Dual Channel Temperature Recorder

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A dual channel temperature recorder is described which can measure temperatures linearly over a range of 0 to 80 C. The sensitivity can be adjusted so that any temperature span, as small as 3°, will cover recorder full scale, and temperatures can be read to 0.1°. The recorder provides two independent, permanent records of temperature variations which can be related directly to the time of day.

Although different types of digital thermometers and temperature recorders are available commercially, the special experimental requirements of the microbiologist or biochemist may limit the choice of commercially available types. As an example, digital thermometers are extremely useful for very accurate and instantaneous measurements of temperature, but they do not always offer an analogue output voltage to operate a recorder. If an analogue output voltage is available, the span is usually so large that temperatures cannot be read to the desired degree of accuracy. Temperature recorders usually have fixed ranges with spans that are too large for accurate temperature readings. They usually do not have provisions for adjustable spans and provide only single-channel recordings. Some biological experiments require the recording of a broad temperature range but with the capability of examining narrow spans within that range. Narrow temperature spans are often very desirable to evaluate properly the sensitivity of a cell culture to temperature changes (J. C. Meinert, C. F. Ehret, and G. A. Anitpa, J. Microb. Ecol., in press).

We have designed and constructed a dual channel temperature recorder (Fig. 1). This instrument is designed to meet most of the needs of the biological experimenter. Design criteria included: the selection of the most desirable temperature range; provisions for narrow span adjustments within the total range to facilitate high-resolution readings; two independent recording channels that give simultaneous adjacent channel recordings for instant data comparison; a simple internal calibration feature to verify all span settings without the need of a water or ice bath; portability and minimum size; and reasonable cost.

Each channel of this instrument has been designed to operate linearly over two selectable temperature ranges from 0 to 40 C and 40 to 80 C. Other temperature ranges could be selected by using appropriate bridge resistors. The recorder span adjustment can be set so that any temperature span, as small as 3°, will cover recorder full scale on either range. Temperatures can then be read to within 0.1°.

It is possible to operate this device as a single-channel temperature recorder simply by eliminating one of the Wheatstone bridge circuits and its matching operational amplifier. However, the additional components required for a two-channel system amount to a total cost increase of only 35% over a single-channel instrument. It would appear that two recording channels are well worth the small additional cost.

MATERIALS AND METHODS

Figure 2 is a schematic diagram of the complete instrument. The Wheatstone bridge measuring circuits (1) is shown to the left. The upper half of the diagram relates to the right channel, and the lower half relates to the left channel. The calibration potentiometer is common to both channels through switch SW2. Both thermistors are in the measuring circuit when SW2 is in the operate position. If either calibrate right or calibrate left is selected, the operating probe will continue to monitor temperature variations while the alternate channel is being calibrated.

The output from the bridge circuit drives a model 741 operational amplifier (Fairchild Semiconductor, Mountain View, Calif.). Gain adjustments are made by the 10,000-ohm span control. Separate 1.5 V power supplies are required for each bridge circuit. A ±15 V power supply can operate both operational amplifiers.

The temperature probes are precision thermistors, model 44104 (Yellow Springs Instrument Co., Yellow Springs, Ohio). Each thermistor is supplied with a resistance versus temperature chart that covers a range of −80 to +150 C in 1° steps. Probes are randomly interchangeable since they match their published resistance versus temperature curve and each other to ±1%. They have a time constant of 2.5
s in a well-stirred water bath and 25 s in still air. Each thermistor is furnished with 3-inch (ca. 7-cm) bare leads that we have connected to an 8-foot (ca. 244-cm) cable. The splice is waterproofed with silicone rubber adhesive sealant (Stauffer-Walker, Adrian, Mich.) and shrinkable tubing. Longer leads may be used when necessary to gain access to remote areas. The sensitive tip area of the probe is sealed in glass, while the remaining body section is flexible and encased in a 2-inch (ca. 5-cm) length of chemically inert Teflon. The body of the probe can be formed to coincide with the contour of the surface area to be monitored.

The recorder is a model 291 dual channel direct current recorder (Rustrak Instrument Division, Manchester, N.H.). Each galvanometer suspension has a sensitivity of 0-1 mA. The basic recorder chart speed is 1 inch (2.54 cm)/h, and the chart paper Y axis is calibrated directly to the time of day. Under continuous operation of the recorder, the chart rolls will last for 31 days. Extra gear train drive units are available that can be easily interchanged to modify the chart speed.

RESULTS AND DISCUSSION

Instrument calibration can be accomplished very quickly by simply referring to the resistance versus temperature chart. Position the selector switch to the calibrate left position. Decide on an appropriate temperature range and set toggle switch SW1 to encompass this range. Dial the upper temperature resistance reading on the calibration potentiometer. (The calibration potentiometer dial is divided into 1,000 divisions and can be read directly from 0 to 10,000 ohms.) Adjust the span control for recorder full-scale deflection. Then dial the resistance reading for the lower temperature desired. Adjust the zero control for recorder zero deflection. Alternately adjust the span and zero...
**Fig. 2.** Schematic diagram of the electronic circuitry of the dual channel temperature recorder.
selector switch to the calibrate right position and repeat the calibration procedure. After this calibration of both channels, the selector switch must be returned to the operate position for normal operation.

Figure 3 is a typical temperature recording of an environmental chamber being maintained at 22°C. Each channel has a span of 20 to 25°C. The right channel recording indicates temperature excursions that occur with the thermistor probe exposed in free air. The left channel probe was immersed in a plastic tube containing 5 ml of a 25% sucrose solution located within 1 inch of the first probe. This record illustrates the capability to monitor accurately and to record temperature variations of a small fraction of a degree.

We have found numerous applications for this temperature recorder and have duplicated its construction for other laboratory experimenters. It has proven to be reliable, stable, accurate, and a very useful device for day to day laboratory temperature measurements.

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LITERATURE CITED

1. Giles, J. N. 1967. Applications, p. 135. In Fairchild Semiconductor linear integrated circuits applications handbook. Fairchild Semiconductor, Mountain View, Calif.