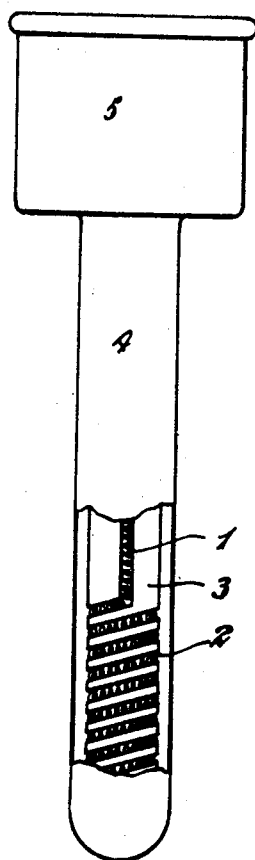


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OF RESISTANCE THERMOMETERS
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ELECTRIC RESISTANCE ELEMENT, MORE PARTICULARLY OF RESISTANCE THERMOMETERS

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2 Claims. (Cl. 201—63)

This invention relates to electric resistance elements, and more particularly to the resistance elements of resistance thermometers.

It is known that small amounts of impurities, of the order of one per cent or less, in a metal, for example, nickel or a nickel alloy, have a definite effect on the temperature-resistance characteristic of the metal. In practice, unless extreme precautions are taken in the manufacture of the metal, every new batch has a somewhat different temperature coefficient and it is therefore a matter of great difficulty to manufacture a resistance element that shall have a consistently uniform temperature resistance curve.

An object of the present invention is to provide a simple method of manufacturing resistance elements, more particularly for resistance thermometers, which shall have a consistently uniform temperature-resistance characteristic despite slight changes in the materials employed.

To this end the effect of small amounts of impurities on the temperature coefficient is utilized by forming the improved resistance element of two or more pieces of resistance material which are of essentially the same composition but differ as regards the amount of impurity present and hence differ as regards their temperature coefficients. Such pieces are connected in series and the resistance of each piece adjusted such that the element as a whole has the desired temperature-resistance characteristic. Thus a change in the degree of impurity present in either or both of the pieces of resistance material merely involves a modification in the resistance, in practice the length, of the pieces and the performance of the element may thereby be retained unimpaired at the desired value.

The adjustment of the resistance of the pieces of resistance material to effect this result will now be explained by the following theoretical analysis and example.

The variation of electrical resistance R with temperature t may be accurately represented for almost all metals by means of a parabolic function

$$R_t = R_0(1 + \alpha t + \beta t^2)$$

where α and β are constants and are known respectively as the first and second order temperature coefficients of resistance of the metal.

For an element consisting of two wires having different coefficients connected in series, the function $R_t = f(t)$ may be written

$$R_t = (R_1 + R_2) \left[1 + \left(\frac{R_1 \alpha_1 + R_2 \alpha_2}{R_1 + R_2} \right) t + \left(\frac{R_1 \beta_1 + R_2 \beta_2}{R_1 + R_2} \right) t^2 \right]$$

where R_1 , α_1 , and β_1 , and R_2 , α_2 and β_2 are the resistance at 0°C. , and first and second order coefficients of the two wires respectively.

The mean first order coefficient α_m for the element is clearly given by

$$\frac{R_1 \alpha_1 + R_2 \alpha_2}{R_1 + R_2}$$

and similarly the mean second order coefficient

β_m is

$$\left(\frac{R_1 \beta_1 + R_2 \beta_2}{R_1 + R_2} \right)$$

It may be remarked here that if the two wires were to have been connected in parallel the relation between resistance and temperature could no longer have been expressed by a parabolic function and it would not be possible to define a mean first or second order coefficient as above.

Over temperature ranges of about 100°C. it has been found that for some metals (e. g. nickel) slight variations in the impurities do not affect the value of the second order coefficient. Hence for elements working over this temperature range the problem of producing a desired temperature-resistance characteristic is reduced to an adjustment of the first order coefficient.

For example, suppose that it is desired to produce a resistance thermometer having a mean first order coefficient of 50×10^{-4} and a resistance of 100 ohms at 0°C. and that wires having first order coefficients of 53.0×10^{-4} and 45.0×10^{-4} are available. Let the element resistance at 0°C. be R_0 then $R_0 = R_1 + R_2$ and substituting for R_2 in the expression given above for the mean first order coefficient, we may write

$$R_1 = \left(\frac{\alpha_m - \alpha_2}{\alpha_1 - \alpha_2} \right) R_0$$

and similarly

$$R_2 = \left(\frac{\alpha_1 - \alpha_m}{\alpha_1 - \alpha_2} \right) R_0$$

or substituting the numerical values given

$$R_1 = 62.5 \text{ ohms and } R_2 = 37.5 \text{ ohms}$$

Hence by connecting in series the two wires each of such length that the first, having the coefficient of 53.0×10^{-4} , is of 62.5 ohms resistance and the second is of 37.5 ohms resistance, a resistance element having the desired properties may be obtained.

It will be clear from the above that similar results may be achieved by connecting three or more different wires in series for as has been shown above the composite or mean first and

second order coefficients, α_m and β_m , always remain as first and second order coefficients however many different wires are used, and hence the resulting temperature-resistance characteristic still remains parabolic.

It will also be clear that if it is desired to correct for variations in the second order coefficient as may occur when the element is to be used to cover a wide range of temperature similar methods may be employed.

It will be appreciated that by a careful adjustment of the resistance of the different wires forming the element, in accordance with this invention, it is possible to make a very fine and simple adjustment of the coefficient of the element. Moreover the coefficient of the manufactured element may be readily maintained at a fixed value despite variations in the quality of different batches of metal for it is only necessary to measure the coefficients of a new batch once and for all when the necessary modifications in resistance and hence the lengths of the wires to be used may be determined.

One method of mounting a resistance element constructed in accordance with this invention is illustrated by the accompanying drawing which shows a resistance thermometer in elevation, part thereof being cut away to show the internal arrangement. The resistance element is in the form of a helix 1 laid in grooves 2 formed in an insulating support 3. The grooves are in the form of a two start thread merging at the upper end with longitudinally arranged grooves leading to the head of the support. The support is protected by a sheath 4 which is provided at its upper end with an enlarged head 5 within which is accommodated sockets, connected with the wire helix, for the reception of a plug or other means of connection with indicating apparatus.

We claim:

1. The method of making a resistance element having a desired temperature-resistance char-

acteristic which consists in forming the element of two series-connected pieces of resistance material which are essentially of the same composition but differ somewhat as regards their first order temperature coefficients of resistance and in choosing the resistance of the said two pieces to satisfy the relation

$$\alpha_m = \frac{R_1\alpha_1 + R_2\alpha_2}{R_1 + R_2}$$

where α_m , α_1 and α_2 are respectively the desired temperature coefficient of the element, the coefficient of the said first piece and the coefficient of the said second piece and R_1 and R_2 are the resistances of the said first and said second pieces respectively.

2. A resistance element having a desired first order temperature coefficient of resistance comprising a first and a second piece of resistance material, connected together in series, the said first and second pieces being of substantially the same composition but differing somewhat as regards their first order temperature coefficients of resistance, the said first piece having a coefficient slightly higher than the said desired coefficient of the element and a resistance equal to

$$\left(\frac{\alpha_m - \alpha_2}{\alpha_1 - \alpha_2} \right) R_0$$

and the said second piece having a coefficient slightly lower than the said desired coefficient and a resistance equal to

$$\left(\frac{\alpha_1 - \alpha_m}{\alpha_1 - \alpha_2} \right) R_0$$

where α_m , α_1 and α_2 are respectively the desired coefficient, the coefficient of the said first piece and the coefficient of the said second piece and R_0 is the resistance of the element as a whole.

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