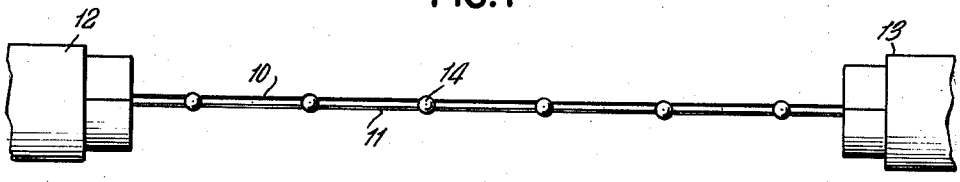
Nov. 12, 1963 M. SAPOFF ET AL 3,110,875

BEAD TYPE THERMISTOR AND METHOD

Filed May 18, 1961

FIG. 1



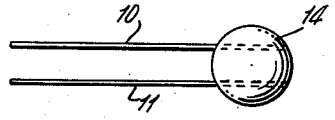


FIG. 2

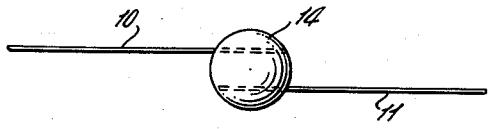


FIG. 3

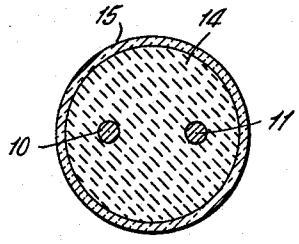


FIG. 4

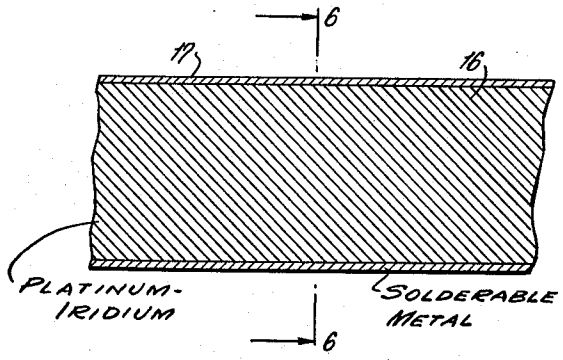


FIG. 5

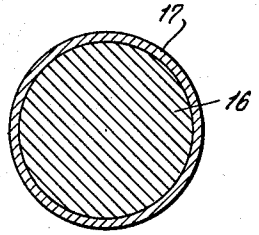


FIG. 6

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United States Patent Office 3,110,875 Patented Nov. 12, 1963

3,110,875

BEAD TYPE THERMISTOR AND METHOD

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Filed May 18, 1961, Ser. No. 110,978
1 Claim. (Cl. 338—22)

This invention relates to thermistors and methods of manufacturing them. The invention has particular reference to the method of manufacturing thermistors having a pair of conductors each of which includes a core of an alloy of platinum-iridium and a covering on the core which can easily be soldered to other conductors.

During the manufacture of thermistors it is necessary to raise the temperature of the thermistor bead and its two conductors to at least one thousand degrees centigrade and maintain this temperature for a short time interval while the bead is being sintered. The beads are then heated again from 700°–900° centigrade for glazing purposes. These high temperatures cause the iridium in the wire conductors to be oxidized and thereafter to resist soldering to other conductors. No efficient flux is known which can be used for soldering oxidized iridium. It is the purpose of this invention to coat the wire conductors with a thin covering of a solderable metal so that the conductors may be joined to other circuits.

An object of the present invention is to provide an improved thermistor which avoids one or more of the disadvantages and limitations of prior art thermistors.

Another object of the present invention is to provide a pair of thermistor conductors which can withstand temperatures of fifteen hundred degrees centigrade during a sintering operation and be capable of soldering to an external circuit when the thermistor is finished.

A further object of the present invention is to simplify the construction of thermistors.

Another object of the present invention is to increase the usefulness of thermistors as circuit components.

The invention comprises a thermistor comprising a bead of powdered calcined metal oxides held together by a binder. A covering of glass surrounds the bead and two conductors are embedded in the bead for connection to an operating circuit. The conductors each include a core of an alloy of platinum and iridium and a covering on the core of a solderable metal. The solderable metal is taken from the group consisting of nickel, tin, copper, gold, iron and cadmium.

In the accompanying drawings, forming a part hereof illustrated one form of embodiment of the invention, in which drawings similar reference characters designate corresponding parts, and in which:

FIGURE 1 is a plan view illustrating how the thermistors are first assembled.

FIGURE 2 is a view of a finished thermistor including two conductors parallel to each other protruding from one side of the thermistor bead.

FIGURE 3 is a view showing a thermistor with the conductors protruding from opposite sides of the thermistor bead.

FIGURE 4 is a cross-sectional view of a thermistor bead showing the glass covering.

FIGURE 5 is a cross-sectional view greatly enlarged of one of the conductors used with the bead and shows a covering of a solderable metal.

FIGURE 6 is a cross sectional view of the conductor shown in FIGURE 5 and is taken along line **6—6** of that figure.

Referring to the drawings, two wires **10** and **11** are stretched between two end clamps **12** and **13**. The wires may be very fine and in most cases have a diameter which is less than 0.005 of an inch. In order for such fine

wires to withstand a moderate degree of stretching they are generally made of an alloy of platinum and iridium, the iridium accounting for considerable strength.

A plurality of beads **14** are placed on the wires in spaced relation. The application may be made by manual means or by the use of a mold. When applied, the beads consist of a slurry of ceramic-like material, such as calcined metallic oxide mixed with a suitable binder. When the beads are quite small they assume the geometric form which approximates a spheroid and completely inclose both wires **10** and **11**. The beads are allowed to dry and then the entire assembly is placed in a furnace and sintered at a temperature which may range from 1000 to 1500 degrees centigrade. The wires are then cut so that each bead is separated from the other beads and contains two conductors which may protrude from one side of the bead adjacent to each other. Alternately, the conductors may protrude from opposite sides of the bead. The beads are now hermetically sealed in a glass covering. This seal may be applied by the application of a slurry of powdered glass with or without a binder and then heated at a temperature which may range from 700 to 900 degrees centigrade. The result is a glass covering which may vary in thickness from .001 to .029 inch.

The application of two cycles to the thermistor always oxidizes the iridium in the conductors and this produces an oxide layer which is non-wettable by commercial solders and prevents the application of solder to the wires, even using fluxes which are generally recommended for stainless steel and other hard-to-solder metals. The rate of oxidation in the 700° to 900° range is particularly rapid.

In order to make the thermistor conductors solderable a coating of metal is next applied to the conductor surfaces. The metal may be nickel, tin, copper, gold, iron or cadmium. The metal covering may be deposited by means of several well-known processes such as electroplating, electrodeless plating or vacuum evaporation. When an electro-plating process is employed, a solution is used as the electrolyte and after the plating is finished it is then necessary to rinse the wires and the bead in a neutralizing solution before the thermistor is suitable for use.

When the conductor film is deposited by vacuum evaporation it is necessary to first mask the bead by means of an insulating coating on the bead. This coating may be Fluoron, varnish, vinyl or any similar insulating medium. In many cases when the metal film consists of copper, an additional coating of tin may be applied to reduce the oxidation of the copper.

The covering process for placing a solderable metal on the conductors may be done before or after the beads are separated from each other. FIGURE 2 shows a common form of bead with conductors **10**, **11**, protruding from one side. For some applications the conductors **10** and **11** are cut so that the remaining wires protrude from opposite sides of the bead as shown in FIGURE 3. The plating process is, of course, independent of the arrangement of conductors or their length.

The cross section of the bead **14** is shown in FIGURE 4. In this view the relative positions of the bead material **14**, the glass covering **15**, and the two conductors **10** and **11** are indicated. The cross-sectional view shown in FIGURE 5 shows one of the conductors with a platinum iridium core **16** and a surface covering of solderable metal **17**. A cross-section of this wire taken along line **6—6** is shown in FIGURE 6.

Having thus fully described the invention, what is claimed as new and desired to be secured by Letters Patent of the United States, is:

A thermistor comprising a quantity of material which includes powdered metal oxides held together by a binder,

said quantity formed into a unitary mass, a covering of glass on said mass for protecting the oxides, and conductors embedded in the bead for connection to an external circuit, said conductors each including a core of an alloy of platinum and iridium with a covering of solderable metal taken from the group consisting of nickel, tin, copper, gold, iron and cadmium.

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