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METHOD OF COATING WIRE-WOUND ELECTRICAL RESISTORS

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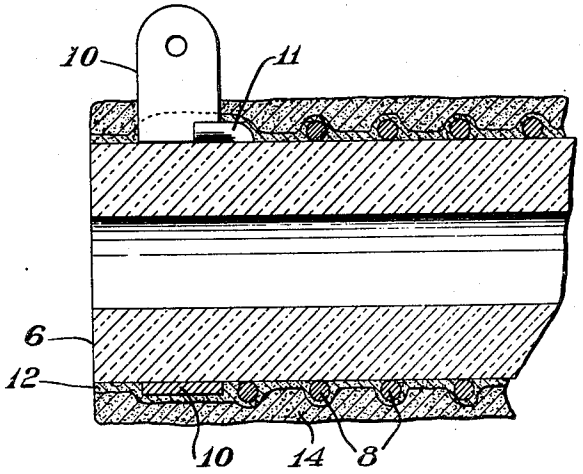


Fig. 1

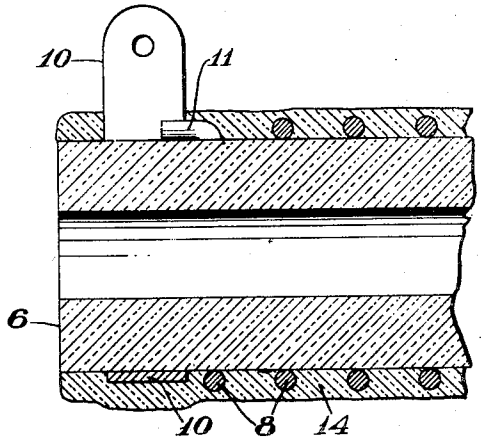


Fig. 2

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METHOD OF COATING WIRE-WOUND ELECTRICAL RESISTORS

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3 Claims. (Cl. 201—67)

1

This invention relates to electrical resistors. More particularly it relates to electrical resistors comprising a cylindrical, generally tubular, core, an electrical resistance wire spirally wound on said core, metallic connecting members on the ends of said core for securing the ends of said wire and providing an electrical connection to said wire, and a vitreous enamel protective coating covering said wire and core and the base of said metallic connecting members.

Many difficulties have been encountered, heretofore, in producing such an electrical resistor which will have a substantially smooth uniform coating of vitreous enamel and which will resist sudden changes in temperature without fracturing. Particular difficulty has been met by axial shifting of the coils of the spirally wound resistance wire during the firing of the enamel coating thereon. The wire coils separate in bunches along the core as a result of high surface tension of the fused enamel.

As the enamel fuses during the firing thereof, the enamel coating sometimes splits and the surface tension on the fused semi-liquid enamel causes the coating to draw away from the split thereby resulting in a widening of the split and often leaving a considerable gap in the coating. The wire coils are also pulled away from each other at the said gap and thereby being drawn into bunches along the core. For obvious reasons this is very objectionable.

The above-described objectionable phenomenon has been remedied to some extent by first coating the wire-wound core with a thin liquid slip of kaolin clay or ball clay and drying the same before application of the vitreous enamel slip and the firing thereof.

It is an object of this invention to provide an improved clay slip which can be applied to a wire-wound resistor as an under-coat for a vitreous enamel to prevent the splitting of the enamel coating, and the bunching of wires, during the firing of the enamel.

It is another object of this invention to provide an improved method for the production of wire-wound enamelled electrical resistors which will be free from split coatings and wire-bunching.

Other objects of the invention will appear hereinafter.

The above objects may be accomplished, in general, by applying to a wire-wound electrical resistor core, a thin slip of kaolin or ball clay containing between 2% and 50% bentonite, and drying the same before application of enamel thereto.

2

The resistor core is generally composed of a ceramic material, for example, steatite porcelain, magnesium silicate or magnesium aluminum silicate. A preferred core is one composed of a ceramic material having a linear expansion coefficient between 6×10^{-6} and 7×10^{-6}.

The resistor core is wound in a conventional manner with an electrical resistance wire, for example, a nickel-chromium alloy or nickel-copper alloy wire, and the wire securely held in place by means of metal fastening tabs or connecting elements to which the ends of the wire are fastened to form an electricity conducting unit from one tab, through the wire to the other tab.

The above-described wire-wound core is then provided with a thin coating of a slip composed of clay (kaolin clay or ball clay) and bentonite suspended in water. Of the total solids in the slip 98% to 50% is clay and 2% to 50% is bentonite. The slip should be made sufficiently fluid to flow between the wire coils and to drain from the spaces between wire coils to leave a substantially uniform coating on the exposed surfaces of the core and wire. It will be readily apparent that if the slip is thick, it will not flow between wire coils but will bridge the space between coils, and as a result a coating of uniform thickness on the wires and the core will not be obtained.

The thinness or fluidity of the slip will depend in large measure upon the size of the wire, the spacing between wires, and the method of application. Sometimes the wire-wound core is heated before dipping in the clay-bentonite slip. Under such circumstances, the slip must be thinner than if the core is cold when dipped. Sometimes a wire-wound core is wetted with water before dipping in the slip. Under such conditions, the slip must be somewhat thicker than if it is dipped while dry. In general, the clay-bentonite slip should contain between 3 and 30 parts water for 1 part solids, and preferably between 5 and 10 parts water for 1 part solids.

The slip is preferably prepared by mixing the clay and bentonite with water in the proportion of 1 part solids to 2 or 3 parts water and ball-milling the mixture for a period of between 1 to 3 hours. The ball-milled product is then diluted with water to the desired consistency.

After application of the clay-bentonite slip, for example, by brushing, spraying or dipping, preferably the latter, the wire-wound core is permitted to drain, for example, by suspending the same from one end thereof, and is then dried. The drying is preferably accomplished by contact with the atmosphere at room temperature, how-

ever, forced air drafts, or even mild baking, can be employed, if desired, to dry the same.

The wire-wound core containing the dry coating of the clay-bentonite mixture is then coated with a vitreous enamel slip in a known manner. Any vitrefiable enamel may be now used for coating of the resistor unit without material danger of splitting of the enamel, or wire-bunching, during firing of the enamel. The enamel slip is then dried and fired in the conventional manner. Although a vitreous enamel of any desired composition can be applied and fired with good results on the wire-wound core containing the clay-bentonite coating in accordance with this invention, outstanding results are obtained with enamels having a low coefficient of expansion. Enamels having a low coefficient of expansion are usually particularly subject to enamel splitting and wire-bunching.

The clay-bentonite under-coating of this invention has particular utility in the production of wire-wound resistors in accordance with the invention disclosed in the copending application of Alden J. Deyrup, Serial No. 551,041, filed August 24, 1944. The enamel coating disclosed in the above-said application contains lead oxide, zinc oxide, boric oxide, alumina and silica in the following proportions by weight.

	Per cent
Lead oxide	28 to 55
Zinc oxide	5 to 20
Boric oxide	10 to 30
Alumina	4 to 10
Silica	11 to 32

and also, if desired, small proportions of other compounds, for example, cobalt oxide, nickel oxide, chromium oxide and zirconium oxide.

These enamel compositions have a very high resistance to fracturing when subjected to sudden changes of temperature. However, these enamels are especially subject to enamel splitting and wire-bunching during firing. By first undercoating the wire-wound core with a clay-bentonite slip, in accordance with the present invention, a particularly desirable enamelled electrical resistor can be produced by the method of said application. By the use of a clay-bentonite undercoating enamelled resistors can be produced with the enamels disclosed in said application without waste or spoilage due to wire-bunching or enamel-splitting. The specific combination of a clay or clay-bentonite under-coating with the enamel coatings of the above-mentioned Deyrup application which leads to new and unobvious results is the subject matter of my copending application Serial No. 553,367, filed September 9, 1944.

The clay-bentonite under-coating of the present invention permits the formation of more uniform and more adherent coatings on wire-wound cores for the prevention of enamel-splitting and wire-bunching. In the absence of the bentonite in the clay composition, the under-coating will flake off from the wire-wound core after it has dried. Furthermore, without the bentonite constituent, the clay cannot be applied in as thin a coating and the enamel over-coating when fired will fail to satisfactorily absorb the same.

The present invention is illustrated by the accompanying drawing showing two stages in the manufacture of electrical resistors in accordance with my invention.

Fig. 1 is an enlarged fragmentary sectional view of a wire-wound core containing a clay-bentonite under-coating and a vitreous enamel slip over-coating.

Fig. 2 is a similar fragmentary sectional view of the finished electrical resistor after firing of the structure shown in Fig. 1.

Referring to Fig. 1 of the drawings, reference numeral 6 designates a tubular ceramic core, upon which is spirally wound a resistance wire 8. The end of the wire 8 is welded, brazed, or otherwise fastened at 11 to metallic tab 10 which is clamped firmly about the core 6. A clay-bentonite composition of the type described above, designated by numeral 12, is shown in a substantially uniform layer about the core 6, the tab 10 and the wire 8. Although, in the stage of production shown in this drawing, the clay-bentonite is dry and contains an overcoating 14 of enamel slip, it will be readily apparent that the clay-bentonite, when applied as a slip (aqueous suspension), was sufficiently thin and fluid to flow in between wire coils and to drain from the spaces between the coils to leave a more or less uniform coating.

In Fig. 2 of the drawings, in which like reference characters designate like parts, the enamel 14 has been fired. It will be noted that the clay-bentonite composition has now substantially vanished. Since the clay-bentonite composition is present in a thin uniform layer as shown in Fig. 1, the fusing of the enamel, during the firing operation permitted an absorption of the clay-bentonite and thereby causing a firm adherence of the enamel to the core 6 and wire 8.

Throughout the specification, reference to parts, percentages and proportions refers to parts, percentages and proportions by weight, unless otherwise specified.

Since it is obvious that many changes and modifications can be made in the above-described details without departing from the nature and spirit of the invention, it is to be understood that the invention is not limited by said details except as set forth in the appended claims.

I claim:

1. The method of making wire-wound electrical resistors which comprises applying to a core wound with resistance wire a coating of a slip comprising an aqueous suspension of a clay taken from the group consisting of kaolin clay and ball clay, and bentonite in a proportion of 98% to 50% clay and 2% to 50% bentonite, the slip being sufficiently fluid to flow between the wire windings and to drain from the spaces between windings to leave a substantially uniform coating on the surfaces contacted, drying said coating, applying a coating of a vitreous enamel slip over said dry clay-bentonite coating, drying said enamel slip, and firing said enamel.

2. The method of making wire-wound electrical resistors which comprises applying to a core wound with resistance wire a coating of a slip comprising an aqueous suspension of a clay taken from the group consisting of kaolin clay and ball clay, and bentonite in a proportion of 98% to 50% clay and 2% to 50% bentonite, said slip containing 3 to 30 parts by weight of water for each part solids and being sufficiently fluid to flow between windings to leave a substantially uniform coating on the surfaces contacted, drying said coating, applying a coating of vitreous enamel slip over said dry clay-bentonite coating, drying said enamel slip, and firing said enamel.

3. The method of making wire-wound electrical resistors which comprises applying to a core wound with resistance wire a coating of a slip comprising an aqueous suspension of a clay taken

from the group consisting of kaolin clay and ball clay, and bentonite in a proportion of 98% to 50% clay and 2% to 50% bentonite, said slip containing 5 to 10 parts by weight of water for each part solids and being sufficiently fluid to flow between windings to leave a substantially uniform coating on the surfaces contacted, drying said coating, applying a coating of vitreous enamel slip over said dry clay-bentonite coating, drying said enamel slip, and firing said enamel.

BURTON C. BRICKER.

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