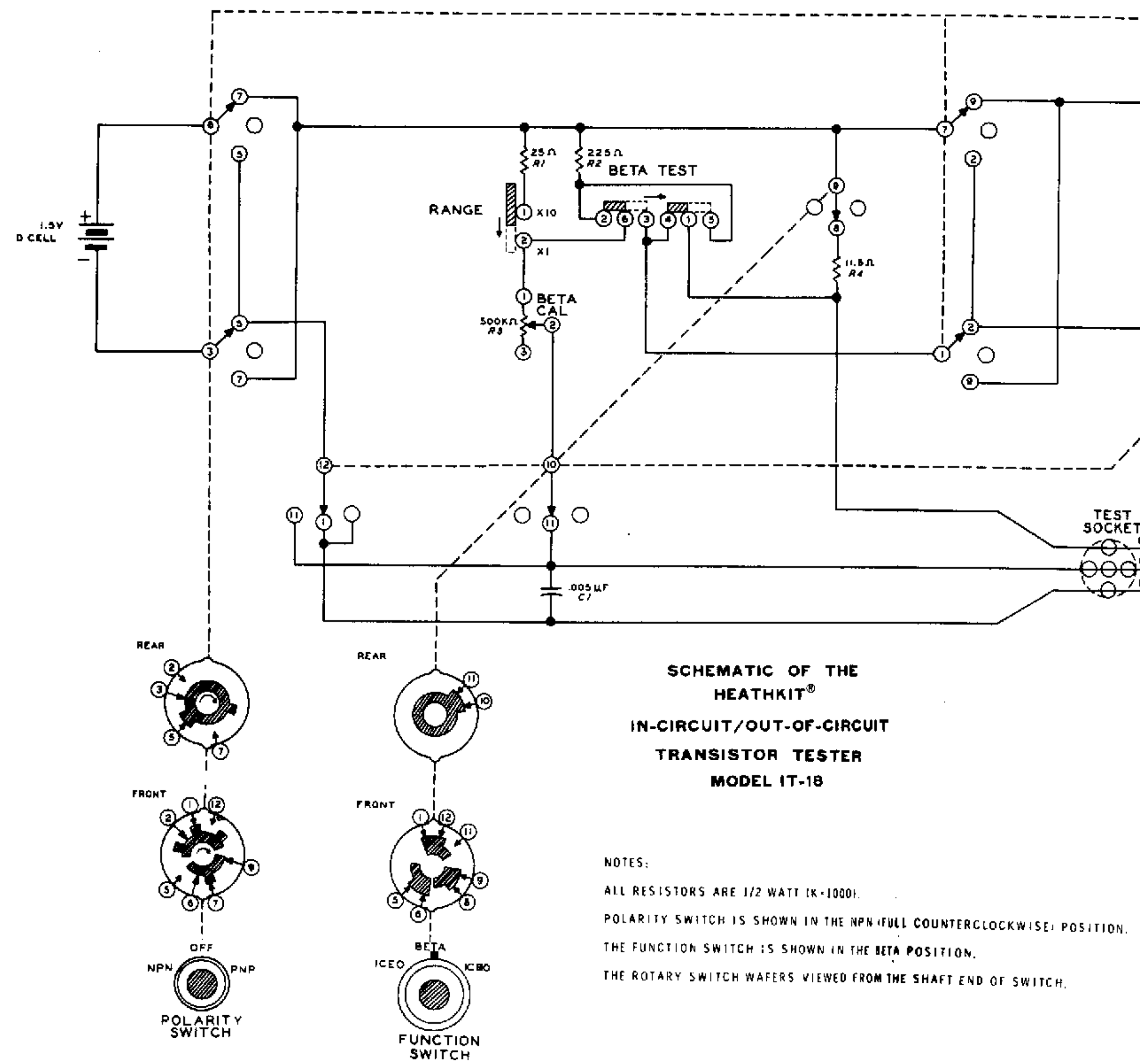


SCHEMATIC OF THE HEATHKIT® IN-CIRCUIT/OUT-OF-CIRCUIT TRANSISTOR TESTER MODEL IT-18

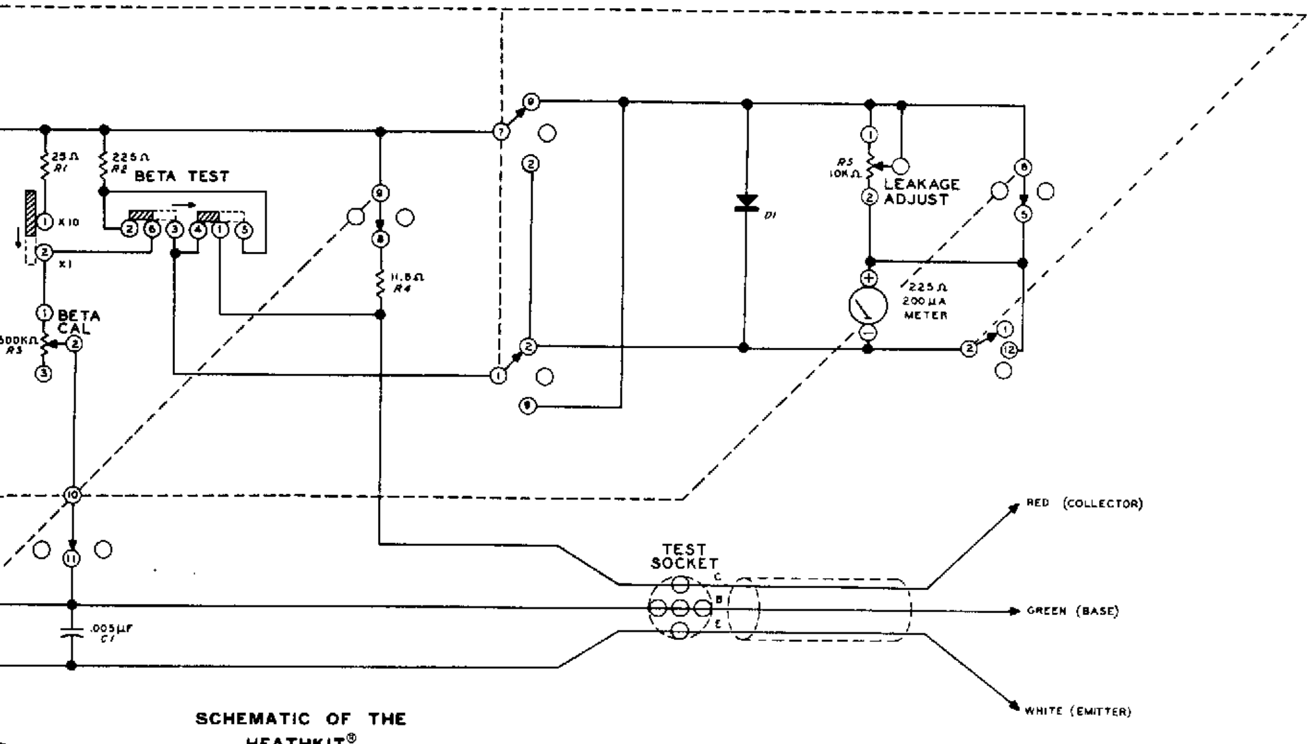
NOTES:

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 WAFERS VIEWED FROM THE SHAFT END OF SWITCH.



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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 μA).
Collector-To-Base Leakage, I_{CBO} *	0-5 mA (midscale = 1000 μA).
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.

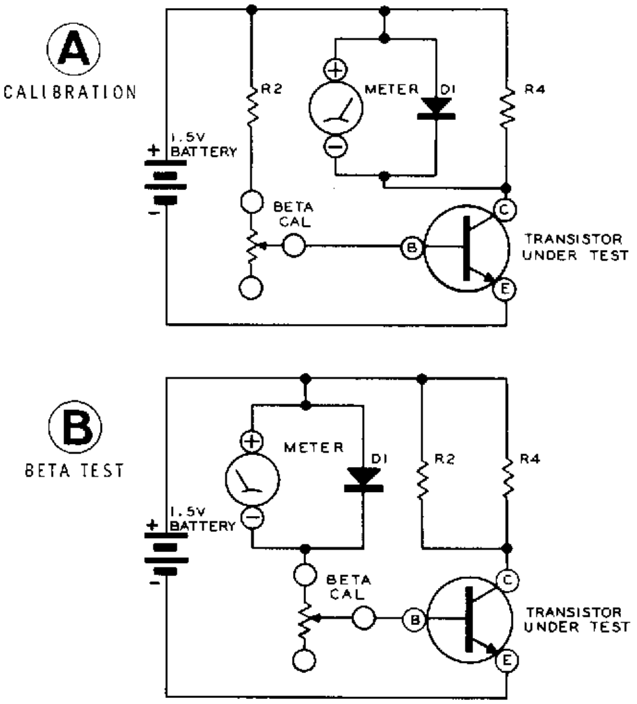

Figure 5

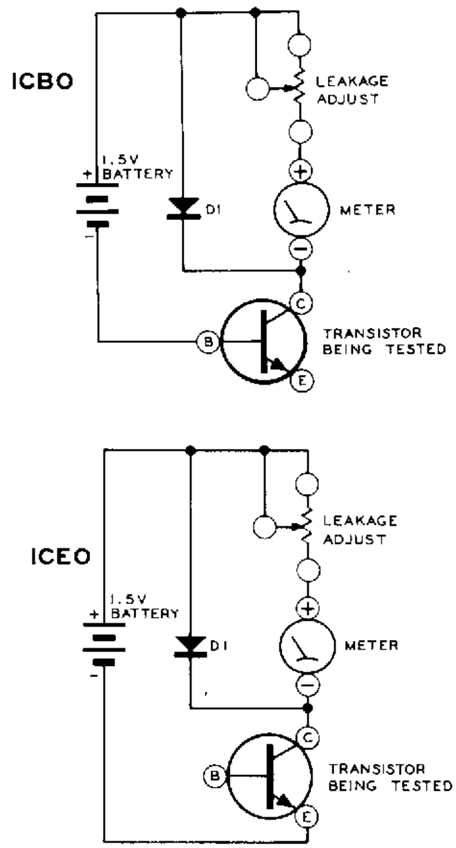

Figure 6

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 25 Ω 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 225 Ω 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.