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In this circuit, a silicon diode is used as a temperature sensor. The junction potential of a silicon diode decreases by about two millivolts per degree centigrade, so that the temperature of the diode can be ascertained by measuring the voltage across it. As a temperature sensor, a diode has the advantages of high linearity and a low time constant. It can moreover be used over a wide temperature range, from −50 up to 200°C.
As the diode voltage has to be measured very precisely, a stable reference source is needed. A good choice is the 723 voltage stabiliser. Although the absolute value of the zener voltage in this IC varies from one 723 to another, the temperature coefficient is very small (typically 0.003%/°C). Furthermore, the 723 can be used to stabilize the 12-volt supply for the rest of the circuit. Note that the pin numbers in the circuit diagram are only correct for the dual-in-line (DIL) version of the 723; the pinning of the metal-can version is shown in the IC list elsewhere in this issue.

The second IC, the 3900, contains four amplifiers of which only two are used. These op-amps do not function in the usual way; they are current-driven rather than voltage-driven. An input can best be regarded as the base of a transistor in a common-emitter configuration. Consequently, the input voltage is always about 0.6 volt.
R1 is connected to the reference voltage and a constant current therefore flows through this resistor. By virtue of its high open-loop gain, the op-amp will adjust its own output so that the same current flows into its inverting input, and the current through the temperature-sensing diode (D1) therefore remains constant.
This arrangement is necessary because the diode is, in effect, a voltage source with a finite internal resistance, and any variation in the current flowing through it would therefore produce a change in the voltage which would be incorrectly interpreted as a change in temperature.

The output voltage at pin 4 is thus equal to the voltage at the inverting input plus the voltage across the diode (the latter varying with temperature). C3 prevents oscillation.
Pin 1 of IC 2B is connected to the fixed reference potential and a constant current therefore flows into the non-inverting input. The inverting input of IC 2B is connected via R2 to the output of IC 2A (pin 4), so that it is driven by a temperature-dependent current. IC 2B amplifies the difference between its input currents to such an extent that the voltage variation at its output (pin 5) can easily be measured with a 5- to 10-volt f.s.d. voltmeter.
If a panel meter is used, Ohm's law will have to be invoked to calculate the series resistance. If a 100-μA f.s.d. instrument with an internal resistance of 1200 Ω is used, the total resistance for 10 V full-scale deflection must be

$$\frac{10\ \text{V}}{100\ \mu\text{A}} = 100\ \text{k}.$$

R5 should therefore be 100 k − 1k2 = 98k8. The nearest standard value (100 k) can be used.
Calibration proceeds as follows: the zero point is first set by P1 with the temperature sensor dipped in a cup of melting ice. Full-scale deflection can then be set with P2; for this the diode can be immersed in a hot liquid whose temperature is known (e.g. boiling water or water which has been checked with a reliable thermometer as being at 50°).

thermometer