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# (54) PTC resistors and method of making

(57) Method for producing class 2 resistors with PTCs, including the following phases:

- fitting, inside a tube which constitutes the container of the resistor, at least two layers of insulating material in correspondence with the internal surface of said tube;
- fitting a heating element composed of one or more PTC elements clamped between a pair of diffusers inside said tube, after fitting one or more centring elements;
- filling the spaces between said heating element and said insulating layer with pulverized magnesium oxide;
- compacting said magnesium oxide;

in which the dimensions of the magnesium oxide grains are below 200 microns.

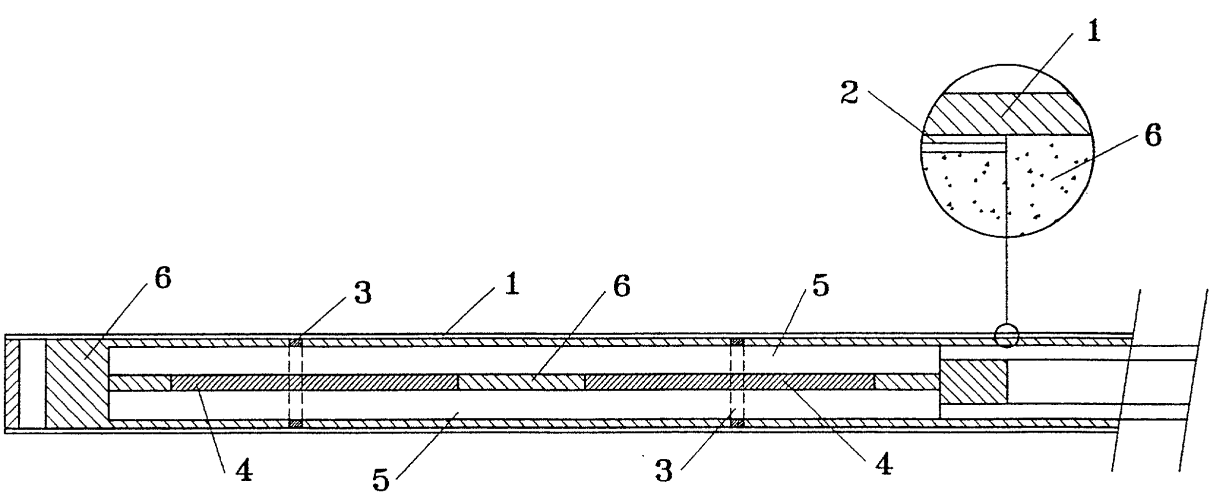


Fig.1

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## Description

**[0001]** The present invention proposes a method to produce class 2 resistors with PTC, in which:

- a double layer of insulating material, particularly kapton or teflon, is arranged inside a tube;
- a heating element constituted of one or more PTC elements clamped between a pair of diffusers is placed inside the tube, centring the assembly using centring rings;
- the space around the heating element is filled with pulverized insulating material, in particular magnesium oxide;
- said insulating material is compacted;

and in which the dimensions of the magnesium oxide grains are below 200 microns, and the average dimension of the grains is preferably around 40 microns.

**[0002]** In this way resistors are obtained in which it is no longer necessary to provide control and/or safety devices such as thermostats and/or thermal fuses as the necessary insulation is guaranteed in any case.

**[0003]** In particular the use of magnesium oxide with the indicated grain size makes it possible to compact the insulating material inside the tube containing the PTC elements without damaging the external coating in kapton.

**[0004]** The invention also relates to the resistors obtained with said method.

**[0005]** Generally, to produce class 2 resistors (resistors which must have double insulation) insulating materials, such as magnesium oxide in grains, are used combined with a second material, generally constituted by a double turn of kapton or teflon.

**[0006]** A first type of resistor in this category comprises a winding of resistive wire fitted inside a tubular container generally made of metal filled with pulverized magnesium oxide.

**[0007]** This tube is then fitted inside a second tube with a larger diameter and the space between them is also filled with magnesium oxide which is subsequently pressed and compacted.

**[0008]** This type of resistor has a diameter which for some applications is considered excessive.

**[0009]** In a second type of resistor the winding of resistive wire is again placed inside a tube which is filled with pulverized magnesium oxide and this tube is then coated with a double layer of kapton or teflon before being fitted inside a second tube, which constitutes the outer casing.

**[0010]** This second type of construction makes it possible to obtain resistors with smaller diameters.

**[0011]** Class 2 resistors in which the heating element is constituted of one or more PTC elements have recently been proposed.

**[0012]** These elements have the considerable advantage of not requiring control and/or safety devices such as thermostats and/or thermal fuses, even if they still present all the problems mentioned above, in relation to the need to provide double insulation.

**[0013]** A first solution to this problem is described in the German patent N. 19737241, which relates to a resistor comprising one or more PTC resistors clamped between a pair of heat diffusing elements, with a first layer of insulating material composed of a plurality of rings in material based on magnesium oxide and silicone rubber, which are fitted on the pack composed of the PTCs and relative diffusers and a second insulating layer composed of a double sheet of kapton wound around these rings.

**[0014]** This is all fitted inside a common container composed of a metal tube and then compacted.

**[0015]** This solution has various advantages compared with prior art, as temperature control devices are no longer necessary and moreover, its dimensions are also smaller than prior art resistors.

**[0016]** However there is still the problem of a somewhat laborious production process, as the insulating rings in a material based on silicone rubber and magnesium oxide must be produced in advance, making it possible to further improve this solution.

**[0017]** In fact, it would be useful to produce a class 2 resistor with PTC heating elements using, as insulating material, common magnesium oxide and kapton or teflon.

**[0018]** Experiments have been conducted in this sense, although these provided somewhat disappointing results as during the phase to compact the magnesium oxide, which is generally performed by hammering, the grains perforated the layer of kapton, thus invalidating the insulating properties of this material.

**[0019]** To find a solution to this problem the applicant conducted numerous experiments, varying all the parameters which may influence the final result and, in particular, varying the magnesium oxide grain size.

**[0020]** In fact, all the resistors produced to date use magnesium oxide in which the average dimension of the grains is around 180 microns and the fraction with dimensions below 45 microns is equivalent to around 6% of the total.

**[0021]** The quantity of fine component is intentionally limited, as this makes filling the element more difficult, so that the general and common tendency of all producers is to use magnesium oxide with grains of a certain dimension.

**[0022]** As an example, tables A and B below provide two examples of typical grain sizes used for this purpose.

| TABLE A | TABLE B |
|---|---|
| > 500 im ........ 0.0% | >500 im ........ 0,0% |
| 425 - 500 ....... 0.0% | >425 im ......... <0.1% |
| 250-425 im ...... 31.4% | 425-355 im ...... 4% |

(continued)

| TABLE A | TABLE B |
|---|---|
| 180-250 im ...... 18.3% | 355-250 im ...... 24% |
| 100 - 180 im .... 26.2% | 250-180 im ...... 20% |
| 75-100 im ........ 8.9% | 180-106 im ...... 24% |
| 45-75 im ......... 9.0% | 106-75 im ....... 13% |
| <-45 im .......... 6.3% | 75-450 im ....... 10% |
| | <45 im .......... 5% |

**[0023]** As previously mentioned, the applicant hypothesized that by varying the grain size appropriately it might be possible to obtain satisfactory results without running into the problems that previously caused this course of action to be abandoned.

**[0024]** Experiments conducted have confirmed this hypothesis to be correct, and have led to the development of the following method, which shall now be illustrated with reference to the attached figures in which:

- figure 1 shows the section along the axis of a resistor according to the invention;
- figure 2 is the section of the resistor in figure 1, according to a direction orthogonal to the previous one.

**[0025]** In accordance with the invention, a class 2 resistor with heating elements constituted by PTCs is produced as follows.

**[0026]** A layer of insulating material 2 composed of a few turns of kapton or teflon, are wound in a winding and fitted into a tube 1, which forms the external casing of the resistor, in order to obtain, on the internal surface of the tube, at least two complete turns of insulating material.

**[0027]** One or more centring elements 3 composed for example of rings made of teflon, silicon rubber or other material capable of withstanding the temperatures developed by the resistor are then fitted into the tube and subsequently the heating element, composed of one or more PTC elements 4 clamped between a pair of diffusers 5, for example in aluminium, is fitted into the tube.

**[0028]** These diffusers will preferably have the form, in section, of a circular sector in which the bending radius corresponds to the radius of the internal surface of the centring elements.

**[0029]** Preferably, the ends of the diffusers will be shaped to define a pair of projecting longitudinal edges, indicated with no. 7 in figure 2, which allow more secure assembly of the PTC plates, preventing them from escaping either entirely or in part from the diffusers and thus guaranteeing optimum electric contact.

**[0030]** These centring elements will have an annular internal surface while the external surface will preferably be polygonal, for example hexagonal, to facilitate the passage of the magnesium oxide dust which is subsequently introduced to provide the primary insulating layer indicated with 6 in the figures.

**[0031]** Once the heating element has been fitted into the tube, the finely triturated magnesium oxide is then introduced to fill all the available spaces around the heating element to provide the primary insulation.

**[0032]** In conformity with one characteristic of the invention, this magnesium oxide has an average grain dimension of around 40 microns, and has no grains with dimensions above 200 microns and preferably no grains with dimensions above 192 microns.

**[0033]** The table below indicates the grain size which, following experiments conducted by the applicant, provided optimum results.

100% <192 im

96 im <7.4%<92 im

48 im <28.7%<96 im

12 im <55.8%<48 im

8.1%<12 im

**[0034]** Once the inside of the resistor has been filled with magnesium oxide this is compacted, for example by hammering after which the tube can be closed and the resistor is ready.

**[0035]** Using magnesium oxide with the grain size indicated it was observed that the subsequent operations to compact and press the grains do not cause any damage to the external coating in kapton or teflon, which thus maintains its integrity.

**[0036]** In this manner, it is possible to obtain a class 2 resistor with PTCs, with compact dimensions and which can be produced at a relatively low cost, as it may be produced using inexpensive materials, already known to and used in the specific sector for some time.

**[0037]** Those skilled in the art may then devise different modifications and variants, which however must all be considered as coming within the scope of the present invention.

## Claims

1. Method for producing class 2 resistors with PTCs, **characterized in that** it includes the following phases:

- fitting, inside a tube which constitutes the container of the resistor , at least two layers of insulating material in correspondence with the internal surface of said tube;
- fitting a heating element composed of one or more PTC elements clamped between a pair of diffusers inside said tube, after fitting one or more centring elements;
- filling the spaces between said heating element and said insulating layer with pulverized magnesium oxide;
- compacting said magnesium oxide;

in which the dimensions of the magnesium oxide grains are below 200 microns.

**2.** Method as claimed in claim 1, **characterized in that** at least 50% of the magnesium oxide has dimensions below 200 ìm.

**3.** Method as claimed in claim 1, **characterized in that** the grains of magnesium have dimensions below 192 im.

**4.** Method as claimed in each of the previous claims, **characterized in that** the magnesium grains have mean dimensions between 30 and 50 microns, in particular 40 ìm.

**5.** Method as claimed in the previous claims, **characterized in that** the magnesium oxide has the following grain size

100% <192 im

96 im <7.4%<92 im

48 im <28.7%<96 im

12 im <55.8%<48 im

8.1%<12 im

**6.** Class 2 resistors with PTCs, produced with the methods as claimed in one or more of the previous claims.

**7.** Class 2 resistors **characterized in that** they have:

- a heating element composed of one or more PTC resistors clamped between a pair of diffusers;
- a tubular container for said heating element;
- an insulating layer in kapton applied to the internal wall of said tube;
- an insulating layer in magnesium oxide with grains with dimensions below 200 microns, between said heating element and said insulating layer in kapton.

**8.** Resistor as claimed in the previous claim, **characterized in that** to maintain the heating element positioned, it has one or more centring elements composed of annular elements and that said centring elements must allow the magnesium oxide grains to pass and flow along the entire length of the tubular container.

**9.** Resistor as claimed in the previous claim, **characterized in that** the ends of said diffusers are shaped so as to define pairs of projecting longitudinal edges, suitable to hold the PTC plates in place, preventing them from escaping either entirely or in part from the diffusers.

**10.** Resistor as claimed in the previous claims, **characterized in that** said magnesium oxide has the following grain size:

100% <192 im

96 im <7.4%<92 im

48 im <28.7%<96 im

12 im <55.8%<48 im

8.1%<12 im

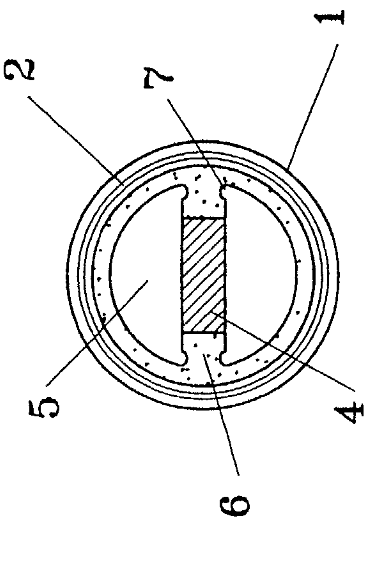


Fig. 2

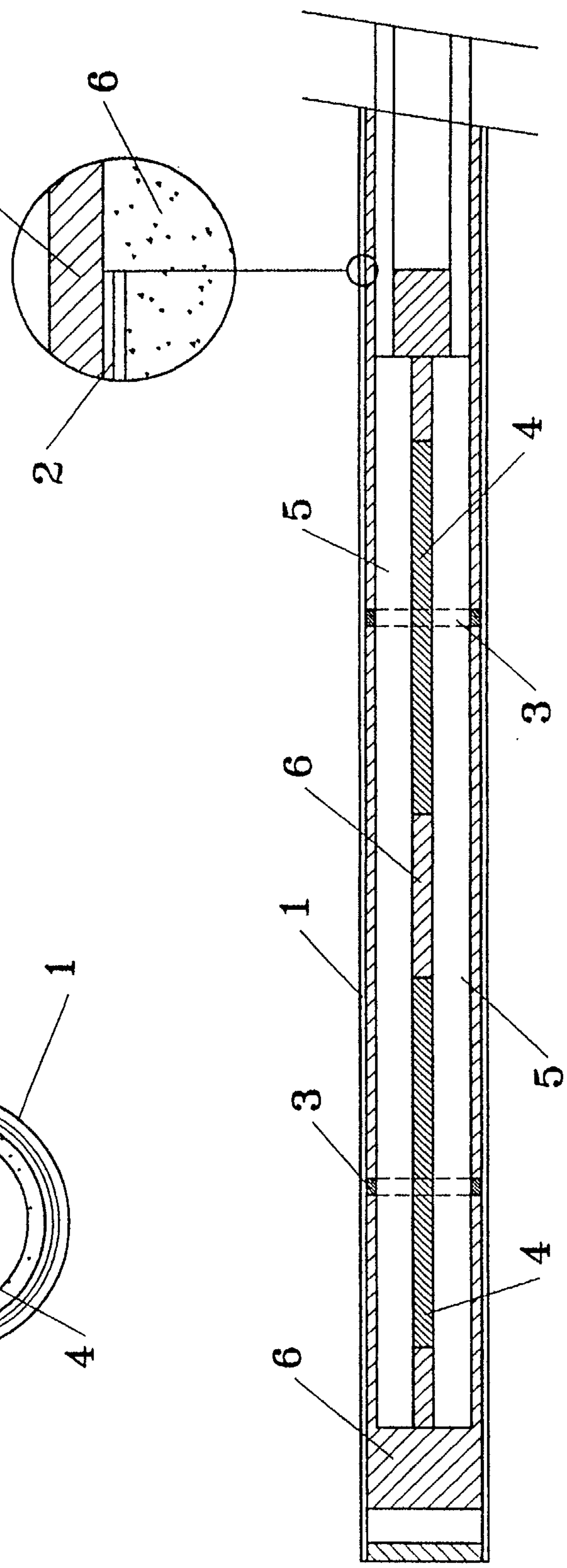


Fig. 1