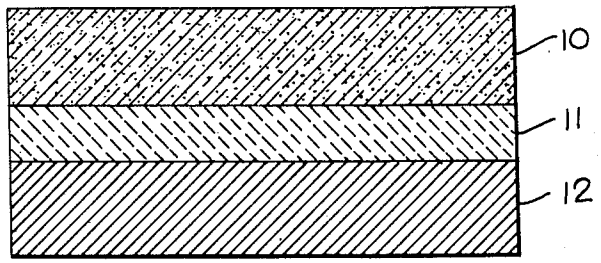
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ELECTRICAL HEATING ELEMENT

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ELECTRICAL HEATING ELEMENT

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This invention relates to improvements in heating elements and particularly to a layer of material which may be applied, in the form of a coating, to flat or curved surfaces, on many types of metals and alloys, on non-metals such as glass, steatite and refractory brick, etc. The heating element herein contemplated can, in fact, be applied to any solid material that has a high heat stability, as in the range of 600° F. to 2000° F. Also, said heating element can be cast, extruded or otherwise molded into desired shapes.

The art of applying thin metal films to the surfaces of non-metallic refractory materials such as glazed pottery has been known for many years. The same usually consists in suspending colloidal particles of a metal such as gold, platinum, palladium, etc., in a suitable liquid medium together with a flux such as bismuth sub-nitrate, then applying such mixture as a coating on the non-metallic refractory surface, and firing to a temperature of 1000° F. 1500° F. The resultant metallic coating is electrically conductive.

More recently, combinations of metallic and ceramic materials have been employed to produce objects called "ceramets." These ceramets, formed under high heat and pressure, retain the high tensile strength of metals and the refractory characteristic of ceramics. This combination, for example, is used in combustion chambers of jet engines. Also, conductive particles, such as silver, have been formed into a paste, and applied to a non-con ductive surface or base in such a manner as to form a circuit pattern for electronic circuits. This is known as printed circuitry.

Further, a prior art electrical heating element consists of finely powdered graphite particles held together with a ceramic bond and formed into rods and bars. Such bars or rods were then fired to cause the ceramic material therein to become vitrified. Such a product comprises an electrical resistance element and will emit heat when subjected to an electric potential.

An object of the present invention is to provide an improved composition of matter that generally comprises a glass base and incorporating electrically conductive particles in an evaporative liquid carrier, the composition being of such consistency as to be capable of application onto a suitable surface by spraying, brushing, roller-coating, dipping, etc.

My invention also has for ts objects to provide an electrical heating element that is economical to manufacture, easy to apply onto a base or support surface, long lasting, effective in operation, and of general superiority and serviceability.

The invention also comprises novel materials and combinations of materials, which will more fully appear in the course of the following description with reference to the drawing illustrating an enlarged sectional view of the heating element according to the present invention.

The present electrical heating element comprises, generally, a layer 10 of glass in finely ground or divided form interspersed with fine particles of electrically conductive materials applied to a vitreous enamel layer 11 on a metallic base member 12. As a heating element, the product of this invention is in fired condition on the surface of a base material or member 12. In its initially mixed form, the glass and the conductive particles comprise a suspension in an evaporative liquid of such consistency that the composition may be sprayed, brushed, roller-coated, dipped, or otherwise applied to the base material.

The proportion of glass to conductive material will be dependent largely on desired heat emission of the heating element and the electrical potential to be applied to induce emission of heat.

The above-indicated liquid-suspended composition, after uniform deposit, in one of the manners indicated, on a base surface, and after evaporation of the solvent liquid carrier, may be fired to a temperature and for a period of time that causes the glass and conductive particles to sinter in a heterogeneous and systematic manner. This sintering phase serves to form an interlock of the glass and conductive particles and also produces a lock or fusion between the surface of the base material and the sintered combination of materials. The nature of the bond between the metallic particles is the same as or comparable to the bond which adheres vitreous porcelain enamel to metal. Similarly, the glass bond here used is of the same nature as the bond between earthenware and a glaze or, for that matter, any ceramic material and a glaze.

I have discovered that an efficient electrical resistance element of the character above indicated can be produced by combining a low melting glass with a mixture of conductive particles. Preferably, metals of relatively low conductivity are employed. A highly efficient heating element has been produced in which nickel has a small percentage of iron mixed thereinto. One part of iron to four parts of nickel by weight, is a proportion that has proved satisfactory, although the same may vary considerably. The range of particle size may be between 50 and 350 mesh with the average thereof preferably preponderant.

Conductive particles as above are combined with a low melting glass composition of the following proportions of ingredients:

	Percent
Silica (SiO_2)	5 to 50
Lead oxide (PbO)	35 to 85
Boric oxide (B_2O_3)	10 to 25
Sodium oxide (Na_2O)	0 to 15
Potassium oxide (K_2O)	0 to 15
Aluminum oxide (Al_2O_3)	0 to 10
Titanum dioxide (TiO_2)	0 to 10
Zirconium dioxide (ZrO_2)	0 to 10
Lithium oxide (Li_2O)	0 to 10
Calcium oxide (CaO)	0 to 10
Barium oxide (BaO)	0 to 10

Raw materials to supply the above oxide ingredients are chosen from readily available commercial grades of ground silica for the silicon dioxide (SiO_2); litharge for the lead oxide (PbO); boric acid (H_3BO_3) for the boric oxide; sodium carbonate for the sodium oxide (Na_2O); potassium carbonate (potash) for the potassium oxide (K_2O); and feldspar or aluminum hydrate for aluminum oxide (Al_2O_3). The last three oxides above listed are suggestive of oxides that may be chosen from a group of alkalis or alkaline earths. The above are suggestive of how the ingredients of the glass portion of the composition may be obtained, since they may be obtained in other usual ways.

To make the glass which I employ in my invention, the raw batch of ingredients is thoroughly intermixed,

placed in a crucible, and heated to 1800° F. to 1900° F., or to a temperature that produces a very fluid liquid. This temperature should be maintained until all gases are evolved and activity ceased as indicated by termination of effervescence. The liquid glass is then cooled by pouring the same slowly into a cold water bath so that the glass becomes fritted and shatters into small particles under the rapid cooling that occurs. The glass particles are then dried to free them of all moisture and the same are then ground as in porcelain ball mills to a particle size of 50 to 325 mesh with the preponderance of the particles 200 mesh.

It is here noted that the ratio of glass to conductive particles will vary according to conditions to be met. For example one embodiment of the invention may be required to fit sheet stainless or mild steel, whereas another embodiment may be required to fit aluminum or an aluminum alloy. Since the thermal expansion of such two metals differs widely, the composition of the heating formulation must be varied, accordingly, to meet these conditions. Other modifications for non-metallic base materials may be used.

In order to provide a heating element suitable for application to a mild steel and having expansion coefficients that are similar to such steel, the low melting glass may comprise:

Glass A

	Percent
Silica (SiO_2)	11.26
Lead oxide (PbO)	67.21
Boric acid H_3BO_3	9.36
Sodium carbonate (Na_2CO_3)	4.37
Feldspar (K_2O; Al_2O_3; 6 SiO_2)	6.94
Lithium carbonate (Li_2CO_3)	.86
	100.00

and finely divided nickel combined in the ratio of one part glass A in a fritted state, one part nickel, and an equal weight of an aromatic solvent, such as toluene.

The mild steel is first coated with a commercial vitreous enamel and the above solution is sprayed onto this non-conductive coating to a desired thickness, say, .005", and then fired to 900° F. for about fifteen minutes. The resultant heating element will have an electrical resistance of .3 ohm per square inch and will retain its bond with the base metal because its expansion characteristics are similar.

In order to provide a heating element suitable for application to aluminum and aluminum alloys and having the expansion characteristics of such metal, the low melting glass may comprise seven parts of glass A, above, and three parts of:

Glass B

	Percent
Lead oxide (PbO)	28.15
Silica (SiO_2)	25.56
Lithium carbonate (Li_2CO_3)	5.36
Sodium carbonate (Na_2CO_3)	15.70
Titanium dioxide (TiO_2)	8.90
Zirconium silicate ($ZrSiO_4$)	1.61
Potassium nitrate (KNO_3)	14.72
	100.00

To the ten parts of glasses A and B, in the indicated proportion, an equal amount of nickel is added and the whole suspended in a solvent, such as toluene, as before. After spraying this solution on a coating of vitreous enamel to a thickness of .005", the same is fired to 900° F. for fifteen minutes. The resultant element will have a resistance of .6 ohm per square inch.

To provide a heating element suitable for application to a non-metallic or dielectric base, for instance, glass-bonded mica, and having the lower expansion characteristics of this material, the low melting glass may comprise nine parts of glass A and one part of glass B, as before, an equal amount of nickel particles and the glass and nickel suspended in toluene, as before. After firing to 900° F. for fifteen minutes, after this mixture is sprayed onto the glass-bonded mica to a thickness of .005", the resultant layer will comprise an electrical heating element having a resistance of .8 ohm per square inch.

It has been found advantageous to vary the thermal expansion of the heating element by substituting sodium oxide and potassium oxide for the boric oxide in the formulation. Thus, where a high expansion is desired, a high amount of alkali is preferably used. Where low expansion is desired, those oxides that are low alkalis are used as well as a higher boric oxide content. This is demonstrated in the examples above given for formulation for bonding to mild steel, aluminum or aluminum alloys, and glass-bonded mica (an example of a non-metallic base material).

By such interchange, the thermal expansion of the heating element may be varied so that an expansion comparable to the normal thermal expansion of the base material may be achieved. This ability to vary balance insures perfect adhesion of the finished heating element to the base material throughout the entire heat range of the element provided.

If the electrical resistance of the heating element is to be varied, I have found this can be accomplished by vary- the ratio of metal particles to glass. Greater resistance may be obtained by using a smaller proportion of conductive particles, and vice versa.

In the development of the present electrical resistance coating, it was found necessary, as above indicated, to electrically insulate the heating element from the base material in event the base material was conductive in any appreciable measure. Such an electrical insulative material preferably should be compatible with both the base material and the heating element. This compatibility preferably includes thermal expansion characteristics in keeping with those of the element and of the base material on which said element is applied. Also, such insulation should be of the proper formulation to assure good adherence. This insulative material may be a ceramic porcelain enamel which may be chosen from the many products which are available on the market and designed for specific enameling requirements. Unlike general porcelain enameling requirements, the present base material, in its application, must be chosen to provide dielectric strength that provides an electrical insulative barrier between the heating element and the base material in the event the base material is conductive.

The heating element of the invention comprises ceramic and conductive particles sinter-bonded to provide an electrical resistance heating element, and because of its sinter-bonded form, appears quite porous under a microscope. While the material is not generally applied to flexible objects, the sintered element does have some flexibility and may be so applied where limited flexibility is present.

Also, a unique feature of the present element and unlike other type electrical elements, in general, is that said element can be designed to have a very positive temperature coefficient of resistance or, by changing conductive particles by selection from the given list and the combination of such conductive particles, the element will have a lower positive coefficient of resistance. In every instance, the element is positive in its temperature coefficient of resistance.

For example, an element containing ceramic and nickel properly proportioned to provide a given resistance will increase or decrease in resistance approximately 2% for 10° F., depending on the temperature ambient. For example, also, a heating element designed for 10 watts/sq. in. at 70° F. will increase in resistance (decrease of wattage) as the temperature rises. In the event the element is turned on at extremely low temperatures, the

heating element then will have more wattage proportionately below 70° F. This unique feature provides a built-in powerstat, in many instances, thereby providing greater power at the low temperatures where it is needed, and reducing power consumption as the temperature rises. In some instances, it is possible to produce a thermostatically controlled element without the use of a thermostat.

While I have described what I now contemplate to be the best mode of carrying out my invention, the same is, of course, subject to modification without departing from the spirit and scope of the invention. I, therefore, do not wish to restrict myself to the particular forms described, but desire to avail myself of all modifications that may fall within the scope of the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In an electrical heating element, the combination of: a metallic base member having given thermal expansion characteristics; a coating of vitreous enamel bonded to a surface area of said base member; and a layer comprising low melting glass frit and electrically conductive metallic particles in substantially equal proportion fired onto said coating, said metallic particles being predominantly nickel and said glass frit being of a composition such that its thermal expansion characteristics are equivalent to said expansion characteristics of said base member, whereby proper adhesion will be maintained between said member and said layer throughout a wide temperature range.

2. The combination according to claim 1, in which the metallic particles comprise a large proportion of nickel and a relatively small proportion of iron.

3. The combination according to claim 1, in which the glass frit is formed of silica and at least one oxide selected from the group consisting of lead, boric, sodium, potassium, aluminum, titanium, zirconium, lithium, calcium, and barium oxides, and in which at least the lead oxide is present.

4. The combination according to claim 1, in which the glass frit is composed of silca, lead oxide, boric acid, sodium carbonate, feldspar, and lithium carbonate; and

in which, the metallic particles are composed of finely divided nickel in a ratio of one part to one part of said glass frit.

5. The combination according to claim 4, in which the metallic base member is mild steel.

6. The combination according to claim 1, in which the glass frit is composed of seven parts each of silica, lead oxide, boric acid, sodium carbonate, feldspar and lithium carbonate and three parts each of lead oxide, silica, lithium carbonate, sodium carbonate, titanium dioxide, zirconium silicate, and potassium nitrate; and in which, the metallic particles are formed of finely divided nickel in the ratio of one part of such glass frit to one part of nickel.

7. The combination according to claim 6, in which the base member is an aluminum containing metal.

8. The combination according to claim 1, in which the glass frit is composed of nine parts each of silica, lead oxide, boric acid, sodium carbonate, feldspar, and lithium carbonate, and three parts each of lead oxide, silica, lithium carbonate, sodium carbonate, titanium dioxide, zirconium silicate and potassium nitrate; and in which, the metallic particles are formed of finely divided nickel in the ratio of one part of said glass frit to one part of nickel.

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