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B. HORSFIELD

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METHOD OF MAKING ELECTRICAL HEATING ELEMENTS

Original Filed July 24, 1940

Fig. 1.

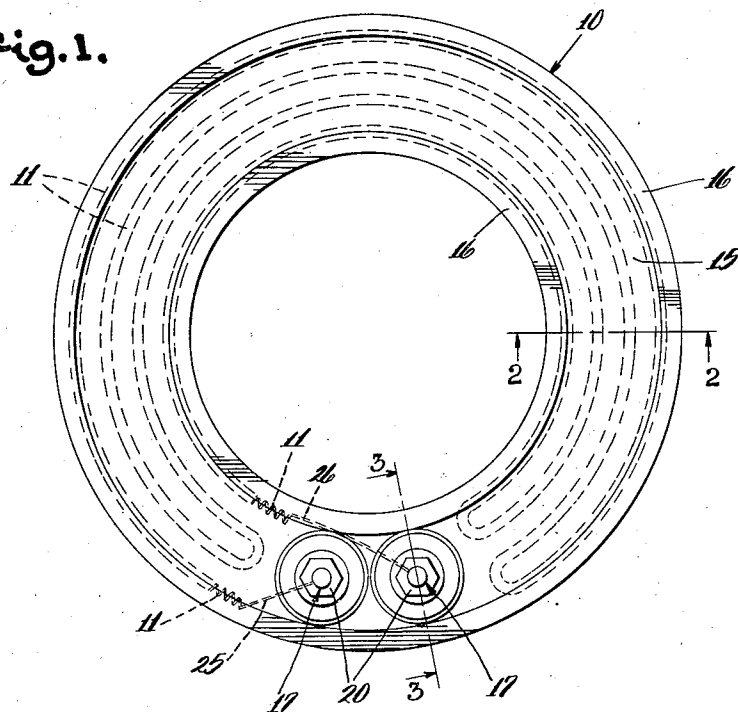


Fig. 2.

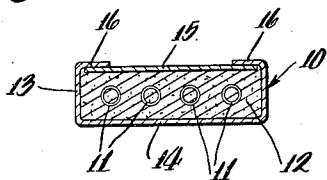
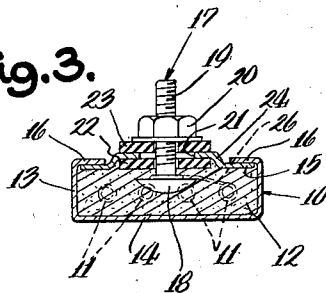


Fig. 3.



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UNITED STATES PATENT OFFICE

2,363,329

METHOD OF MAKING ELECTRICAL
HEATING ELEMENTS

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mesne assignments, to Edwin L. Wiegand Com-
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sylvania

Original application July 24, 1940, Serial No.
347,185. Divided and this application April 26,
1941, Serial No. 390,566

8 Claims. (Cl. 18—59)

My invention relates to electrical heating elements and more particularly to such elements comprising a resistor disposed in and insulated from a metallic sheath. The principal object of my invention is to provide new and improved methods of making the same. This application is a division of my application Serial No. 347,185, filed July 24, 1940.

In the drawing accompanying and forming a part of this application, I have shown, for purposes of illustration, one form of electrical heating element of the aforesaid type, and in this drawing:

Figure 1 is a plan view of an annular type of heating element, and

Figures 2 and 3 are sections taken on the lines 2—2 and 3—3 respectively of Figure 1.

The heating element illustrated comprises a sheet metal sheath 10 here shown as of annular form. The sheath 10 has disposed therein a resistor 11 suitably insulated from the sheath by insulating material 12. The resistor 11 is here shown as made of helically wound wire, but it will be apparent to those skilled in the art that it may be made of other forms of electric resistance material, wound or bent in other ways.

The sheath 10 is here shown as comprising a sheet metal channel 13 of annular form providing a plane wall 14, and a sheet metal cover plate 15, the marginal portions 16 of the sides of the channel 13 being bent or crimped over the cover plate 15.

The heating element is provided with terminals in the form of studs 17 having any suitable form of heads 18, the shanks 19 of the studs being desirably threaded to receive nuts 20. The cover plate 15 has apertures 21 through which the shanks 19 are disposed, and the shanks are suitably insulated as by mica washers 22, 23.

In Figure 1 the studs 17 are shown as mounted side-by-side in suitably circumferentially spaced relation, and the cover plate 15 may have an embossed portion 24 in the region of the studs 17.

The ends 25, 26 of the resistor 11 are suitably connected to the studs 17 respectively, the intermediate helical portion of the resistor being disposed concentrically of the sheath 10 and looped back and forth a desired number of times so as to provide a desired number of strands, in this instance four in number, it being understood that the number of strands may be any other number.

One way of constructing the heating element illustrated is as follows. The resistor 11 and studs 17 are supported on a suitable tool or form (not shown) analogous to the tool shown in the patent

to Wiegand 1,133,347, March 30, 1935, the tool, of course, having a resistor-supporting part which is of such shape and size that it will fit into the channel 13. The resistor 11, carried by the tool, is introduced into an open coverless channel, such as 13 before the margins 16 are crimped, the channel 13 being partly filled to a predetermined level with insulating material which is in a plastic, plastoid, or impressionable condition, and consequently the resistor 11 becomes embedded in the insulating material. The tool is then withdrawn, leaving the resistor 11 embedded in the insulating material. Additional insulating material is then introduced in the channel, over the embedded resistor, and the insulating material may then be compressed to a desired density. The cover 15 and washers 22 being applied, the margins 16 are crimped over the cover, and the element subjected to high pressure to compact the insulating material 12. The element may be subjected to various drying or baking steps, or both, at various intermediate stages of manufacture before and after the cover 15 is applied, and as a final treatment if desired.

The body of insulating material must of course be refractory, and it is desirable that it comprise a selected material that has suitable electrical-insulating properties, and desirably good heat-conducting properties. In instances where a bonding material has been mixed with the selected heat-conducting electrical-insulating material it has been common to use clay as the bonding material. My invention contemplates the avoidance of the use of clay.

I have found that a body of insulating material suitable for use in electrical heating elements may be made by mixing a selected electrical-insulating heat-conducting material such as, for example, zircon (zirconium silicate) or other suitable material, with a bonding material made of magnesium oxide and phosphoric acid. For example, the mixture for introduction into the sheath, as hereinbefore described, may be prepared as follows. The bonding material is prepared by mixing magnesium oxide (MgO) and phosphoric acid (H₃PO₄) of 85% strength, both preferably chemically pure, in the proportion of 65 grams magnesium oxide to 115 cubic centimetres of the phosphoric acid, that is, by weight approximately 36% magnesium oxide and 64% phosphoric acid. This mixture, particularly when heated, evidently reacts to form a refractory phosphate of magnesium which I believe to be magnesium pyrophosphate (Mg₂P₂O₇), and I mix the ingredients in the aforesaid proportions

with the purpose of providing that compound. For reasons hereinafter stated, the mixture of magnesium oxide and phosphoric acid should be slightly acid, that is, there should be a slight excess of phosphoric acid over that necessary to react with the magnesium oxide to produce the magnesium pyrophosphate. The absolute amount of excess phosphoric acid may range from a few drops to approximately a cubic centimeter, depending somewhat upon the amount of bonding material being made up, but in any case desirably the excess is added in such amount that the acidity of the material is such that its pH is approximately $5\frac{1}{2}$ to $4\frac{1}{2}$. The magnesium oxide and phosphoric acid are mixed to a thin slurry which is then dried down to a sticky putty-like mass. This mass is then mixed with the zircon which desirably has been slightly dampened with water; and, preferably, talc is included in the mixture as a mechanical dilutant for the bonding material. This mixture is then used to embed the resistor as hereinbefore described.

The amount of phosphoric acid and magnesium oxide are adjusted, to obtain slight acidity as hereinbefore set forth, for the purpose of securing the desired plasticity and coherence, in other words, for securing the desired workability of the mass of insulating material. It is desirable in connection with the making of electrical heating elements of the insulation-embedded resistor type that the mixture of selected heat-conducting electrical-insulating material and bonding material have about the mechanical workability of clay in the resistor-embedding stage of manufacture, the heating element being thereafter baked or otherwise heat treated to convert the body of insulating material into a hard, firm cake.

The ingredients may be taken in the following proportions, as an example of a satisfactory batch: bonding material, comprising 260 grams of magnesium oxide mixed with 460 cubic centimetres of phosphoric acid of 85% strength, prepared as hereinbefore described, is mixed with 4000 grams of zircon and 180 grams of talc. This mass when baked provides a cake in the finished heating element of suitable firmness and hardness. Heating elements embodying such a body of insulating material when operating at energy dissipations up to approximately 30 watts per square inch of heating surface, show a remarkably low electrical leakage when the terminals of a source of alternating current are connected to the resistor and sheath respectively, in a range from 220 volts to a high test voltage of the order of 1200 volts.

While excellent results are obtained by using the ingredients for the body of insulating material in the proportions hereinbefore given, that is, about 14 to 15% of the bonding material, 81 to 82% of zircon, and 3 to 4% of talc, I do not limit myself to these specific proportions. Generally speaking, the percentage of bonding material is selected to provide a cake of satisfactory mechanical characteristics for a particular use while at the same time providing a cake having the desired electrical characteristics for that particular use. I prefer to include talc because the electrical characteristics are improved. The talc is used in such sufficient percentage as will improve the electrical characteristics of the cake but at the same time will not impair the desired mechanical characteristics, that is, its desired hardness and firmness.

When talc is used I prefer to use an electrical

insulator grade of talc or steatite. It is of course understood that talc when heated or burned is converted into steatite. The talc desirably should be low in lime and alkali salts, and should burn satisfactorily. A pure dead white talc which is white-burning is preferred. A talc which contains a considerable percentage of magnetic material and iron oxide will burn a light brown and such a talc, while it may be used, is not as good as white-burning talc. The talc used in mixtures embodying my invention is desirably finely ground.

While I have illustrated one form of electrical heating element of a type of heating elements, it will be understood that my invention may be embodied in other suitable forms of that type and in other suitable types of electrical heating elements.

From the foregoing it will be apparent to those skilled in the art that each of the disclosed embodiments of my invention provides a new and improved method of making electrical heating element, and accordingly, each accomplishes the principal object of my invention. On the other hand, it also will be obvious to those skilled in the art that the disclosed embodiments of my invention may be variously changed and modified, or features thereof, singly or collectively, embodied in other combinations than those disclosed, without departing from the spirit of my invention, or sacrificing all of the advantages thereof, and that accordingly, the disclosure herein is illustrative only, and my invention is not limited thereto.

I claim:

1. The method of making an electrical heating element which comprises mixing magnesium oxide and phosphoric acid in predetermined proportions, drying the resultant mass to a sticky putty-like product of slight acidity, mixing said product in selected proportion with particles of heat-conducting electrical-insulating material to form a plastic material of desired workability, embedding a resistor in a mass of said plastic material, and applying heat to harden said mass of plastic material.

2. The method of making an electrical heating element which comprises mixing magnesium oxide and phosphoric acid in predetermined proportions, drying the resultant mass to a sticky putty-like product of slight acidity, mixing said product in selected proportion with particles of heat-conducting electrical-insulating material and talc to form a plastic material of desired workability, embedding a resistor in a mass of said plastic material, and applying heat to harden said mass of plastic material.

3. The method of making an electrical heating element which comprises mixing magnesium oxide and phosphoric acid in predetermined proportions, drying the resultant mass to a sticky putty-like product of slight acidity, mixing said product in selected proportion with zircon to form a plastic material of desired workability, embedding a resistor in a mass of said plastic material, and applying heat to harden said mass of plastic material.

4. The method of making an electrical heating element which comprises mixing magnesium oxide and phosphoric acid in predetermined proportions, drying the resultant mass to a sticky putty-like product of slight acidity, mixing said product in selected proportion with zircon and talc to form a plastic material of desired workability, embedding a resistor in a mass of said

ability, embedding a resistor in a mass of said

plastic material, and applying heat to harden said mass of plastic material.

5. The method of making an electrical heating element which comprises mixing approximately 36 parts by weight of magnesium oxide with 64 parts by weight of 85% phosphoric acid, adding sufficient phosphoric acid so that the acidity of the mixture is such that its pH is approximately $5\frac{1}{2}$ to $4\frac{1}{2}$, drying the resultant mass to a sticky putty-like product, mixing said product in selected proportion with particles of heat-conducting electrical-insulating material to form a plastic material of desired workability, embedding a resistor in a mass of said plastic material, and applying heat to harden said mass of plastic material.

6. The method of making an electrical heating element which comprises mixing approximately 36 parts by weight of magnesium oxide with 64 parts by weight of 85% phosphoric acid, adding sufficient phosphoric acid so that the acidity of the mixture is such that its pH is approximately $5\frac{1}{2}$ to $4\frac{1}{2}$, drying the resultant mass to a sticky putty-like product, mixing said product in selected proportion with zircon to form a plastic material of desired workability, embedding a resistor in a mass of said plastic material, and applying heat to harden said mass of plastic material.

7. The method of making an electrical heating element which comprises mixing approximately 36 parts by weight of magnesium oxide with 64 parts by weight of 85% phosphoric acid, adding sufficient phosphoric acid so that the acidity of the mixture is such that its pH is approximately $5\frac{1}{2}$ to $4\frac{1}{2}$, drying the resultant mass to a sticky putty-like product, mixing said product in selected proportion with zircon and talc to form a plastic material of desired workability, embedding a resistor in a mass of said plastic material, and applying heat to harden said mass of plastic material.

8. The method of making an electrical heating element which comprises mixing approximately 36 parts by weight of magnesium oxide with 64 parts by weight of 85% phosphoric acid, adding sufficient phosphoric acid so that the acidity of the mixture is such that its pH is approximately $5\frac{1}{2}$ to $4\frac{1}{2}$, drying the resultant mass to a sticky putty-like product, mixing said product with zircon and talc to form a plastic material of desired workability, the ingredients of said material being in the approximate proportions of 14 to 15% of said product, 81 to 82% of zircon, and 3 to 4% of talc, embedding a resistor in a mass of said plastic material, and applying heat to harden said mass of plastic material.

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