

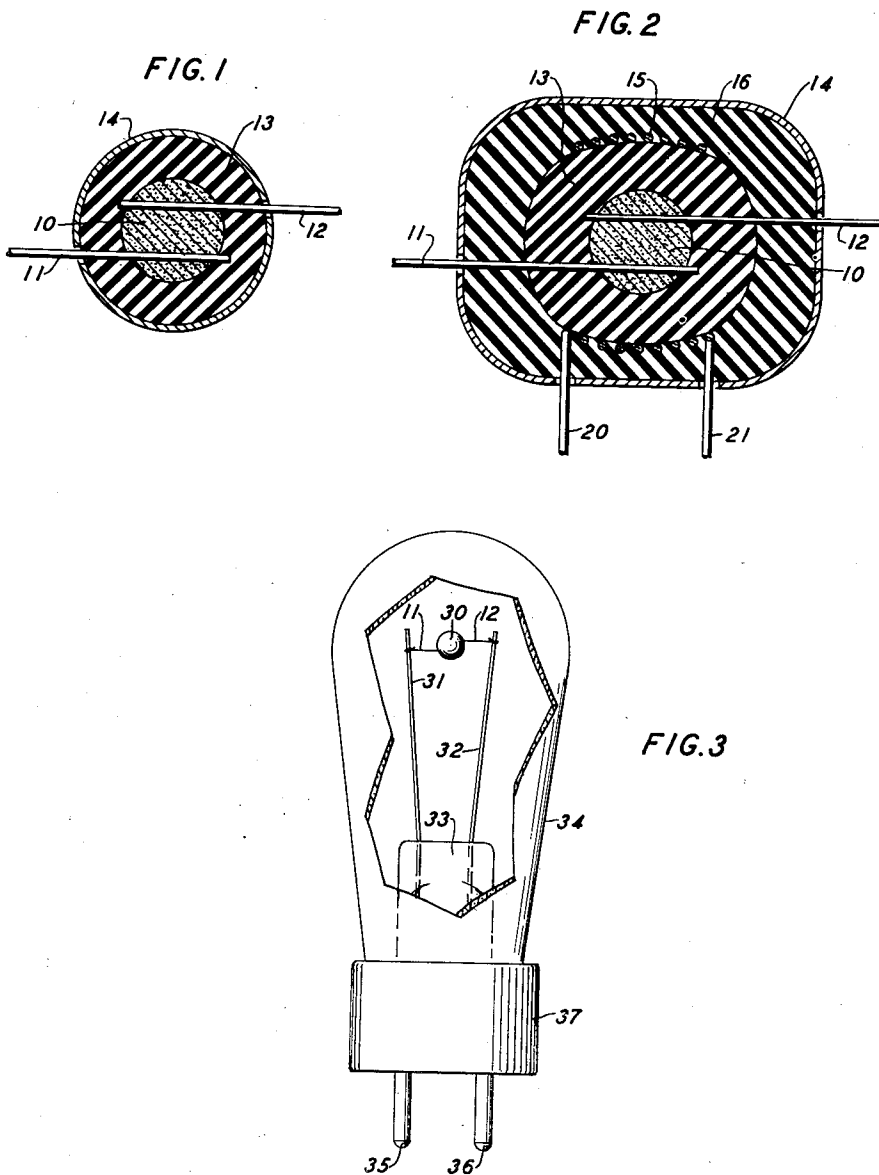
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G. L. PEARSON

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RESISTOR DEVICE

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INVENTOR
G. L. PEARSON
BY
Otto C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

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RESISTOR DEVICE

Gerald L. Pearson, Millington, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

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This invention relates to high resistance temperature coefficient resistors and more particularly to methods and means for controlling the thermal characteristics of such resistors.

A resistor having a relatively high temperature coefficient of resistance, which may, for convenience, be called a "thermistor," may in one of its simplest forms, comprise a small body or bead of suitable semiconductive material having a pair of conductive leads embedded therein. Such a device changes its resistance as a function of the temperature due to the heating effect of the current flowing therethrough and is known as a directly heated thermistor. The temperature of a thermistor may also be changed by means of a separate heater, usually electrical, associated with the semiconductive body. Such a thermistor is said to be indirectly heated. Due to heat losses, the power required to change the resistance of devices of the above-described type is relatively high. Furthermore, since these devices are relatively small, they have low thermal capacity, which in some cases allows an undesired modulation of the current controlled thereby.

An object therefore of this invention is to reduce the heat losses in thermistor devices.

Another object of this invention is to control the thermal capacity of thermistor devices while maintaining low heat loss characteristics therein.

One feature of this invention resides in reducing heat losses due to conduction by using for the lead wires, metallic alloys, which have a low heat conductivity without having an unreasonably high electrical resistance.

Another feature of the invention lies in providing, outside of the semiconductive element, a covering of material having low emissivity to reduce heat loss therefrom by radiation.

In accordance with a further feature of this invention the thermally sensitive resistor body is embedded in a mass of material that increases the thermal capacity of the device.

Other and further objects and features of the invention will be understood more fully and clearly from the following description of illustrative embodiments thereof taken in connection with the appended drawing in which:

Fig. 1 is a sectional view of a resistor device made in accordance with this invention;

Fig. 2 is a sectional view of another resistor device also made in accordance with this invention; and

Fig. 3 shows a resistor of the type involved in this invention, enclosed in an evacuated envelope.

In Fig. 1 is shown a directly heated thermistor.

This thermistor comprises a body 10 of resistance material, having a high temperature coefficient of resistance, with a pair of conductors 11 and 12 embedded therein to serve as electrodes and connecting leads. Surrounding the body 10 and in intimate thermal contact therewith is a mass 13 of insulating material, for example, glass. Around the insulating material 13 is a relatively thin layer or shield 14 of metal, covering the whole external surface of said insulating material, except for a very small portion immediately adjacent to each of the conductors 11 and 12. The thickness of layer 14, as illustrated, has been somewhat exaggerated in the interest of clarity. The material of layer 14 may be gold, silver, platinum, or some other metal that may be given a high polish and which has a low emissivity at the frequencies of interest. The mass 13 which acts as a thermal load may be varied in volume to obtain the desired thermal capacity.

An indirectly heated thermistor is shown in Fig. 2. It comprises a resistance body 10 having embedded conductors 11 and 12 and an insulating cover 13 similar to those of the device shown in Fig. 1. A heater coil 15 on the insulating material 13 is enclosed in a body 16 of insulating material molded therearound. A pair of heater leads 20 and 21 extend from the coil 15. A thin metallic layer or shield 14 like that of the Fig. 1 device covers the outside of body 16 except for small areas immediately adjacent to leads 10, 11, 20 and 21.

In Fig. 3 is shown a resistor unit 30 supported by means of its leads 11 and 12 on a pair of wires 31 and 32 which also serve as connecting leads. The unit 30 may be, for example, like the one shown in Fig. 1. The wires 31 and 32 are secured in the press 33 of an envelope 34. A pair of terminals 35 and 36 in an insulating base 37 are connected respectively to wires 31 and 32. The envelope should be evacuated to a pressure in the order of 10^{-5} millimeters of mercury.

By placing the thermistor devices in an envelope, evacuated as above indicated, the heat loss due to conduction or convection through the ambient atmosphere is substantially eliminated. However, as previously set forth there remain in thermistors as heretofore designed, conduction losses through the leads and radiation losses from the heated surfaces. There may be some other losses including a radiation loss from the leads, but the above-noted losses are relatively high compared to the others.

To greatly minimize the conduction loss through the leads a material having low thermal

conductivity coupled with a suitable electrical resistivity is employed. The leads to the resistor body, e. g. leads 11 and 12, must have a relatively high electrical conductivity and the heater coil and leads, e. g. 15, 20 and 21, a relatively high resistance.

As a general proposition the thermal and electrical conductivities of materials go hand in hand. That is, a material of high thermal conductivity has high electrical conductivity and vice versa. Thus the heater winding and leads of indirectly heated thermistors, which have a high electrical resistance, also have a reasonably low thermal conductivity. On the other hand, the leads to the body of high resistance-temperature coefficient material are required to have a relatively high electrical conductivity, which tends to give them also a high thermal conductivity, which makes for high heat losses by conduction therethrough.

It has been proven theoretically that for pure metals there is a constant relation between thermal conductivity and electrical resistivity. This relation, which is known as the Wiedemann-Franz ratio, may be expressed as $K\rho/T$ where K is thermal conductivity in watt centimeter degree centigrade, ρ is the electrical resistivity in ohm centimeters and T is temperature in degrees absolute. For pure metals this ratio is close to the theoretical constant 2.23×10^{-8} watt ohm centimeter degrees. However, for some alloys the value is either high or low. Since the thermal conductivity for many alloys is low, an alloy having an abnormally low Wiedemann-Franz ratio is particularly suitable for leads to the resistor body and one having an abnormally high ratio for heater coils and leads.

In thermistors of the type illustrated, having leads embedded in the body of resistance material, the leads have been made of a metal that would maintain its characteristics at relatively high temperatures. For example, thermistors comprising various combinations of metal oxides are heat treated at temperatures between 800° and 1450° C. The leads, therefore, must be able to stand such temperatures without oxidizing or otherwise deteriorating. One material which has been used for such leads is platinum.

It has been found in accordance with this invention that alloys of platinum, palladium, iridium, rhodium, ruthenium and osmium are particularly suitable for thermistor leads. From the viewpoint of economy an alloy of the less expensive platinum or palladium with a smaller amount of one of the other metals is desirable. Alloys of platinum and iridium or platinum and rhodium have been found to be particularly suitable, taking into consideration both the performance and the economic factors. The electrical resistivity of these alloys is higher than that of many of the pure metals; but the thermal conductivity is much lower. For example, in a platinum-iridium alloy, the Wiedemann-Franz ratio is progressively reduced below that for pure platinum by additions of from approximately 12 to 30 per cent iridium. Similar results are obtainable by adding rhodium to platinum or by the combination of others of the metals above noted. The thermal conductivity of platinum may also be reduced by adding thereto small amounts of copper or iron. If the added copper or iron is in the order of 2 per cent, the alloy will not oxidize at the heat-treating temperatures.

Loss of heat from a thermistor device by radiation may be greatly reduced by placing a layer or shield of material having low emissivity, out-

side of the device. Metals capable of sustaining a high polish are particularly suitable. Since such materials have relatively high electrical conductivities, provision must be made to prevent short-circuiting of the resistance body. The radiation inhibiting layer or shield may be placed over the insulation that encloses the resistor body, as illustrated in Fig. 1 or outside of the insulating layer covering the heater coil as in Fig. 2. In either case care must be taken to insulate the leads from the metallic covering to avoid short-circuiting of the resistor body and heater. This may be done in various ways.

The metallic layer may be applied by chemical deposition while a very small area immediately adjacent the lead is masked. The masking may be done, for example, by means of a small piece of rubber having a slit or perforation to accommodate the lead. This mask is pressed tightly against the resistor body during the deposition process.

Another way of applying the metal layer is by means of the so-called "bright" solutions. One of these solutions, e. g. gold bright, which comprises gold chloride, oil of rosemary and oil of lavender, is applied to the surface of the device to be coated. The device is then heated sufficiently i. e. to about 800° C., to change the material to the metallic state. Such a metallic coating may be applied without masking, which short-circuits the leads. The short circuit may be removed by applying a discharge from a condenser or other high frequency discharge apparatus across the leads for a short time. This action effectively insulates the leads from the metallic coating. The appearance of the metallic layer is not changed by the treatment in so far as can be ascertained by inspection with the naked eye. For the sake of clarity of illustration in Figs. 1 and 2, small areas around the leads have been shown as free from the metallic coating.

Since thermistors of the type herein disclosed are usually operated at temperatures below 400° C., the wave-lengths of radiant energy involved are from 1 to 100 microns. For the wave-lengths in question, metals are poor radiators and insulators or semiconductive materials are relatively good radiators. It is thus seen that the addition of a metal layer greatly cuts down the energy loss by radiation.

The emissivity of many metals, particularly those that take a high polish, is in the order of one-tenth or less than that of a black body. For example, platinum or gold radiates about .05 as much, and silver .02 as much as a black body, while glass radiates 0.8 as well as a black body at thermistor operating temperatures. Gold and platinum are particularly useful since they resist any tendency to tarnish. A surface, which when bright, has an emissivity of less than 0.1 may go up to 0.2 when tarnished. Hence materials that will retain a bright surface under operating conditions are preferable to those which tarnish.

As may be seen from the foregoing, the features of this invention aid materially in controlling the thermal characteristics of thermistor devices. Since each of the heat loss inhibiting features tends to raise the temperature of the device for a given power input and the resistance is a function of temperature, a given resistance variation may be attained with less expenditure of power than heretofore. Loading of the thermistor body with additional material to increase

its thermal capacity also increases its superficial area and thus its emission. However, such loading can be done without unduly increasing the radiation loss because the radiation inhibiting covering more than compensates for the increased loss.

Although specific exemplary embodiments of the invention have been disclosed in the foregoing detailed description thereof, it is to be understood that the scope of said invention is not limited thereby but by the appended claims only.

What is claimed is:

1. A resistance device comprising a small body of high resistance-temperature coefficient material having metallic connecting leads secured thereto, said leads composed of an alloy having a Wiedemann-Franz ratio lower than that for pure metals, a thermal loading mass of insulating material surrounding and in intimate contact with the surface of said body and embedding a portion of said leads, and a layer of bright metal adhering to the entire surface of said mass ex-

cept for small areas immediately adjacent said leads, said layer having an exterior surface that radiates one-tenth as well as a black body.

2. A resistance device comprising a small body of high resistance-temperature coefficient material, spaced leads of 70 per cent platinum and 30 per cent iridium alloy, embedded in said body, a layer of glass embedding said body and a thin film of bright gold on said layer but insulated from said leads.

3. A resistor device comprising a small body of a material the resistance of which is highly sensitive to temperature, a mass of insulating material surrounding and in intimate contact with said body, a layer of metallic material having a bright surface surrounding said mass and electrical connections to said body, said connections being made of an alloy composed of platinum and one of the metals from the group consisting of iridium and rhodium.

GERALD L. PEARSON.