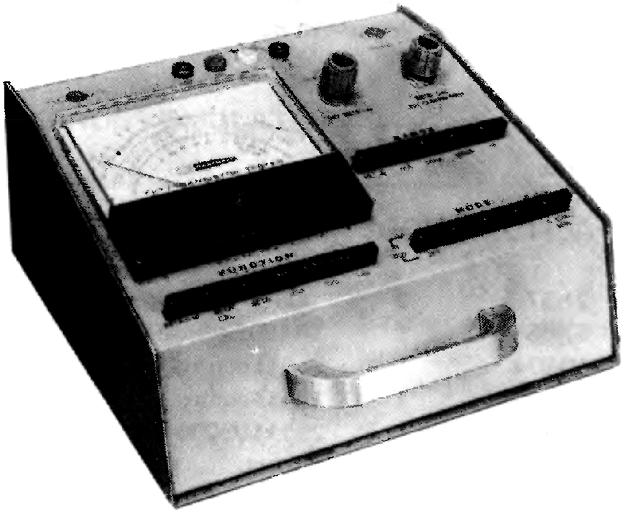
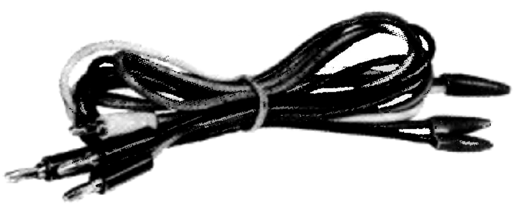
Assembly and Operation of the HEATHKIT

FET/TRANSISTOR TESTER

MODEL IT-121





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HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

Check the equipment to see that all parts and screws are in place. Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least THREE INCHES of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

SPECIFICATIONS

DC Beta	1 to 5000 with the following ranges available: 1 to 50, 5 to 250, 10 to 500, 50 to 2500, 100 to 5000.
Collector Currents Available	1 mA, 5 mA, 10 mA, 50 mA, 100 mA, 500 mA, and 1 A.
G_m	0 to 50,000 μmhos.
Leakage Measurements	Five current ranges, ±5%.
(Iceo, Ices, Icbo, Idss, Igss)	0-100 μA, 0-1 mA, 0-10 mA, 0-100 mA, 0-1 A
Out-of-Circuit Accuracy	±2%, ±2% arc for DC beta and leakage.
In-Circuit Accuracy	Indicates good or bad transistor, FET, diode, SCR, or triac.
Diode Test	Tests for forward conduction and reverse leakage (out-of-circuit).
SCR and Triac Tests	Tests for proper conduction and blocking.
Unijunction Transistor Test	Measures Ieb_2s, Ib_2b_1s, and Emitter Current (out-of-circuit).
Power	Two 1-1/2 volt D cells.
Dimensions (overall)	9-9/16" wide x 8-5/8" deep x 5-1/4" high.
Net Weight (Less batteries)	3-1/2 lbs.

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 41) while you read this "Circuit Description."

General Consideration

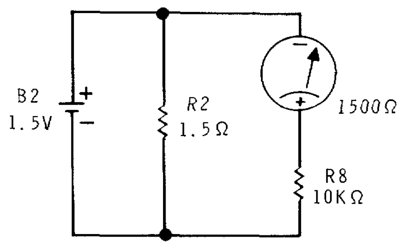
All of the following circuit explanations refer only to NPN transistors or N channel FET's. The descriptions also apply equally to PNP transistors and P channel FET's except that the polarity of the meter and both batteries (B1 and B2) must be reversed.

Diode D1 protects the meter by limiting the voltage across it to 0.6 volts. Capacitors C1 and C2 prevent oscillations from occurring in the device being tested. Resistors R5 and R6 limit the current to protect controls R11 and R12 in case a short circuit occurs. For simplicity, the above components are not shown in the following partial schematics.

All switches are shown on the Schematic in the released (out) position even though this configuration does not represent a particular test. This enables you to easily trace a particular test circuit by pressing (mentally) only the switch related to that test.

BATTERY TEST

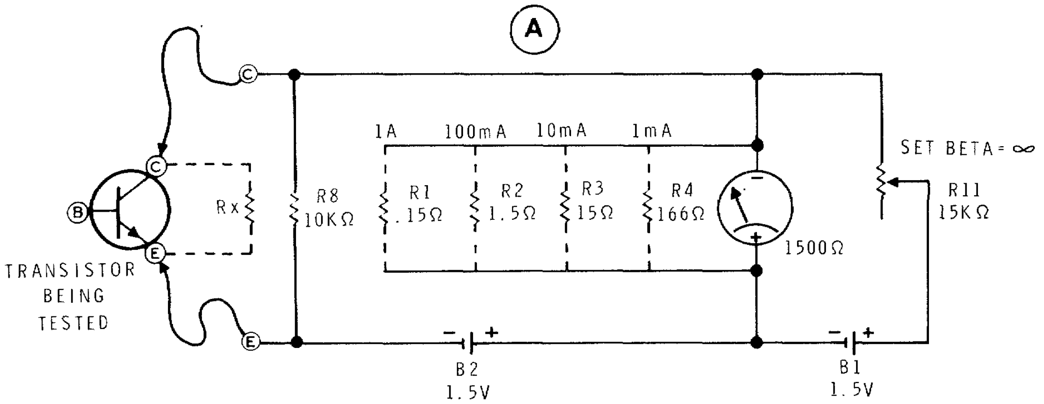
Each battery is tested separately. The NPN position of the NPN-PNP switch connects battery B1 into the battery testing circuit. The PNP position of the NPN-PNP switch connects battery B2 into the battery testing circuit. A load, simulating operating conditions, is connected across each battery while the battery voltage is being measured. This assures that the battery is capable of supplying adequate current and voltage for the tests.



BAT TEST

Figure 5

When the Bat Test switch is pressed, resistor R2 is placed across the battery terminals to load the battery. See Figure 5. The meter, now functioning as a voltmeter, measures the battery voltage. If the battery is serviceable (0.9 volt or more), the meter pointer will fall within the Bat OK mark on the meter.



BETA=∞

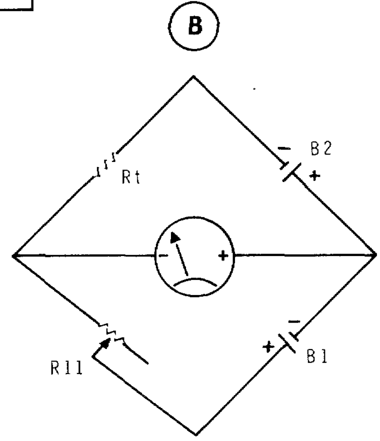


Figure 6

BETA = ∞

The "beta = ∞" circuit, as shown in Part A of Figure 6, primarily compensates for the transistor collector load resistance, R8, and in-circuit resistances, Rx.

This circuit is basically a bridge circuit as shown in Part B of Figure 6. Resistor Rt represents load resistor R8 plus any in-circuit resistance, Rx. Because Rx varies widely from one circuit to another, control R11 (Set Beta = ∞) provides a means of balancing the bridge circuit. A true representation of beta can now be achieved since any unbalance that occurs in subsequent tests will be directly associated with the transistor collector current.

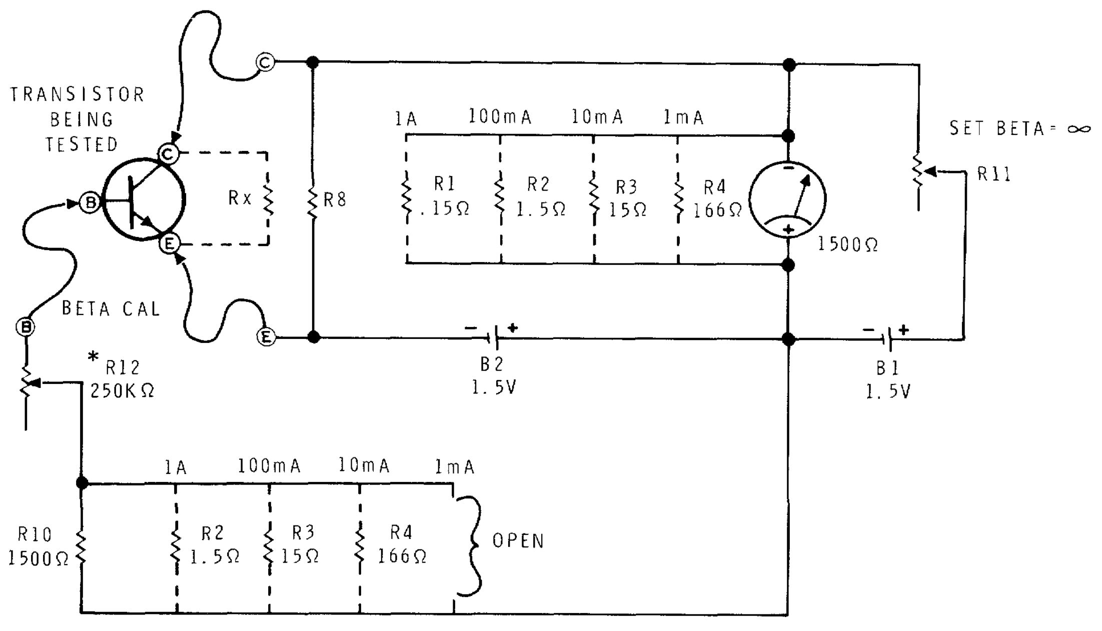
Resistors R1 through R4 are meter shunt resistances for the 1 A through 1 mA ranges respectively. The 100 μA range does not use a meter shunt resistor.

BETA CAL

The base of the transistor is now connected into the circuit through control R12 (Beta Cal) and resistor R10. See Figure 7. Control R12 adjusts the base current of the transistor until sufficient collector current flows through the meter to place the pointer over the CAL X10 mark (full scale). The collector current is now equal to the particular current range you selected.

Because resistor R10 is the same value as the meter resistance, the meter and resistor R10 can be interchanged in the following tests to measure base current without changing the collector current.

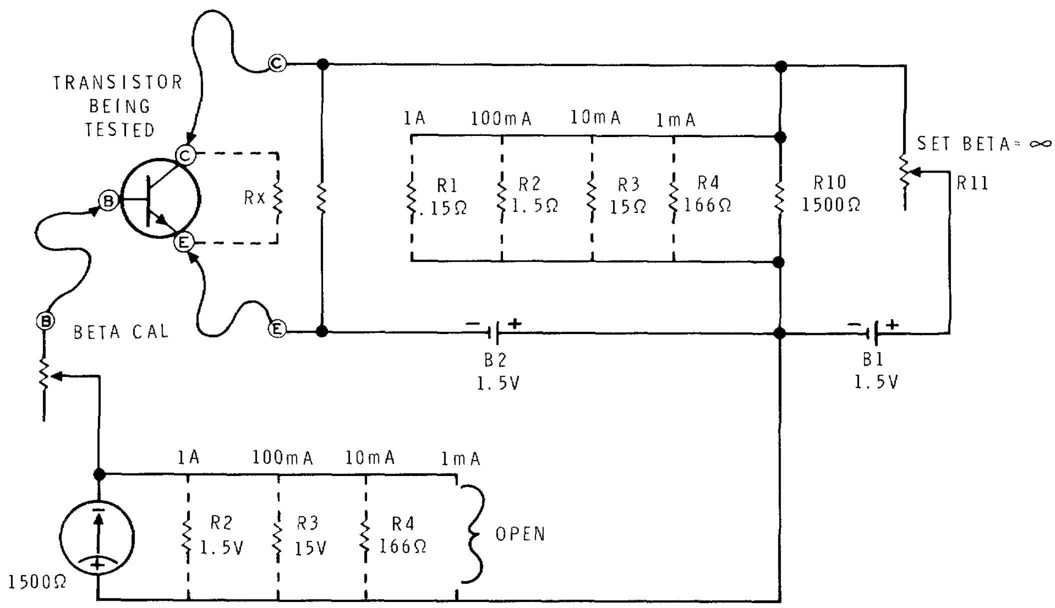
Notice that a shunt resistor is in parallel with resistor R10. This total resistance (R10 and its shunt) is ten times larger than the resistance of the meter and its shunt for the same range. Thus, when the meter is placed in the base circuit, it will read 1/10 the current measured in the collector circuit.



* R13 (5000Ω)
IF CONTROL IS PULLED
OUT (1A RANGE ONLY).

BETA CAL

Figure 7



BETA

Figure 8

BETA

This circuit is similar to the beta cal circuit except that the meter is now in the base circuit and resistor R10 is in the collector circuit. See Figure 8. Also, because the shunt resistor that was previously across R10 is now across the meter, only 1/10 the current is required for full-scale meter deflection.

Since beta, by definition, is collector current (Ic)/base current (Ib), these currents could be measured and the ratio computed to obtain beta. However, the meter scale takes into account the currents and their ratio, and reads directly in terms of beta.

For example, when the 10 mA current range is selected, and the Beta Cal control is adjusted to place the meter pointer over the CAL X10 mark (full scale), a collector current of 10 mA flows through the device. Now, when the meter is in the base circuit, assume that a 1 mA current flows. The meter pointer will deflect full scale (1 mA) and indicate a beta of 1 times a multiplier of 10 (CAL X10). Thus, beta = 10. The same result can be obtained from the formula:

$$\frac{IC}{IB} = \frac{10\ mA}{1\ mA} = 10$$

Icbo, Ices, AND Iceo

Leakage currents are measured by placing a battery and the meter (and its shunt resistance) in series with two of the transistor leads. The meter indicates leakage current from 0 to 1 ampere, depending on the current range selected. Since the leakage currents are quite small, usually measured in microamperes (μA), the transistor must be removed from the circuit.

Icbo is the measurement of the current that flows between the collector and the base of the transistor with the emitter open (unconnected). See Figure 9.

Ices is the measurement of the current that flows between the collector and the emitter of the transistor with the base connected to the emitter. See Figure 10.

Iceo is the measurement of the current that flows between the collector and the emitter of the transistor with the base open (unconnected). See Figure 11.

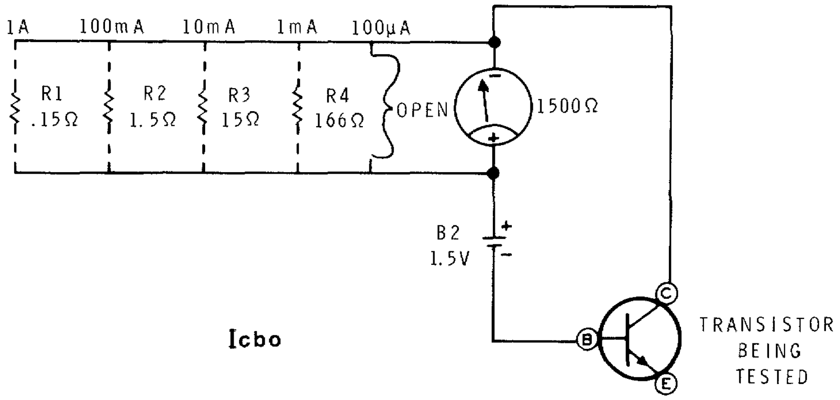


Figure 9

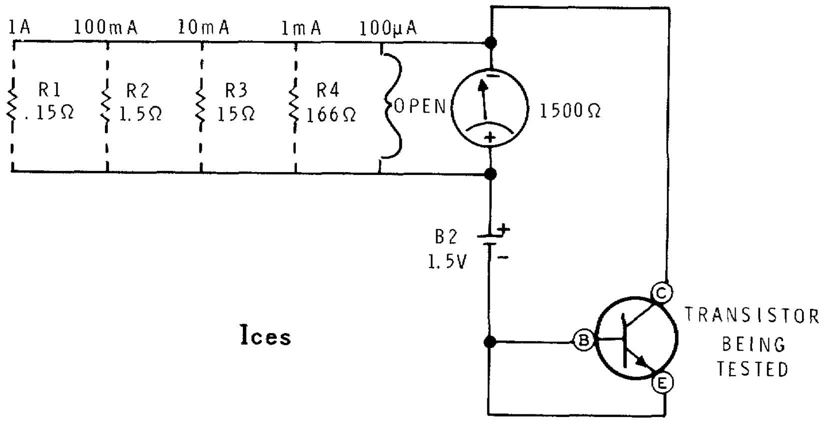


Figure 10

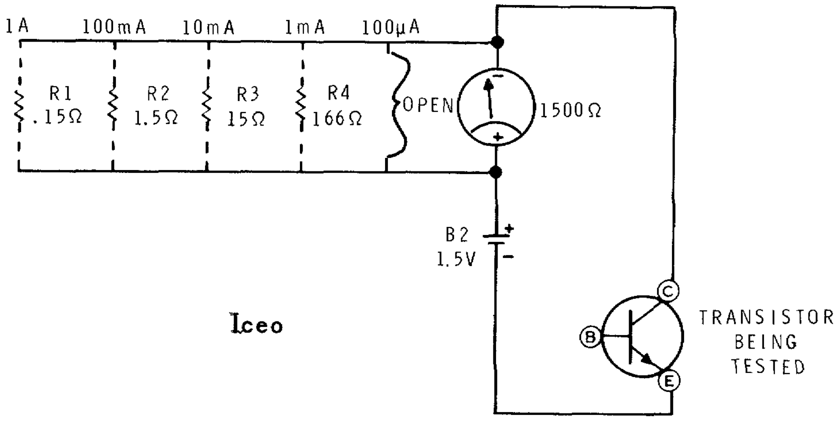
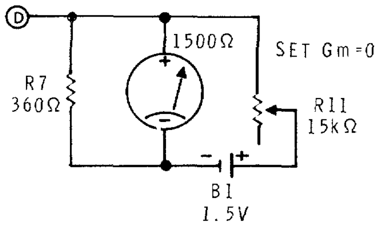
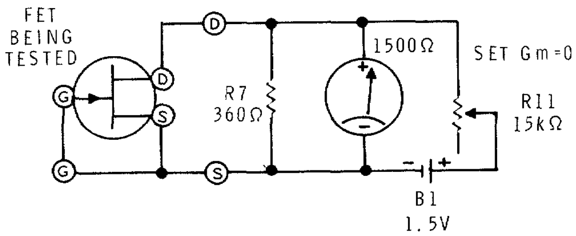


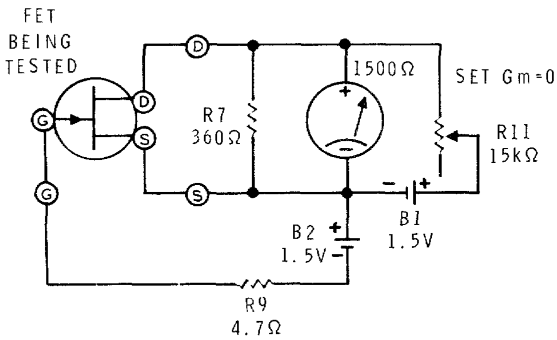
Figure 11



Gm=O
Figure 12



Gm
Figure 13



GATE 1 / GATE 2
Figure 14

Gm = 0

Battery B1 and control R11 (Set Gm = 0) are placed in series with the meter and shunt resistor R7 as shown in Figure 12. This circuit forms a shunt type ohmmeter that will be used to measure the source-to-drain resistance in the Gm test. Control R11 is adjusted here to place the meter pointer over the 0 mark (full scale). Notice that the FET is not connected into the circuit at this time, even though it may be connected to the Tester.

Gm

Because Gm (transconductance) is the reciprocal of resistance, an ohmmeter type circuit can measure Gm. See Figure 13. Notice that the Gm meter scale is similar to a typical ohmmeter scale.

In this test, the drain and source leads of the FET are connected in shunt with the meter. An FET with a low drain-to-source resistance has a Gm that approaches ∞. This is because the FET shunts most of the meter current. If the drain-to-source resistance is high, the Gm approaches 0. This is because the FET shunts very little meter current.

Typically, values of transconductance are expressed in μmhos (the meter indication multiplied by 1000).

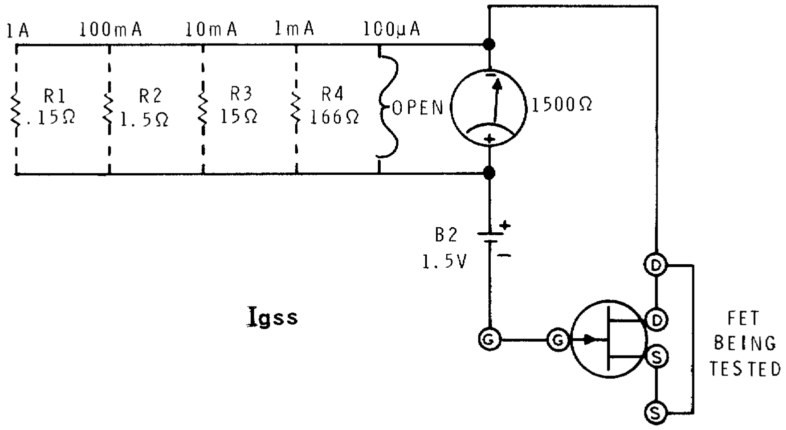


Figure 15

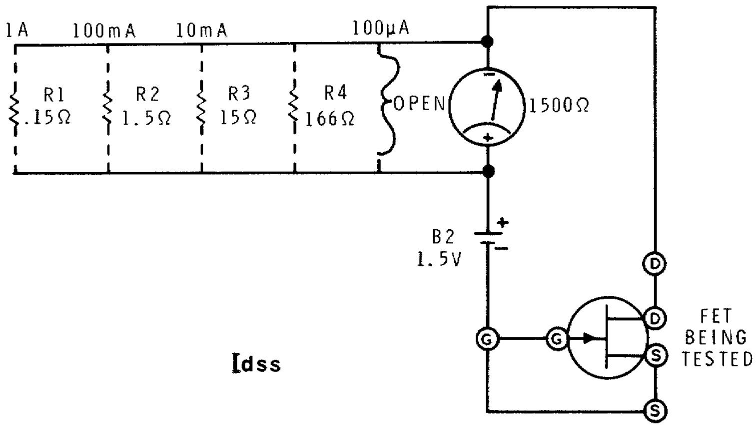


Figure 16

GATE 1 AND GATE 2

The "Gate 1" circuit is similar to the Gm circuit. See Figure 14. However, the Gate 1 test places a reverse bias on the gate of the FET through resistor R9. This causes the channel of the FET to become electrically narrower, increasing its resistance, decreasing its Gm. A noticeable decrease in Gm should be apparent when the Gate 1 switch is pressed.

If the FET is a dual gate device, the Gate 2 switch will reverse bias the second gate. A noticeable decrease in Gm should also be apparent when the Gate 2 switch is pressed.

Igss AND Idss

Leakage currents are measured by placing a battery and the meter (and its shunt resistance) in series with two of the FET leads. The meter indicates leakage current from 0 to 1 ampere, depending on the current range selected. Since the leakage currents are quite small, usually measured in microamperes (μA), the FET must be removed from the circuit.

Igss is the measurement of the current that flows between the gate and the source of the FET with the drain connected to the source. See Figure 15.

Idss is the measurement of the current that flows between the drain and the source of the FET with the gate connected to the source. See Figure 16.

CIRCUIT BOARD X-RAY VIEWS

NOTE: To identify a part shown in one of these Views, so you can order a replacement, proceed in either of the following ways:

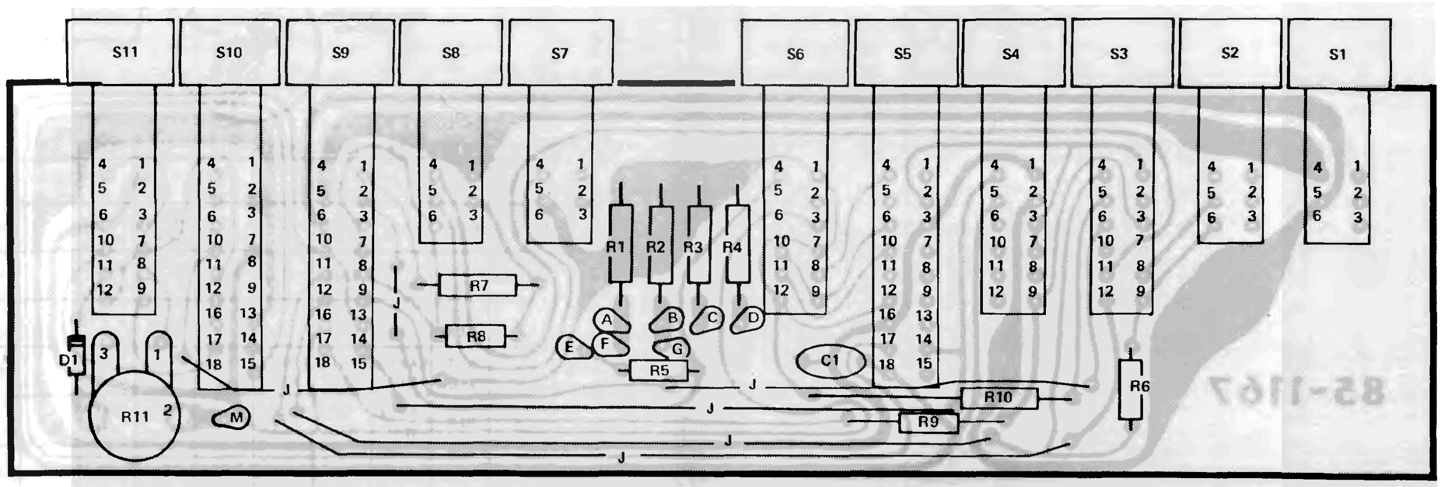
1. A. Refer to the place where the part is installed in the Step-by-Step instructions and note the "Description" of the part (for example: 1500 Ω or .005 μF).

   B. Look up this Description in the "Parts List."

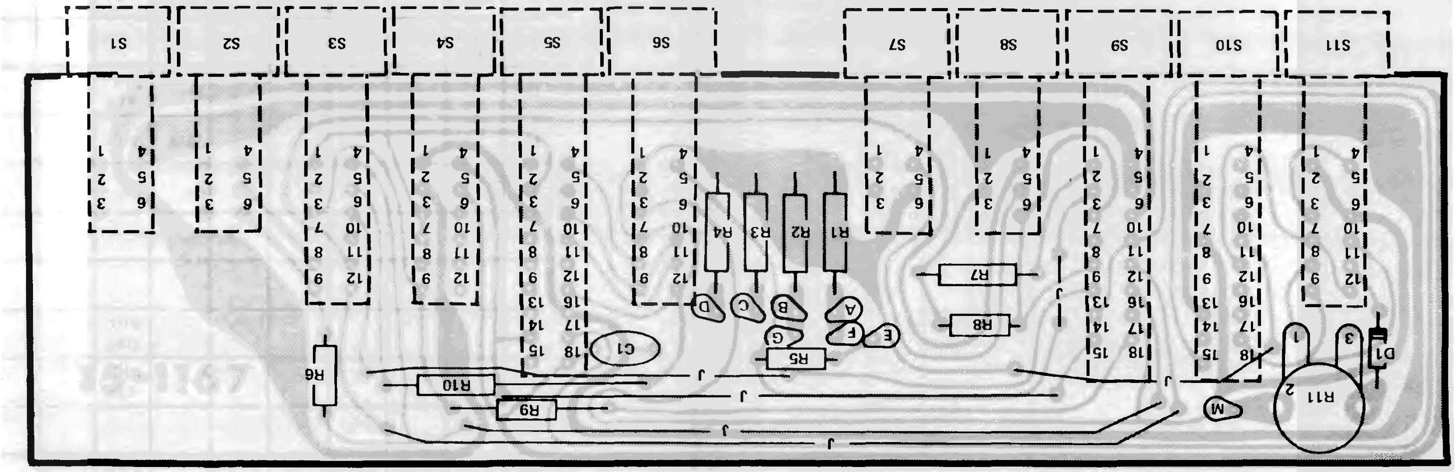
2. A. Note the identification number of the part (R-number, C-number, etc.).

   B. Locate the same identification number (next to the part) on the Schematic. The "Description" of the part will also appear near the part.

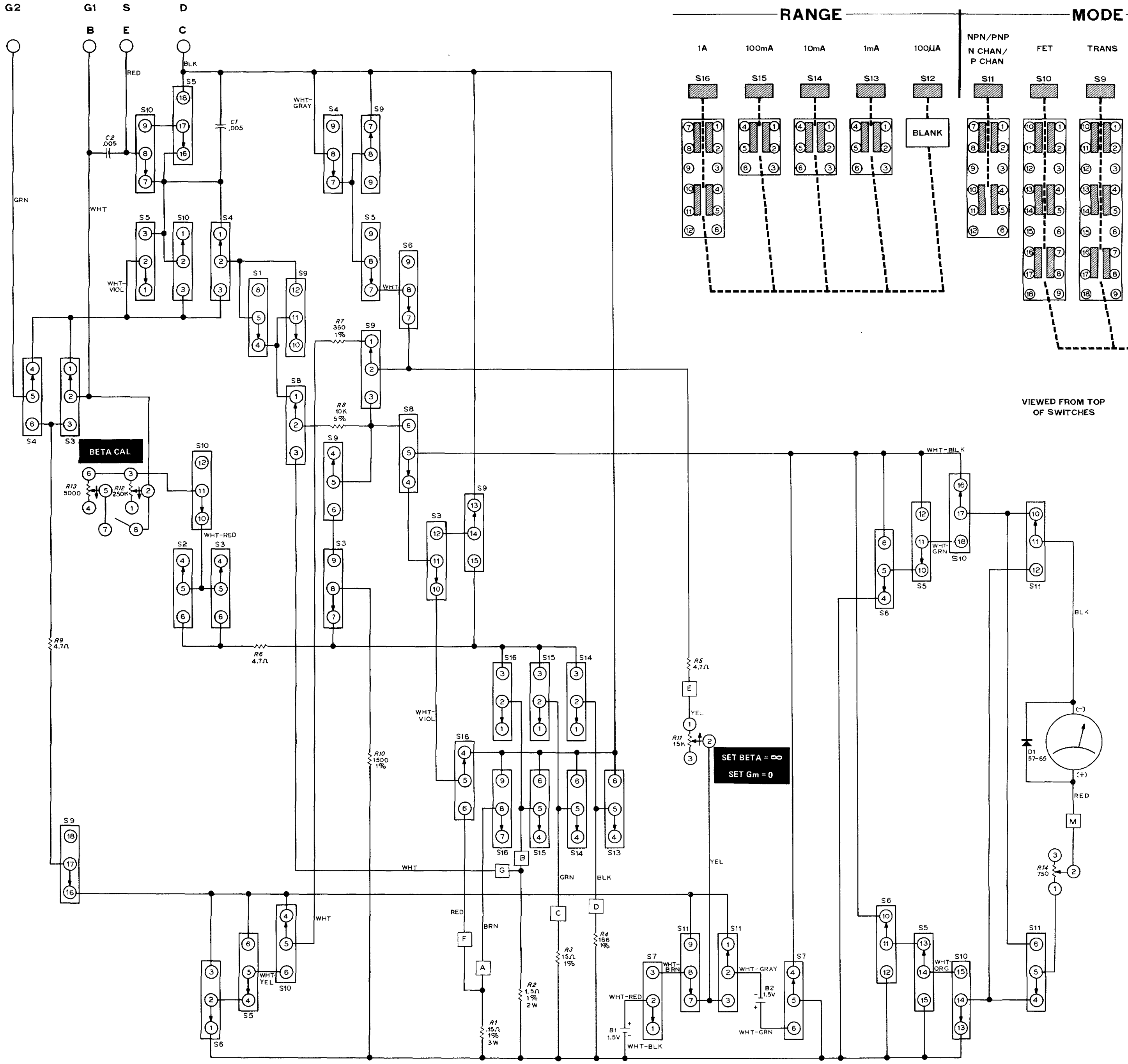
   C. Look up this Description in the "Parts List."

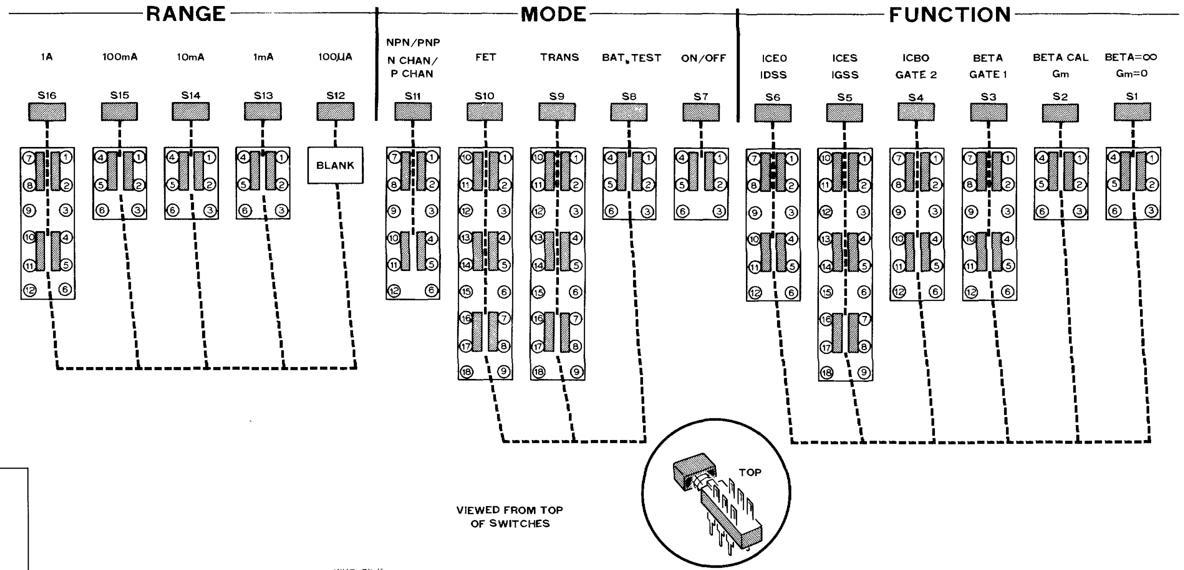


(VIEWED FROM COMPONENT SIDE)



(VIEWED FROM FOIL SIDE)

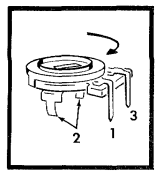




SCHEMATIC OF THE HEATHKIT®
FET/TRANSISTOR TESTER
MODEL IT-121

NOTES:

1. ALL RESISTORS ARE 1/2 WATT 5% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES ARE IN μF.
3. THE ARROW INDICATES CLOCKWISE ROTATION OF A CONTROL OR SWITCH, AS VIEWED FROM THE KNOB END OR AS SHOWN FOR CIRCUIT BOARD CONTROLS. THE CIRCUIT BOARD CONTROL LUG NUMBERS CORRESPOND TO THOSE SHOWN ON THE SCHEMATIC AND X-RAY VIEWS.



4. REFER TO THE CHASSIS PHOTOGRAPH AND CIRCUIT BOARD X-RAY VIEW FOR THE PHYSICAL LOCATION OF PARTS.
5. ALL SWITCHES ARE SHOWN IN THE RELEASED (OUT) POSITION EVEN THOUGH THEY DO NOT REPRESENT A SPECIFIC OPERATING CONFIGURATION.
6. ☐ THIS SYMBOL INDICATES A LETTERED CIRCUIT BOARD CONNECTION.