

Assembly
and
Operation
of the



IN-CIRCUIT/
OUT-OF-CIRCUIT
TRANSISTOR TESTER

MODEL IT-18



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INTRODUCTION

The Heathkit Model IT-18 In-Circuit/Out-Of-Circuit Transistor Tester is a quality instrument for testing of transistors or diodes. Its low internal impedance and handy test leads enable you to check transistors without removing the transistors from the circuit. A test Socket is also provided for checking low power transistors that are removed from the circuit.

The large, easy-to-read meter permits direct reading of DC Beta (gain) on two ranges. The Transistor Tester also enables you to make leakage measurements for transistors and diodes, and to make a positive identification of NPN or PNP type transistors.

The self-contained power supply, which consists of a single 1-1/2 volt D cell, makes the instrument fully portable. This low voltage will not damage a transistor or diode that is incorrectly connected to the Tester. Since no battery current is drawn unless a transistor or diode is being tested, long battery life is assured.

The rugged circuit construction and durable shock-resistant case combined with convenient easy-to-use operation provides you with a test instrument of fine quality and long dependable service.

Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

PARTS LIST

To order replacement parts, refer to the Replacement Parts Price List and use the Parts Order Form furnished with this kit.

<u>PART No.</u>	<u>PARTS Per Kit</u>	<u>DESCRIPTION</u>	<u>PART No.</u>	<u>PARTS Per Kit</u>	<u>DESCRIPTION</u>
RESISTORS (1/2 Watt)-CAPACITOR			Hardware (cont'd.)		
(1)1-112	1	180 Ω resistor (brown-gray-brown)	(13)252-15	4	4-40 nut
(2)2-250	1	11.8 Ω precision resistor	(14)252-7	3	Control nut
2-251	1	25 Ω precision resistor	(15)253-10	3	Control flat washer
2-252	1	225 Ω precision resistor	(16)254-4	3	Control lockwasher
(3)21-57	1	.005 μ F disc capacitor	(17)254-7	2	#3 lockwasher
			(18)254-9	4	#4 lockwasher
			(19)255-15	4	#6 x 1/2" spacer
CONTROLS-SWITCHES			WIRE		
(4)10-201	1	10 k Ω control	344-59	1	Hookup wire
(5)10-254	1	500 k Ω control	347-7	1	4-conductor cable
(6)60-24	1	SPST rocker switch			
(7)60-43	1	DPDT rocker switch			
(8)63-493	1	Rotary switch			
63-494	1	Rotary switch(spring return)			
HARDWARE			KNOBS		
(9)250-175	2	2-56 x 3/8" screw	(20)462-246	1	Large knob
(10)250-206	4	6-32 x 11/16" screw	(21)462-249	1	Small knob
(11)250-52	4	4-40 x 1/4" screw	462-250	1	Small knob with white marker
(12)252-51	2	2-56 nut			

PART No. PARTS Per Kit DESCRIPTION

GENERAL

(22) 56-26	1	Diode 1N191 (brown-white-brown)
(23) 73-34	3	Test clip insulator
(24) 75-107	1	Strain relief
95-35	1	Case
(25) 214-76	1	Battery holder
(26) 260-53	3	Test clip
407-133	1	Meter
(27) 434-116	1	Transistor socket
(28) 455-50	3	Knob insert
203-525	1	Front panel
346-20	1	Heat shrinkable sleeving

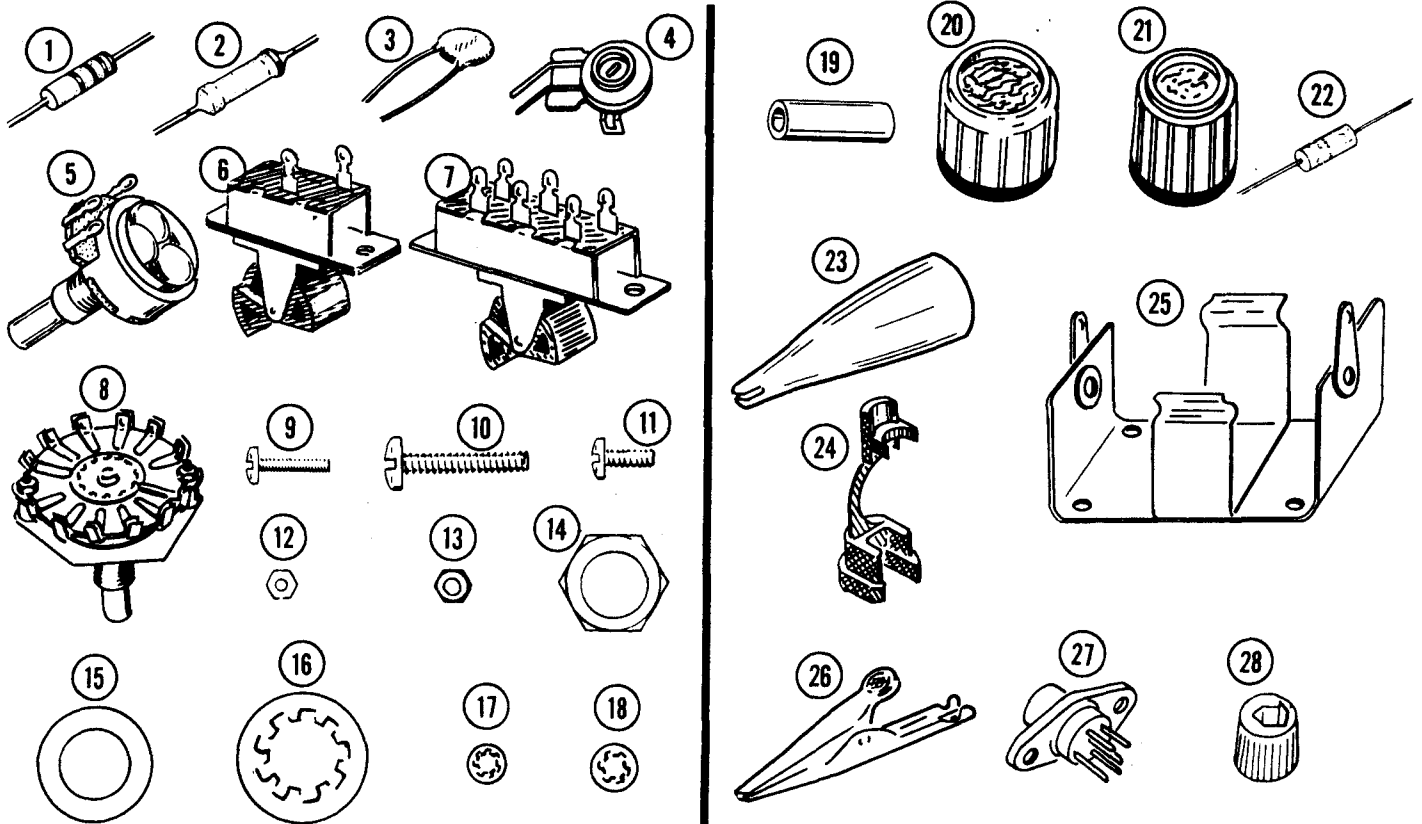
PART No. PARTS Per Kit DESCRIPTION

General (cont'd.)

390-309	1	Transistor lead identification label
390-307	1	Case identification label
391-34	1	Blue and white identification label
597-308	1	Kit Builders Guide
597-260	1	Parts Order Form
	1	Instruction Manual (See front cover for part number,) Solder

NOTE: A 1-1/2 volt "D" cell battery (not supplied) is required for operation of this instrument. You may want to purchase this battery now, before you start to assemble the kit.

PARTS PICTORIAL



STEP-BY-STEP ASSEMBLY

Before starting to assemble this kit, read the "Kit Builders Guide" for complete information on tools, wiring, soldering, and step-by-step assembly procedures. Refer to the Chassis Photograph on Page 23 for physical location of parts on the chassis.

PARTS MOUNTING

Refer to Pictorial 1 (fold-out from Page 7) for the following steps.

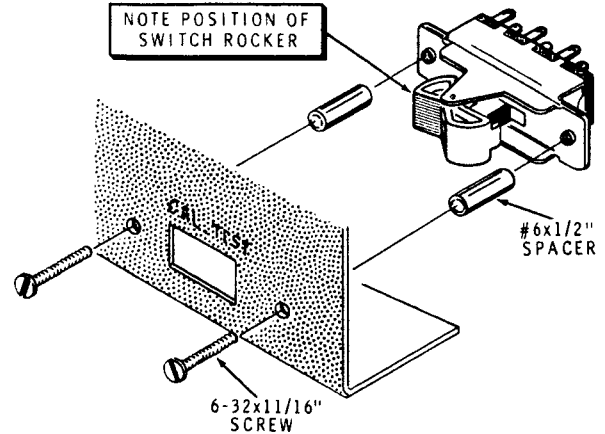
NOTE: As you mount each part, use the hardware specified in the step and position the part as shown in the Pictorial.

- () Lay a soft cloth on your work area to protect the face of the chassis from becoming scratched.
- () Refer to Detail 1A and mount the DPDT rocker switch (#60-43) at AA with two 6-32 x 11/16" screws, and two #6 x 1/2" spacers. Mount the switch so it normally rests in the CAL position.
- () Locate the transistor socket. Refer to Detail 1B and bend lug 1 back only slightly. The lug numbers are stamped on the socket. Then position the socket at AB with the bent #1 lug toward the top of the front panel. Secure with two 2-56 x 3/8" screws, two #3 lockwashers, and two 2-56 nuts. Do not overtighten.

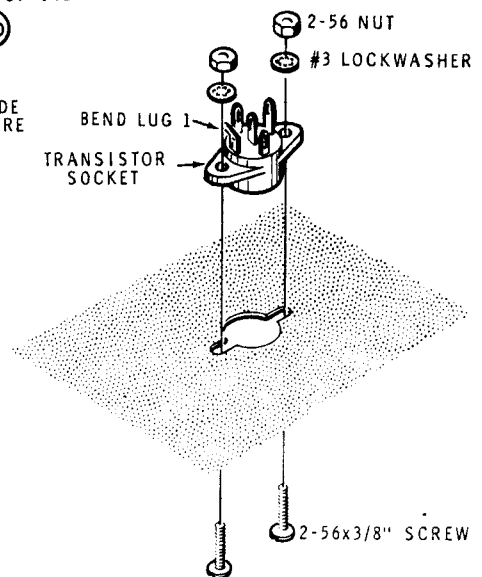
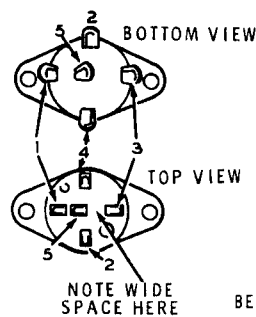
NOTE: When wiring this kit you may find it easier to prepare the lengths of hookup wire ahead of time as in the following step. To prepare a wire, cut it to the indicated length and strip 1/4" of insulation from each end. The wires are listed in the order in which they will be used. For your convenience, a scale is provided at the bottom of this page.

- () Prepare the following lengths of hookup wire:

- 7"
- 5"
- 4-1/2"



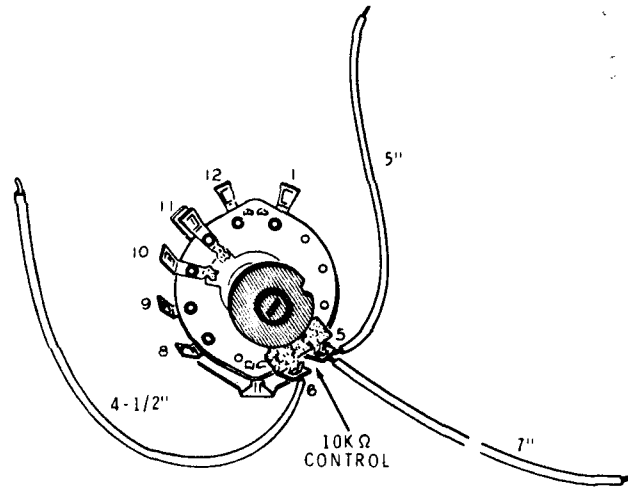
Detail 1A



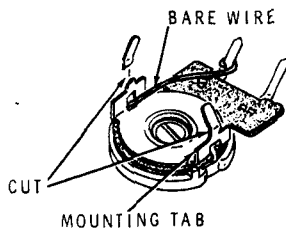
Detail 1B



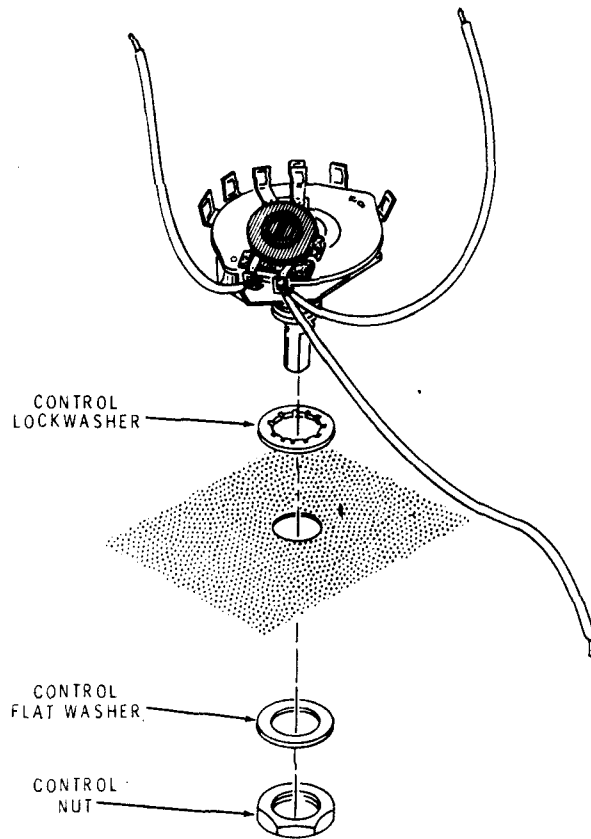
- () Locate spring return rotary switch #63-494 and position it as shown in Detail 1D. Connect one end of the 7" wire to lug 5 (NS).
- () Connect one end of the 5" wire to lug 5 of this rotary switch (NS).
- () Connect one end of the 4-1/2" wire to lug 6 of this rotary switch (NS).
- () Remove the insulation from a 1" length of hookup wire.
- () Solder one end of this wire to one lug of the 10 kΩ control as shown in Detail 1C. Solder the other end to the base of the control mounting tab. Then use a pair of diagonal cutters to cut the mounting tabs off the control.



Detail 1D

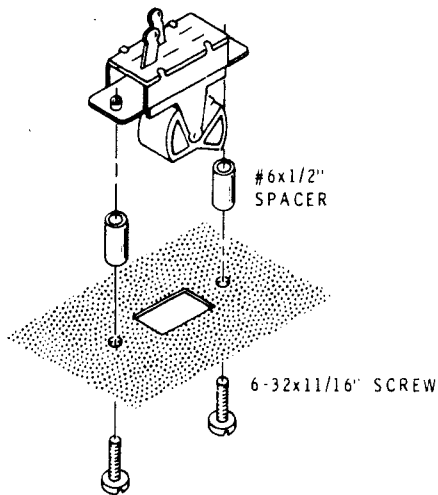


Detail 1C



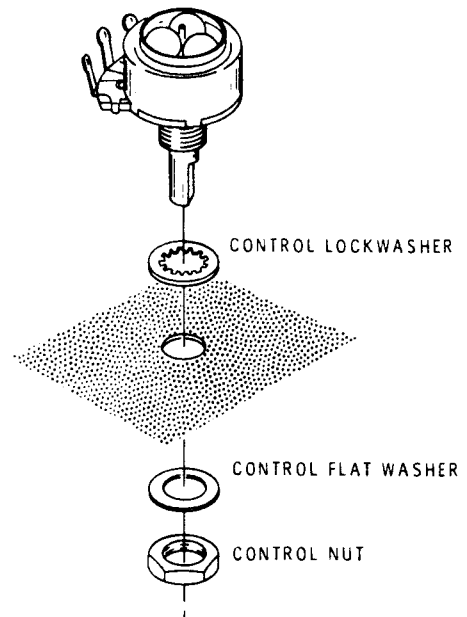
Detail 1E

- () Connect the 10 kΩ control to lugs 5 (S-3) and 6 (S-2) of the rotary switch. Be sure the metal parts of the control do not touch the metal rotor.
- () Mount this rotary switch at AD as shown in Detail 1E with a control lockwasher, a control flatwasher, and a control nut.

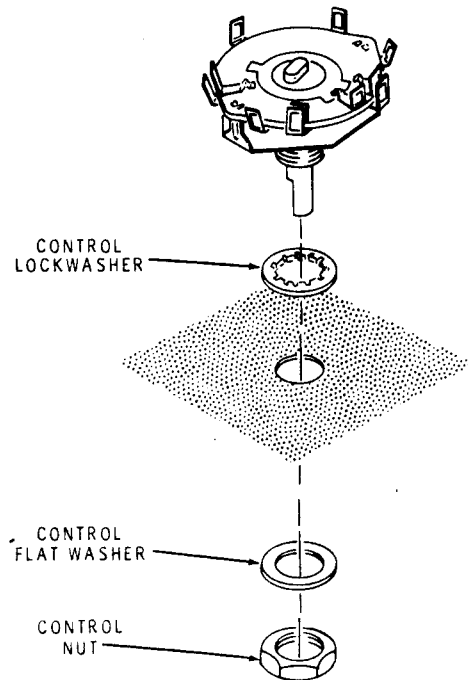


Detail 1F

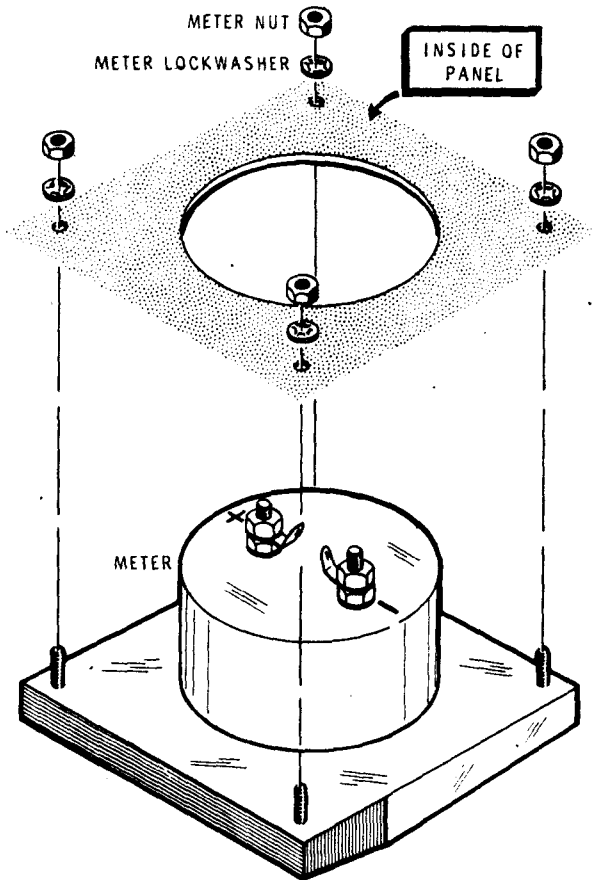
- () Refer to Detail 1F and mount the SPST rocker switch at AE with two 6-32 x 11/16" screws; and two #6 x 1/2" spacers. Position the switch as shown in Pictorial 1.
- () Mount the 500 kΩ control at AF with a control lockwasher, a control flat washer, and a control nut as shown in Detail 1G.
- () Refer to Detail 1H and mount rotary switch #63-493 at AG with a control lockwasher, a control flat washer and a control nut.



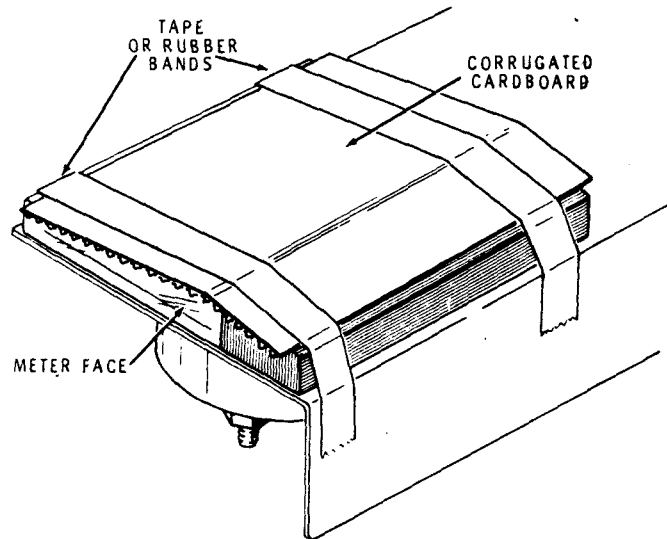
Detail 1G



Detail 1H

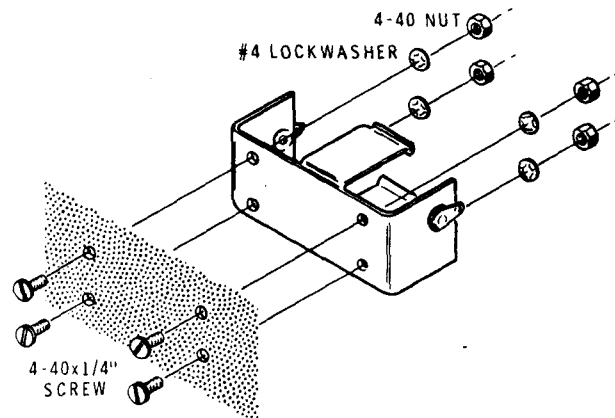


Detail 1J



Detail 1K

- () Refer to Detail 1J and mount the meter at AH. Use the hardware included with the meter.
- () Place a soft cloth on your work bench beneath the meter face, or cut a 4" x 5" piece of cardboard and tape it over the meter face as shown in Detail 1K. This will protect the face from being scratched during construction.
- () Refer to Detail 1L and mount the battery holder at AJ with four 4-40 x 1/4" screws, four #4 lockwashers, and four 4-40 nuts. Be sure to position the positive (+) end as shown.



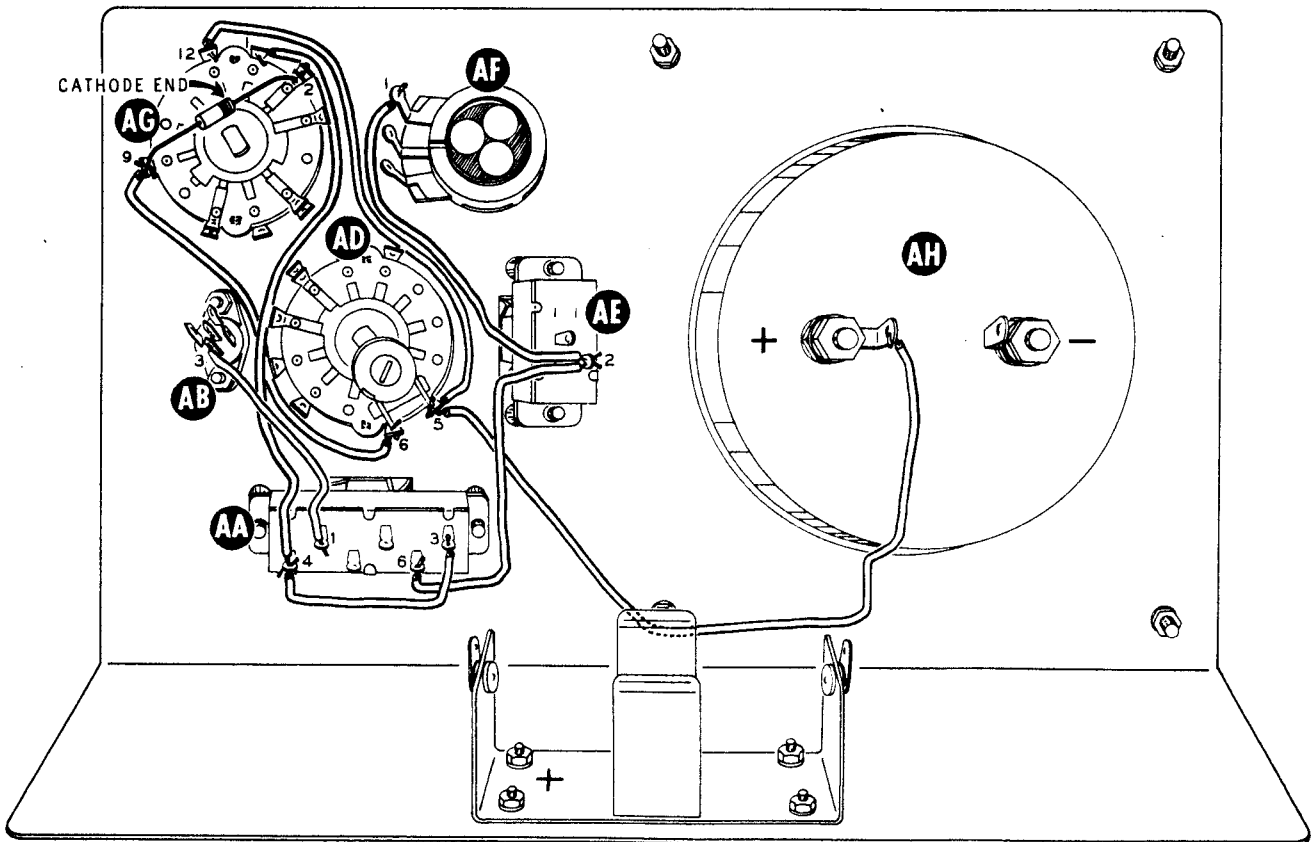
Detail 1L

CHASSIS WIRING

Refer to Pictorial 2 for the following steps.

NOTE: The wire lengths may appear longer than necessary to reach their terminating points. Therefore, position the wires down against the chassis as shown in the Pictorial to make the kit as neat as possible.

- () Connect the free end of the 5" wire coming from lug 5 of rotary switch AD to lug 12 of rotary switch AG (S-1).
- () Connect the free end of the 7" wire coming from lug 5 of rotary switch AD to the positive (+) terminal of meter AH (S-1).
- () Connect the free end of the 4-1/2" wire coming from lug 6 of rotary switch AD to lug 9 of rotary switch AG (NS).
- () Prepare the following lengths of hookup wire:
 3-1/2"
 4-1/2"
 2"
 5-1/2"
 3"
- () Connect a 3-1/2" wire from lug 2 of switch AE (NS) to lug 1 of control AF (S-1).
- () Connect a 4-1/2" wire from lug 2 of switch AE (S-2) to lug 6 of switch AA (S-1).
- () Connect a 2" wire from lug 3 (S-1) to lug 4 (NS) of switch AA.
- () Connect a 5-1/2" wire from lug 4 of switch AA (S-2) to lug 1 of rotary switch AG (S-1).
- () Connect a 3" wire from lug 1 of switch AA (NS) to lug 3 of transistor socket AB (NS).



PICTORIAL 2

10"

NOTE: When installing the diode in the next step, be sure to position the cathode end as shown. The cathode end is marked with colored bands.

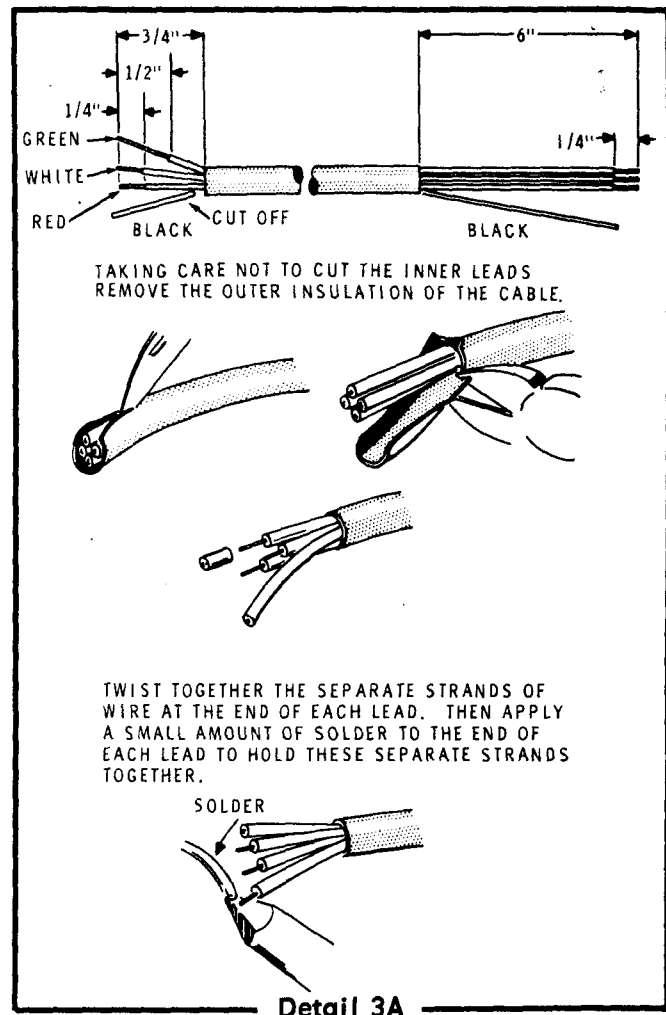
When making a connection to a double lug on the rotary switch, as in the next step, pass the wire end through both lugs.

- () Connect the cathode end of the diode to lug 2 of rotary switch AG (NS).
- () Bend the leads of the diode so it is about 1/4" above the center of the rotary switch. Then connect the other lead of the diode to lug 9 of rotary switch AG (S-2).
- () Prepare the following lengths of hookup wire:

10"	2-1/2"
7"	2-1/4"
9-1/2"	1-1/2"

Refer to Pictorial 3 for the following steps.

- () Connect a 10" wire from the negative (-) meter terminal (S-1) to lug 2 of rotary switch AG (S-2).
- () Connect a 7" wire from lug 6 of rotary switch AG (S-1) to the positive (+) terminal on battery holder AJ (S-1). Make sure that this wire does not touch the battery holder.
- () Connect a 9-1/2" wire from lug 3 of rotary switch AG (S-1) to the negative (-) terminal of battery holder AJ (S-1).
- () Connect a 2-1/2" wire from lug 2 of control AF (S-1) to lug 10 of rotary switch AD (S-1).
- () Connect a 2-1/4" wire from lug 1 of rotary switch AD (NS) to lug 1 of transistor socket AB (NS).
- () Connect a 1-1/2" wire from lug 11 of rotary switch AD (NS) to lug 2 of transistor socket AB (NS).
- () Remove 1/2" of insulation from a length of hookup wire. Connect this bare wire between lug 5 of rotary switch AG and lug 12 of rotary switch AD. Solder both lugs and cut off any excess wire.

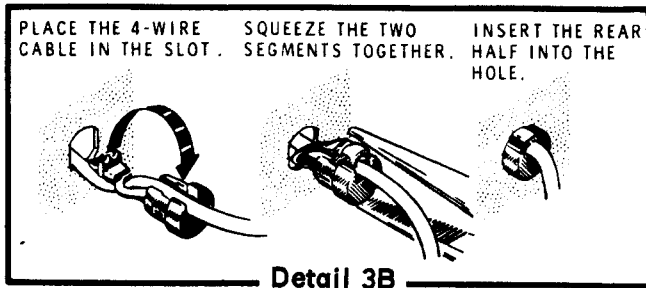


- () Refer to Detail 3A and prepare the 4-wire cable as shown.

In the next steps, the end of the 4-wire cable with the short leads will be connected to the transistor socket. After the connections are made, cut off any excess wire ends at this end of the cable. Be careful that the transistor socket lugs do not touch each other or touch the socket mounting hardware. Refer to the inset drawing on Pictorial 3.

- () Twist lugs 4, 5, and 2 of transistor socket AB so the holes in these lugs are in line with each other (so a wire can pass straight through all three lugs in the next step).
- () Pass the green wire through lugs 4, 5, and 2 of transistor socket AB. Solder the green wire to each lug it passed through.

- () Connect the white wire to lug 1 of transistor socket AB (S-2).
- () Connect the red wire to lug 3 of transistor socket AB (S-2).
- () Route the 4-wire cable under switch AA and through hole AK.
- () Refer to Detail 3B and install the strain relief on the 4-wire cable at AK.

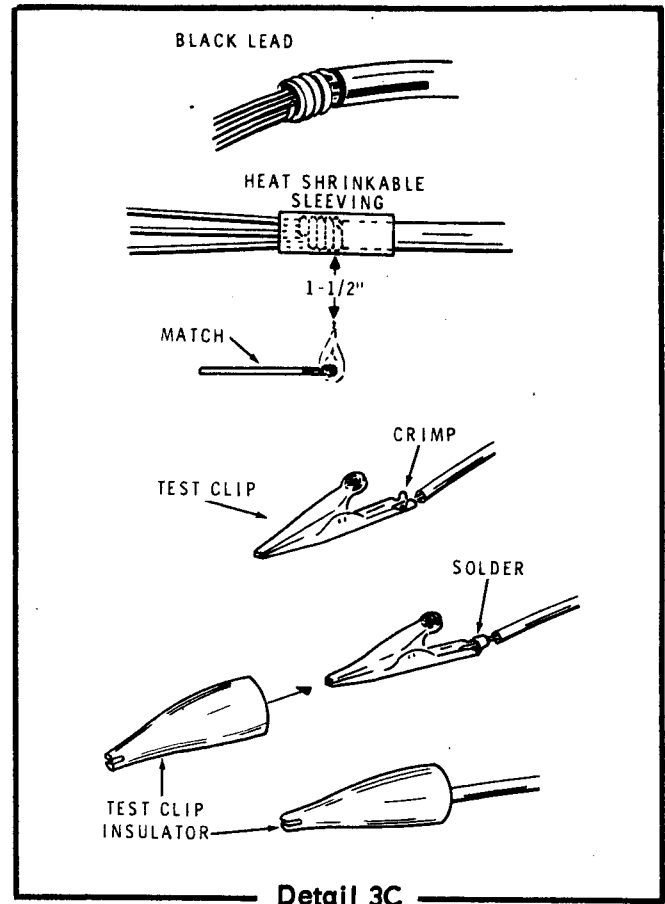


- () Connect the $.005 \mu\text{F}$ disc capacitor between lug 11 (S-2) and lug 1 (S-2) of rotary switch AD. Cut off excess lead lengths.
- () Connect the 11.8Ω precision resistor from lug 1 of switch AA (S-2) to lug 8 of rotary switch AD (S-1).

NOTE: Where a wire passes through a connection and then goes to another point, as in the next step, it will count as two wires in the solder instructions (S-2), one entering and one leaving the connection.

- () Pass one lead of the 225Ω precision resistor through lug 2 (S-2) to lug 5 of switch AA (S-1).
- () Pass the other lead of the 225Ω resistor through lug 9 of rotary switch AD (NS) to lug 7 of rotary switch AG (S-1).
- () Connect the 25Ω precision resistor between lug 1 of switch AE (S-1) and lug 9 of rotary switch AD (S-3).

NOTE: The 180Ω (brown-gray-brown) resistor will be used in the Adjustments section of the Manual.



Refer to Detail 3C for the next four steps.

- () Locate the black wire on the long end of the 4-wire cable. Wrap the black wire around the other wires starting at the point where they emerge from the cable.
- () Slide the length of heat shrinkable sleeving over the wires and position it over the end of the cable sheath, so as to cover the end of the cable sheath and the black wrapped wire. Hold a lighted match beneath the shrinkable sleeving so that the tip of the flame is $1\text{-}1/2$ " below the sleeving. Rotate the cable and sleeving to shrink the sleeving evenly.



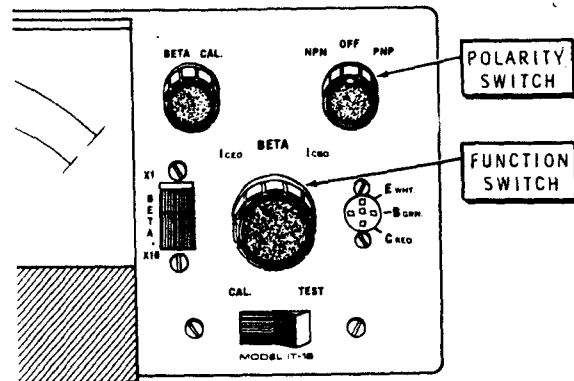
- () Connect a test clip to each of the three cable wires; crimp the back portion of the test clip around the bare end of the wire and solder the connection.
- () Install the test clip insulators by pushing each insulator over the end of a test clip.

This completes the wiring of your Heathkit In-Circuit/Out-Of-Circuit Transistor Tester. Inspect all connections to be sure they are soldered. Shake out any wire clippings or solder splashes. Then proceed to Knob Installation.

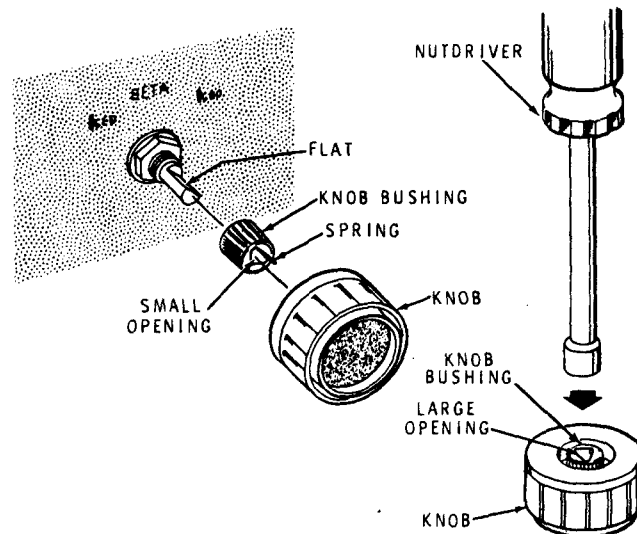
KNOB INSTALLATION

Refer to Pictorial 4 for the following steps.

- () Place knob inserts on the three control shafts on the front panel.
- () Locate the large knob and position it on the Function switch shaft. Gently press the knob onto the insert until the insert is started into the knob cavity as shown in Detail 4A.
- () Remove the Function switch knob with the insert and place it face down on your work bench. Use a nutdriver or some suitable instrument to press the insert firmly into the knob. Then replace the knob on the Function switch shaft.
- () Turn the Polarity switch shaft to its center position. Locate the small knob with the white mark and install it on the knob insert with the white mark facing up in the OFF position.
- () Install the remaining knob on the BETA CAL control shaft.
- () Remove the shorting wire from the meter terminals. Also remove any protective covering that you taped over the meter face.



PICTORIAL 4



Detail 4A

ADJUSTMENTS

Refer to Figure 1 for the following steps.

() Set the controls as follows:

- BETA CAL (calibration): Full counterclockwise.
- POLARITY: OFF.
- RANGE: X1.
- FUNCTION switch: BETA.
- LEAKAGE control (on rear of FUNCTION switch): Full counterclockwise (when viewed from the rear of the panel).

NOTE: Refer to the In Case Of Difficulty section of the Manual (Page 18) if you do not obtain the correct results in any of the following steps.

() The meter needle should be on the extreme left mark on the scale as shown in Figure 1. If the needle is not over this mark, slowly turn the Mechanical Adjust screw, while lightly tapping the face of the meter with your finger to properly position the needle.

() Install the D cell (1-1/2 volt battery) in the battery holder. Position the positive (+) end of the battery to the positive (+) terminals of the battery holder. Refer to Figure 2. Make sure the metal parts of the test leads are not touching each other.

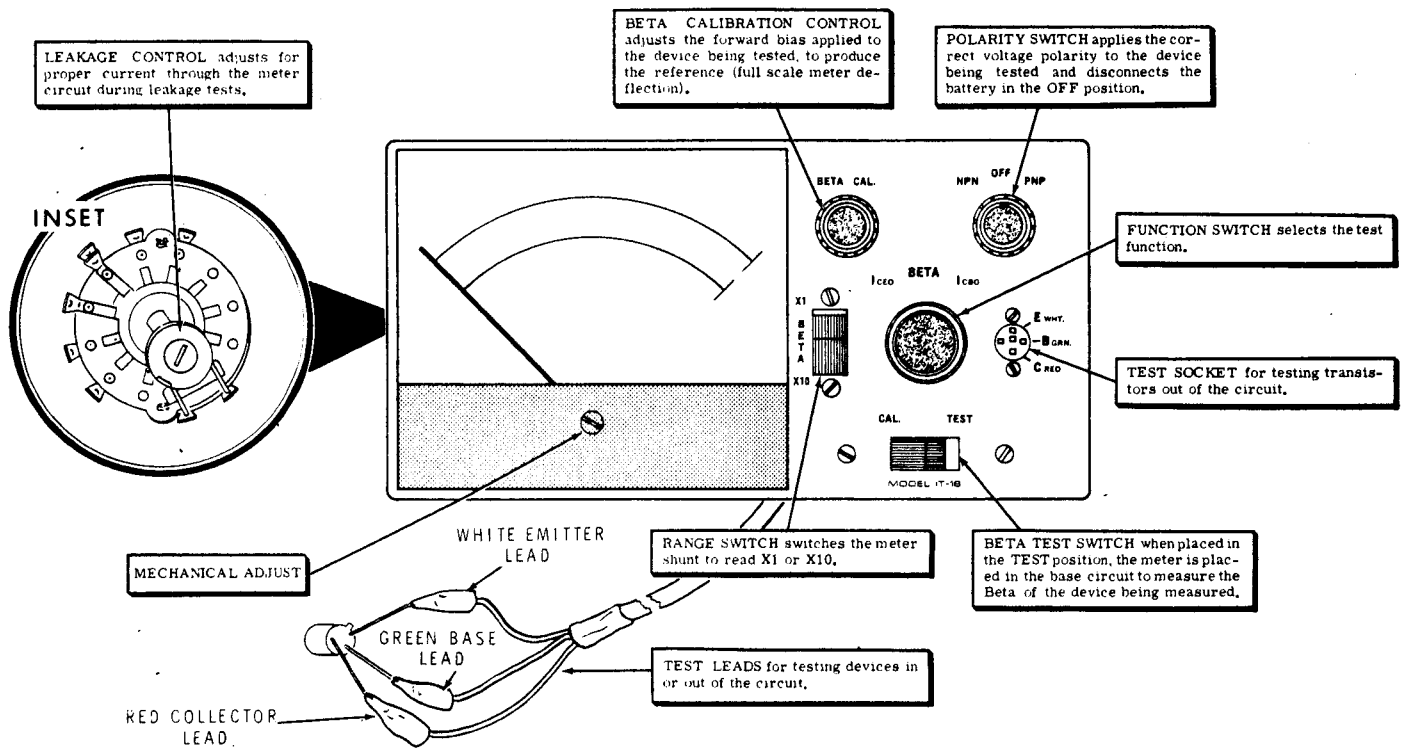
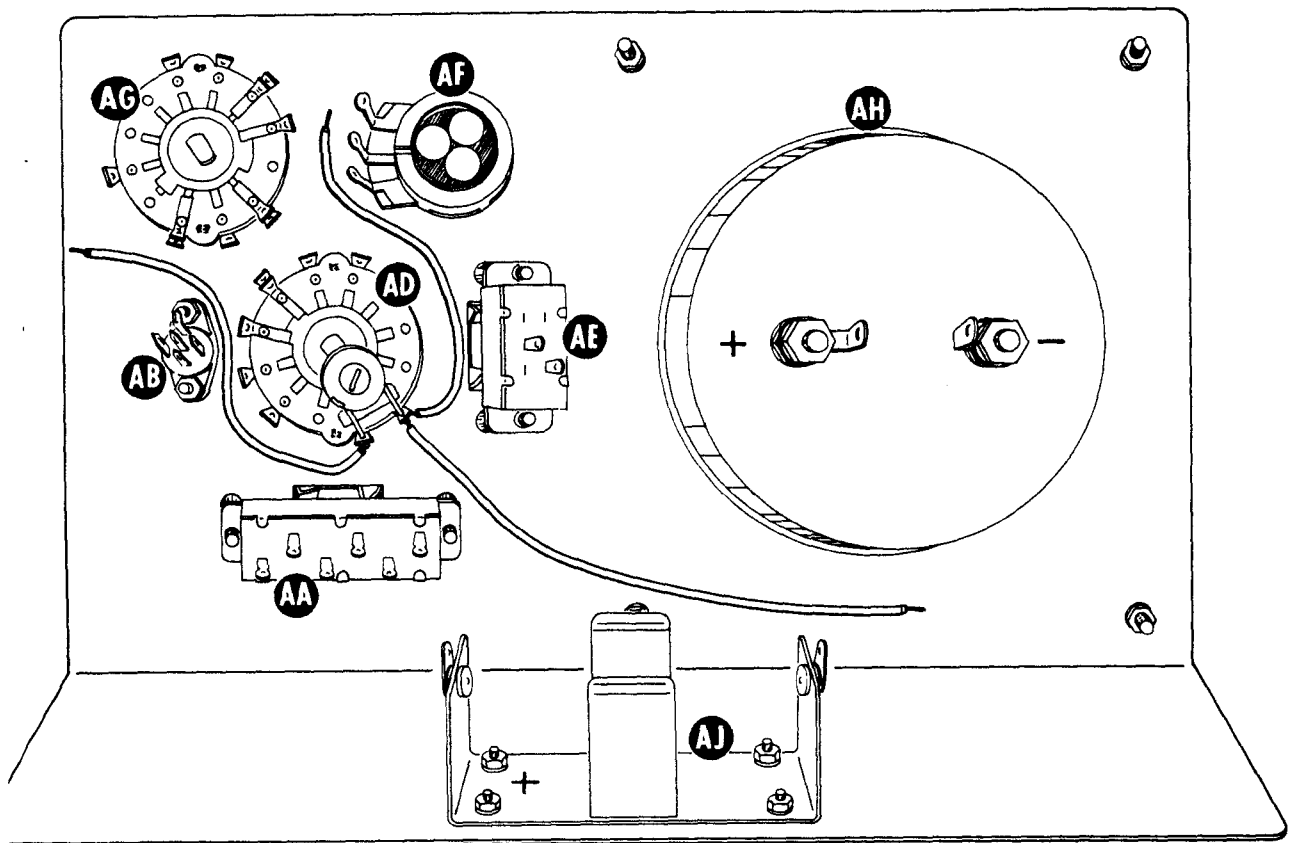


Figure 1



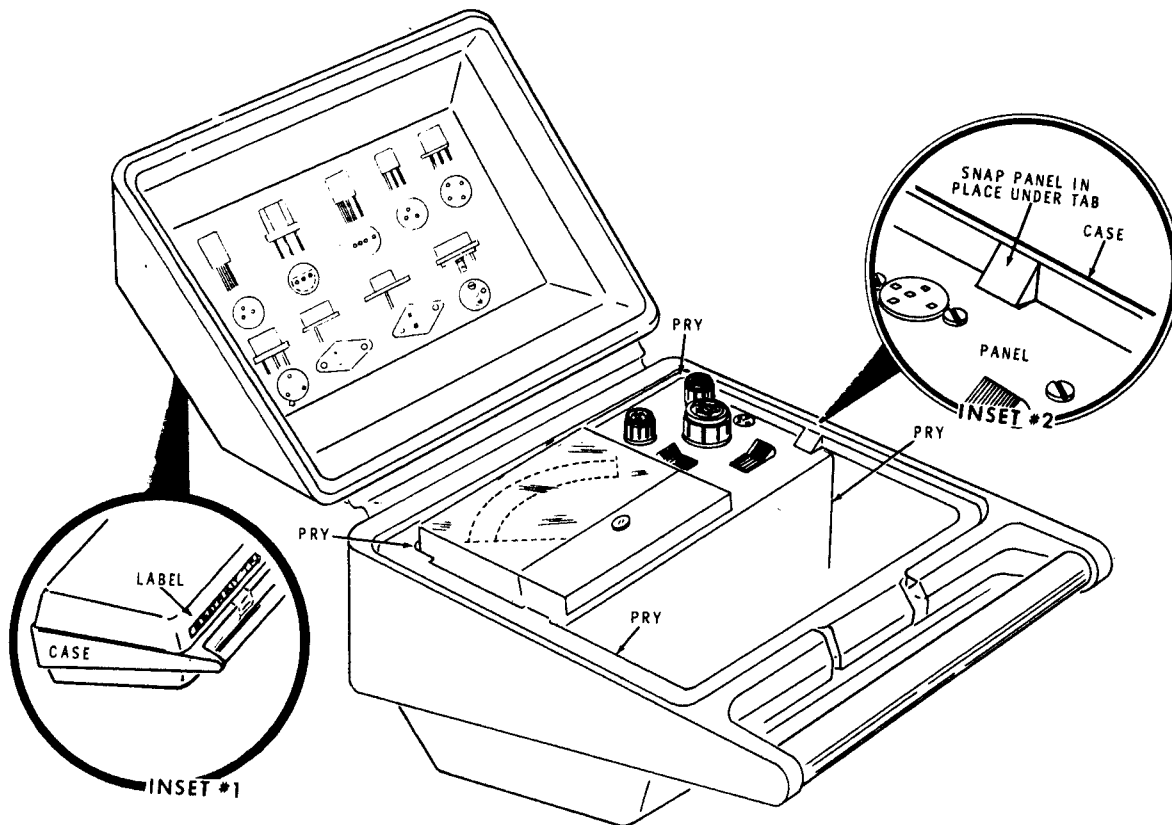
PICTORIAL 1

FINAL ASSEMBLY

Refer to Pictorial 5 for the following steps.

- () Position the front panel with the meter face up in the case. Spread the sides slightly to allow the panel to seat on the ledge under the side tabs. The case is stiff, so you may have to use a screwdriver with a wide blade to pry the sides of the case at the points shown.
- () Press the panel toward the cover "hinge" until it snaps into position.
- () Peel the backing paper from the transistor lead identification label and press it into place inside the cover of the case.
- () Peel the backing paper from the case identification label and press it into place on top of the case cover.

This completes the assembly of your In-Circuit/Out-Of-Circuit Transistor Tester.



PICTORIAL 5

OPERATION

GENERAL INFORMATION

Refer to Figure 3 to identify the emitter (E), base (B), and collector (C) leads of several different types of transistors.

Transistors may either be plugged into the test socket on the Transistor Tester or the test leads may be used. To use the test leads, connect the white lead to the emitter (E), the green lead to the base (B), and the red lead to the collector (C) of the transistor to be tested. NOTE: The In-Circuit/Out-Of-Circuit Transistor Tester will not check special purpose devices, such as F.E.T.'s (Field Effect Transistors), zener diodes, or devices that normally have very high leakage. Check the device against the manufacturer's specifications if you are in doubt.

NOTE: Some transistors have a fourth lead connected to an internal shield. Leave this shield

lead disconnected in the test procedure (bend it up out of the way when plugging transistors into the transistor test socket).

For in-circuit transistor testing, you may sometimes find it difficult to connect the test leads to a transistor because its leads are either too short or inaccessible. In such cases, you can usually connect each test lead to the lead of another component that is connected to the desired terminal on the transistor. See Figure 4. To determine where you can connect the test leads on a circuit board, shine a lamp through the circuit board; this will enable you to trace each foil from the transistor to the other components. In a case where this is impractical, solder a short piece of wire to the printed circuit foil that is connected to the transistor lead and connect the test lead to this wire.

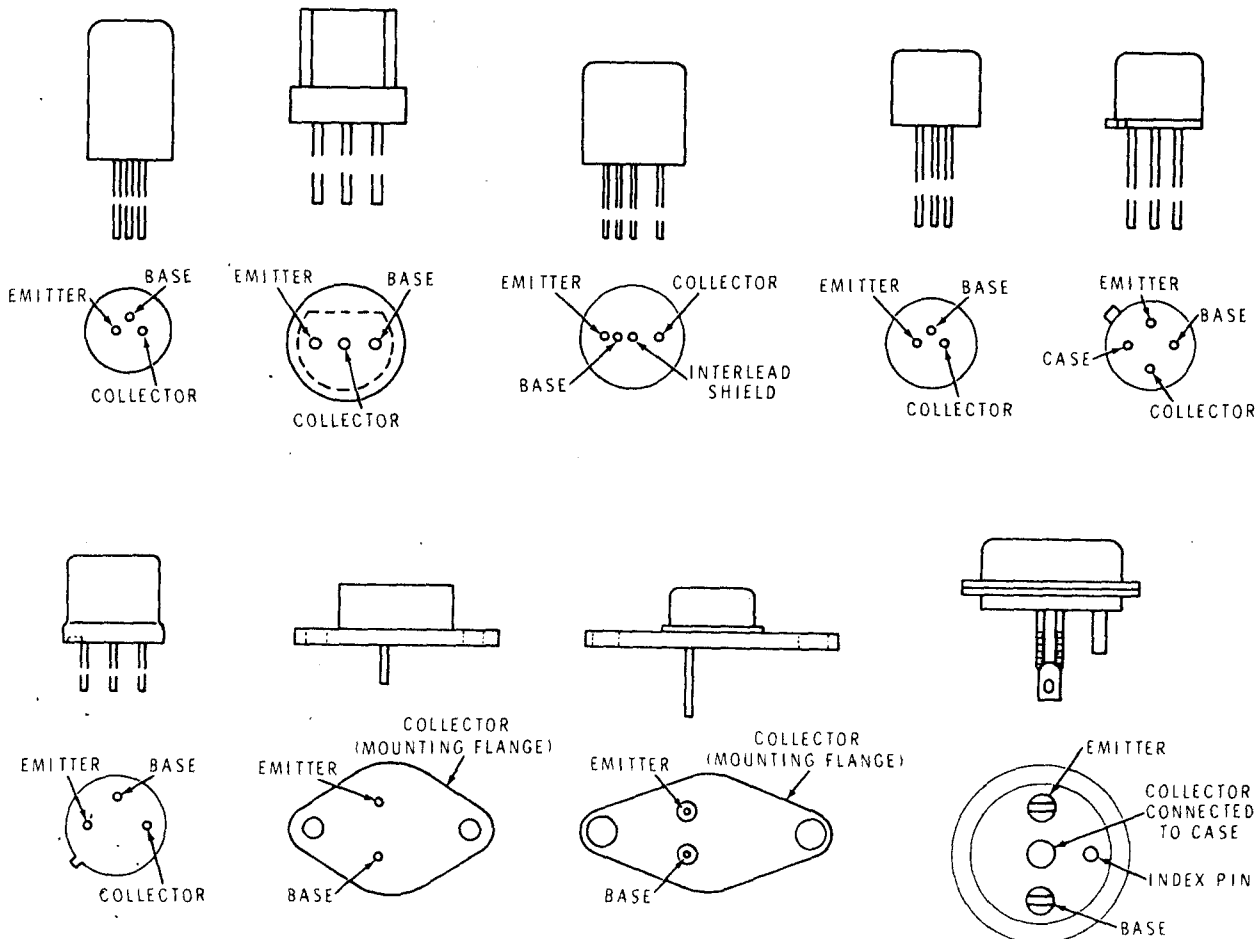


Figure 3

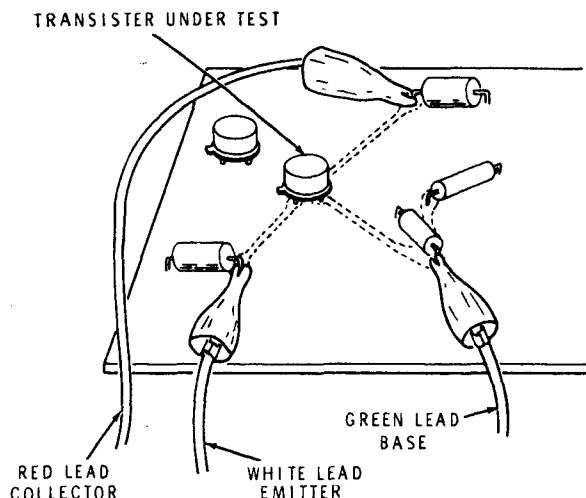


Figure 4

Refer to a Transistor Manual for complete information on most common transistor types, including both physical details and electrical characteristics. DC beta, the gain measurement made on this Tester, is referred to as h_{FE} in a Transistor Manual.

TESTING TRANSISTORS

Beta (Gain) Test

Out-of-circuit beta (gain) tests are always quite accurate, but the accuracy of an in-circuit test depends on the shunting resistances of the circuit in which the transistor is being used. If the transistor being tested indicates a gain in the circuit, you may consider the transistor to be good.

- () Connect the transistor to be checked to the Transistor Tester.

NOTE: It is only necessary to perform one of the next two steps. If you know the polarity of the transistor (NPN or PNP), perform Step 1. If you do not know its polarity, perform Step 2.

- () 1. Turn the POLARITY switch to the proper polarity for the transistor (NPN or PNP). Adjust the BETA CAL control to bring the meter to the CAL (calibrate) position.

- () 2. Place the POLARITY switch in the PNP position and turn the BETA CAL control to bring the meter to the CAL (calibrate) position. If you are able to calibrate the meter, the transistor is a PNP type. If you are unable to calibrate the meter, turn the POLARITY switch to the NPN position. If the meter calibrates now, the transistor is an NPN type. NOTE: If the meter will not calibrate properly on either position, the transistor may be faulty (open or shorted). Compare with a transistor of known quality.

- () Press the CAL/TEST switch to the TEST position. The meter will read directly in beta on the top scale of the meter. If the needle swings to the left beyond 50, set the RANGE switch in the X10 position. Now when the TEST switch is depressed, the meter reading must be multiplied by 10 to obtain the correct gain.

NOTE: If a transistor is connected to the Tester with the collector and emitter leads interchanged, the transistor will show a gain but it will be very low. If you obtain a low gain reading, interchange the collector and emitter leads and check again. If the reading increases, the transistor is now connected correctly. The following chart is a rough guide to out-of-circuit gain values of transistors found in various circuits. For more exact values, refer to the listings in a Transistor Manual for the transistor being tested.

TRANSISTOR TYPE	TYPICAL BETA RANGE
RF-IF	2-50
Power	10-100
Audio	40-400



Leakage Tests

NOTE: Leakage tests must always be made with the transistor out of the circuit, since the resistance in the circuit could cause an erroneous reading.

Most low-power silicon transistors have very low leakage with the collector to base leakage current (I_{CBO}) usually less than $1 \mu A$ (one microampere). High-power silicon transistors may indicate an I_{CBO} up to $50 \mu A$.

In germanium transistors, I_{CBO} can range from several microamperes to as high as $5 k\mu A$ (5 mA). The following chart is a rough guide to help you determine if leakage is too high in a germanium transistor. If in doubt, refer to a Transistor Manual.

Germanium Transistor Type	Typical Leakage Current
RF-IF	0-5 μA
Audio	5-10 μA
Power	50-5 $k\mu A$

- () Turn the FUNCTION switch to the I_{CBO} position. The meter will read collector to base current (I_{CBO}) in microamperes ($k=1000$ on the leakage scale).

- () Turn the FUNCTION switch to the I_{CEO} position. The meter will read the collector to emitter leakage current (I_{CEO}) on the leakage scale. Collector to emitter leakage current will always be greater than the collector to base leakage (I_{CBO}).

NOTE: Leakage current will increase with an increase in temperature. Even body heat from holding a transistor in your hand can increase the leakage current.

TESTING DIODES

- () Connect the white test lead to the cathode of the diode and the red test lead to the anode of the diode.
- () Turn the POLARITY switch to the NPN position. The meter should deflect up-scale and normally go off scale to the right. Then place the POLARITY switch in the PNP position; the meter should return to or near the zero reading on the leakage scale. If the meter goes off scale to the right in both positions, the diode is shorted. If the meter remains at zero on both positions, the diode is open.

BATTERY CHECK

To check the battery in the Transistor Tester, connect the 180Ω resistor between the red and white test leads, hold the FUNCTION switch in the I_{CEO} position and turn the POLARITY switch to the NPN position. The meter should read full scale ($5k\mu A$). If the meter pointer will not come to full scale when the LEAKAGE control is adjusted, the battery is weak and should be replaced. Beta will always measure correctly if the meter can be adjusted to the CAL mark.

IN CASE OF DIFFICULTY

1. Recheck the wiring. Trace each lead and wire 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 builder.
 2. About 90% of the kits that are returned for repair are defective due to poor connections and soldering. Therefore many troubles can be eliminated by reheating all connections to make sure they are soldered as illustrated in the soldering section of the Kit Builders Guide.
 3. Check the values of the component parts. Be sure that the proper parts have been wired into each circuit, as shown in the Pictorials and as called out in the wiring instructions.
 4. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring or components, causing a short circuit.
- NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the Service and Warranty section of the "Kit Builders Guide", and to the "Factory Repair Service" information on fold-out from Page 24 of this Manual.

Troubleshooting Chart

DIFFICULTY	POSSIBLE CAUSE
Meter pegs to the left when the 180 Ω resistor is connected between the white (emitter) and red (collector) test leads.	<ol style="list-style-type: none"> 1. Battery installed backward in battery holder. 2. Meter leads interchanged.
Meter does not deflect when 180 Ω resistor is connected between the white (emitter) and red (collector) test leads.	<ol style="list-style-type: none"> 1. Battery not making contact. Remove battery, bend ends of battery holder toward each other, replace and rotate the battery in the holder to insure a good electrical connection.
All transistors appear to have excessive leakage.	<ol style="list-style-type: none"> 1. Diode in the circuit installed backward. 2. Diode in the circuit open.

SPECIFICATIONS

DC BETA	X1 range: 2 to 100. X10 range: 20 to 1000.
Out-Of-Circuit Accuracy	±5%.
In-Circuit Accuracy	Indicates good or bad.
Collector-To-Emitter Leakage, I_{CEO} *	0-5 mA (midscale = 1000 μ A).
Collector-To-Base Leakage, I_{CBO} *	0-5 mA (midscale = 1000 μ A).
Diode Testing	In-circuit or out-of-circuit tests. Meter Indication shows that diode is either good, shorted, or open.
Power	One 1-1/2 volt size D cell.
Dimensions (overall)	9-3/8" wide x 5-3/8" high x 9" deep.
Color	Beige panel and cabinet.
Net Weight	2-1/4 lbs.

* Out of circuit only.

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.

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 23) while reading the Circuit Description.

The In-Circuit/Out-Of-Circuit Transistor Tester measures beta (gain) and leakage. The circuit of the Transistor Tester is basically a low-impedance, common-emitter amplifier without a transistor; the transistor being tested completes the circuit. Note on the Schematic that the emitter of the transistor being tested (the emitter of the test socket and test lead) is connected through lugs 1 and 12 of the Function switch and lugs 5 and 3 of the Polarity switch to -1.5 volts. The base of the transistor (as now shown) is connected through lugs 11 and 10 of the Function switch, the Beta Cal control, the Beta Test switch, resistor R2, and lugs 7 and 6 of the Polarity switch to +1.5 volts. The collector (as now shown) is connected to +1.5 volts through two parallel paths: one path goes through R4 and lugs 8 and 9 of the Function switch; the other path goes through the Beta Test switch, lugs 1 and 2 of the Polarity switch, the meter, lugs 5 and 6 of the function switch, and lugs 9, 7, and 6 of the Polarity switch.

At current levels through the meter that are below 200 μA , diode D1 does not conduct. As the current through the meter increases, D1 conducts and by-passes current in excess of 200 μA around the meter. This provides protection for the meter.

Power is supplied by a 1-1/2 volt flashlight battery (size D cell). The five sections of the Polarity switch, in the Off position, disconnect the battery and meter circuits, and place a short across the meter terminals for dynamic damping of the meter movement during transit. In the NPN and PNP positions, this switch removes the short from the meter and applies voltage of the correct polarity to the circuit.

It is possible to check transistors without removing them from a circuit because the resistances in the Transistor Tester are considerably lower than those encountered in most transistor circuits. This means that any parallel current paths around the Transistor being tested will not draw enough current to cause any appreciable error in the beta reading on the Transistor Tester.

BETA (GAIN) TEST

The collector current of a transistor depends on and is proportional to its base current. Therefore, transistor Beta (gain) is equal to the ratio of these currents.

$$\text{Beta} = \frac{\text{collector current } I_C}{\text{base current } I_B}$$

The gain of any transistor can therefore be determined by carefully measuring these two currents and dividing the collector current by the base current.

In this circuit, Beta Cal control R3 is in series with the base of the transistor and it controls the base current. The base current in turn, controls the collector current by varying the forward bias applied to the transistor. Collector current passes through shunt resistor R4 and through the Beta Test switch to the meter circuit.

The collector current is adjusted by the Beta Cal control to a 4 mA reference point (the calibration point on the meter scale). This first condition, where the collector current is measured and the Beta Test switch is in the Cal position, is shown in the simplified schematic of Figure 5A.

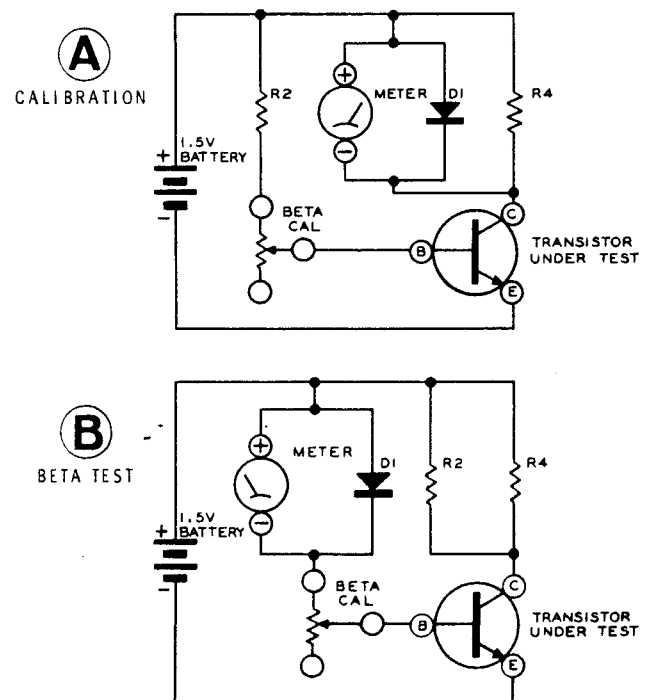


Figure 5

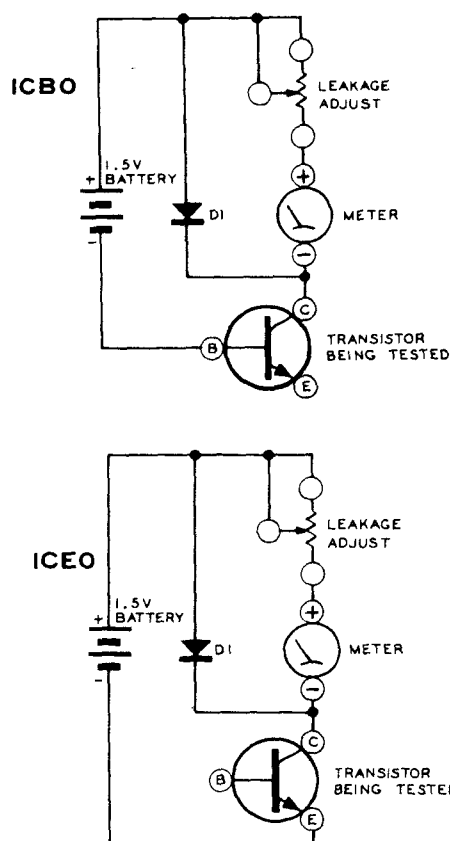


Figure 6

Figure 5B shows what happens when the Beta Test switch is pressed into the Test position. The positions in the circuit of the meter and resistor R2 are reversed, and the meter now measures the base current of the transistor. Base current is calibrated on the meter in direct proportion to the 4 mA reference current; the meter therefore reads directly in terms of gain, or beta. For example: with a collector current of 4 mA (calibration point) and a base current of .08 mA, the beta of a transistor would be 50.

$$\frac{4 \text{ mA}}{.08 \text{ mA}} = 50$$

The Range switch, in the X1 position, shunts resistor R2 with resistor R1 to bypass the increased current of low beta transistors. When the Range switch is in the X10 position, resistor R1 is removed from the circuit, and the full current flows through R2.

LEAKAGE TEST

This Test measures I_{CBO} and I_{CEO} leakage. I_{CBO} is the current that flows from the collector to the base of a transistor when the emitter is open. It is similar to grid current in a vacuum tube circuit. I_{CEO} is the current that flows from the collector to the emitter when the base is open.

The I_{CBO} or I_{CEO} leakage tests must be performed with the transistor removed from the circuit. If the transistor were left in the circuit, additional leakage currents would flow in the other resistances that shunt the transistor. These added leakage currents would cause an erroneous reading on the Tester.

When the Function switch is in the I_{CBO} position, battery voltage is applied from the collector to the base of the transistor (reverse bias), with the emitter open. See Figure 6. The meter, shunted by diode D1, is connected in series with this circuit to measure the leakage current of the transistor.

In the I_{CEO} position, battery voltage is applied from the collector to the emitter, with the base open. See Figure 6. The meter again measures the leakage current.

Diode D1 acts as an open circuit at lower current levels, so the full leakage current passes through the meter. As the leakage current increases, the voltage across diode D1 increases until it starts conducting. This passes some of the current around the meter, thus increasing the range of the upper end of the meter scale.

Leakage adjust control R5, when properly adjusted, allows .2 mA of current (full scale deflection) to pass through the meter when 4.8 mA of current passes through diode D1, indicating a total of 5 k (5 mA) on the leakage scale.

Capacitor C1 shorts out any high frequencies to prevent the circuit from oscillating.

FUNCTIONAL PARTS LIST

Battery: Power supply for all tests.

Polarity switch: In the NPN and PNP positions, this switch applies voltage of the correct polarity to the meter circuit and to the transistor being tested. When switched to OFF, the battery circuit is disconnected and the meter is shorted.

Function switch: Changes the circuit from a basic amplifier in the BETA position to a diode test circuit in the leakage (I_{CEO} , I_{CBO}) positions.

Beta X1/X10 switch: Places a 25Ω resistor across the meter in the X1 position. Removes this resistor in the X10 position to increase the range of the meter.

Beta Test switch: Interchanges the meter and 225Ω resistor between the collector and base circuits to maintain equivalent operating conditions for the calibrate and test readings.

Beta Cal control: Adjusts the forward bias applied to the device under test to produce the correct 4 mA reference current in the collector circuit.

Leakage Adjust control: Used as a current limiting resistor to determine the amount of current that will flow through the meter and diode.

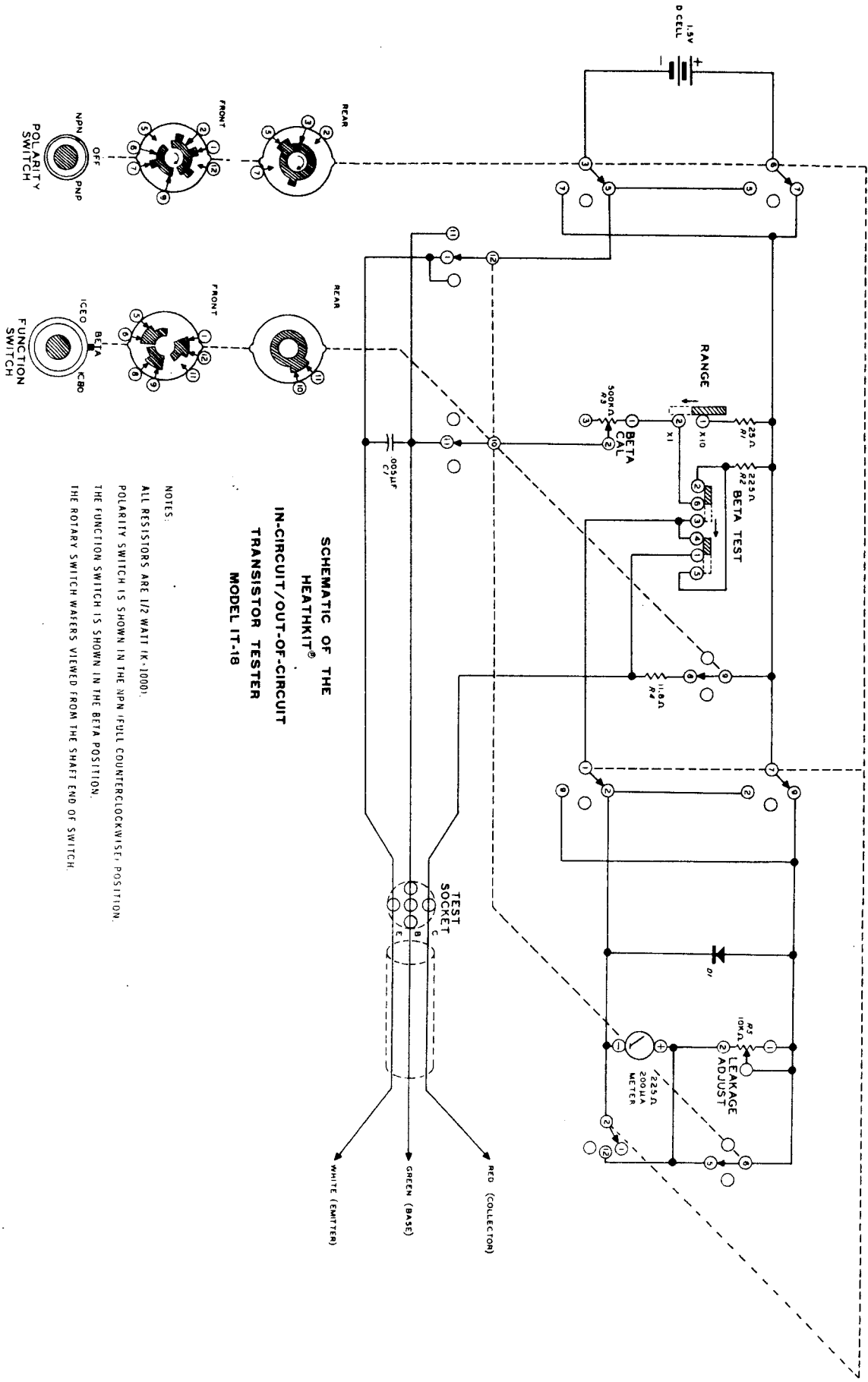
Resistor R1: Used as a meter shunt in the base circuit to bypass increased current when measuring low beta transistors on the X1 range.

Resistor R2: This resistor, which is equivalent to the meter resistance, maintains correct transistor operating currents when you switch from the Beta Cal to the Beta Test position.

Resistor R4: Shunts high current around the meter when the meter is in the collector circuit.

Capacitor C1: Provides an AC signal path to ground to prevent the transistor under test from oscillating.

Diode D1: Meter protection shunt for Beta tests. Increases the meter range on the leakage tests.



**SCHEMATIC OF THE
HEATHKIT®
IN-CIRCUIT/OUT-OF-CIRCUIT
TRANSISTOR TESTER
MODEL IT-18**

- NOTES:**
- ALL RESISTORS ARE 1/2 WATT (K-1000).
 - POLARITY SWITCH IS SHOWN IN THE NPN (FULL COUNTERCLOCKWISE) POSITION.
 - THE FUNCTION SWITCH IS SHOWN IN THE BETA POSITION.
 - THE ROTARY SWITCH WASERS VIEWED FROM THE SHAFT END OF SWITCH.

