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METHOD OF COATING WIRE-WOUND ELECTRICAL RESISTORS

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2 Claims. (Cl. 117—70)

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This invention relates to the production of wire-wound electrical resistors; more particularly, it relates to the production of wire-wound resistors comprising a base or tube of ceramic material, a winding of resistance wire thereon, suitable clips, clamps, ferrules, tabs, or other metallic fasteners at the ends of the wire to secure the resistance wire in position and provide means for establishing electrical contact therewith, and a coating of vitreous enamel applied over the entire unit, except for the ends of said fasteners, for the purpose of holding the resistance wire in place, insulating the turns of wire from each other and from outside contact, and protecting the wire against deteriorating influences such as moisture, electrolytes or atmospheric oxidation.

In the production of the above-described vitreous enamel-coated, wire-wound electrical resistors, it is generally desired to apply a sufficiently thick enamel coating to cover the wire and all but the ends of the fasteners completely so that a smooth, even surface will result, and complete protection from atmospheric influences is afforded. If it is attempted to apply all the enamel desired in a single application, or even in two applications, and the enamel fired, severe wire-bunching, enamel crawling and tearing are commonly encountered. By the term "wire-bunching" is meant the shifting or crawling of the wire coils axially of the ceramic core, thus causing uneven spacing of the coils from each other. For this reason, it is customary to apply the enamel in three or more coatings, each coat being fired to a smooth, glossy coating before the next application of enamel. This method of individually applying and separately firing three or more coatings of enamel operates fairly well and without serious difficulty when the resistors are constructed with fine resistance wire, i. e., wire having a diameter of less than 0.003 inch.

In the construction of resistors with resistance wire having a diameter greater than 0.005 inch, extremely serious difficulties are encountered with blistering during the firing of the second or subsequently applied coatings, even though the enamel has been applied in three or more coatings. Such blistering results in an uneven final enamel coating with small holes and weak spots which often result in subsequent failure in use. When blistering is encountered in the production of enameled resistors comprising fine resistance wire, it may generally be obviated by the use of degassed wire, available commercially. The use of degassed wire in wire sizes above 0.005 inch diameter does not eliminate the above-mentioned blistering and the resulting holes and weak spots in the enamel coating. Although not all large wire size resistors subject to blistering in the firing of the enamel coatings turn out to be defective, such a proportion is defective as to

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constitute serious losses upon inspection—culling after manufacture.

It is an object of this invention to provide a method of applying and firing enamel coatings on wire-wound electrical resistors which will greatly reduce blistering of the enamel during the firing operations.

It is another object of this invention to provide a method of making wire-wound, vitreous-enameled electrical resistors with wire having a diameter of at least 0.005 inch in which the tendency to blister during firing of the enamel is greatly reduced.

Other objects of the invention will appear hereinafter.

The objects of this invention may be accomplished, in general, by successively applying three or more coats of enamel over the wire-wound structure but firing said successive coats in a particular manner and order as follows:

(1) The first coating of enamel is fired to completely fuse the enamel to form a smooth, glossy coating.

(2) The next succeeding coat or coats, except the last coat, are fired to such an extent that the enamel sinters and enamel particles are bonded to each other but the enamel coating remains porous.

(3) The last coat is fired to form all of the applied enamel into a smooth, even, glossy coating.

In accordance with this invention, the previously encountered objectionable blistering during the firing of the final enamel coating is greatly reduced, and generally completely eliminated, by firing the intermediate coating or coatings between the first and last coatings to a critical degree, namely, to such a degree that sintering and bonding of enamel particles takes place to form a porous, non-continuous surface. If the firing is carried out to a lesser degree, i. e., less than that point at which sintering and bonding of the enamel particles takes place, wire-bunching and enamel tearing will be encountered. If the firing is carried out to a greater degree, i. e., beyond that point at which a porous, non-continuous surface is obtained, blistering will take place in the subsequent final firing operation.

The degree of firing is, of course, a function of time and temperature, the exact time and temperature depending upon the composition of the enamel. The degree of firing necessary to produce sintering and bonding of enamel particles to form a porous, non-continuous surface is, however, readily determinable for any enamel composition by visible inspection. Sintering and bonding of particles is recognized when a coherent, solid mass is formed. Porosity is readily recognized by applying a drop of ink or dye solution to the enamel. If the surface is porous, the ink

or dye will be seen to migrate into the enamel coating.

The firing of the intermediate coats to the necessary degree can be accomplished by firing at a high temperature for a short period of time or at a lower temperature for a longer period of time, as desired. The minimum temperature of firing must, of course, be above the sintering temperature of a substantial proportion of enamel particles in the enamel, but the maximum temperature depends upon the time of firing. If the firing time is sufficiently short, the temperature employed for firing the intermediate coatings may actually exceed the temperature at which the first and last coatings are fired. Generally, however, it is desired to fire the intermediate coatings at a temperature less than the firing temperature for the first and last coatings. With commonly employed enamels, for a given time of firing, there is a range of about 50° C. between the stage where the enamel sinters and bonds but remains porous and the stage where porosity disappears due to fusion.

The present invention is applicable to any vitreous enamel used in the production of enamel-coated, wire-wound resistors where the employment of enamel leads to difficulty from blistering.

Although it is no part of this invention, it is preferred to apply to the resistor wire windings a coating of clay before application of enamel in accordance with the invention disclosed in Zander Patent No. 2,398,686. However, the advantages of this invention will be obtained with or without such clay coating.

The following example is given to illustrate the method of this invention with regard to a particular enamel, it being understood that the details of the example are not to be considered as limiting the invention thereto.

Example

A Nichrome resistance wire having a diameter of 0.01 inch was wound and fastened to the ends of a steatite porcelain tube two inches in length and one-half inch in diameter. The tube containing the resistance wire was first dipped in a clay slip and dried in the manner disclosed in the above-said Zander patent. The clay-coated, wire-wound tube was then enameled in the following manner:

An enamel frit containing:

	Per cent
PbO	18.9
ZnO	24.3
B_2O_3	24.8
SiO_2	19.8
Al_2O_3	7.7
CoO	1.8
ZrO_2	2.1
Na_2O	0.6

was mixed with the following materials and then ground to pass through a 30-mesh sieve to produce a resistor coating enamel slip,

	Per cent
Enamel frit	60.0
Litharge (PbO)	10.3
Zirconia (ZrO_2)	2.5
Flint (SiO_2)	2.9
Sodium silicate (23.5% Na_2O; 76.5% SiO_2)	0.8
Borax ($Na_2B_4O_7 \cdot 10H_2O$)	1.2
Water	22.3

The several coatings of enamel slip were applied by dipping and allowing excess to drain off. After application of each coating of enamel slip, the resistor was thoroughly dried before firing. The first coat was fired at a temperature of 750° C. for ten minutes, whereupon it became smooth and glossy. The second coat was fired at a temperature of 500° C. for a like period of time, whereupon it became a coherent, solid mass but remained mat and porous. The third coating was fired at a temperature of 750° C. for ten minutes, whereupon the entire enamel mass on the resistor appeared smooth, even, and glossy. The resulting resistors were uniformly free of any flaws or defects.

Similar resistors enameled in the conventional manner, each coating being fired to a smooth, glossy surface at a temperature of 750° C., resulted in the production of enameled resistors in which a high proportion contained uneven coatings and holes as a result of blister formation during firing. These uneven coatings and holes were sufficiently severe to cause rejection upon inspection or possible failure in service.

Reference in the specification and claims to parts, proportions and percentages, unless otherwise specified, refers to parts, proportions and percentages by weight.

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 to be limited to said details except as set forth in the appended claims.

What is claimed is:

1. In the production of vitreous enamel coated, wire-wound electrical resistors containing a ceramic core the steps comprising alternately applying and firing at least three successive coats of vitreous enamel on the wire-wound core, firing the first coat at a time and temperature to produce a smooth, glossy surface, firing every additional coat, except the last coat, at a time and temperautre to sinter and bond the enamel particles to form a solid, porous surface, and firing the last coat to form all of the applied enamel into a smooth, even, glossy coating.

2. In the production of vitreous enamel coated, wire-wound electrical resistors containing a ceramic core the steps comprising alternately applying and firing at least three successive coats of vitreous enamel on a wire-wound core, firing the first coat at a temperature to produce a smooth, glossy surface, firing every additional coat, except the last coat, at a lower temperature to sinter and bond the enamel particles to form a solid, porous surface, and firing the last coat to form all of the applied enamel into a smooth, even, glossy coating.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,365,331	McCulloch	Jan. 11, 1921
2,213,969	Ruben	Sept. 10, 1940
2,416,864	Bricker	Mar. 4, 1947
2,491,965	Ganci	Dec. 20, 1949