

[54] **METHOD OF MANUFACTURING
THERMISTOR**

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[52] U.S. Cl. **29/612, 29/613, 29/619**

[51] Int. Cl. **H01c 7/04**

[58] Field of Search 29/612, 613, 619, 621;
338/22, 23

[56] **References Cited**

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[57] **ABSTRACT**

The disclosure is directed to thermistors for temperature measurement and method of making the same, wherein the yield in the manufacture is very high and the choice of the products can be made in the midway of the manufacture so that small-sized thermistors having little change in the resistance for the long use can be obtained inexpensively, said thermistors being usable at a high temperature. The method includes the steps of forming a disc-shaped thermistor body, coating a heat resisting conductive material on both sides of the body to provide electrodes, connecting metallic leads to the electrodes, disposing the resultant body in a glass member, and heating the glass member to embed the resultant body in the glass while simultaneously firing the heat resisting conductive material.

2 Claims, 2 Drawing Figures

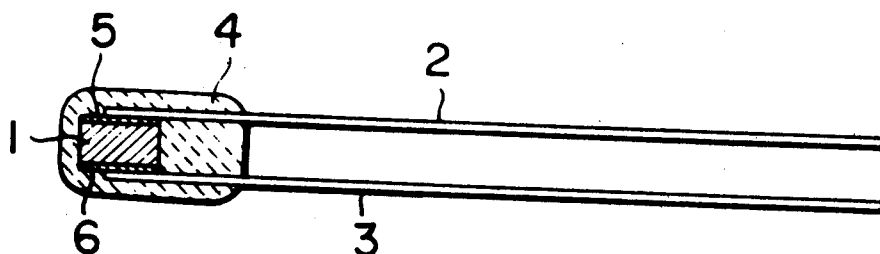


FIG. 1

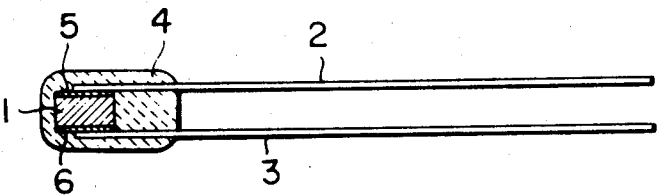
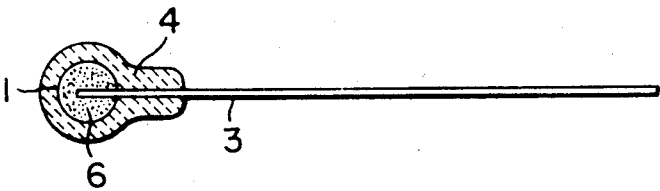


FIG. 2



METHOD OF MANUFACTURING THERMISTOR

This is a division, of Ser. No. 325,655, filed Jan. 22, 1973.

This invention relates to thermistors for temperature measurement and method of manufacturing the same.

In accordance with the invention there is provided a thermistor for temperature measurement, which is superior in mass productivity, and capable of being manufactured inexpensively and with high yield and stability used up to a high temperature.

Thermistors for temperature measurement are usually manufactured by sintering powdery metal oxide such as manganese oxide, nickel oxide and cobalt oxide, and can be classified into two types, namely bead type and disc type. The bead type thermistor comprises two parallel thin platinum wires and a body formed by applying a slurried mass obtained by mixing the above mentioned powdery metal oxide with water, between the two parallel thin platinum wires, oscillating the mass to render it into a spherical form, drying it and sintering it at a temperature of one thousand and several hundred degrees. The resistance value is selected by cutting one of the two parallel platinum wires. The other wire ends are welded to lead lines such as Dumet wires, and the resultant system is sealed with fused glass. This type of thermistor is stable for use at a high temperature since it is sealed with glass. However, its manufacture is quite complicated, and the mass productivity is inferior. Therefore, it is difficult to obtain thermistors of uniform characteristics, which leads to low yield and high manufacturing cost. The disc type thermistor, on the other hand, comprises electrodes formed by applying a conductive coating material directly to the opposite sides of a disc-shaped body which is made by pressure-molding metal oxide powder and sintering it, and suitable lead wires being attached to the above electrode with solder and covered thereon with an insulating coating material such as lacquer or enamel. With this type of thermistor, which is produced by pressure molding, the mass productivity is superior, and it is possible to obtain comparatively uniform characteristic, leading to high yield and low manufacturing cost. However, as the connection between the lead wires and the electrodes is soldered and covered with the coating material, this type of thermistor cannot be used at temperatures above about 150° C. Also, it lacks in stability, and its resistance is prone to great change during long use.

An object of the invention is to provide a thermistor for temperature measurement and a method of making the same, which eliminates the above mentioned drawbacks while retaining only the merits of the prior-art thermistors, the thermistor of which being reduced in size.

The present invention shall be further explained in the following.

The resistance R (ohms) of the thermistor at temperature T (degrees in Kelvin) is given as

$$R = R_0 \exp \{ B(1/T - 1/T_0) \}$$

where R_0 is the thermistor resistance at temperature T_0 and B is a constant depending upon the material of the thermistor. It is very important that the individual thermistors be less subject to changes of the resistance R_0 and that constant B be made small so that the therm-

istor is provided with a stable characteristic. Also, it is important that the deviations of the design values of resistance R_0 and factor B are small. In case of manufacture of small-size thermistors for temperature measurement the labor expense is extremely high compared to the material cost. Therefore, in order to obtain thermistors inexpensively it is necessary to reduce the number of manufacturing steps and increase the output. Besides, while it is apparent that with constant resistivity the resistance R_0 depends upon the shape and dimensions, with fluctuations of pressure when molding the material and variations of the sintered molding shape due to moisture content, it is difficult to have uniform resistance R_0 .

In accordance with the invention a large plate-like body is produced by molding and sintering, and it is then precisely finished by polishing or like means into a predetermined thickness. Then, pellet-like bodies of the eventual thermistor are cut from this plate-like body of the supersonic cutting technique. Therefore, it is possible to efficiently and inexpensively manufacture thermistors having uniform characteristics with high volume. Also, as the electrodes can be formed by applying a heat-resistant conducting coating material to the opposite sides of the plate-like body before cutting the plate-like body into pellets, it is possible to obtain more uniform coating of the electrode material and extremely increased production efficiency. Further, it is readily possible to produce extremely small disc-like thermistor bodies with a diameter of about 0.5 mm, which has heretofore been impossible. By way of example, according to the invention it is possible to cut 331 pellets with a diameter of 1mm from a large disc body with a diameter of 30 mm within 1 minute.

The prior-art disc type thermistors, in which the lead wires are soldered to the electrodes, are not stable for use in concealment with glass at high temperature. In accordance with the invention, the lead wires are connected to the electrodes for firing with a heat-resisting conductive coating material. This connection is so sound that even if, for example, a platinum wire having a diameter of 8/100 mm is connected to the thermistor electrode and pulled, only the wire will be broken, but no damage will be caused in the connecting part. Further, according to the present invention a metallic wire such as platinum wire or Dumet wire which is capable of sealing air-tightly in the glass is used as the lead wire so that complicated process for further connecting other lead wires may be eliminated. With the above mentioned structure the thermistor body can be airtightly sealed in fused glass. Thus, it is possible to obtain an extremely stable thermistor capable of being used up to a very high temperature.

If the lead wires such as Dumet wires are connected to the electrode with the conductive coating material and then fired in an atmosphere containing oxygen, for example, in air, the surface of the electrode will be considerably oxidized. Therefore, when such an electrode assembly with its oxidized surface is sealed in the fused glass, the thermistor body will be contaminated with the powder of the oxidation film peeled from the electrode surface, or it will be so imperfectly sealed as to impair the air-tightness. In order to avoid the undesirable oxidation, the firing is effected in an inert gas or reducing gas atmosphere. In this case, however, the thermistor is liable to be denatured so that the change in its resistance may be increased over long use. Fur-

ther, the use of the lead wire free from oxidation such as platinum wire would increase the manufacturing cost and the removal of the oxidized film by a chemical treatment would impair the thermistor body due to attachment of a chemical liquid to the body.

In accordance with the invention, the problem of oxidation is solved by simultaneously carrying out the step of fixing the lead wire with the conductive coating material and the step of sealing thermistor body within the fused glass. The conductive coating material is composed of a metallic or organic component and an inorganic component such as glass. The organic component is mostly evaporated at the time of drying, and is almost completely expelled through evaporation and oxidation before it is treated at the firing temperature. Also, the inorganic component is not evaporated before and at the time of firing. Thus, by simultaneously carrying out firing and sealing, the thermistor characteristics will not be affected by these steps at all, and it is possible to improve production efficiency.

In one embodiment of the method according to the invention, oxides of manganese, nickel, cobalt, etc. are mixed in a desired mixing ratio and pulverized, and the resultant powdery material is pressure molded to obtain a disc-like molding of several ten millimeters in diameter and about 1 millimeter in thickness. The molding is then sintered at a temperature of one thousand and several hundred degrees. Then, the opposite sides of the sintered molding are lapped with a parallel lapping machine into a predetermined thickness of, for instance, 0.5 mm. Then, (a material composed chiefly of gold or gold and platinum such as Item No. 8115 or 7553 of Du Pont Nemours, E. I. & Company) is applied to the opposite sides of the disc and fired at a temperature of 900° to 1,000° C to form the electrode. The resultant disc, is then bonded to a glass plate or the like by an adhesive, and then several hundreds of pellets with a diameter of, for instance, 1 mm are simultaneously stamped from the disc by a ultrasonic wave means. Thus, the disc-shaped thermistor bodies of small-size provided on their opposite sides with the electrodes are formed. The thermistor bodies thus formed are subjected to inspection to choose ones of excellent quality. The chosen thermistor body, to which the lead wires such as Dumet wires or platinum wires are connected with the above mentioned conductive coating material, is dried at a temperature of above 100° C. Thereafter, the thermistor body is disposed in a short tube of soda glass, having a thermal expansion coefficient which exerts no bad influence on the thermistor body, and then heated through a tunnel kiln at about 800° C so as to fuse the glass tube, thereby simultaneously carrying out sealing of the thermistor body and firing of the conductive coating material to which the lead wires are attached.

The thermistor body as above mentioned can alternatively be formed by directly pressure molding the pellets having the desired diameter and thickness, sintering them, coating both their surfaces with the conductive coating material and firing them. This firing may be effected simultaneously with firing of the lead wires at the time of fusing the glass. It may further be effected by heating the thermistor body at 900° to 1,000° C in an atmosphere of an inert gas or the like after connecting the lead wires to the electrode with the conductive coating material and then sealing the thermistor body in the glass. In this case, however, there sometimes re-

sults the above mentioned impairment to the properties of the thermistor body. As an alternative for sealing the thermistor body in the fused glass, the body may be coated with glass powder and then heated.

Now, the present invention shall be described with reference to the accompany drawings, in which,

FIG. 1 is a vertical sectional view of a thermistor according to the invention; and

FIG. 2 is a lateral sectional view of the embodiment shown in FIG. 1.

Electrodes 5 and 6 are formed by firing a heat-resisting conductive coating material to fix it to the both surfaces of a disc-shaped thermistor body, having a diameter of less than 1 mm. Lead wires 2 and 3 such as Dumet wires or platinum wires which are capable of air-tightly sealing with glass are connected at their base portions to the electrodes 5 and 6 by firing the heat-resisting conductive coating material. The thermistor body 1, electrodes 5 and 6 and base portions of the lead wires 2 and 3 thus assembled are embedded in a glass body 4.

The thermistor made by the invention is so high in the production in the manufacturing process that the production can be improved five times as much as the connectional bead type thermistors which provided merely about 10 percent yield. In addition to the above, the conventional bead-type thermistors can not make choice of the products in the mid-way of the manufacturing process, whereas according to the present invention the thermistors can be screened in the process of forming the thermistor body. In this screened state wherein the inferior ones were removed the yield can further be improved to be more than ten times. Further, while it has heretofore been impossible to manufacture disc-type thermistors with a diameter of less than 2 mm, whereas according to the invention it is readily possible to obtain thermistors with a diameter of about 0.5 mm. Furthermore, while the yield in case of the prior-art disc-type thermistors with a diameter of 2 mm has been about 50 percent, according to the invention it is readily possible to achieve a yield above 90 percent for thermistors with a diameter of 2 mm. Still further, experimental results regarding the resistance change during long use at working temperatures of 100°, 200° and 300° C are respectively lower than 0.1 percent, 0.2 percent and 0.3 percent, the values of which are substantially the same as those of the prior-art bead type thermistors. Thus, according to the invention the manufacturing efficiency can considerably be improved, and the thermistors which can be mass-produced at lower cost can be obtained. Besides, since the thermistor is embedded and sealed in the glass, it is very stable and can be used up to a very high temperature.

What is claimed is:

1. A method of making thermistor for temperature measurement comprising the steps of forming a disc-shaped body after molding and sintering powdery material, coating a heat-resisting conductive coating material on the both sides of said disc-shaped body to provide electrodes, connecting metallic lead wires capable of being sealed with glass to said electrodes with the heat-resisting conductive coating material, disposing the resultant body in a glass member and heating said glass member to fuse it so as to embed said body in the glass, while simultaneously firing the heat-resisting con-

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ductive coating material to which said lead wires are attached.

2. A method of making thermistor for temperature measurement according to claim 1, wherein said glass

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member is heated and fused through a tunnel kiln at a temperature suitable for fusing the glass used and firing the heat-resisting conductive coating material.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,820,239 Dated June 28, 1974

Inventor(s) Yasushi NAGATA

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Heading of the patent, insert --

[30] Foreign Application Priority Data

May 2, 1972 Japan.....43274/47 --.

Signed and Sealed this

twenty-third Day of March 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks