Electronic Thermometer

HERE IS AN INEXPENSIVE ELECTRONIC thermometer than can be built in just one evening. It is capable of measuring temperatures over a range of from −30°F to +120°F.

The circuit is shown in Fig. 1; its operation is fairly straightforward. A diode-connected 2N3904 transistor forms a voltage divider with R1. The transistor is used as the temperature sensor and, for best results, should be connected to the rest of the circuit using twisted wire as shown. As temperature increases, the voltage drop across the transistor changes by approximately −1.166 millivolts-per-°F. As a result, the current at pin 3 of IC1, a 741 op-amp with a gain of 5, decreases as the temperature measured by the sensor increases.

A second 741 op-amp, IC2, is configured as an inverting amplifier. Since pin 3 of that IC is grounded, pin 2 is at a virtual ground and the sum of all currents into that pin must be zero. Resistors R5 and R6 are used to calibrate the circuit. Once R6 is adjusted (more on that later), the current flow through those resistors will be constant. At a temperature of about −30°F, the current through R4 (that resistor is formed by connecting a 910- and a 1600-ohm resistor in parallel) should equal the current through R5 and R6.

At higher temperatures, the current through R4 will be less than the current through R5 and R6. Since the sum of the currents at pin 2 of IC2 should be zero, current will be drawn from the output (pin 6) of that IC to offset the difference. That current must pass through M1, and the amount of current drawn is, of course, measured by the meter. As the relationship between the amount of current drawn and the measured temperature is linear, it is relatively easy to calibrate the meter to indicate measured temperature.

If the temperature goes below −30°F a reverse current will be generated. As that reverse current is undesirable, its flow is prevented by inserting D1 into the circuit as shown.

Calibration is also straightforward. When properly done, a temperature of −30°F will result in a meter reading of 0 milliamps, while a temperature of 120°F will result in a meter reading of 1 milliamp. Divide the scale between those points into equal segments and mark the divisions with the appropriate corresponding temperatures. Note that dividing the scale into more parts will result in greater accuracy; if you divide it into 150 equal segments, for instance, each division will equal one degree. The calibration is completed by placing the sensor in an environment with a known temperature, such as an ice-point bath. The ice point of water is approximately 32°F. That is the temperature at which water and ice can co-exist in the same container. To prepare the bath, place water and ice in a large glass beaker or similar container, wait a few minutes for the temperature of the bath to stablize, and verify that the temperature is indeed 32°F using another thermometer that is known to be accurate. Then, simply place the sensor in the bath and adjust R6 until you get the correct meter reading.

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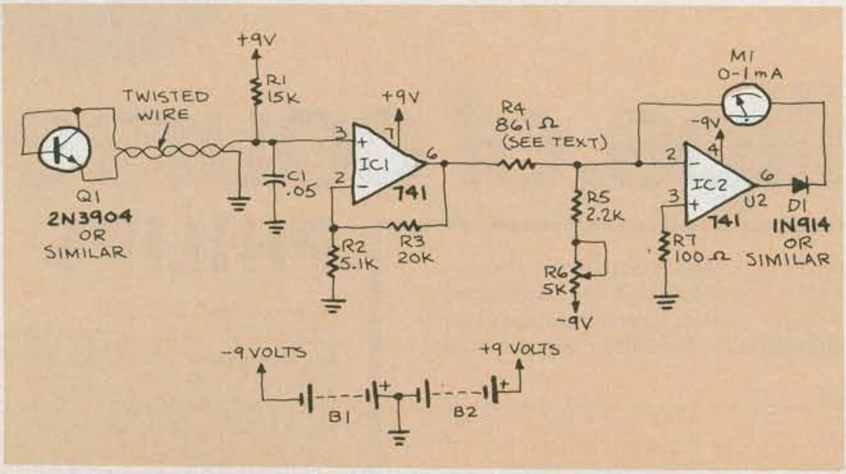

FIG. 1