March 28, 1961 W. L. HAMPTON 2,977,558

THERMAL RESPONSIVE RESISTANCE DEVICES

Filed June 19, 1958

Fig. 1

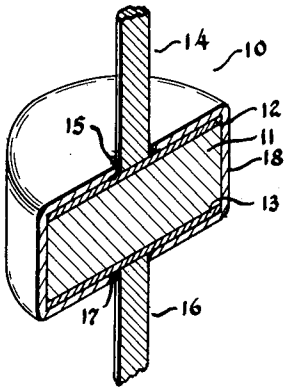


Fig. 4

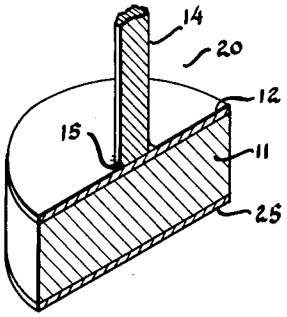


Fig. 6

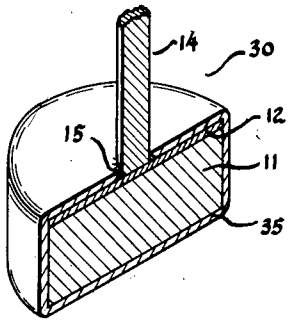


Fig. 2

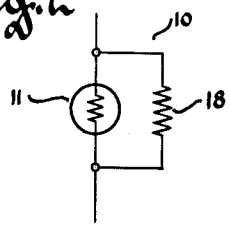


Fig. 5

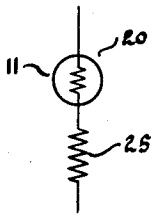
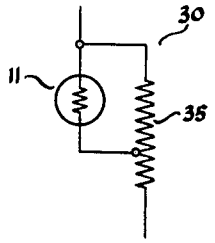


Fig. 7



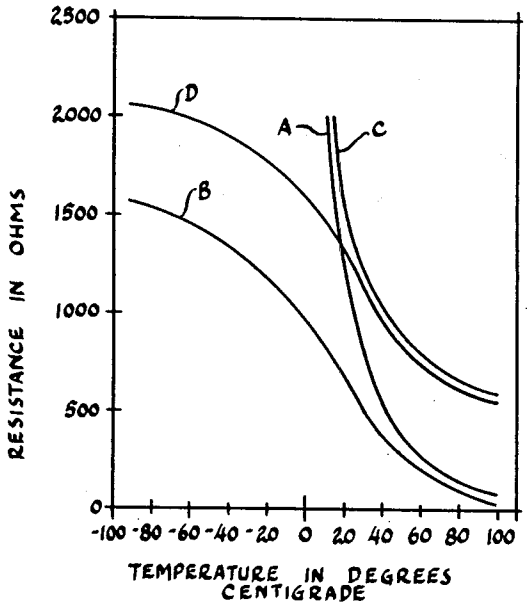


Fig. 3

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THERMAL RESPONSIVE RESISTANCE DEVICES

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4 Claims. (Cl. 338—22)

This invention relates generally to thermally responsive electrtical resistance devices. While not limited thereto, the invention relates particularly to thermally responsive electrical resistance devices comprising thermistors coated with electrically conductive resistance material.

Thermistors are generally considered to be thermally responsive electrical resistance elements formed of semiconductive materials, such as certain metallic oxides, which have a relatively high negative temperature coefficient of resistance, i.e., materials which exhibit a rapid and substantial increase in resistance to the flow of electrical current therethrough in response to a decrease in temperature. Resistors are frequently employed with thermistors for a number of reasons. Thus, a resistor might be placed in series or parallel with a thermistor to modify its electrical characteristics, or a heater resistor might be physically as well as electrically associated with a thermistor to maintain the latter heated when exposed to ambient temperatures which would otherwise tend to render the ltater non-conductive for all practical purposes. In any event, while it may be desirable to closely associate a thermistor and a resistor, spatial considerations in the device employing the thermistor may prevent it. Then, on the other hand, while close physical association of a resistor with a thermistor might be desirable for certain reasons, such an association might not be practical because of the tendency of the resistor and its connections to absorb heat from the thermistor and thus interfere with its proper operation. It is desirable, therefore, to provide improved thermally responsive electrical devices which overcome the aforementioned and other difficulties and which have other advantages.

Accordingly, it is an object of this invention to provide improved thermally responsive electrical resistance devices which comprise thermally responsive electrical resistance members to which there adheres a coating of electrically conductive material, said devices being adapted so that electrical current may flow through the said resistance members and the said conductive material.

Another object is to provide improved devices of the aforesaid character which have thermal-electric characteristics which differ from the thermal-electric characteristics of the constituent parts of the devices.

Still another object is to provide improved devices of the aforesaid character which are adapted upon the passage of electrical current therethrough to have the thermally responsive electrical resistance members heated by the coating of electrically conductive material.

A further and more specific object is to provide an improved thermally responsive electrical resistance device comprising a thermistor which is provided with an adhering coat of electrical resistance material, both the thermistor and the coating adapted to have electrical current flow therethrough.

A still further object is to provide improved devices of the aforesaid character which are extremely compact, thermally and electrically efficient, relatively simple and economical to manufacture, and which lend themselves to a wide variety of uses.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawing illustrates several preferred embodiments of the invention which will hereinafter be described, it being understood that the embodiments illustrated are susceptible of various modifications with respect to details thereof without departing from the scope of the appended claims.

In the drawing,

Figure 1 is a greatly enlarged isometric sectional view of one form of device incorporating the invention;

Fig. 2 is a diagrammatic showing of the electrical circuitry of the form of device shown in Fig. 1;

Fig. 3 is a graph showing the performance characteristics of the devices shown in Figs. 1, 4 and 6, and of certain constituent elements thereof;

Fig. 4 is a greatly enlarged isometric sectional view of a second form of device incorporating the invention;

Fig. 5 is a diagrammatic showing of the electrical circuitry of the form of device shown in Fig. 4;

Fig. 6 is a greatly enlarged isometric sectional view of a third form of device incorporating the invention; and

Fig. 7 is a diagrammatic showing of the electrical circuitry of the form of device shown in Fig. 6.

Referring to Fig. 1, the numeral **10** designates one form of thermally responsive resistance unit made in accordance with the invention. Unit **10** comprises a thermistor device **11** which preferably has the configuration of a circular wafer or disc. Preferably, the flat upper and lower surfaces of thermistor **11** are plated, coated or otherwise provided during manufacture with relatively thin layers or surfaces **12** and **13**, respectively, of electrically conductive metal such as silver which facilitates the attachment of electrical conductors to the thermistor. One end of an electrical conductor wire **14** is electrically and mechanically attachd to metal surface **12** by a solder joint **15** and one end of a similar wire **16** is similarly attached to metal surface **13** by a solder joint **17**. Conductor wires **14** and **16** adapt device **10** for connection to a suitable circuit. A coating **18** of electrically conductive resistance material is then applied by spraying, brushing, dipping, or other means, so as to cover the surfaces **12** and **13** and the exposed periphery of thermistor **11**. For purposes of illustration the thickness of coating **18** has been somewhat exaggerated. Preferably, coating **18** is a type of commercially available thermosetting or air-setting semiliquid plastic material in which electrically conductive resistance material is suspended. When coating **18** has dried or set, an electrically conductive coating of resistance material adheres to the surfaces to which it has been applied. That portion of coating **18** extending between metallic surfaces **12** and **13** forms an electrical resistance path which is in parallel with or shunts thermistor **11** as Fig. 2 makes clear. Such coating material is commercially available in various grades which have different degrees of conductivity. The quantity of material applied will, of course, have an affect on the value of the resistance in parallel with thermistor **11**.

Fig. 3 shows a graph wherein electrical resistance in ohms is plotted against temperature in degrees centigrade. It is to be understood that the values are selected merely to illustrate the relative performance of devices incorporating the invention. The curve A depicts the typical performance characteristic of a thermistor device such as **11** and shows that its resistance increases rapidly as a function of decrease in the tem-

perature thereof. The curve B depicts the performance characteristic of unit 10 when conductors 14 and 16 are connected to a suitable source of power and current flows through thermistor 11 and coating 18 in a parallel path. The characteristic of unit 10 differs from that of thermistor 11 for the reason that coating 18 is in parallel with the thermistor 11. Unit 10 retains much of the sensitivity of thermistor 11 within a desired range of ambient temperatures.

If preferred, coating 18 may be applied in bands or stripes which form electrical paths between surfaces 12 and 13 but which leave much of the peripheral surface area of the thermistor and the metallic surfaces 12 and 13 exposed.

In some installations the resistance value of coating 18 and its disposition on thermistor 11 is such that the passage of current through the coating will exert a heating effect on the thermistor, thus maintaining the thermistor conductive when exposed to ambient temperatures which would normally render the thermistor nonconductive for all practical purposes. As Fig. 1 shows, coating 18 completely encapsulates thermistor 11 in order to obtain the maximum heating effect. Because of the relative thinness of coating 18, however, the thermal sensitivity of thermistor 11 is not significantly affected; the coating absorbs little if any heat from the thermistor and does not tend to insulate it from the ambient changes.

It is apparent that unit 10 and the suggested modifications thereof are relatively compact, simply constructed, trouble free types of thermal responsive devices which may be put to many uses. Such devcies are especially useful in installations wherein a thermistor must be maintained heated (i.e., at very low ambient tempratures) and/or wherein space is at a premium and resistance must be placed in parallel with a thermistor.

Referring to Fig. 4, the numeral 20 designates a second form of thermally responsive resistance unit made in accordance with the invention. In the embodiment shown in Fig. 4, reference characters identical to those of Fig. 1 have been employed to designate like elements. Unit 20 comprises thermistor device 11 hereinbefore described which is provided with metallic surface 12 to which one end of conductor wire 14 is attached by solder joint 15. The bottom of thermistor 11 in unit 20 is not provided with a metallic surface but instead is provided with adhering coating 25 of resistance material such as that hereinbefore described. Coating 25 or some portion thereof is adapted to come in contact with a suitable conductor or some form of conductive surface (not shown). In unit 20 thermistor 11 and coating 25 are in series connection as Fig. 5 makes clear.

Referring again to Fig. 3, the curve C depicts the performance characteristic of unit 20 and shows that the total resistance of the device is greater than that of thermistor 11 when operated at the same temperature but that such difference is much greater at elevated temperatures.

Coating 25 cannot effect heating of thermistor 11 if unit 20 is first energized when thermistor 11 is at a low temperature that has rendered thermistor 11 nonconductive for all practical purposes. Coating 25 if properly selected can, however, exert a heating effect on thermistor 11 which will cause a change in rate in the increase in the resistance of unit 20 as the ambient temperature is lowered, provided unit 20 is energized before the temperature is lowered. It is apparent that unit 20 is a relatively compact resistance device having many of the advantages specified in connection with unit 10.

Referring to Fig. 6, the numeral 30 designates a third form of thermally responsive resistance unit made in accordance with the invention. In the embodiment shown in Fig. 6, reference characters identical to those of Figs. 1 and 4 have been employed to designate like elements. Unit 30 comprises thermistor 11 hereinbefore described which is provided with metallic surface 12 to which one end of conductor wire 14 is attached by solder joint 15. The bottom of thermistor 11 in unit 30 is not provided with a metallic layer but instead is provided with an adhering coating 35 of resistance material such as that hereinbefore described which also covers the periphery of the thermistor and portions of metallic layer 12. Coating 35 or some portion thereof (preferably the flat lower surface) is adapted to come in contact with a suitable conductor (not shown). In unit 30 thermistor 11 is in parallel with a first portion of coating 35 and the thermistor and the said first portion of the coating are in series with another portion of the coating, as Fig. 7 makes clear.

Referring again to Fig. 3, the curve D depicts the performance characteristic of unit 30 and shows that it combines, to come extent, the characteristics and advantages of the units 10 and 20 hereinbefore described.

It is apparent that in carrying out the invention thermistor devices having shapes other than that shown may be employed and various types of coatings could be applied in ways other than those shown to obtain desired results.

I claim:

1. In a temperature responsive electrical resistance unit, in combination, a thermistor having two spaced apart surfaces, said thermistor having a high negative temperature coefficient of resistance, electrically conductive material adhering to both spaced apart surfaces of said thermistor, said electrically conductive material adapted to have electrical conductors electrically connected thereto, and resistance material adhering to said thermistor and to said electrically conductive material and in electrical and mechanical connection therewith, said resistance material having a relatively low temperature coefficient of resistance as compared to that of said thermistor.

2. The combination according to claim 1 wherein said resistance material substantially encapsulates said thermistor and the electrically conductive material adhering to both of the said surfaces thereof to effect heating of said thermistor upon the passage of current through said resistance material.

3. In a temperature responsive electrical resistance unit, in combination, a thermistor having two spaced apart surfaces, said thermistor having a high negative temperature coefficient of resistance, electrically conductive material adhering to one of said spaced apart surfaces of said thermistor, said electrically conductive material adapted to have electrical conductors electrically connected thereto, and resistance material adhering to the other of said spaced apart surfaces of said thermistor, said resistance material adapted to have electrical conductors electrically connected thereto, said resistance material having a relatively low temperature coefficient of resistance as compared to that of said thermistor.

4. In a temperature responsive electrical resistance unit, in combination, a thermistor, said thermistor having a high negative temperature coefficient of resistance, electrically conductive material adhering to a portion of the surface of said thermistor, said electrically conductive material adapted to have electrical conductors electrically connected thereto and resistance material adhering to said thermistor and to said electrically conductive material and in electrical and mechanical connection therewith, said resistance material adapted to have electrical conductors electrically connected thereto, said resistance material having a relatively low temperature coefficient of resistance as compared to that of said thermistor.

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