Note

A NEW TYPE OF TEMPERATURE SENSOR FOR DTA APPARATUS *

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The temperature dependence of resistance is frequently used for temperature measurements along with thermocouples. Thermal resistances are also used for temperature sensors in differential thermal analysis. Where a constant current flows through two thermal resistances, the difference in the voltage drop over the two resistances is a measure of the temperature difference of the two resistances. A four-point measurement is not taken because of the need for two further supply wires, which involve an additional loss of heat. The fact that the current through the two resistances is unequal if there is a temperature difference is not taken into account, which is an additional error in the measurement.

DESCRIPTION OF THE TEMPERATURE SENSOR

The experiments were carried out using four resistances in a Wheatstone bridge arrangement on the sample holder. Two resistances arranged crosswise form two temperature sensors (Fig. 1). The bridge is supplied with a constant current by two wires. Two additional supply wires are required for registering the temperature difference. Thus four wires are needed, the same as when using thermocouples or thermal resistances for measuring the dT signal. Each current in the two circuits of the bridge has the same value because the sum of two resistances of each circuit is equal.

$$R_{1,2} = R_1 + R_2 = R'_1 + R'_2 = R'_{1,2}$$

If both temperature sensors have the same temperature, the potential drops over R_1 and R_2 are equal, as are the potential drops over R'_1 and R'_2.
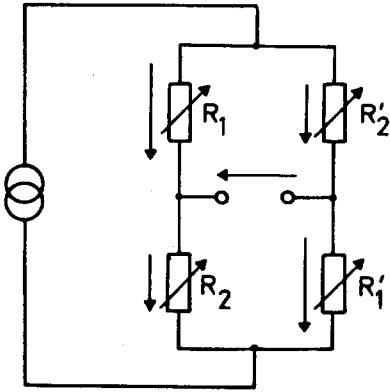
$$U_1 = U_2 = U'_1 = U'_2$$

The resulting bridge voltage drop is zero [Fig. 1(a)]. If sensor 1 undergoes a change in temperature while sensor 2 remains constant, the values of R_1 and R'_1 will also change.

$$dR_1 = dR_1 + dR'_1$$

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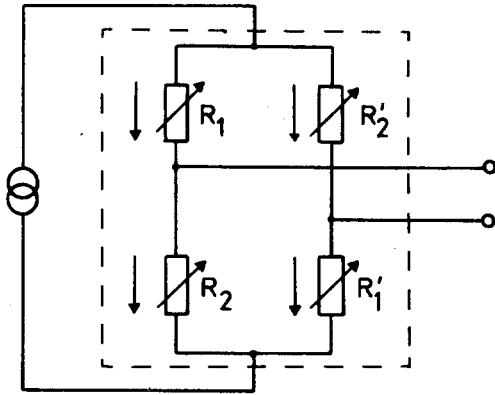
(a)

(b)

Fig. 1. (a) Wheatstone bridge arrangement. $U_1 = U_2 = U_3 = U_4$ indicated by the arrows. $dU = 0$. (b) The resistances arranged crosswise, are at different temperatures. The voltage drops of the paired resistances are not the same, which results in a dU not equal to zero.

Because the bridge is supplied with a constant current the potential drop over R_1 will change its value about

$$dU = 1/2[R_1 + R_1 \times \alpha(T + dT) - (R_1 + R_1 \times \alpha \times T)]$$

$$= R_1 \times \alpha \times dT$$

R_1' undergoes the same variation and the changing potential drop is also dU. The resulting bridge voltage drop is then $U_b = 2dU$ [Fig. 1(b)]. Figure 2 is a photograph of the temperature sensor showing the Wheatstone bridge circuit. In order to rectify small differences between the resistances, the bridge is equipped with a zero adjustment (Fig. 3).
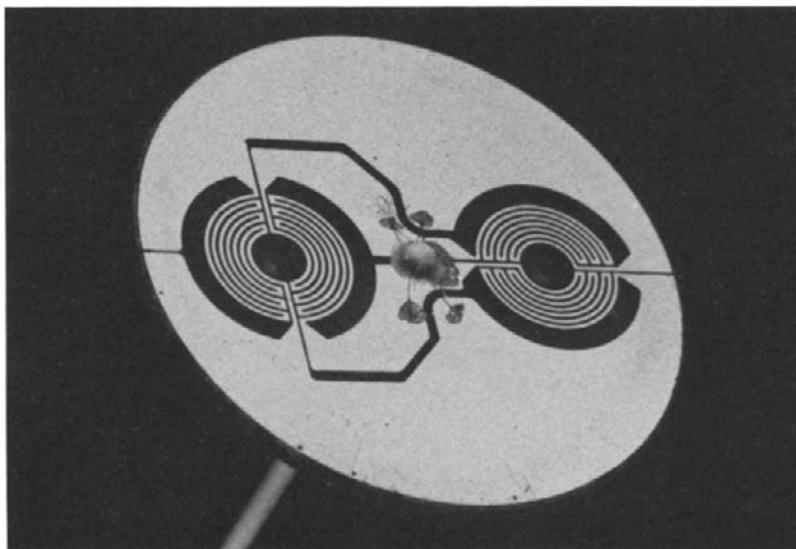
Fig. 2. Temperature sensor.

THE DTA CELL

The DTA cell consists of the furnace, sample chamber and two covers (Fig. 4). All parts are manufactured with refined silver because of its low specific heat capacity, good heat conduction, and chemical stability. The furnace is cup-shaped with a double helix groove in which the filament is embedded. The gas supply for measurement with a flowing gas stream is outlined under the aspect of a minimal influence of the thermal homogeneity. The warmed gas reaches the lower gas chamber through a silver pipe. The gas obtains the temperature of the furnace and flows through bore-holes in the upper gas chamber. Possible small temperature differences will be
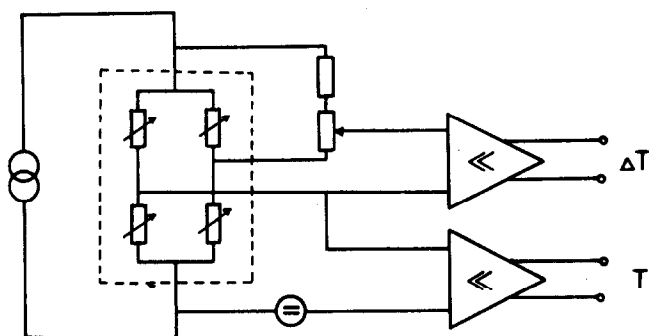

Fig. 3. Schematic construction of the electrical circuit. For zero trimming a potentiometer is switched parallel to the largest resistance. The thermal resistance and the potentiometer are in the ratio 1 : 10000. The two amplifiers have a high input resistance.
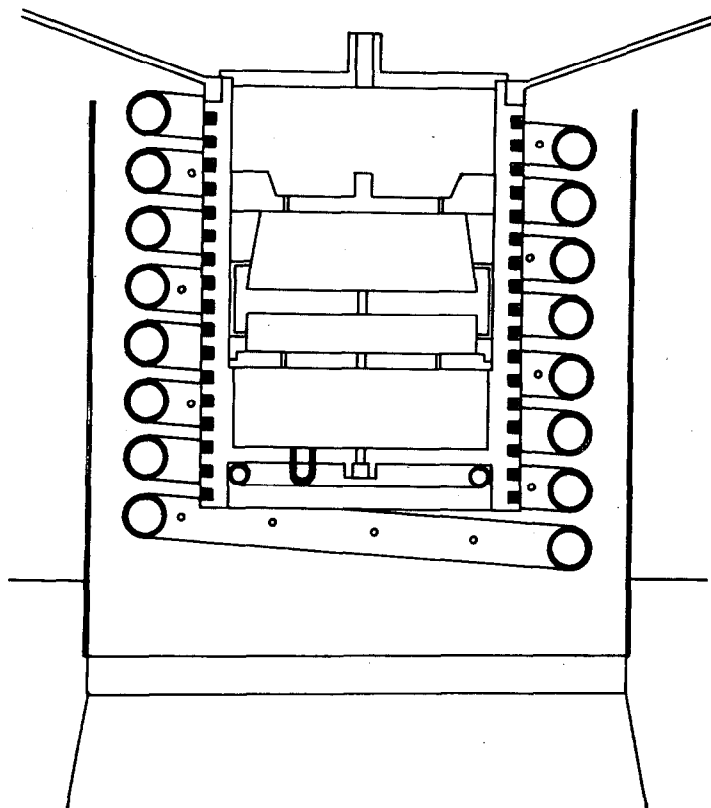
Fig. 4. Sectional drawing of the DTA cell.

balanced. The gas reaches the sample chamber through four channels. The sample holder is glued to the bottom of the sample chamber.

The DTA cell is equipped with two cooling systems. Using a ventilator, it is possible to cool down to 325 K with a rate of 5 K min^{-1}. Without the use of a ventilator, the final temperature with a constant cooling rate of 5 K min^{-1} remains at 375 K. For the temperature region below room temperature, another cooling system is outlined. Liquid nitrogen is vaporized in a Dewar flask. The cool gaseous nitrogen flows to a copper coil which surrounds the DTA cell and the gas will spread out through holes central to cell. With a cooling rate of 5 K min^{-1}, a temperature of 130 K is reached. The lowest temperature point commonly reached is 110 K.