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ELECTRIC RESISTIVE DEVICE

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Fig. 1.

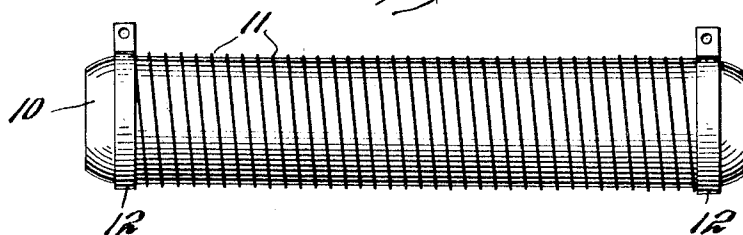
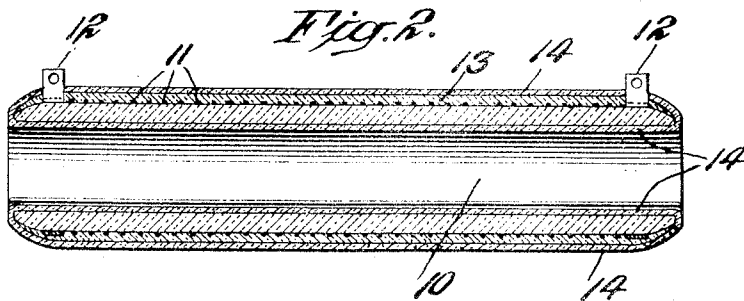


Fig. 2.



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ELECTRIC RESISTIVE DEVICE

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12 Claims. (Cl. 201-64)

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This invention relates to resistive devices wherein the resistive conductor is embedded in insulating material. The invention is applicable to tubular units with terminals or ferrules and with or without intervening taps, also to plate forms, rheostats and to various types and forms of resistive devices.

The main object of the invention is to produce resistive devices which are specially adapted to withstand extreme thermal shocks, high humidity and immersion and which will fulfill the severe tests and requirements of special U. S. Government specifications and requirements.

Although enamel embedded resistive devices have been produced which are fully satisfactory for the usual requirements of temperature changes and humidity conditions, yet when extreme conditions are to be faced such as on marine vessels, aircraft and for military use under extreme temperature changes and humid conditions and especially when subjected to salt water, resort must be had to special protective provisions. Extreme thermal changes or shocks tend to cause stresses and strains in the coating and in the ceramic core where such a core is used, resulting in crazes or cracks which render the device vulnerable to moisture and especially to salt water. Additional shocks produce more and deeper crazes and cracks which permit more moisture or salt water to penetrate to the resistive conductor and corrode it, both by chemical and electrochemical action.

The present invention overcomes these difficulties by the provision of a buffer coat over the embedding insulating material and over the core which serves to reduce the effect of thermal shocks to the inner coating and core and overcome the prior difficulties. The buffer coat must be of a different character than the inner coating and core and in general must have a degree of elasticity and also be of low thermal conductivity compared with that of the inner coating and core to properly protect the inner coating and core. Also for best results the buffer coating should be water repellent and this is accomplished by impregnating the buffer coating with a moisture repellent material or covering it with a film to render it moisture- and waterproof. The use of a buffer coating properly applied and having the desirable characteristics and rendering the same waterproof has been found to fulfill the most exacting requirements even in units of large size and capacity. The protective buffer coating is applicable not only to enamel embedded resistive devices but to those having other

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types of insulating coatings such as cement mixtures and various other forms of insulating compositions.

As an illustrative example, the invention will be explained as applied particularly to an enamel embedded resistive device and to a wire wound tubular resistor having a ceramic core.

Fig. 1 of the accompanying drawing is a side view of such a unit before the application of any coating; and Fig. 2 is a longitudinal cross section of the completed device showing the coatings applied.

Referring to the drawing, the supporting ceramic core 10 is shown in the form of a tube having the resistive conductor 11 wound thereon. The resistor is shown connected at its ends to two terminal bands 12 from the projecting ends of which connection may be made to an external circuit. The resistor may be provided with intermediate tap or ferrule connections if desired. The enamel coating 13 is applied to cover or embed the resistive conductor and terminal bands by dipping the unit in enamel material, by sifting the material thereon, or by spraying or otherwise. The unit is then placed in a furnace and heated to a sufficiently high temperature to fuse the coating and form the vitreous adhesive insulating enamel coating. This basic resistor unit made in accordance with prior known methods and composition of materials is now ready for the application of the buffer coating; and instead of an enamel coating it may be of any other suitable material, the enamel coating being taken as an illustrative particular example.

The buffer coating 14 is next applied over the enamel coating and also inside of the tubular core for best results, although in some cases and especially in units of small size it may be unnecessary to cover the inside of the core. The buffer coating is of a character which adheres to the basic coating and to the core support. This buffer coating serves to absorb the effect of extreme thermal shocks and prevent injury to the basic unit by decreasing the temperature gradient between the average temperature of the embedding material and the average temperature of the basic core support. The buffer coat in addition to having low thermal conductivity is resilient and yieldable to stresses caused by severe thermal shocks.

A desirable buffer coat for the particular basic unit selected is of vitreous enamel material specially prepared and treated to give the coating a multitude of small voids resulting in a coating of low heat conductivity and high resiliency.

The enamel mixture is of a composition adapted to mature at a lower temperature, or as low, as the basic enamel coating. This material is powdered to a fineness suitable for dipping or spraying. This powdered mixture is then suspended in a medium or vehicle such as sodium silicate or potassium silicate, or a mixture of both, in aqueous solution. The concentration chosen is such as to give a multitude of voids within the structure which is important in determining its resiliency and ability to withstand shocks without crazing or breaking. The basic unit is then coated with this mixture and allowed to dry slowly at room temperature to form a good set without any cracking of the surface. After thoroughly drying, preferably over night, the coated units are then baked for several hours at about 300° F., after which according to one method they are placed in a continuous or periodic kiln and fired to fusion, the temperature depending on the composition of the buffer material. In the case of the enamel composition described below, such a temperature would be 1300 to 1350° F. Under the treatment just considered and using the particular composition described below, the resultant structure of the buffer coating contains voids in the form of a multiplicity of bubbles interconnected with thin intervening resilient membranes.

An example of the composition of the buffer coating for application to the basic unit is as follows: Powered enamel material 22 pounds, silicate solution 1 gallon.

The powdered enamel material may have the following composition showing the molecular equivalents:

K ₂ O, .114	Cr ₂ O ₃ , 1.1
Na ₂ O, .243	B ₂ O ₃ , .9
ZnO, .334	Ni ₂ O ₃ , .1
BaO, .309	SiO ₂ , 1.84
Al ₂ O ₃ , 1.9	

The silicate solution may be as follows:

25% potassium silicate having the composition

K₂O, 1.2 SiO₂—35° Baumé

25% sodium silicate having the composition

Na₂O, 2.9 SiO₂—47° Baumé

50% water

the above proportions being by volume.

The enamel material is stirred into the silicate solution and the whole is vibrated to eliminate as much trapped air as possible before application of the mixture to the basic unit.

After the applied buffer coat mixture is matured as above described, the units are then given a treatment for repelling water therefrom. For that purpose the units are dipped, sprayed, vacuum or pressure treated by high heat resistant silicone oils of proper viscosity. This treatment results in the surface having a water repellent property, that is, any water or moisture will lodge as round balls or globules in a discontinuous arrangement insuring high surface resistivity against moisture. This silicone oil treatment causes a thin film to form over the buffer coat which may also penetrate to some extent within the buffer coat.

Instead of using high temperature silicone oils for the final waterproof coating, suitable varnishes or elastic polymers may be used or any suitable liquid materials which are water repellent and high heat resistant. The choice of

the waterproof covering depends upon the operating temperatures to which the completed units are to be subjected.

Another method of treatment is similar to that already described except that instead of firing the buffer coating to fusion as above described, the coating is fired only to incipient fusion which in the case of the particular enamel composition above given is 1150° F. This gives the matured buffer coating a porous structure with voids in the form of crevices more or less interconnected, or it may, depending on the firing temperature and the approach to fusion, also contain some bubbles distributed throughout the coating. Fusion reduces the porosity and increases the presence of the bubbles within the structure. Thus according to the firing temperature used, the buffer coating may be quite porous with interior voids in the form of crevices, may contain voids mainly in the form of a multiplicity of bubbles, or may have a combination of both and may have a large variation in the relationship of the degree of porosity to the degree of presence of bubbles. The greater the porosity, the greater will be the impregnation of the waterproof coating within the buffer coat.

It will be understood that instead of the basic unit having a vitreous enamel coating, it may be of any suitable cement type or of other inorganic insulating embedding material. Also instead of using the particular described enamel composition in the buffer coat, other enamel compositions may be used, also cement mixtures, or other inorganic adhesive compositions. Likewise the silicate solution may be varied to have alkali to silica ratios falling within wide limits. Also in place of the silicate solution various suitable organic and inorganic substances which decompose and cause gassing upon being heated can be used in conjunction with enamel, cement or other buffer coat compositions and thereby produce a frothy mixture for the buffer coat. The method of treatment would, of course, depend upon the type of substances used.

Although the invention has been particularly described with reference to a tubular type resistor, it will be understood that it is applicable to other shapes and forms and to plate types and to various forms of rheostats and resistive devices without departing from the scope of the invention.

I claim:

1. A resistive device having a resistive conductor embedded in an adhesive inorganic insulating coating, and an adhesive buffer coating covering said embedding coating, said buffer coating being composed of a mixture of enamel material and a silicate and having a structure containing a multitude of small interior voids.

2. A resistive device having a resistive conductor embedded in an adhesive inorganic insulating coating, and an adhesive buffer coating covering said embedding coating, said buffer coating being composed of a mixture of enamel material and a silicate and having a structure containing a multitude of small interior voids, and a waterproof, water repellent and high heat resistant composition applied to said buffer coating.

3. A resistive device having a resistive conductor embedded in an adhesive inorganic insulating coating, and an adhesive buffer coating covering said embedding coating, said buffer coating being composed of a mixture of enamel material and a silicate and having a structure

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containing a multitude of small interior voids, and a waterproof, water repellent high temperature silicone composition applied to said buffer coating.

4. The method of making a resistive device which comprises embedding the resistive conductor with adhesive inorganic insulating material, curing said material to form a basic coating, applying an additional adhesive inorganic coating containing gas forming material over said basic coating, and curing said additional coating to form a buffer coating containing a multitude of small interior voids.

5. The method of making a resistive device which comprises embedding the resistive conductor with adhesive inorganic insulating material, curing said material to form a basic coating, applying an additional adhesive inorganic coating containing gas forming material over said basic coating, curing said additional coating to form a buffer coating containing a multitude of small interior voids, and then applying a waterproof, water repellent heat resistant composition to said buffer coating.

6. The method of making a resistive device which comprises embedding the resistive conductor with adhesive inorganic insulating material, curing said material to form a basic coating, applying an additional adhesive inorganic insulating coating composed of a mixture of enamel material and a silicate over said coating, and curing said additional coating to form a buffer coating containing a multitude of small interior voids.

7. The method of making a resistive device which comprises embedding the resistive conductor with adhesive inorganic insulating material, curing said material to form a basic coating, applying an additional adhesive inorganic insulating coating composed of a mixture of enamel material and a silicate over said coating, curing said additional coating to form a buffer coating containing a multitude of small interior voids, and then applying a waterproof, water repellent high temperature silicone composition to said buffer coating.

8. A resistive device having a resistive conductor embedded in an adhesive inorganic insulating material, and a buffer coating of a mixture of inorganic adhesive insulating material and of material containing a multiplicity of small voids distributed throughout the inorganic material of the buffer coating covering and adhering to said embedding material, whereby said coating has a lower thermal conductivity compared with that of said embedding material.

9. A resistive device having a resistive conductor embedded in an adhesive inorganic insulating material, a buffer coating of a mixture of inorganic adhesive insulating material and of material containing a multiplicity of small voids

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distributed throughout the inorganic material of the buffer coating covering and adhering to said embedding material, whereby said coating has a lower thermal conductivity compared with that of said embedding material, and a waterproof, water repellent, high heat resistant composition applied to said buffer coating.

10. A resistive device having a resistive conductor embedded in a vitreous adhesive insulating enamel material, and a buffer coating of inorganic adhesive insulating material covering and adhering to said embedding material, said coating containing a multiplicity of small interior voids whereby said coating has a lower thermal conductivity compared with that of said embedding material.

11. A resistive device having a support with an opening passing through it longitudinally, a resistive conductor carried by said support, an adhesive inorganic insulating material embedding said conductor, and a buffer coating of inorganic adhesive insulating material covering and adhering to said embedding material and also covering the interior portion of the support where said opening passes through it, said buffer coating having a lower thermal conductivity than the embedding material.

12. A resistive device having a support with an opening passing through it longitudinally, a resistive conductor carried by said support, an adhesive inorganic insulating material embedding said conductor, and a buffer coating of inorganic adhesive insulating material covering and adhering to said embedding material and also covering the interior portion of the support where said opening passes through it, and said buffer coating containing a multiplicity of small interior voids, said buffer coating having a lower thermal conductivity than the embedding material.

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