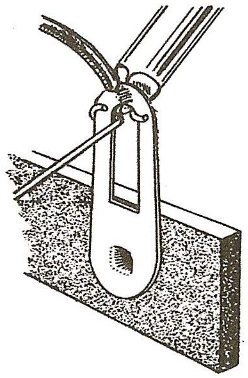
A poor or cold solder joint will usually look crystalline and have a grainy texture, or the solder will stand up in a blob and will not have adhered to the joint. Such joints should be reheated until the solder flows smoothly over the entire junction. In some cases, it may be necessary to add a little more solder to achieve a smooth bright appearance.



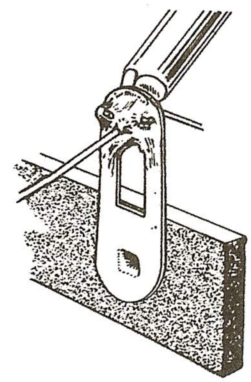
CRIMP WIRES



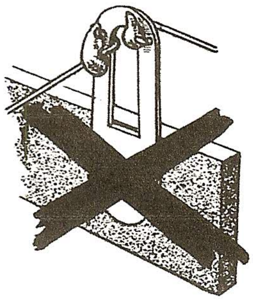
HEAT CONNECTION



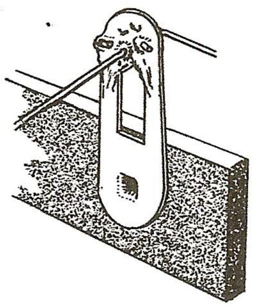
APPLY SOLDER



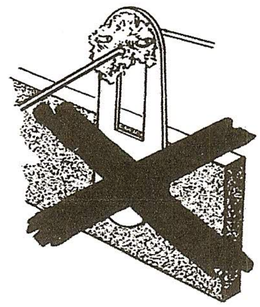
ALLOW SOLDER TO FLOW



COLD SOLDER JOINT CONNECTION INSUFFICIENTLY HEATED



PROPER SOLDER CONNECTION



COLD SOLDER JOINT CONNECTION MOVED WHILE COOLING

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

STEP-BY-STEP PROCEDURE

The following instructions are presented in a logical step-by-step sequence to enable you to complete your kit with the least possible confusion. Be sure to read each step all the way through before beginning the specified operation. Also read several steps ahead of the actual step being performed. This will familiarize you with the relationship of the subsequent operations. When the step is completed, check it off in the space provided. This is particularly important as it may prevent errors or omissions, especially if your work is interrupted. Some kit builders have also found it helpful to mark each lead in colored pencil on the Pictorial as it is added.

The fold-out diagrams in this manual may be removed and attached to the wall above your working area; but, because they are an integral part of the instructions, they should be returned to the manual after the kit is completed.

In general, the illustrations in this manual correspond to the actual configuration of the kit; however, in some instances the illustrations may be slightly distorted to facilitate clearly showing all of the parts.

The abbreviation "NS" indicates that a connection should not be soldered yet as other wires will be added. When the last wire is installed, the terminal should be soldered and the abbreviation "S" is used to indicate this. Note that a number will appear after each solder instruction. This number indicates the number of leads that are supposed to be connected to the terminal in point before it is soldered. For example, if the instruction reads, "Connect a lead to lug 1 (S-2)," it will be understood that there will be two leads connected to the terminal at the time it is soldered. (In cases where a lead passes through a terminal or lug and then connects to another point, it will count as two leads, one entering and one leaving the terminal.)

The steps directing the installation of resistors include color codes to help identify the parts. Also, if a part is identified by a letter-number designation on the Schematic, its designation will appear in the construction step which directs its installation.

STEP-BY-STEP ASSEMBLY

MECHANICAL ASSEMBLY

Refer to Pictorial 1 for the following steps.

(√) Mount the 9-pin tube socket at V2. Use 3-48 screws and 3-48 nuts. See Detail 1A. Orient the blank space as shown in Pictorial 1.

(√) Similarly, mount the 7-pin tube socket at V1. Be sure the blank space is placed as shown.

(√) Install 3/8" rubber grommets in holes B, G, and P.

(√) Mount one of the 10 KΩ tab-mounting controls at D. Twist each tab 1/4 turn with long-nose pliers. See Detail 1B.

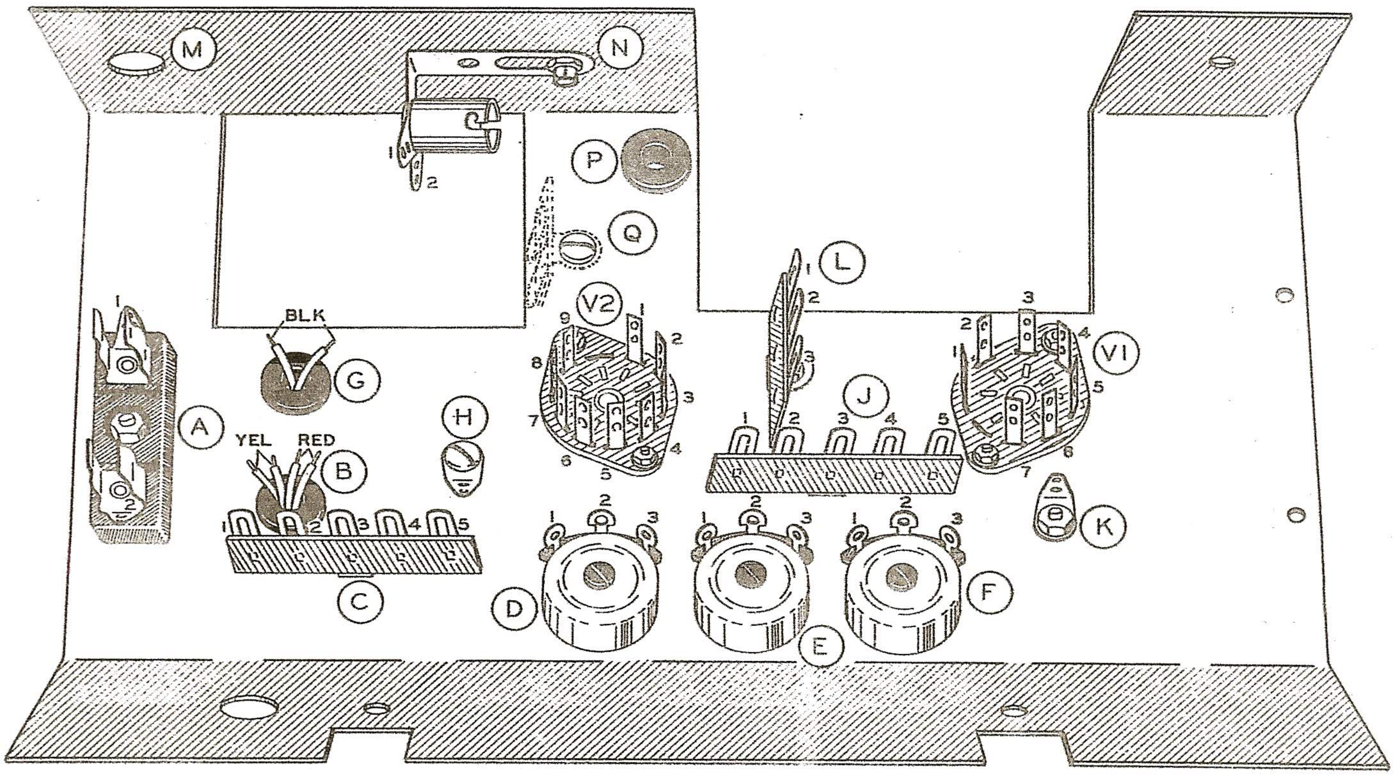
(√) Similarly, mount 10 KΩ tab-mounting controls at E and F.

NOTE: The phrase "#6 hardware" means 6-32 screws, #6 lockwashers, and 6-32 nuts.

(√) Mount a 5-lug terminal strip at C. Use #6 hardware. See Detail 1D.

(√) Mount a 5-lug terminal strip at J. Use #6 hardware.

(√) Mount a #6 solder lug at K. Use a 6-32 screw and a 6-32 nut.



Pictorial 1

(X) Mount a 3-lug terminal strip at L. Use #6 hardware.

(X) Mount a 2-lug terminal strip at Q, on top of the chassis. Use #6 hardware.

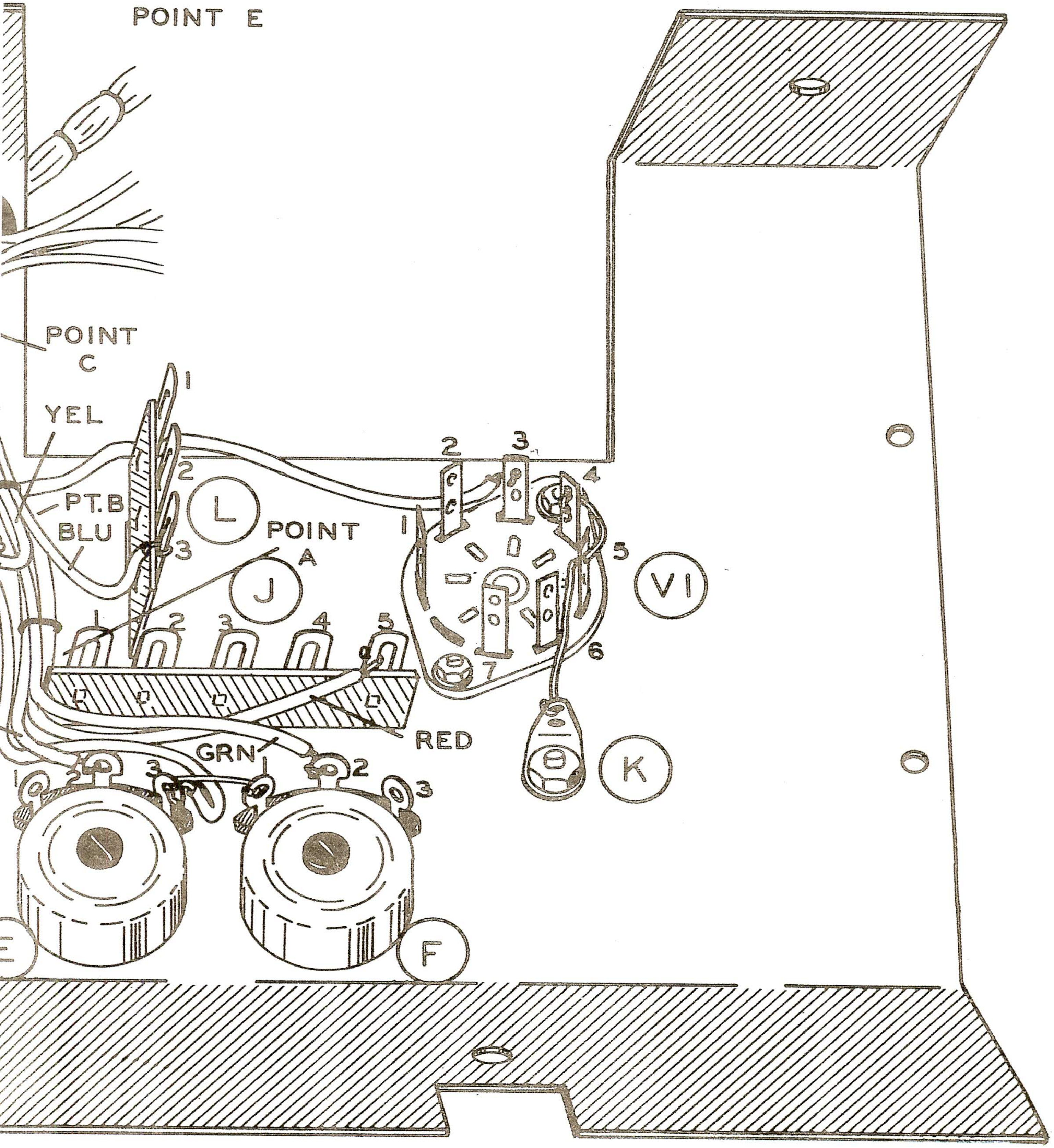
(X) Cut the power transformer (#54-2) leads to the following lengths: (Refer to Step 2 on Page 7 before cutting the leads.)

Red	-	2-3/4"
Red	-	2-1/4"
Yellow	-	1-3/4"
Yellow	-	1-3/4"
Black	-	2-1/4"
Black	-	2-1/4"

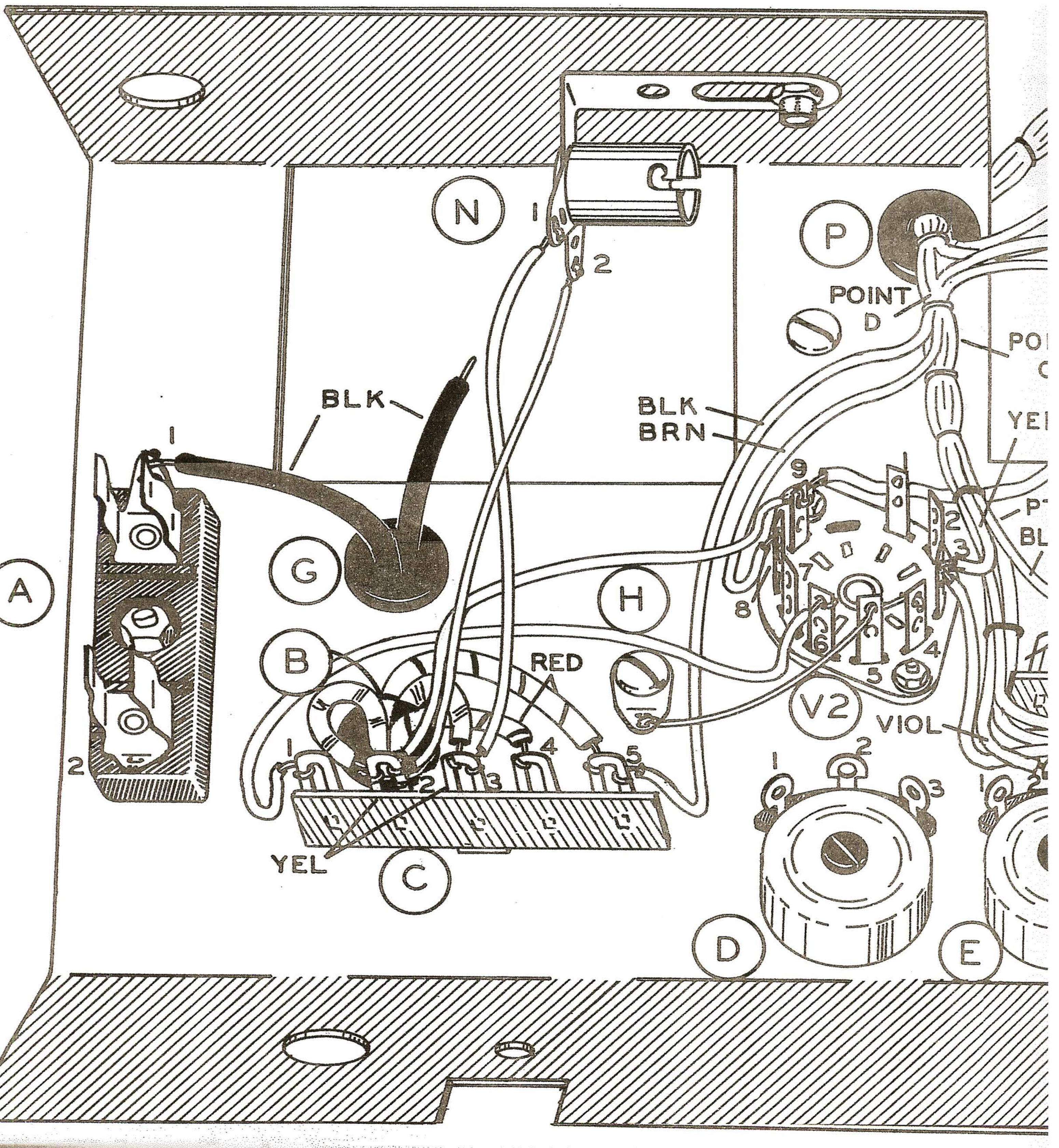
(X) Strip 1/4" of insulation from the end of each lead and tin. ("Tin means melt a small amount of solder over the exposed wire end.)

(X) Referring to Detail 1C, mount the power transformer, fuse block A, and solder lug H. Orient the transformer with the two black leads through grommet G and the remaining leads through grommet B. Secure the transformer and the parts with #6 hardware shown in Detail 1C.

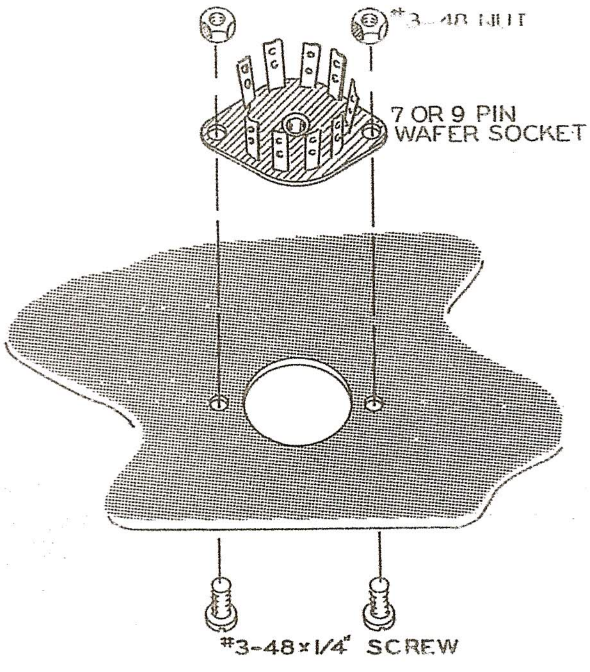
(X) Temporarily mount the pilot lamp socket at N. Use the lamp jewel and the 9/32" jewel mounting nut. See Detail 1E.


POINT E
POINT C
YEL
PT. B
BLU
L
POINT A
J
1
2
3
1
2
3
4
5
2
3
4
1
5
6
7
V1
RED
GRN
K
1
2
3
1
2
3
E
F

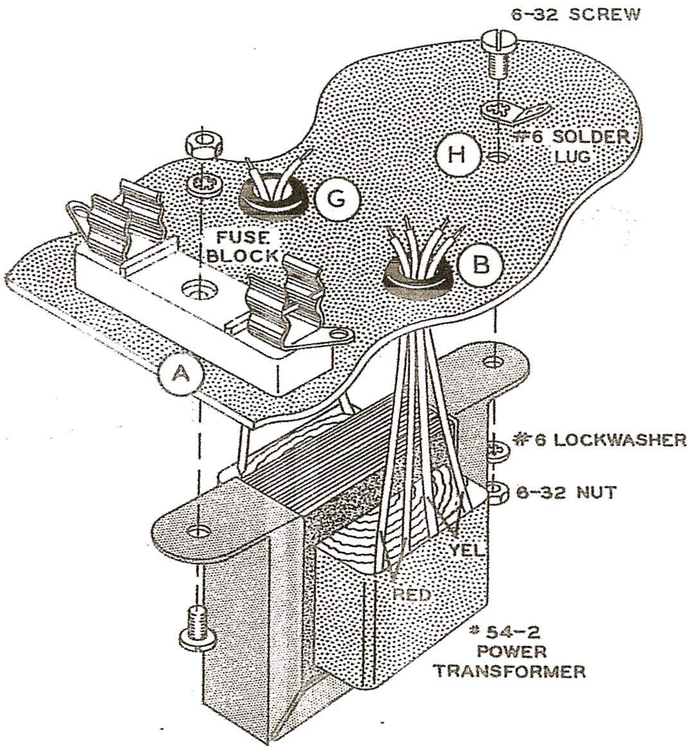
orial 2

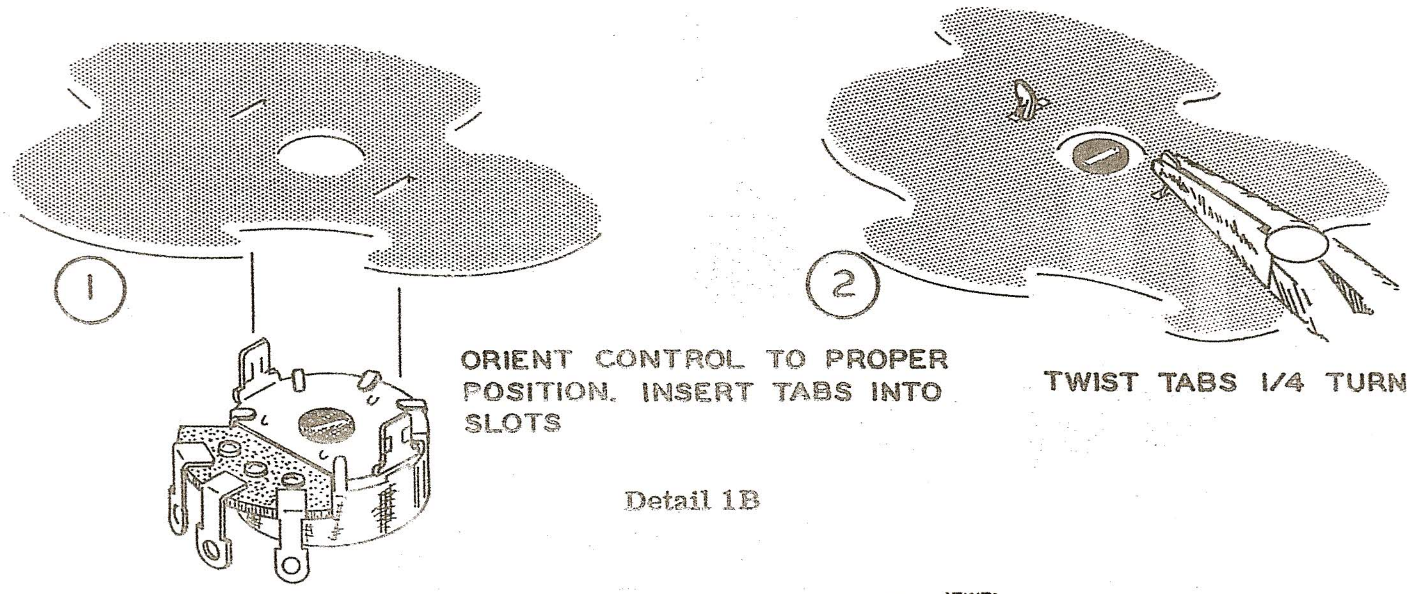


Pictorial 2

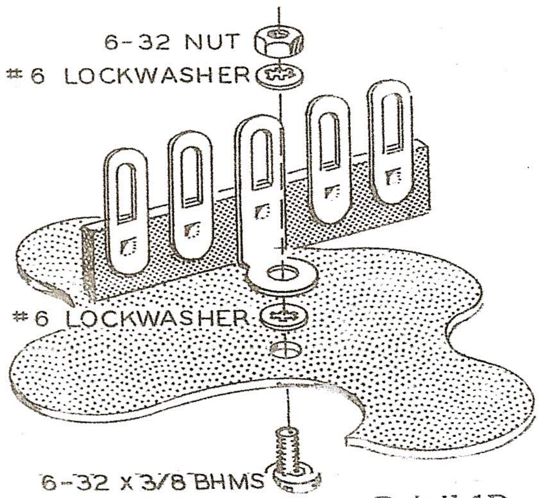


Detail 1A

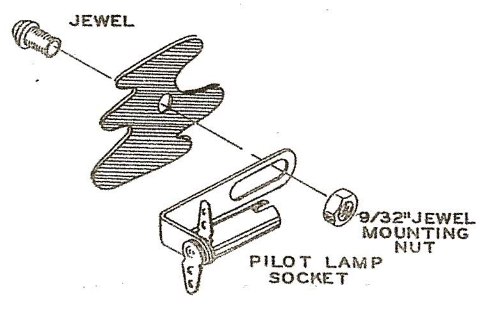




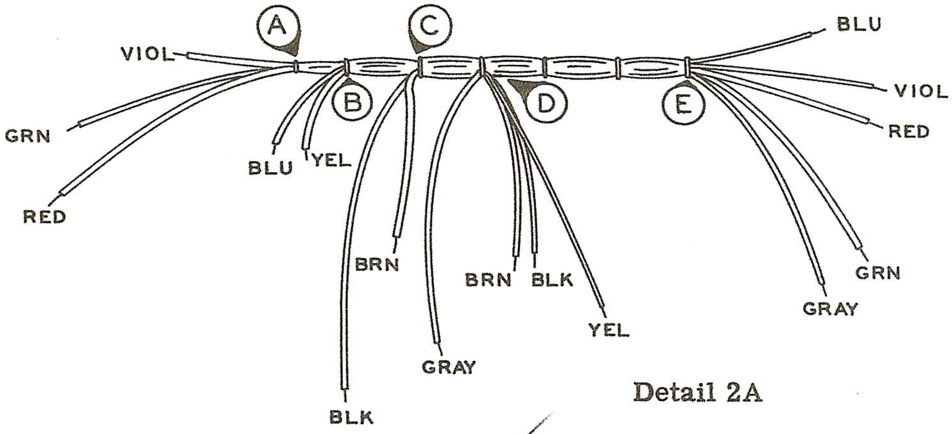
Detail 1B



Detail 1D



Detail 1E



Detail 2A

INITIAL WIRING

Refer to Pictorial 2 for the following steps.

( ) Connect either of the black transformer leads to lug 1 of fuse block A (S-1).

( ) Connect the longer red transformer lead to lug 5 of terminal strip C (NS).

( ) Connect the other red transformer lead to lug 4 of terminal strip C (NS).

( ) Connect either of the yellow transformer leads to lug 3 of terminal strip C (NS).

( ) Connect the other yellow transformer lead to lug 2 of terminal strip C (NS).

NOTE: In the following steps, cut hookup wires to the specified lengths, strip 1/4" of insulation from each end and then make the connections.

( ) Connect a 3-1/2" wire from lug 2 of terminal strip C (NS) to lug 2 of pilot lamp socket N (S-1).

( ) Connect a 4-1/2" wire from lug 3 of terminal strip C (S-2) to lug 1 of pilot lamp socket N (S-1).

( ) Connect a 4" wire from lug 1 of terminal strip C (NS) to lug 6 of tube socket V2 (NS).

( ) Connect one end of a bare wire to solder lug H (NS). Connect the other end of this wire through lug 5 (NS) to lug 4 (S-1) of V2. Now, solder lug 5 of V2 (S-2).

( ) Connect a 4" wire from lug 2 of terminal strip C (S-3) to lug 9 of tube socket V2 (NS).

( ) Connect a 4-3/4" wire from lug 9 of tube socket V2 (S-2) to lug 3 of tube socket V1 (S-1).

( ) Strip one end of a 3 1/2" wire to 3/4". Connect this end through lug 3 of control E (NS) to lug 1 of control F (S-1). Now, solder lug 3 of E (S-2). Connect the other end of this wire to lug 3 of tube socket V2 (NS).

( ) Connect one end of a bare wire to solder lug K (NS). Connect the other end of this wire through lug 5 (NS) to lug 4 (S-1) of tube socket V1. Now, solder lug 5 of V1 (S-2).

( ) Locate the 8-wire harness and compare it to Detail 2A. Place the wires coming from point E through grommet P, from the bottom of the chassis. Carefully dress the harness as shown in Pictorial 2.

Connect the wires coming from point A of the harness as follows:

( ) Red to lug 5 of terminal strip J (NS).

( ) Green to lug 2 of control F (S-1).

( ) Violet to lug 2 of control E (S-1).

Connect the wires coming from point B of the harness as follows:

( ) Blue to lug 3 of terminal strip L (NS).

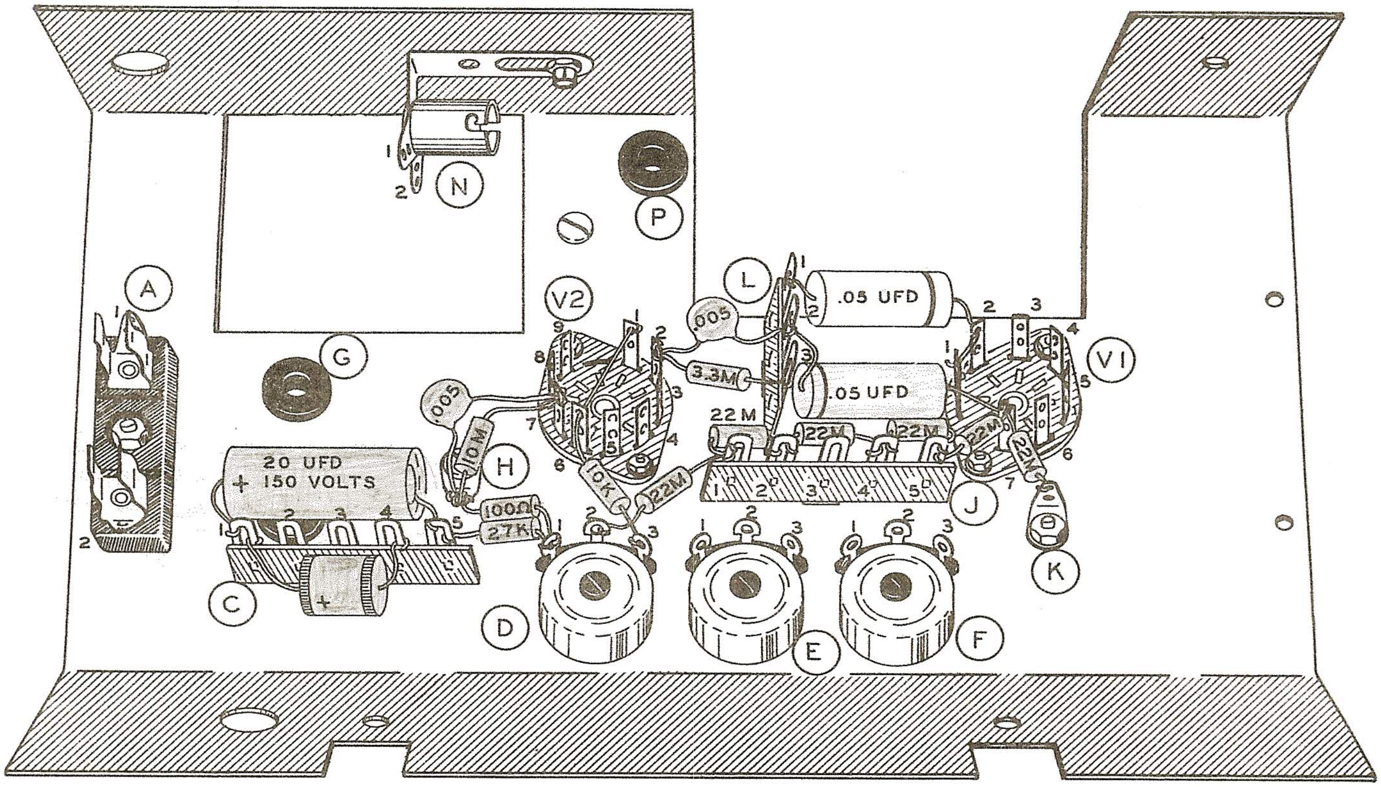
( ) Yellow to lug 3 of tube socket V2 (S-2).

Connect the wires coming from point C of the harness as follows:

( ) Brown to lug 8 of tube socket V2 (NS).

( ) Black to lug 5 of terminal strip C (NS).

The wires coming from points D and E of the harness will be connected later.



Pictorial 3

COMPONENT INSTALLATION

Refer to Pictorial 3 for the following steps.

( ) D1. Connect the positive (+) lead of the selenium rectifier to lug 1 of terminal strip C (NS). Connect the other lead to lug 4 of C (S-2).

( ) R16. Connect a 10 megohm (brown-black-blue) resistor from solder lug H (NS) to lug 7 of tube socket V2 (NS).

( ) R38. Connect a 10 KΩ (brown-black-orange) resistor from lug 3 of control D (S-1) through lug 6 (S-3) of tube socket V2 to lug 1 (S-1) of V2.

( ) R36. Connect a 100 Ω (brown-black-brown) resistor from solder lug H (NS) to lug 1 of control D (NS).

( ) R35. Connect a 27 KΩ (red-violet-orange) resistor from lug 1 of control D (S-2) to lug 5 of terminal strip C (NS).

( ) R11. Connect a 22 megohm (red-red-blue) resistor from lug 2 of control D (S-1) to lug 1 of terminal strip J (NS).

( ) R10. Connect a 22 megohm (red-red-blue) resistor between lugs 1 (S-2) and 2 (NS) of terminal strip J.

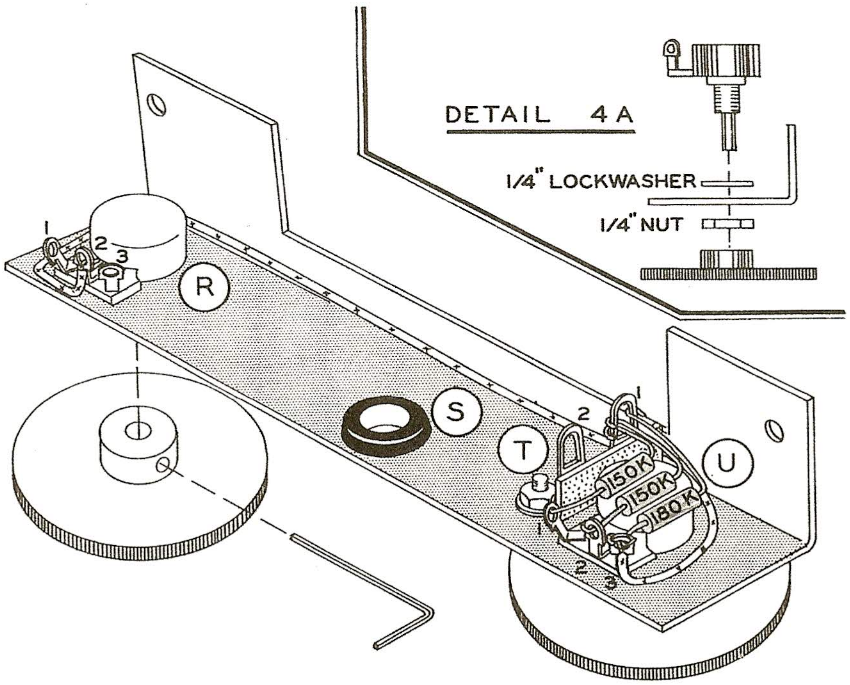
( ) R9. Connect a 22 megohm (red-red-blue) resistor between lugs 2 (S-2) and 4 (NS) of terminal strip J.

( ) R8. Connect a 22 megohm (red-red-blue) resistor between lugs 4 (S-2) and 5 (NS) of terminal strip J.

( ) R1. Connect a 22 megohm (red-red-blue) resistor from lug 5 of terminal strip J (S-3) to lug 7 of tube socket V1 (NS).

( ) R6. Connect a 22 megohm (red-red-blue) resistor from lug 7 of tube socket V1 (NS) to solder lug K (S-2).

( ) R12. Connect a 3.3 megohm (orange-orange-green) resistor from lug 2 of tube socket V2 (NS) to lug 3 of terminal strip L (S-2).



Pictorial 4

( ) C5. Connect one lead of a .005 μfd disc ceramic capacitor to lug 7 of tube socket V2 (S-2). Connect the other lead of this capacitor to solder lug H (S-4).

( ) C6. Connect the positive (+) lead of the 20 μfd 150 volt electrolytic capacitor to lug 1 of terminal strip C (S-3). Connect the other lead to lug 5 of terminal strip C (S-4).

( ) C4. Connect a .005 μfd disc ceramic capacitor from lug 2 of tube socket V2 (S-2) to lug 2 of terminal strip L (NS).

( ) C3. Connect a .05 μfd tubular capacitor from lug 2 of terminal strip L (S-2) to lug 7 of tube socket V1 (S-3).

( ) C2. Connect one lead of a .05 μfd tubular capacitor to lug 1 of terminal strip L (NS). Connect the other lead of this capacitor through lug 2 (NS) to lug 1 (S-1) of tube socket V1. Now, solder lug 2 of V1 (S-2).

CONTROL BRACKET SUBASSEMBLY

Refer to Pictorial 4 for the following steps.

( ) Install a 3/8" rubber grommet in hole S.

( ) R13. Mount the 10 KΩ OHMS ADjust control (#10-113) R. Use a 1/4" lockwasher and nut. See Detail 4A.

( ) R33. Similarly mount the 10 KΩ ZERO ADjust control (#10-113) U.

( ) Mount a 2-lug terminal strip at T. Use #6 hardware.

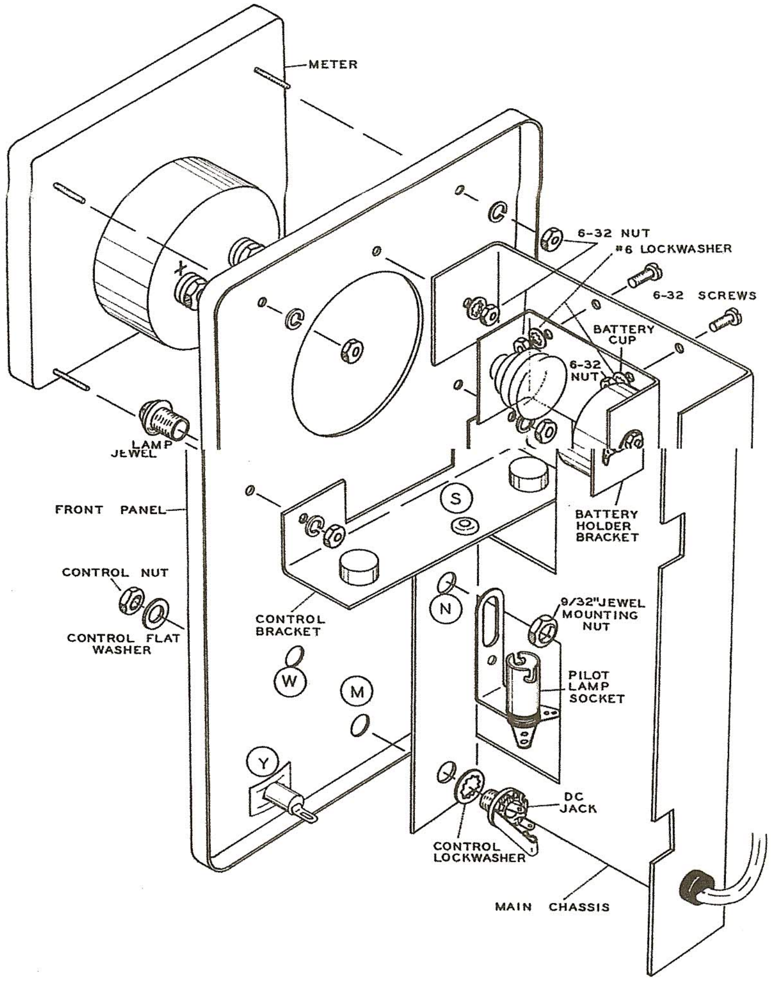
( ) R34. Connect a 150 KΩ (brown-green-yellow) resistor from lug 1 of control U (NS) to lug 1 of terminal strip T (NS).

( ) R32. Connect another 150 KΩ (brown-green-yellow) resistor from lug 2 of control U (S-1) to lug 1 of terminal strip T (NS).

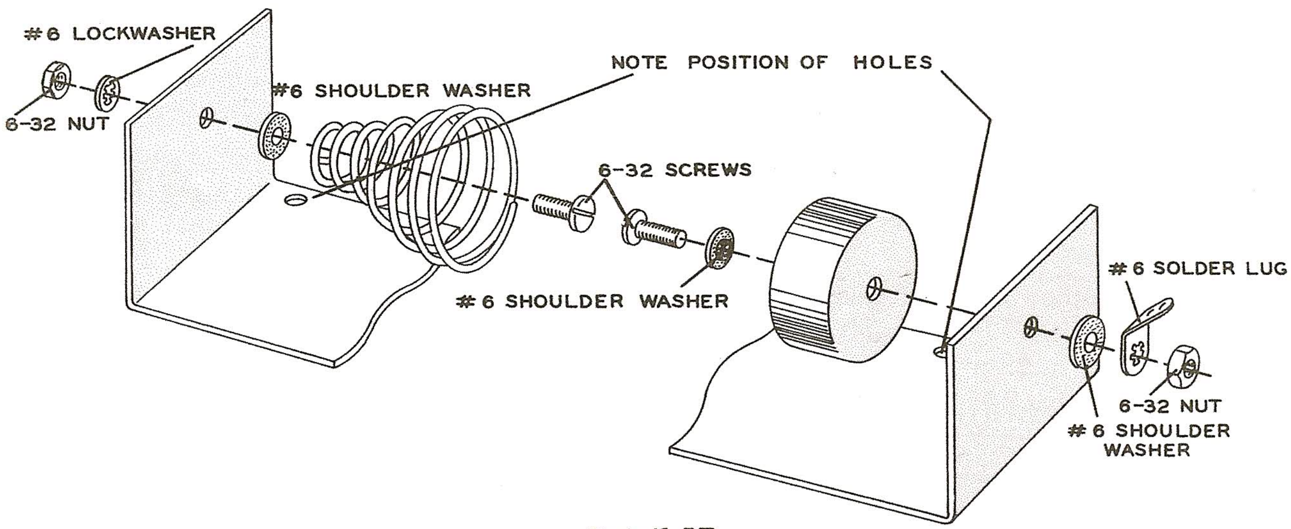
( ) R31. Connect a 180 KΩ (brown-gray-yellow) resistor from lug 3 of control U (NS) to lug 1 of terminal strip T (NS).

( ) Connect a 7-1/4" wire from lug 3 of control U (S-2) to lug 2 of control R (NS).

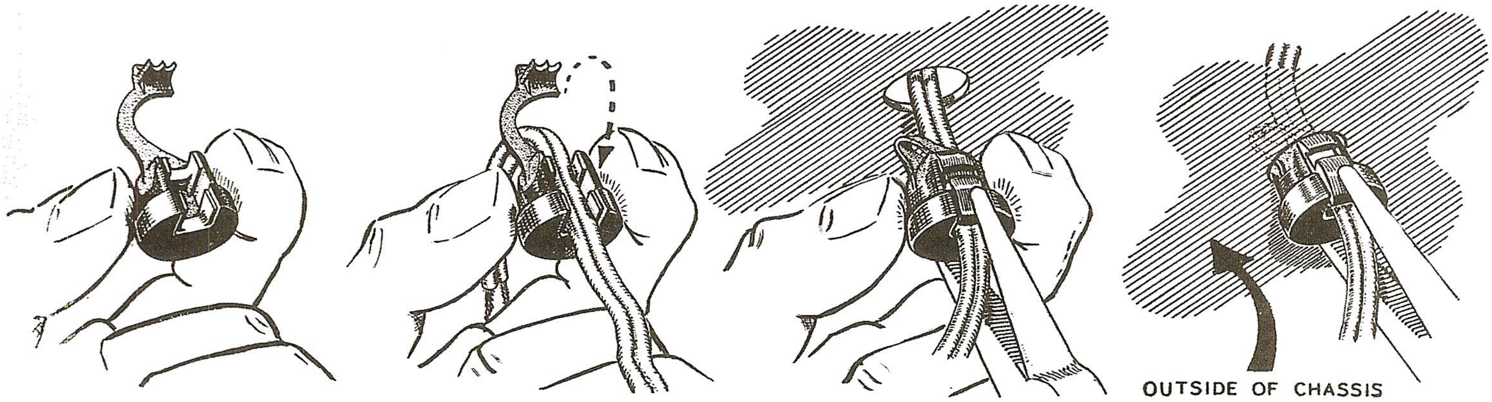
( ) Mount the thumbknobs on controls R and U.



Pictorial 5



Detail 5B



Detail 5C

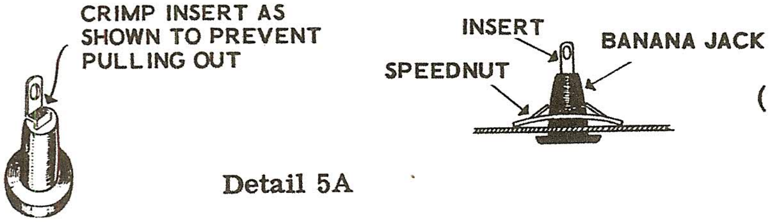
FRONT PANEL MOUNTING

Refer to Pictorial 5 for the following steps.

( ) Locate the red and black banana jacks and the banana jack inserts.

( ) Place the banana jack insert into these jacks. Secure the inserts by bending the small tab outward. See Detail 5A.

( ) Install the red banana jack at Z and the black banana jack at Y. See Detail 5A.



Detail 5A

( ) Remove the lamp jewel from the front of the main chassis.

( ) Mount the chassis to the front panel by placing the jewel through the hole in the front panel, then through the chassis and pilot lamp socket. Screw the 9/32" nut onto the jewel. Do not tighten securely at this time.

( ) Fasten the top of the chassis by placing a 6-32 screw through the dimpled hole in the front panel and through the chassis. Secure the screw with a #6 lockwasher and 6-32 nut. Do not tighten securely at this time.

( ) Install the DC phone jack at M. Orient as shown. Use the thin 3/8" lockwasher, flat control washer and a control nut. Now, tighten the DC jack, the jewel nut, and the #6 hardware.

( ) Refering to Pictorial 5, position the control bracket and insert the four leads from the cable harness through grommet S.

( ) Now, install the meter and secure the control bracket to the front panel using the two bottom meter studs. Use the hardware supplied with the meter.

( ) Adjust the position of the control bracket and the thumbknobs on their controls so that they turn freely without rubbing the front panel.

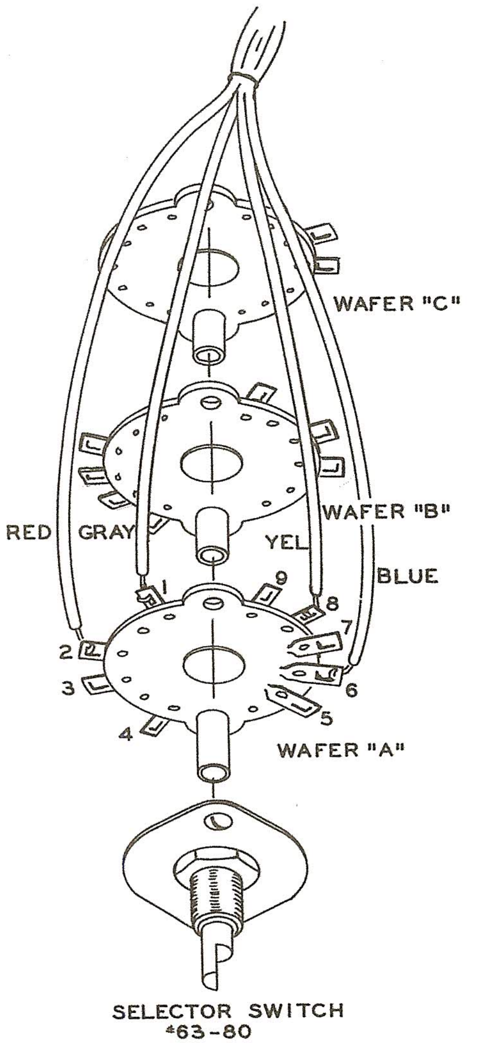
( ) Locate the battery holder bracket and mount the battery spring to it. Use #6 hardware and a #6 shoulder washer, as shown in Detail 5B.

( ) Mount the battery cup on the battery holder bracket. Use a 6-32 screw, two #6 shoulder washers, a #6 solder lug and a 6-32 nut. See Detail 5B.

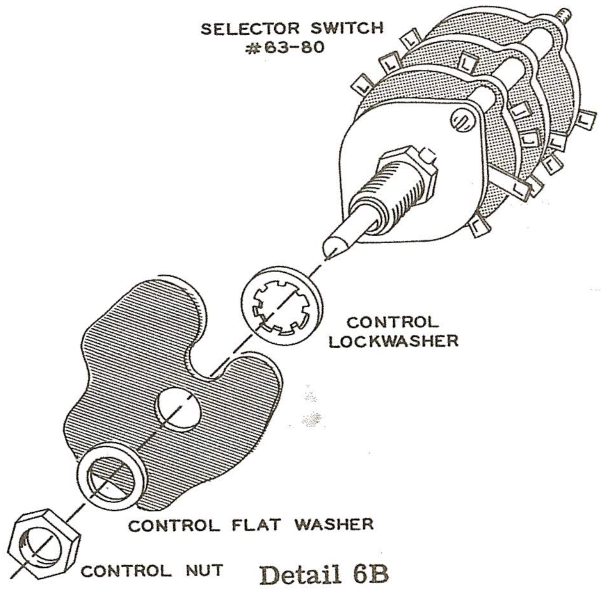
( ) Install the battery holder bracket on the main chassis with #6 hardware.

( ) Install the line cord and line cord strain relief bushing in the hole in the rear chassis apron as indicated in Detail 5C. There should be approximately 4-1/2" of line cord inside of the chassis.

( ) Cut 2-1/2" from one of the line cord wires. Connect this wire to lug 2 of fuse block A (S-1). Leave the other line cord wire free at this time.



Detail 6A



Detail 6B

SELECTOR SWITCH SUBASSEMBLY

Refer to Detail 6A for the following steps.

( ) Locate the Selector switch (#63-80). Turn the shaft fully counterclockwise and place it on your work area as shown in Detail 6A.

NOTE: The Selector switch has three wafers, each with several lugs. The first wafer (nearest the shaft) is called wafer A, the middle wafer is called wafer B, and the rear wafer is C. The lugs on each wafer are numbered as shown in Detail 6A. For instance, lug A2 refers to lug 2 on wafer A.

( ) Locate the 4 wire harness and identify the end that has the shortest yellow wire coming from it. This end will be connected in the following steps.

Wire Color	Switch Lug
Gray	A1 (S-1)
Red	A2 (S-1)
Blue	A6 (S-1)
Yellow	A8 (S-1)

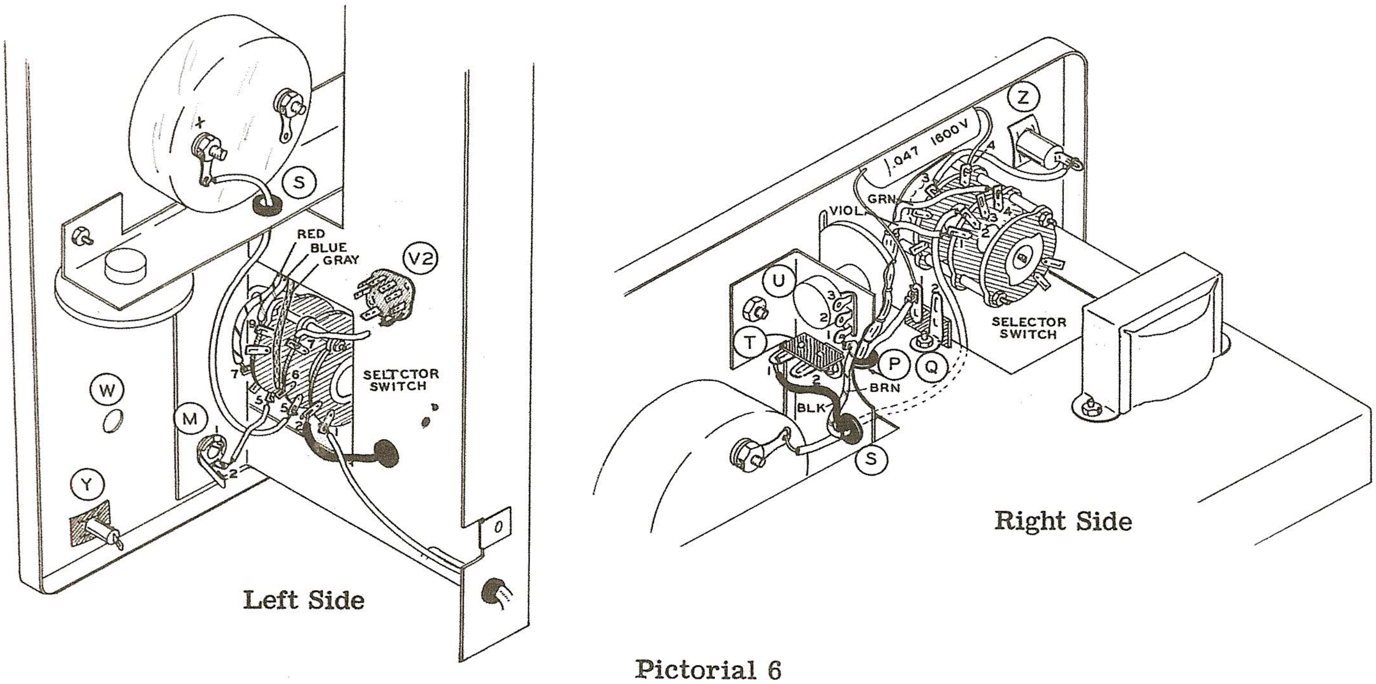
( ) Mount the Selector switch. Use a control lockwasher, control flat washer, and control nut. See Detail 6B and Pictorial 6. Position the switch with the flat portion of the shaft opposite the AC OFF marking on the front panel. Dress the harness toward hole W.

WIRING THE LEFT SIDE OF THE SELECTOR SWITCH

Refer to Pictorial 6 (left side) for the following steps.

( ) Connect the red wire coming from point E of the 8 wire harness to lug 7 on wafer A of the Selector switch (S-1).

( ) Connect the blue wire coming from point E of the 8 wire harness to lug 9 on wafer A of the Selector switch (S-1).



Pictorial 6

( ) Connect the gray wire coming from point E of the 8 wire harness to lug 6 on wafer B of the Selector switch (S-1).

( ) Connect a 2-1/4" wire from lug 2 of DC jack M (S-1) to lug 5 on wafer A of the Selector switch (S-1).

( ) Connect a 2-1/2" wire from lug 8 of tube socket V2 (S-2) to lug 7 on wafer B of the Selector switch (S-1).

( ) Connect one end of a 5-1/2" wire to lug 5 on wafer B of the Selector switch (S-1). Pass this wire through grommet S and connect the other end to the positive (+) terminal of the meter (S-1).

( ) Connect the remaining black transformer lead to lug 2 on wafer C of the Selector switch (S-1).

( ) Connect the remaining line cord lead to lug 1 on wafer C of the Selector switch (S-1).

WIRING RIGHT SIDE OF SELECTOR SWITCH

Refer to Pictorial 6 (right side) for the following steps.

( ) Connect a 2-1/2" wire from lug 3 on wafer A of the Selector switch (S-1) to banana jack Z (S-1).

( ) Connect the violet wire coming from point E of the 8 wire harness to lug 1 on wafer B of the Selector switch (S-1).

( ) Connect one end of a 6" wire to lug 2 on wafer B of the Selector switch (S-1). Pass this wire through the cutout in the chassis and through grommet S. Connect the other end of this wire to the remaining meter terminal (S-1).

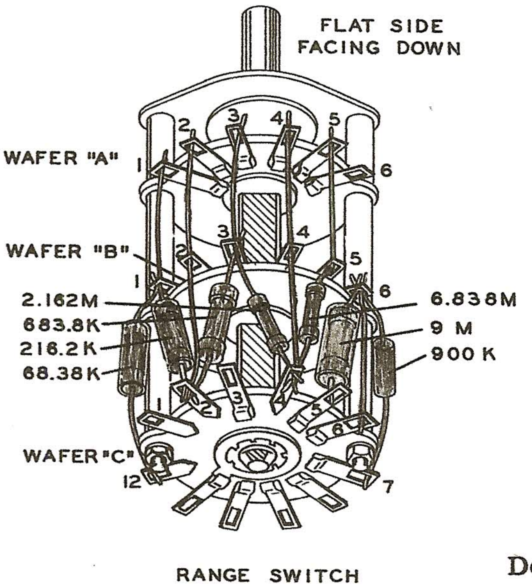
( ) Connect the green wire coming from point E of the harness to lug 4 (S-1) on wafer B of the Selector switch.

( ) Connect one end of a 6" wire to lug 1 of terminal strip Q (NS). Pass this wire through grommet P; it will be connected later.

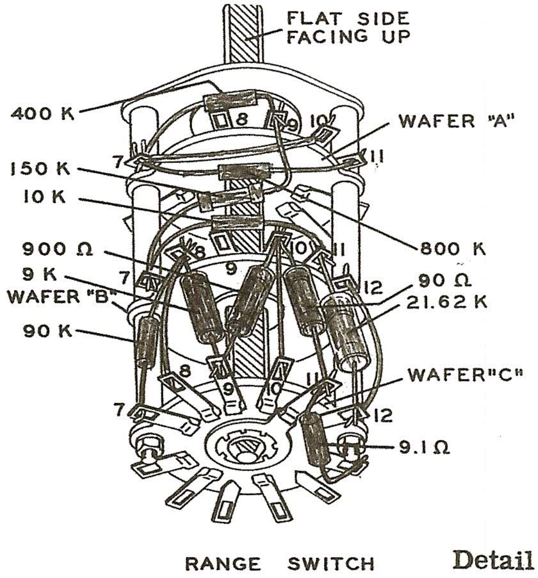
( ) C1. Connect the .047 μfd 1600 V tubular capacitor from lug 4 on wafer A of the Selector switch (S-1) to lug 1 of terminal strip Q (S-2).

( ) Connect the black harness wire coming through grommet S to lug 1 of terminal strip T (S-4).

( ) Connect the brown harness wire coming through grommet S to lug 1 of control U (S-2).



Detail 7A



Detail 7B

RANGE SWITCH SUBASSEMBLY

Refer to Detail 7A for the following steps.

( ) Locate the Range switch (#63-79). Turn the shaft completely counterclockwise, then place the switch on your work area with the flat portion of the shaft facing down.

NOTE: The Range switch has three wafers, each with several lugs. The first wafer (nearest the shaft) is called wafer A, the middle wafer is B, and the rear wafer is C. The lugs on each wafer are numbered as shown in Detail 7A. For instance, lug B4 refers to lug 4 on wafer B.

( ) R20. Connect one lead of a 216.2 KΩ resistor to lug C2 (NS). Feed the other lead through lug B1 (NS) and connect to lug A1 (S-1).

( ) Connect a bare wire from lug C2 (NS) through lug B2 (NS) to lug A2 (S-1). Now solder lug B2 (S-2).

( ) R18. Connect a 2.162 megohm resistor from lug C4 (NS) through lug B3 (NS) to lug A3 (S-1).

( ) Connect a bare wire from lug C4 (NS) through lug B4 (NS) to lug A4 (S-1). Now solder lug B4 (S-2).

( ) R17. Connect a 6.838 megohm resistor from lug C4 (S-3) through lug B5 (NS) to lug A5 (NS). Now solder lug B5 (S-2).

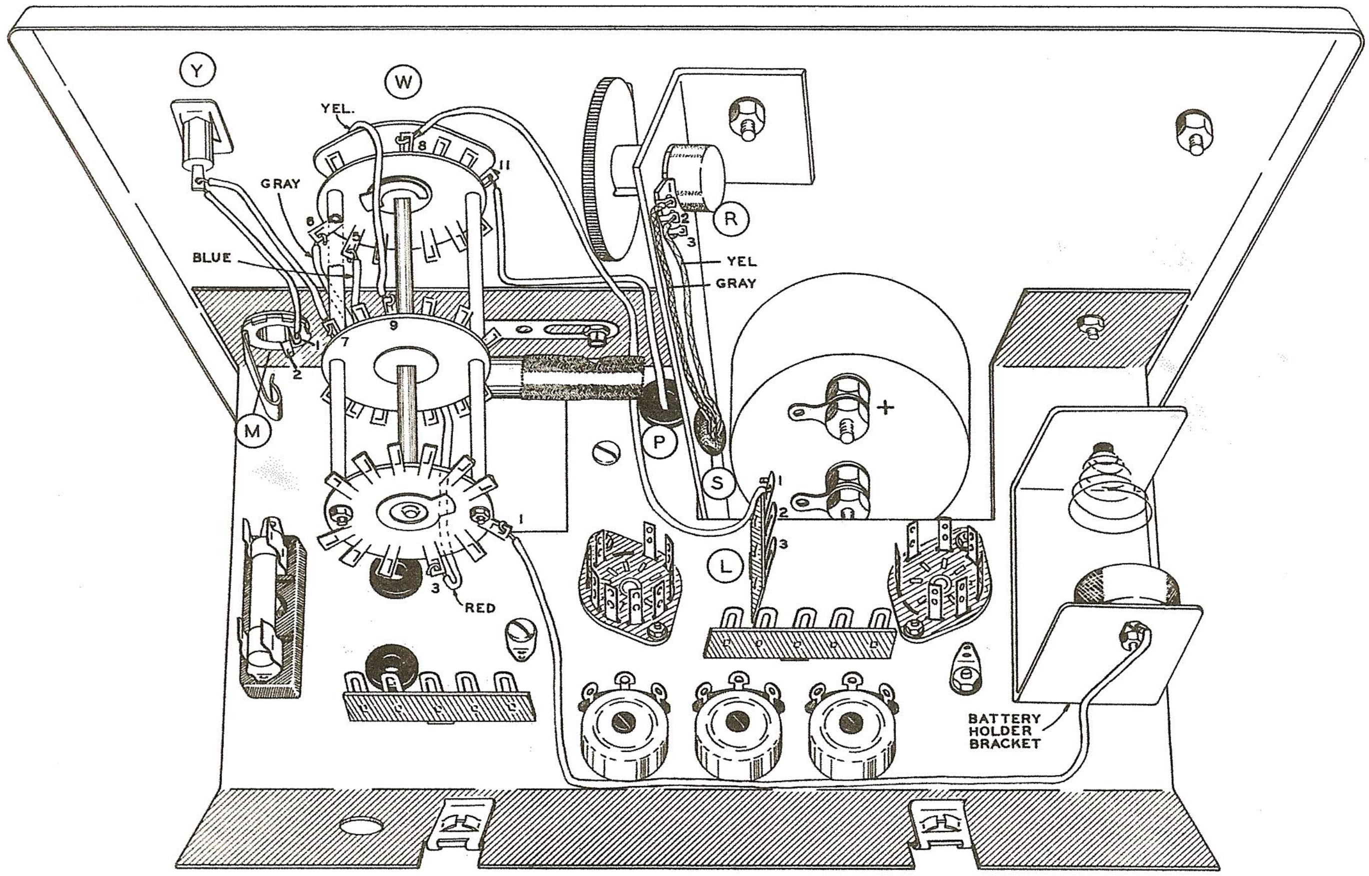
Complete the Range switch subassembly as follows:

Connect		From	To
( ) R21.	68.38 KΩ	B1 (S-3)	C12 (NS)
( ) R19.	683.8 KΩ	B3 (S-3)	C2 (S-3)
( ) R24.	9 megohm	B6 (NS)	C5 (S-1)
( ) R25.	900 KΩ	B6 (NS)	C7 (NS)
( ) Bare wire		B6 (S-3)	C6 (S-1)

Refer to Detail 7B for the following steps.

Connect	From	To
( ) R4. 800 KΩ	A7 (NS)	A11 (NS)*
( ) 1-3/4" hookup wire	A7 (NS)	A10 (S-1)
( ) R2. 150 KΩ	A9 (NS)	B7 (NS)
( ) R3. 400 KΩ	A9 (S-2)	A7 (S-3)
( ) R23. 10 KΩ	B7 (NS)	B11 (NS)
( ) R26. 90 KΩ	B8 (NS)	C7 (S-2)
( ) Bare wire	B8 (NS)	C8 (S-1)
( ) R27. 9 KΩ	B8 (S-3)	C9 (NS)

* Dress away from rotor and shaft.



Pictorial 7

Connect	From	To
(✓) R28. 900 Ω	B10 (NS)	C9 (S-2)
(✓) Bare wire	B10 (NS)	C10 (S-1)
(✓) R29. 90 Ω	B10 (S-3)	C11 (NS)
(✓) Bare wire	B12 (S-1)	C12 (NS)
(✓) R22. 21.62 KΩ	B11 (S-2)	C12 (S-3)
( ) R30. 9.1 Ω (white-brown-gold)	C11 (S-2)	C1 (NS)

Note: All lugs should now be soldered except A5, A6, A8, A11, B7, B9, C1, and C3.

RANGE SWITCH INSTALLATION

Refer to Pictorial 7 for the following steps.

(✓) Mount the Range switch at location W. Use a control lockwasher, control flat washer and control nut. Orient the switch as shown in Pictorial 7. The flat of the shaft should point toward the 1500 V position on the front panel when the switch shaft is fully counterclockwise.

Connect the harness wires coming from the Selector switch to the Range switch as follows:

Wire Color	Switch Lug
(✓) Blue	A5 (S-2)
(✓) Gray	A6 (S-1)
(✓) Red	C3 (S-1)
(✓) Yellow	B9 (S-1)

(✓) Connect a 2-3/4" wire from lug 1 of DC jack M (S-1) to the black banana jack Y (NS).

(✓) Connect a 2-1/2" wire from the black banana jack Y (S-2) to lug B7 of the Range switch (S-3).

(✓) Connect the wire coming from grommet P to A11 of the Range switch (S-2).

( ) Connect an 8" wire from lug 1 of terminal strip L (S-2) to A8 of the Range switch (S-1).

( ) Connect an 8" wire from C1 of the Range switch (S-2) to the solder lug on the battery bracket (S-1).

( ) Connect the gray harness wire coming through grommet S to lug 1 of control R (S-1).

( ) Connect the yellow harness wire coming through grommet S to lug 2 of control R (S-2).

( ) Install the speednuts on the rear apron of the chassis, Be sure the flat side is to the rear.

( ) Install the fuse in fuse holder A.

( ) Place the #47 pilot lamp in the pilot lamp socket N.

( ) Referring to Detail 7C, locate the short length of fiber glass sleeving. Squeeze the sleeving together and cut a notch in one side, near the center. Place the sleeving over the pilot lamp. The notch should line up with the red jewel. Now tighten the jewel mounting nut securely.

( ) Install the tubes in their appropriate sockets (V1-6AL5, V2-12AU7).

( ) Install the large black knobs on the Range and Selector switches. The setscrew in the knobs should be placed over the flats on the shafts. Tighten the setscrews securely.

Carefully inspect instrument construction and check the arrangement of all wiring. Be sure that wiring or components are not positioned so that short circuits may occur. Check all solder points. Shake out all loose wire cuttings, insulation and other debris that may have accumulated during the assembly of the instrument.

PRELIMINARY TEST

Plug the VTVM line cord into a 117 volt 60 cycle AC source. Do not attempt to operate the instrument from a DC or 25 cycle supply as serious damage will result. Switch the selector knob to the DC+ or DC- position and the Range switch to the 1.5 volt position. The tubes and pilot lamp should light. Within 15 or 20 seconds of warmup time, there should be some degree of ZERO ADJust control action, which will permit the meter pointer to deflect over a limited range of the dial. During the preliminary warmup, check the instrument assembly very carefully for any indication of overheating which would result from errors in construction. Assuming that the instrument will respond in the manner indicated, it will be safe to leave it turned on to thoroughly warm up while the balance of the kit project is completed. This will consist of test lead preparation and cabinet assembly. Refer to Figure 1 for test lead preparation.

( ) COMMON TEST LEAD: Connect the black banana plug on one end of the black test lead and an alligator clip on the other. Figure 1 shows this operation. The banana plug is assembled by slipping the black insulator sleeve over the black lead. Insert the stripped wire into the plug and wrap it once around the plug as shown. Screw the sleeve onto the plug securely. No solder is required.

( ) DC TEST LEAD: The DC test lead is made by connecting the phone plug on one end of the shielded test lead; the inner wire conductor to the phone plug tip connection and the wire shield to the phone plug sleeve. On the other end, a 1 megohm resistor is connected to the inner wire and is slipped inside the black test prod. See Figure 1. It is important that the shield portion of the test lead at the resistor end does not touch the resistor or solder connection. Do not connect the shield to anything at this point. The only shield connection is made at the phone plug end. After soldering the resistor to the inner conductor of the test lead, do not wrap the joint with tape of any kind as this could cause a high resistance leakage path across the shield portion and the resistor lead, resulting in inaccurate measurement.

( ) AC-OHMS TEST LEAD: The AC ohms test lead is made by connecting the red banana plug on one end of the red test lead and the red test prod on the other. Figure 1 shows the construction.

( ) Fasten the handle on the case, using two #10 screws.

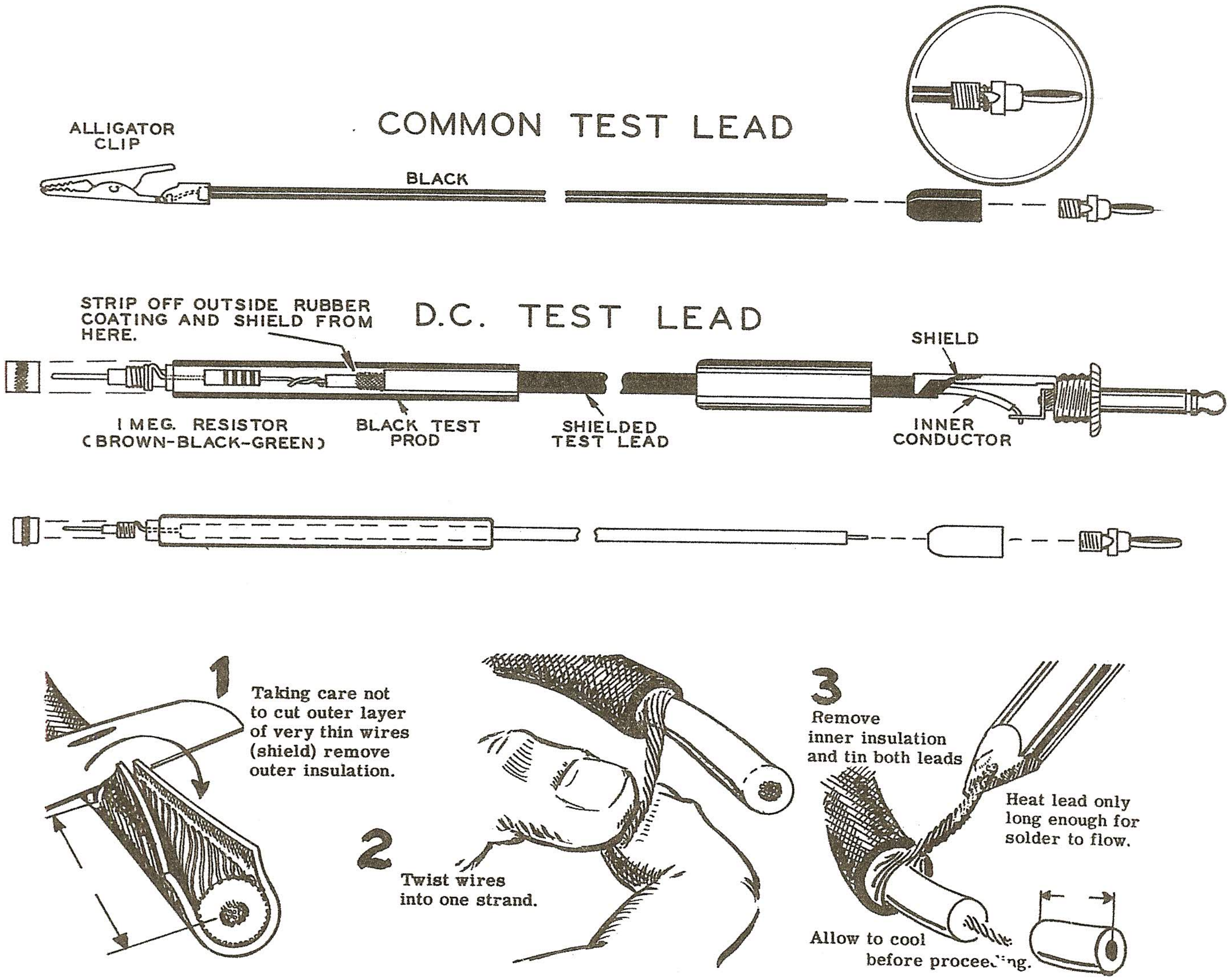
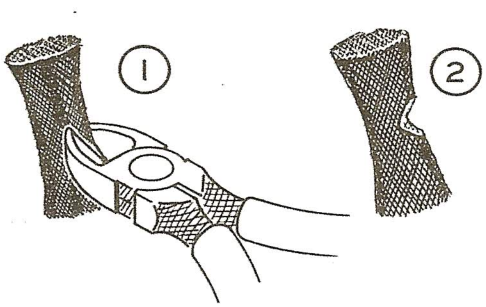


Figure 1



Detail 7C

TEST AND CALIBRATION

During the preparation of the test leads and cabinet, the VTVM has had an opportunity to warm up thoroughly and should now be calibrated.

Turn the instrument off and make sure that the mechanical zero position of the meter pointer is correct. If not, adjust as follows:

Place the instrument in normal operating position. Turn the plastic screw on the meter face with a screwdriver while gently tapping the meter face with one finger until the pointer coincides with the zero line on the left side of the scale. Turn the instrument on again.

( ) Set the Selector switch to DC+. Check operation of the ZERO ADJust control. Turning this control should move the meter pointer part way up scale. Set the pointer to zero at the left side of the scale and check for zero positioning when the Selector switch is changed to DC-. It should be possible to obtain a ZERO ADJust control position that will permit the meter pointer to remain stationary when switching through from DC+ to DC-. If there is an appreciable zero shift of more than two divisions on the scale, it should be regarded merely as an indication that additional aging of the 12AU7 tube is required. This aging can be obtained by leaving the instrument turned on for a period of 48 hours or more, or through continued use of the VTVM with periodic calibration.

DC CALIBRATE:

Insert the common and DC test leads. Set the Selector switch to DC+ and the Range switch to 1.5 V. Connect the DC and common test leads to the flashlight cell supplied and adjust the DC Calibrate control so that the meter pointer falls directly over the very small red dot on the meter face. Approach the red dot going up scale by turning the screwdriver control and watch the meter read 1.4 volts, and 1.5 volts, and then the red dot. As soon as the red dot is reached, stop turning the DC Calibrate control. Remember that the Range switch must be set on 1.5 V for this adjustment.

OHMS CHECK:

Turn off VTVM. To install the battery, start the top (+) end of the battery into the battery cup and then pull the spring out and over the bottom (-) end of the battery. Now push the spring and the battery in so the spring, battery, and battery cup are all in line. Turn on the VTVM and set the Selector switch to OHMS. Set OHMS ADJust for full scale (infinity). Insert the AC-OHMS test lead and touch the probe to the common test clip. The meter pointer should drop to zero at the left end of scale (no resistance).

WARNING: 117 volt AC line is dangerous. Proceed with due care.

AC CALIBRATE:

Temporarily remove the AC OHMS test lead. Set Range switch to 1.5 V and Selector switch to AC. Adjust AC Balance control so no movement is noticed in the pointer when switching from AC through DC- to DC+. Now set Range switch to 150 V and the Selector switch to AC. Reinsert the AC ohms lead. Connect the AC ohms and common leads to the 117 volt AC line.

Adjust the AC Calibrate control until the pointer indicates the line voltage (117 volts AC).

AGING AND FINAL CALIBRATION

It is recommended that the tubes be aged before final calibration. This is accomplished by keeping the instrument turned on for a period of at least 48 hours. Final calibration should be done in the same way as the initial calibration. Careful calibration will result in a more accurate instrument. If a standard AC meter is available, it is desirable to use such an instrument to check the accuracy of the IM-10. Preferably, use a voltage near full scale on the VTVM as for instance, 140 volts or 40 volts on the 150 volt or 50 volt range respectively. The DC scales may also be calibrated using a DC meter of known accuracy. One of the major advantages of kit form instrument construction is that the kit builder becomes thoroughly familiar with the calibration procedure and is therefore in an excellent position to periodically check VTVM operating accuracy, instead of assuming that usual factory instrument calibration is still valid.

After final calibration, place the instrument in the cabinet and install the two 6-32 screws through the back and into the speednuts. The instrument is now ready for use. The power consumption of the VTVM is very low and there is no objection to leaving the instrument on continuously during the daily work period rather than turning it off each time a measurement function is completed. Daily operation for a period of several hours or more will also serve the purpose of minimizing possible moisture accumulation.

IN CASE OF DIFFICULTY

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the constructor.

2. It is interesting to note that about 90% of the kits that are returned for repair, malfunction due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as illustrated in the Figures found in the PROPER SOLDERING TECHNIQUES section of this manual.

3. Check the tubes with a tube tester or by substitution of tubes of the same types and known to be good.

4. Check the values of the component parts. Be sure that the proper part has been wired into the circuit, as shown in the pictorial diagrams and as called out in the wiring instructions.

5. Check for bits of solder, wire ends or other foreign matter which may be lodged in the wiring.

6. If, after making previous checks, the trouble is still not located and a voltmeter is available, check voltage readings against those found on the Schematic Diagram. NOTE: All voltage readings were taken with a HEATHKIT Vacuum Tube Voltmeter. Voltages may vary 10% due to line voltage and component variations.

7. A review of the Circuit Description will prove helpful in determining where to look for trouble.

TROUBLESHOOTING CHART

COMPLETELY INOPERATIVE

1. Make sure that power is being applied to the instrument. This may be measured across the primary winding of the power transformer (black leads, 117 volts AC).
2. If pilot lamp and tube filaments do not light, check voltage between the yellow leads of power transformer. (5-6 volts AC)
3. Check voltage between each end of electrolytic capacitor and ground. Correct voltages are shown on the schematic.
4. Check the 12AU7 tube.

INABILITY TO OBTAIN DC BALANCE

1. Check the 12AU7 tube for an unbalanced condition. (Substitution)
2. Check the 10 megohm resistor, R16, (brown-black-blue).
3. Check the two .005 capacitors C4 and C5 in grid circuits of the 12AU7 tube. (Pins 2 and 7)
4. Check the components in the cathode circuits of the 12AU7 tube. (Pins 3 and 8). These circuits include ZERO ADJust control, R33, the 150 KΩ, R34, and R32 resistors, and the 180 KΩ, R31.
5. Check Range Switch construction carefully.

AC INOPERATIVE

1. Check the 6AL5 tube.
2. Check C1 .047 μfd 1600 volt and the two .05 μfd capacitors, C2 and C3.
3. Check Selector Switch construction carefully.

AC BALANCE

1. Disconnect test leads from instrument before adjusting the AC balance control as directed in the manual.
2. It is imperative that DC balance be obtained before this adjustment is made.

INACCURATE AC READINGS (The inability to obtain AC calibration).

1. Check capacitors C1, C2 and C3.
2. Check the 6AL5 tube.
3. Check the AC calibrate control, R14. NOTE: With the test leads inserted, there may be a residual reading. This is due to stray AC pickup in the test leads and can be attributed to the instrument's excellent sensitivity.

INACCURATE DC READINGS

1. Check the DC calibrate control, R15.
2. Check resistor in DC test prod.

OHMS INOPERATIVE

1. Check the "Ohms Adjust" control, R2, for correct value.
2. Check Range Switch construction.

OHMS INACCURATE

1. Check the battery. (Substitution)
2. Check the value of all resistors on the range switch which have a value beginning with the number "9". (The 9.1 ohm R30 should receiver special attention.) NOTE: The ohms section of the IM-10 is not intended for use as a standard. Where a great degree of accuracy is required, a bridge should be used.

USING THE IM-10

The vacuum tube voltmeter has many advantages over the non-electronic voltmeter. The largest advantage is its ability to measure voltages without significantly loading the circuitry. This characteristic enables the voltage to be measured accurately. This is desirable, especially in high impedance circuits such as oscillator grid circuits, resistance coupled amplifiers, and AVC networks.

To illustrate the advantages of the VTVM, assume that a resistance coupled audio amplifier with a 500 KΩ plate load resistor is operating from a 100 volt plate source. See Figure 2.

The plate voltage is 50 volts, therefore, the tube acts as a 500 KΩ resistor. When measuring the plate voltage with a conventional 1000 ohms-per-volt meter on the 100 volt scale the meter represents a 100 KΩ resistor placed in parallel with the tube. See Figure 2A. The voltage on the plate would then be about 14 volts as shown on the meter. This large amount of error is caused by the shunt resistance of the meter. Using the VTVM on any scale, the full 11 megohms input resistance is placed in parallel with the tube. See Figure 2B. The voltage on the plate is then about 49 volts or 2% lower than the normal operating voltage. Thus accurate readings can be obtained only with the high resistance provided by a VTVM.

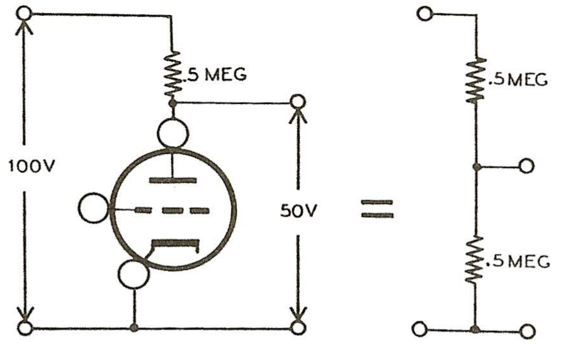


Figure 2

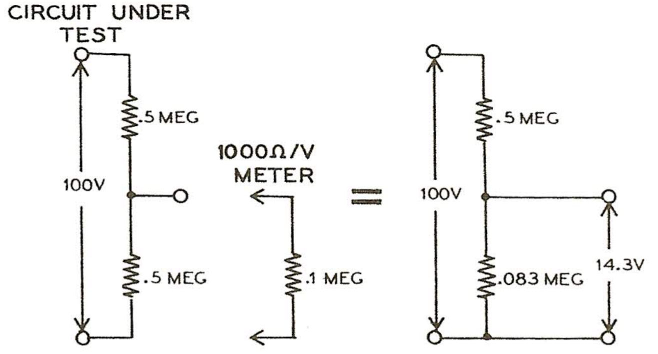


Figure 2A

To measure +DC voltages, connect the COMMON (black) test lead to the "cold" (common) side of the voltage. In transformer operated equipment common is usually the chassis.

Set the Range switch to the range which will handle the voltage to be measured. If the voltage is unknown, set the Range switch to the 1500 volt range. Touch the DC test probe to the voltage point. If the meter does not read in the upper 2/3 of the meter scale, reduce the setting of the Range switch. A meter reading in the upper portion of the meter scale is the most accurate. To measure -DC voltages place the Selector Switch to the DC- position and repeat the above steps.

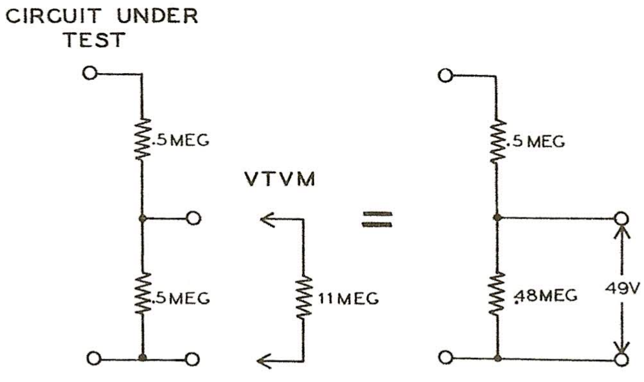


Figure 2B

The voltage ranges provided by the IM-10 were selected for the greatest ease in reading and for convenience in making voltage measurements. The 1.5 V, 5 V, and the 15 V ranges will be very handy for bias and filament voltage measurements. The 50 V and 150 V ranges will be handy, and used most often, when checking AC-DC type equipment. The 500 V range will be used most when measuring B+ voltages in transformer operated equipment.

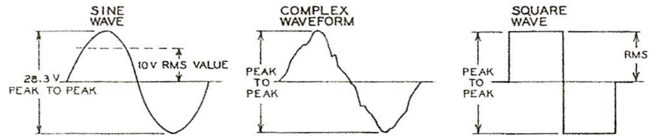


Figure 3

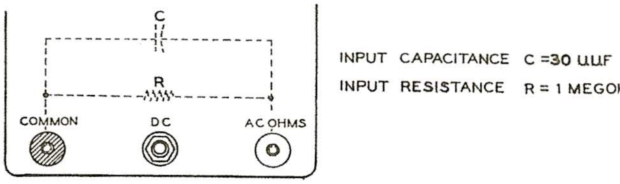


Figure 4

AC VOLTAGE MEASUREMENTS

AC voltage readings are obtained by rectifying the AC voltage and applying the resulting DC voltage to the VTVM circuitry. The rectifier circuit is a half-wave doubler and the DC output is proportional to the peak-to-peak value of the applied AC.

For sine wave voltages, the rms value is .35 times the peak-to-peak value. For complex waveforms this ratio does not necessarily hold true, and may vary from practically zero for thin spikes to .5 for square waves. See Figure 3.

For sine wave voltages over 5 volts, the rms value is read on the same scale as a DC voltage. When using the 1.5 volt and 5 volt ranges, the 1.5 and 5 volt AC scales should be read.

To measure AC voltage with the VTVM, connect the COMMON (black) lead to the COMMON or "cold" side of the voltage to be measured. Set the Selector switch to AC and set the Range switch to a range greater than the voltage to be measured, if known. If unknown, set to 1500 V. With the red test probe, touch the point in the circuit at which the voltage is to be measured. If the meter moves less than 1/3 of full scale, switch to the next lower range. The maximum AC voltage that can be safely measured with your VTVM is 1500 volts, and this limit must not be exceeded. The meter scale of the IM-10 is calibrated in rms.

DC accelerating potentials developed in TV receiver flyback power supply systems can be safely measured through the use of the HEATHKIT High Voltage Probe, in conjunction with the VTVM. This probe, with its precision multiplier resistor mounted in a safety plastic probe housing, will provide a multiplication factory of 100 for the VTVM DC ranges. 30,000 volts DC is generally considered the safe upper limit for these measurements.

When connecting the VTVM to the circuit under test, the VTVM input resistance R and input capacitance C are effectively placed in parallel with the voltage source. This may change the actual voltage to be measured through loading. See Figure 4.

At low frequencies, such as the power line frequencies of 50 or 60 cycles, the effects of capacitance loading may usually be disregarded and thus the loading by the VTVM may be considered the same as connecting a 1 megohm resistor across the voltage source.

At higher frequencies, the capacitor reactance decreases. At 10 kc for example, it is approximately 170 KΩ. Such a value may seriously affect the voltage at the point of measurement.

The loading effect of both input capacitance and resistance depend on the source impedance. In low impedance circuits, such as 50 to 600 Ω, no noticeable error is introduced in the voltage reading through circuit loading. Then the specified frequency response of the VTVM becomes the limiting factor.

As a general rule, it should be kept in mind that frequency response and loading may affect the accuracy of the voltage reading obtained. Consider the resistive loading of 1 megohm regardless of frequency, and the capacitive loading effect at the frequency involved. The actual capacitance of the instrument and the leads may also affect the tuning of low capacitance resonant circuits.

Knowledge of the values in the circuit under test and the values of the input R and C of the VTVM will permit valid readings to be obtained for a wide range of impedances within the full frequency response of the instrument.

The HEATHKIT VTVM is an extremely sensitive electronic AC voltmeter and, as the human body picks up AC when near any AC wires, the meter will indicate this pickup. Never touch the AC probe when on the lower ranges. Zero should be set with the AC probe shorted to the COMMON clip.

RESISTANCE MEASUREMENTS

To measure resistance with the VTVM, connect the COMMON (black) lead to one side of the resistor or circuit to be measured. Set the Selector to OHMS and set the Range switch to such a range that the reading will fall as near mid-scale as possible. Set the OHMS ADJ. control so the meter indicates exactly full scale (infinity on ohms scale) with the red test lead not connected to a resistor or circuit. Then touch the red test prod to the other side of the resistor or circuit to be measured. Read resistance on OHMS scale and multiply by the proper factor as shown on the Range switch settings.

NOTE: Although a battery is used to measure resistance, the indication is obtained through the electronic meter circuit and therefore the VTVM must be connected to the AC power line and turned on. Establish the habit of never leaving the instrument set in the OHMS position as this could greatly shorten the life of the ohmmeter battery, particularly if the test leads are accidentally shorted together when lying on the service bench.

DECIBEL SCALE

The human ear does not respond to the volume of sound in proportion to voltage or power level, therefore, a unit of measure called the "bel" was adopted. The "bel" is more nearly equivalent to human hearing ratios. Normally the reading is given in 1/10 of a "bel" or a "decibel" (db). Different reference points for "0 db" have been adopted for various purposes. The trend in recent years is to use 1 milliwatt in a 600 Ω load as the 0 db reference, particularly for audio work. This is equal to .774 volts.

On the IM-10, the meter pointer position that corresponds to 0 db is 7.74 on the 0-15 scale. Due to the special calibration used on the 1.5 V and 5 V AC scales, slight inaccuracies will be introduced into the db reading when making decibel measurements with the Range switch in the 1.5 V and 5 V positions.

The resistance values of the voltage divider were chosen so that each progressive setting of the range switch represents a change of 10 db. For example, if the signal voltage at the input of an amplifier read 0 db in the 1.5 volt position and the output voltage read 0 db in the 15 volt position it would indicate that the amplifier has a gain of 20 db.

Since the decibel is a current, voltage, or power ratio, it may be used as such without specifying the reference level. A fidelity curve may be run on an amplifier by feeding in a signal of variable frequency but constant amplitude. At a reference frequency of 400 cycles adjust the input voltage for a convenient indication, 0 db for instance, on the VTVM connected to the output. As the input frequency is varied, the output variation may be noted directly in db above and below the specified reference level.

READING THE METER

The voltage markings on the Range switch refer to the full scale reading. For DC measurements the scale is marked 0-15 and 0-50 for voltage. This scale is also used on AC except for the 1.5 V and 5 V ranges. For 1.5 volts DC read the 15 V scale and move the decimal one place to the left. For example, a reading of 8 would be .8 volts. For 5 volts DC read the 50 V scale. For example, a reading of 40 would be 4 volts. On the 15 V range, read the 0-15 V scale directly. On the 50 V range, read the 0-50 V scale directly. On the 150 V range, read the 0-15 V scale and move the decimal one place to the right. For example, a reading of 13 would be 130 volts. On the 500 V range, read the 50 V scale and move the decimal point one place to the right. For example, a reading of 40 would be 400 volts. When using the 1500 V range, use the 15 V scale and move the decimal two places to the right. For example, a reading of 12 would be 1200 volts.

When measuring up to 1.5 volts AC, read the 1.5 V AC ONLY range directly; this scale is lettered in red. On the 5 V range, use the 5 V AC ONLY scale and read it directly. This scale is also lettered in red.

Resistance measurements are read on the top scale which is lettered in green. The markings RX1 indicate that you should read the scale directly. For RX100, add two zeros to the reading. For RX10K, add four zeros and on RX1MEG add six zeros or read the scale directly in megohms.

CENTER SCALE "O" POSITION

Your IM-10 VTVM features a convenient center scale zero position. The adjustment range of the panel ZERO ADJ. control will permit center scale zero deflection of the meter pointer when selector switch is set to DC+.

SERVICE INFORMATION

SERVICE

If, after applying the information contained in this manual and your best efforts, you are still unable to obtain proper performance, it is suggested that you take advantage of the technical facilities which the Heath Company makes available to its customers.

The Technical Consultation Department is maintained for your benefit. This service is available to you at no charge. Its primary purpose is to provide assistance for those who encounter difficulty in the construction, operation or maintenance of HEATHKIT equipment. It is not intended, and is not equipped to function as a general source of technical information involving kit modifications nor anything other than the normal and specified performance of HEATHKIT equipment.

Although the Technical Consultants are familiar with all details of this kit, the effectiveness of their advice will depend entirely upon the amount and the accuracy of the information furnished by you. In a sense, YOU MUST QUALIFY for GOOD technical advice by helping the consultants to help you. Please use this outline:

1. Before writing, fully investigate each of the hints and suggestions listed in this manual under "IN CASE OF DIFFICULTY." Possibly it will not be necessary to write.

2. When writing, clearly describe the nature of the trouble and mention all associated equipment. Specifically report operating procedures, switch positions, connections to other units and anything else that might help to isolate the cause of trouble.

3. Report fully on the results obtained when testing the unit initially and when following the suggestions under "IN CASE OF DIFFICULTY." Be as specific as possible and include voltage readings if test equipment is available.

4. Identify the kit model number and date of purchase, if available.

5. Print or type your name and address, preferably in two places on the letter.

With the preceding information, the consultant will know exactly what kit you have, what you would like it to do for you and the difficulty you wish to correct. The date of purchase tells him whether or not engineering changes have been made since it was shipped to you. He will know what you have done in an effort to locate the cause of trouble and, thereby, avoid repetitious suggestions. In short, he will devote full time to the problem at hand, and through his familiarity with the kit, plus your accurate report, he will be able to give you a complete and helpful answer. If replacement parts are required, they will be shipped to you, subject to the terms of the Warranty.

The Factory Service facilities are also available to you, in case you are not familiar enough with electronics to provide our consultants with sufficient information on which to base a diagnosis of your difficulty, or in the event that you prefer to have the difficulty corrected in this manner. You may return the completed instrument to the Heath Company for inspection and necessary repairs and adjustments. You will be charged a minimal service fee, plus the price of any additional parts or material required. However, if the completed kit is returned within the Warranty period, parts charges will be governed by the terms of the Warranty. State the date of purchase, if possible.

Local Service by Authorized HEATHKIT Service Centers is also available in some areas and often will be your fastest, most efficient method of obtaining service for your HEATHKIT equipment. Although you may find charges for local service somewhat higher than for factory service, the amount of increase is usually offset by the transportation charge you would pay if you elected to return your kit to the Heath Company.

HEATHKIT Service Centers will honor the regular 90 day HEATHKIT Parts Warranty on all kits, whether purchased through a dealer or directly from Heath Company; however, it will be necessary that you verify the purchase date of your kit.

Under the conditions specified in the Warranty, replacement parts are supplied without charge; however, if the Service Center assists you in locating a defective part (or parts) in your kit, or installs a replacement part for you, you may be charged for this service.

HEATHKIT equipment purchased locally and returned to Heath Company for service must be accompanied by your copy of the dated sales receipt from your authorized HEATHKIT dealer in order to be eligible for parts replacement under the terms of the Warranty.

THIS SERVICE POLICY APPLIES ONLY TO COMPLETED EQUIPMENT CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Equipment that has been modified in design will not be accepted for repair. If there is evidence of acid core solder or paste fluxes, the equipment will be returned NOT repaired.

For information regarding modification of HEATHKIT equipment for special applications, it is suggested that you refer to any one or more of the many publications that are available on all phases of electronics. They can be obtained at or through your local library, as well as at most electronic equipment stores. Although the Heath Company sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for special purposes. Therefore, such modifications must be made at the discretion of the kit builder, using information available from sources other than the Heath Company.

REPLACEMENTS

Material supplied with HEATHKIT products has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information.

A. Thoroughly identify the part in question by using the part number and description found in the manual Parts List.

B. Identify the type and model number of kit in which it is used.

C. Mention date of purchase.

D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. PLEASE DO NOT RETURN THE ORIGINAL COMPONENT UNTIL SPECIFICALLY REQUESTED TO DO SO. Do not dismantle the component in question as this will void the guarantee. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SHIPPING INSTRUCTIONS

In the event that your instrument must be returned for service, these instructions should be carefully followed.

ATTACH A TAG TO THE EQUIPMENT BEARING YOUR NAME, COMPLETE ADDRESS, DATE OF PURCHASE, AND A BRIEF DESCRIPTION OF THE DIFFICULTY ENCOUNTERED. Wrap the equipment in heavy paper, exercising care to prevent damage. Place the wrapped equipment in a stout carton of such size that at least three inches of shredded paper, excelsior, or other resilient packing material can be placed between all sides of the wrapped equipment and the carton. Close and seal the carton with gummed paper tape, or alternately, tie securely with stout cord. Clearly print the address on the carton as follows:

To: HEATH COMPANY
Benton Harbor, Michigan

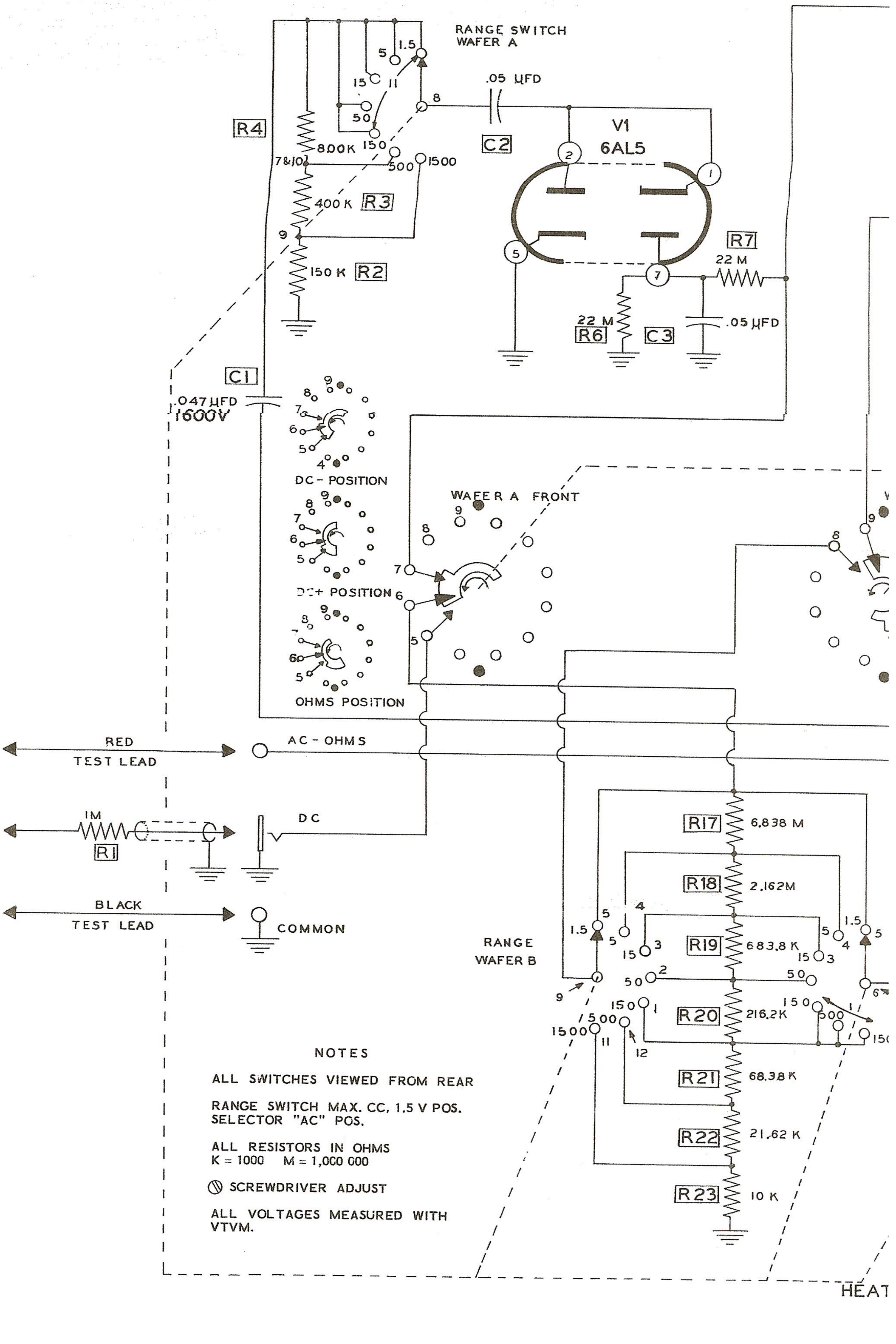
Include your name and return address on the outside of the carton. Preferably affix one or more "Fragile" or "Handle With Care" labels to the carton, or otherwise so mark with a crayon of bright color. Ship by parcel post or prepaid express; note that a carrier cannot be held responsible for damage in transit if, in HIS OPINION, the article is inadequately packed for shipment.

WARRANTY

Heath Company warrants that for a period of three months from the date of shipment, all Heathkit parts shall be free of defects in materials and workmanship under normal use and service and that in fulfillment of any breach of such warranty, Heath Company shall replace such defective parts upon the return of the same to its factory. The foregoing warranty shall apply only to the original buyer, and is and shall be in lieu of all other warranties, whether express or implied and of all other obligations or liabilities on the part of Heath Company and in no event shall Heath Company be liable for any anticipated profits, consequential damages, loss of time or other losses incurred by the buyer in connection with the purchase, assembly or operation of Heathkits or components thereof. No replacement shall be made of parts damaged by the buyer in the course of handling or assembling Heathkit equipment.

NOTE: The foregoing warranty is completely void and we will not replace, repair or service instruments or parts thereof in which acid core solder or paste fluxes have been used.

HEATH COMPANY



NOTES

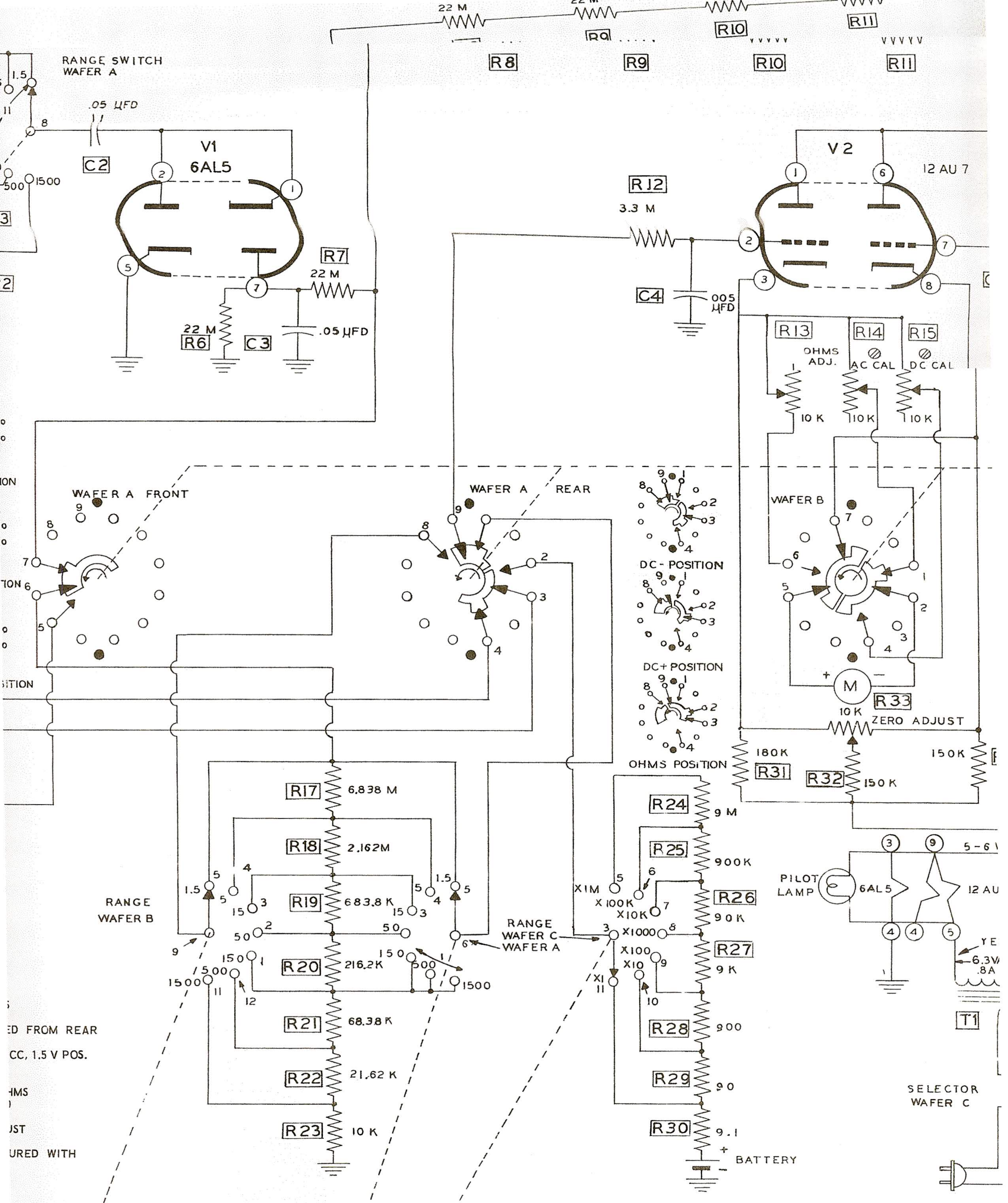
ALL SWITCHES VIEWED FROM REAR

RANGE SWITCH MAX. CC, 1.5 V POS.
SELECTOR "AC" POS.

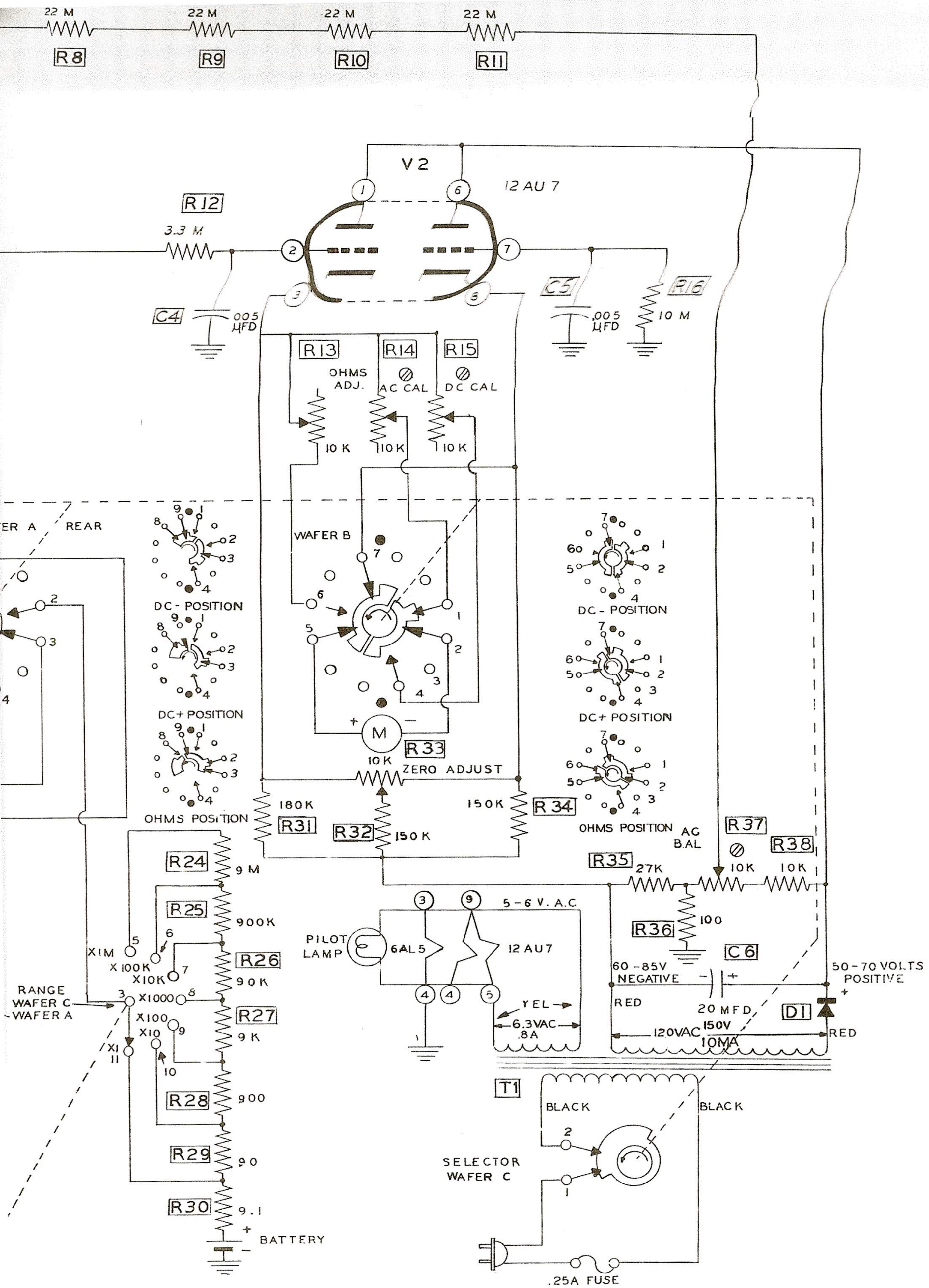
ALL RESISTORS IN OHMS
K = 1000 M = 1,000 000

⊘ SCREWDRIVER ADJUST

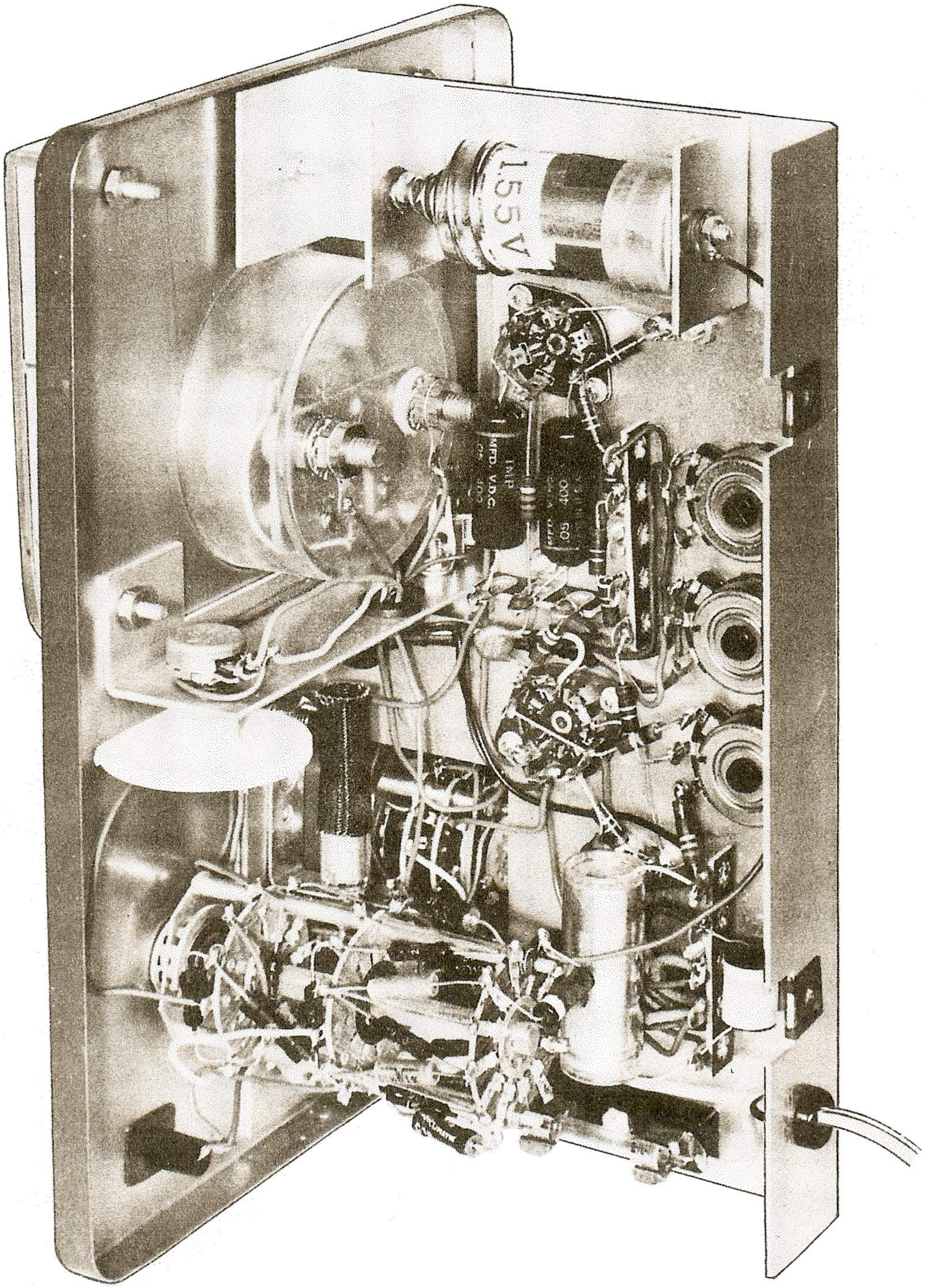
ALL VOLTAGES MEASURED WITH VTVM.

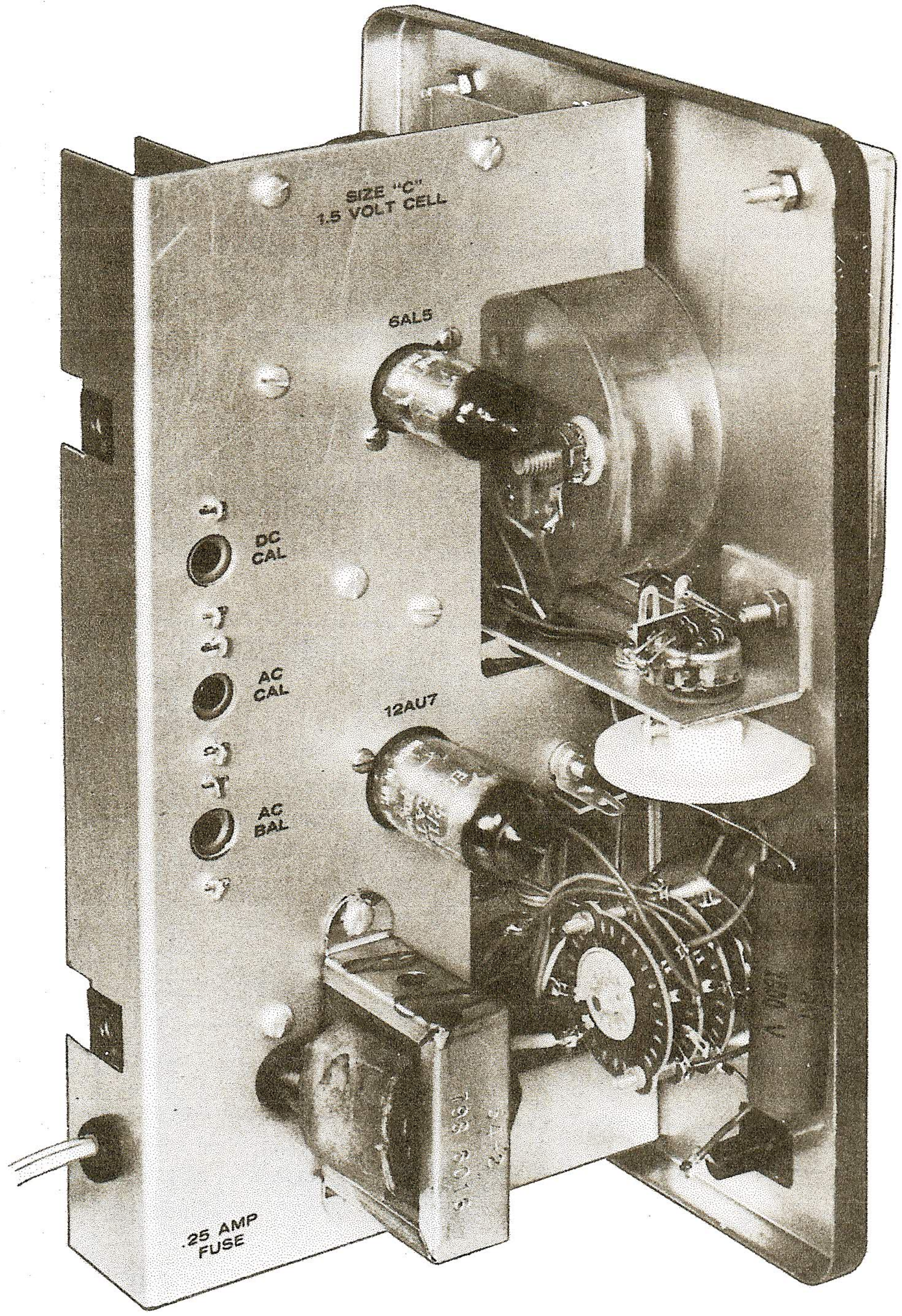


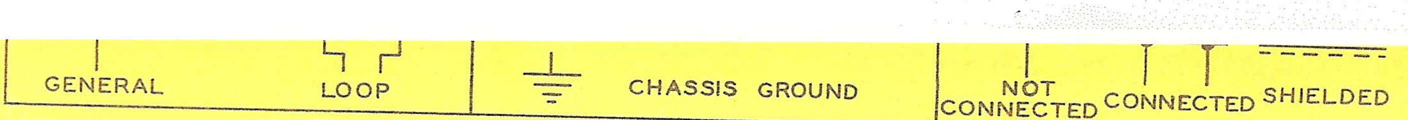
HEATHKIT SERVICE BENCH VTVM
MODEL IM-10



KIT SERVICE BENCH VTVM
MODEL IM-10


1.55V


SIZE "C"
1.5 VOLT CELL
6AL5
DC
CAL
AC
CAL
12AU7
AC
BAL
.25 AMP
FUSE


GENERAL
LOOP
CHASSIS GROUND
NOT
CONNECTED
CONNECTED
SHIELDED