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NOTE

An Algol Program for Calibrating Resistance Thermometers at Low Temperatures[1]

Carbon resistors are remarkably convenient for use as thermometers at low temperatures because, being semiconductors, their resistance varies approximately exponentially with inverse temperature resulting in an increase in sensitivity with decreasing temperature. Typically, one calibrates the device by measuring resistance at several known temperatures in the region of interest. In many experiments it is useful to have an analytic expression for temperature as a function of resistance so that the raw data can be analyzed by computer. This note describes a program which fits an equation to the calibration points.

In general, a simple exponential function cannot describe the data precisely over the entire temperature range [1]. It was found that the following equation described the resistance to better than 10^{-4} °K.

$$\frac{1}{T} = \sum_{i=-2}^{3} A_i[\log (R - L)]^i. \tag{1}$$

Here L is the lead resistance which cannot be measured directly since it changes independently from the thermometer between room temperature and the low temperatures of interest (L is constant at low temperatures).

The program is organized around a search procedure which minimizes a function, $F(L)$, which is convex down on some interval. The Fibonacci numbers [2] are used to generate changes in L; this allows L to be determined to 10^{-4} of the original interval in fewer than twenty calculations.

The function to be minimized is

$$F(L) = \left(\frac{1}{T_{\text{measured}}} - \frac{1}{T_{\text{calculated}}}\right) T^2_{\text{measured}}, \tag{2}$$

where the factor T^2 is present to prevent overweighting of the lowest temperature

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[2] Present address. Physics Department, Wesleyan University, Middletown, Connecticut 06457.

points. For each trial value of L, the A_i are fitted using a least-squares method. The program then selects the values of L and A_i which give the best fit.

Copies of this program and a write-up including flow diagrams are available from the author.

REFERENCES

1. J. R. CLEMENT AND E. H. QUINNELL, *Rev. Sci. Instr.* **23**, 213 (1952).
2. R. BELLMAN AND S. DREYFUS, "Applied Dynamic Programming." Princeton University Press, Princeton, New Jersey (1962).

B. BERTMAN

Physics Department, Duke University
Durham, North Carolina

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