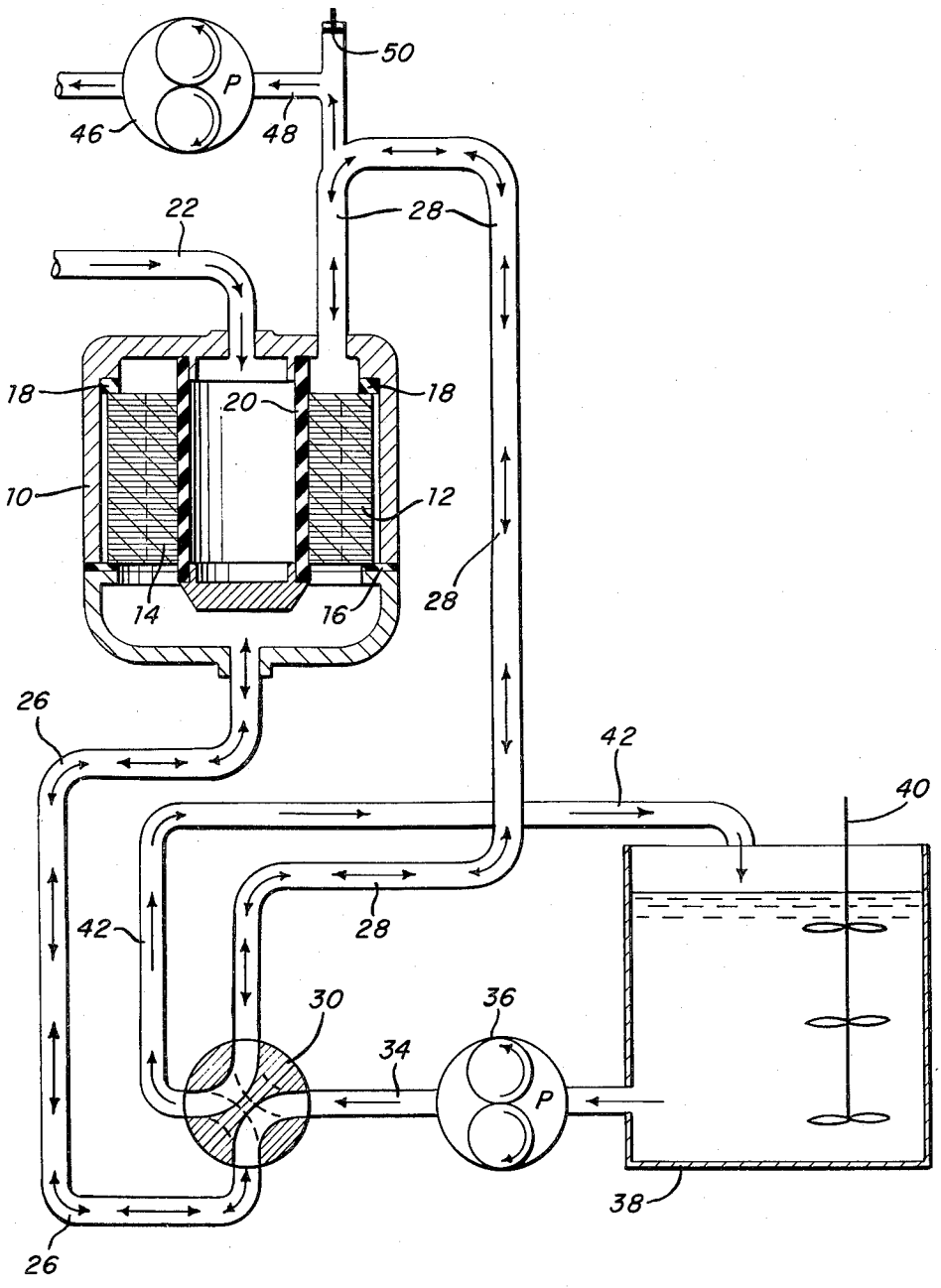
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INSULATION COATING AND METHOD OF APPLICATION THEREOF

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INSULATION COATING AND METHOD OF APPLICATION THEREOF

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This invention relates to insulation coating material and to the method of application thereof. The invention relates more particularly to a ceramic electrical insulating coating for surfaces of portions of electrical machines. The invention relates still more particularly to a coating for the slots of rotors and stators of electric motors. However the invention is not so limited in that it may be used for coating of other surfaces.

An object of this invention is to provide an electrical insulation coating material for the surfaces of portions of elements of electrical machines, such as a coating for the wall surfaces of the slots of rotors and stators.

Another object of this invention is to provide such a coating which can be easily and readily applied at comparatively low cost.

Another object of the invention is to provide such a coating which is extremely durable and has long life.

Another object of this invention is to provide such a coating which has very fine electrical insulation properties, which is capable of withstanding high temperatures, and which is not subject to deterioration by moisture.

Another object of this invention is to provide such a coating which may be applied and used in a very thin form. Thus, the coating does not appreciably interfere with heat conduction from a winding.

Another object of this invention is to provide a coating material and method of application thereof which cleans a surface as it is applied thereto so that a separate cleaning process is not required.

Another object of this invention is to provide a coating for the slots of a laminated rotor or stator which coating when applied makes possible the insertion of conductor material into the slots without interference with the relative positions of the laminations; thus treatment of the laminations after application of winding material is eliminated.

Another object of this invention is to provide a coating process in which a portion of the process can be carried out simultaneously with a heat treating process for normalizing or annealing of the steel of the laminations.

The material and process of this application may be used in connection with the provision of an electrical insulation coating to the surfaces of portions of elements of electrical machines. The invention is primarily adapted to the provision of an electrical insulation coating to the surfaces of slots of a stator or rotor of an electric motor.

The coating of this invention may be applied to the slots of rotors and stators in the manner shown in copending application Serial No. 690,705, filed October 17, 1957, in which two of the inventors therein are also the inventors in regard to this application. Said application discloses the method of passing a slurry through the slots of an element, such as a rotor or stator, of an electric machine.

The FIGURE in the drawing illustrates apparatus which may be used to apply a coating of this invention.

A coating chamber 10 is shown containing an electrical element such as an annular stator member 12 which has a plurality of slots 14 at the inner portion thereof. The apparatus is adapted to coat the surfaces of the slots 14. The member 12 may also be a rotor or other element having portions for coating in accordance with this invention. Suitable sealing members such as 16 and 18 engage the outer edges of the stator 12. An elastomeric mandrel 20 is adapted to have pressure applied therein by means of fluid from a conduit 22 which is forced into the mandrel 20 and urges the mandrel 20 into firm engagement with the inner surfaces of the stator 12. Conduit members 26 and 28 are connected to the coating chamber 10. Thus, only the slots 14 are open as passages for flow of fluid through the chamber 10.

The conduit members 26 and 28 are also connected to any suitable four-way valve member such as the rotary valve 30. A fluid line 34 extends from the valve member 30 to any suitable pump device 36 which pumps fluid from a tank 38 to the four-way valve 30. The tank 38 contains a quantity of the coating composition discussed below. If desired, the coating composition may be agitated by means of an agitator member 40. A return line 42 connects the valve 30 to the tank 38.

Preferably, a suitable vacuum pump 46 is connected by a line 48 to the conduit 28 for evacuation of the coating chamber 10.

The operation of the apparatus is as follows: the stator 12 is placed in the coating chamber 10 and the chamber 10 is then closed and sealed. The mandrel 20 is expanded into engagement with the inner surface of the stator 12 by means of any suitable fluid forced into the mandrel 20 through the conduit 22. Then, the pump 36 is started and circulates the coating composition from the tank 38 through the valve 30 and through the lines 26 and 28.

By suitable operation of the valve 30 the coating solution from the tank 38 can be forced through the slots 14 of the stator 12 in one direction, followed by forcing the solution from the tank 38 through the slots 14 of the stator 12 in the opposite direction. After the desired period for such circulation of the coating composition, the pump 36 is stopped and the vacuum pump 46 is started for evacuation of the coating chamber 10 to draw all excess fluid from the slots 14 of the stator 12 and from within the coating chamber 10. Then, a vent valve 50 connected to the conduit 28 is opened, permitting restoration of atmospheric pressure to the coating chamber 10. Then, internal pressure is removed from the mandrel 20 by removal of the fluid pressure which is applied through the conduit 22. The coating chamber 10 is then opened and the stator 12 is removed.

The coating of this invention comprises ceramic material of finely divided particles which are carried in a suitable liquid vehicle to form a slurry. The slurry is passed through the slots of the element of the electric machine. Some of the finely divided particles are deposited upon the wall surfaces of the slot so that when passage of the slurry is stopped the finely divided particles remain upon the wall surfaces of the slots. The vehicle which carries the finely divided particles is one which readily evaporates when the electric machine element is exposed to room temperature following passage of the slurry through the slots thereof.

Then the element of the electric machine is placed in an oven or the like in which the temperature is brought to a value slightly above the fusing point of at least some of the finely divided particles. Thus, the particles are joined and firmly bonded as a coating upon the surfaces of the slots.

The slots are ordinarily formed in the slots of punched laminations, the laminations having edge portions thereof which are somewhat hardened by the punching process. It is customary to anneal or normalize the steel of the laminations after the punching process in order that the steel of the laminations will have its best magnetic qualities. The process of annealing can be carried out during and immediately following the fusing of the finely divided

particles in the forming of the coating upon the surfaces of the slots. Preferably, the finely divided material is selected so that a portion thereof fuses at a temperature which is also a favorable temperature for heat treatment of the steel of the laminations. Thus, the fusing and heat treating are carried on simultaneously. The fusing process requires a lesser amount of time than the heat treatment process, but after the desired temperature is obtained in the electrical element for the fusing and for the annealing, the temperature may be maintained for a somewhat longer period after the fusing occurs in order to complete the heat treatment process. However, the heat treatment temperature employed may be slightly lower than the fusing temperature of the frit so that the temperature may be reduced slightly after the fusing and during the heat treatment of the steel.

In this invention, in general, a suitable composition for passing over the surface to be coated is as follows:

50 to 75 parts, 150 to 250 mesh frit of fusion point from 800° to 1200° F.
15 to 35 parts, 75 mesh to 150 mesh frit of fusion point 1400° to 1600° F.
1 to 10 parts silica, finely ground
1 to 10 parts tabular alumina
1 to 10 parts asbestine, finely ground
3 to 15 parts of a liquid vehicle comprising:
3 to 15 parts acetone
0 to 5 parts lower of a lower alkyl acetate
0 to 5 parts alcohol—
In which all parts are by weight

A composition such as set forth above is forced to flow over a surface to be coated. For example the composition may be forced through the slots of an element of an electrical device such as a rotor or stator upon which it is desired to place an insulation coating prior to providing a winding within the slots. Such a process is disclosed in our said copending application Serial No. 690,705. The finely divided particles are deposited upon edge portions of the laminations in which the slots are formed. After sufficient flow of the composition to deposit the desired amount of the finely divided particles, the flow of the composition is stopped and any portions of the liquid vehicle which remain in the slots or upon the surfaces are permitted to evaporate.

The element is then placed into a furnace or the like in which the temperature of the element is brought to a value slightly above the fuse point of some of the finely divided particles. For example, in the use of the composition set forth in the above example, the frit having the lower fusing temperature fuses readily at 1200 degrees Fahrenheit. After the deposition of the finely divided particles upon the surface to be coated, the element having said surface is brought to a temperature of about 1200 to 1250 degrees Fahrenheit. Thus, the lower fusing frit fuses while the second frit of higher fusing temperatures does not fuse. The fusing of the first frit requires only a few minutes.

However, due to the fact that a temperature of 1200 to 1250 degrees Fahrenheit is a very suitable temperature for heat treatment of steels used in the laminations of electrical elements, such temperature is maintained for a longer period than is necessary for the fusing of the first frit. The longer period of time at this temperature serves to heat treat the steel of which the laminations are composed. The time provided for the heat treatment is usually not sufficient for a complete heat treatment but is sufficient to treat the steel to a certain economical degree. Thus, fusing and heat treating may be carried on simultaneously by means of the method of this invention. If annealing is not desired or if heat treatment is to be done at another temperature, a material in frit form may be selected which fuses at a temperature other than 1200 degrees Fahrenheit.

After the element is removed from the furnace or the like, the element is permitted to cool rather slowly for the purpose of completing the annealing or normalizing for maintaining good magnetic steel structure in the laminations.

Thus, the surface to be coated has a good ceramic coating and the steel structure of the laminations is prepared to a practical economical value.

If it is desired to provide coating having some roughness characteristics, the amount of frit which does not fuse at the furnace or oven temperature may be greater.

If a rather thin coating is desired, the amount of liquid vehicle in the composition may be increased, while a thicker coating may be obtained by decreasing the percentage of liquid vehicle in the composition. Of course, the thickness of the coating obtained is also dependent upon the length of time that the composition is forced to flow over the surface to be coated.

In some instances the composition is forced in one direction over hte surface for a given time, followed by reversal of the direction of flow for a given time, as shown in the drawing. It has been found that such reversal of flow may sometimes provide a thicker coating or a coating which has fewer depressions or pin holes therein.

The alumina, the asbestos or asbestine, and the silica assist in providing certain refinements in the quality of the coating obtained. Such ingredients may reduce the amount of shrinkage, or may aid in the holding of firmness in the fused coating during the increased time for annealing or normalizing. Such ingredients may also aid in obtaining a thicker coating upon a single application thereof or during a shorter time of flow of the composition over the surface.

The coating and process of this invention are particularly adapted to the production of elements at a high rate such as by automatically operating machines and the like as the elements are operated upon in seriatim relation.

The following examples illustrate more specific embodiments of the coating compositions of the present invention, but the invention is not to be considered as limited thereto.

Example 1

65 parts frit #801 (1200° F. fuse point)
25 parts frit #2501 (1500° F. fuse point)
2 parts silica
2 parts tabular alumina
5 parts acetone
All parts being by weight

The formulation of Example 1 can be varied, for example, by adding 2 parts asbestine to aid in holding the wet film in place. The composition may also be varied by utilizing 1 or 2 parts of butyl acetate along with the acetone to slightly change the characteristics of the vehicle.

Example 2

	Parts by weight
200 mesh frit of 1200° F. fuse point	65
100 mesh frit of 1500° F. fuse point	25
Silica powder (coarse)	2
Tabular alumina	2
Acetone	5

This formulation can be varied, for example, by substituting about 40 parts of 200 mesh frit of 1500° F. fuse point for a like number of parts of the 100 mesh frit.

Example 3

The same materials and proportions are used as in Example 2 except that the acetone is replaced by a mixture of acetone and methyl alcohol in 80/20 ratio by volume.

Example 4

	Parts by weight
200 mesh 1200° F. frit	60
100 mesh 1500° F. frit	18
200 mesh 1500° F. frit	10
#10 silica	2
Asbetine	2
Tabular alumina	2
Butyl acetate	6

While the coating compositions will ordinarily contain only the described components, it will be understood that compositions consisting essentially of the described components can be employed even though they may contain minor amounts of other components, such as antioxidants, stabilizers, fillers, or other conventional additives, so long as the added components do not deleteriously affect the properties of or change the fundamental character of the coating material.

The coating material, for example that of Example 2, is ordinarily applied by flowing over the surface of the machine part for a sufficient time to give a coating about 0.001 to 0.002 inch thick, or any other desired thickness, and the coating is then permitted to dry with evaporation of the liquid vehicle, and then the part is heated to the fusion point of at least the lower fusing frit to fuse the material, and the heating can be continued if desired to anneal or normalize the metal of the part. It is preferable to apply the coating under pressure in a closed chamber, and use forced air drying followed by evacuation of the chamber to set the coating material.

The ingredients and proportions of the coating compositions described herein can be varied to some extent in certain particulars without departing from the invention, as will be recognized by those skilled in the art in view of the present disclosure.

The ceramic or porcelain enamel used in the invention is of a type known as frit, i.e., an enamel such as a complex alkaline boro-silicate glass, usually containing fluorine, produced by melting a mixture such as borax, feldspar, quartz and cryolite. For a lower melting frit, the present invention can utilize an enamel of a type in common use and prepared from the above components in portions to give a fusing range in the order of 800 to 1200° F. Similarly, frits identified by a fusing range of the order of 1400 to 1600° F. can be selected from those in common use and prepared from the above components and will be suitable for the higher melting frit in the composition of the present invention.

The particle size of the frit can also be varied, for example from 300 mesh to 50 mesh; it is often desirable to employ two different particle sizes of the higher fusing frit, for example a combination of 200 mesh with 100 mesh; uses of the larger particle size gives added roughness to the resulting coating. Mesh size, as used herein, refers to particles of a size to pass through mesh of the designated number of openings per inch, as determined by conventional procedure.

The frits utilized herein, while defined by their fusing temperature, were selected to have and do have the required dielectric strength, adhesion characteristics, minimum shrinkage, flexibility and shock resistance; the frits also have long life at high temperature, as required when the fusing process is combined with a normalizing or annealing process for the steel components, for example, two hours at high temperature.

The silica for use herein is any ordinary, finely divided silica, such as silica flour; the silica adds roughness and helps retard shrink. The alumina for use herein is preferably tabular. The alumina is a filler having good electrical insulating properties and helps retard shrinkage. Asbestine, which optionally can be used, is preferably finely divided fibrous asbestos.

As the liquid vehicle for use in the present invention,

fairly volatile organic solvents are generally satisfactory, particularly those singly or in admixture to provide a vehicle boiling in the range of about 50° to 100° F., or more preferably in the range of 70° to 80° F. A low boiling temperature is necessary to have a quick setting solution, and to avoid runs in the surface, but if the vehicle boils at too low a temperature, the application conditions are more difficult to control. Such vehicles can be comprised of hydrocarbons, for example, aliphatic hydrocarbons such as the lower liquid alkanes, e.g., pentane, hexane, etc.; or aromatic hydrocarbons, e.g., benzene, toluol, mineral spirits, etc. However, it is often desirable to use liquids having some polar properties, or functional groups, e.g., alcohols, ketones, lower alkyl esters, etc. in order to have improved solvent and cleaning properties along with affinity for moisture. It is understood that the foregoing or other solvents of the type contemplated will be utilized in admixture with each other as and if required to give vehicles of the desired boiling ranges.

The amount of liquid vehicle for use in coating compositions according to the present invention will generally be about 3 to 15 parts by weight per 100 parts by weight of coating composition. However, somewhat larger amounts of vehicle can be used if a thin coating is desired, as ordinarily the use of "thinner" compositions results in thinner coatings. The thickness of a composition suitable for coating purposes according to the present invention can also be defined by viscosity or specific gravity measurements. In general, suitable compositions will have specific gravity in the range of 35° Baumé to 60° Baumé, the compositions for coating the slots of a rotor preferably being in the range of 40° to 45° Baumé, and those for coating the slots of a stator preferably being in the range of 50° to 55° Baumé to give a slightly thicker coating.

It will be understood that acetone has been found especially suitable and superior as a vehicle in the coating process of the present invention because of its combination of proper volatility, solvent and cleaning ability, affinity for oil and moisture, and because of the desirable properties of the resulting coating. Examples of other liquids which can satisfactorily be employed in the liquid vehicles are butyl acetate, methyl ethyl ketone, acetone 80% combined with 20% methyl alcohol, toluol, mineral spirits, isopropyl alcohol, methyl alcohol, ethyl alcohol, etc.

While illustrative examples of the compositions and various ways of practicing the process of the present invention are given herein it will be understood that various changes and modifications can be made within the spirit of the invention.

Having thus described our invention, we claim:

1. An insulating coating composition comprising 50 to 75 parts of 150 to 250 mesh frit of fusion point of about 800° to 1200° F., 15 to 35 parts of 75 to 150 mesh frit of fusion point 1400° to 1600° F., 1 to 10 parts silica, and 1 to 10 parts tabular alumina, all parts being by weight, suspended in an organic liquid vehicle of boiling point in the range of 50° to 100° F. and present in an amount to give a specific gravity of 35° to 60° Baumé.

2. The composition of claim 1 in which the liquid vehicle comprises alcohol.

3. The composition of claim 1 in which the liquid vehicle comprises acetone.

4. The composition of claim 1 in which the liquid vehicle comprises a lower alkyl acetate.

5. An insulating coating composition comprising 50 to 75 parts of 150 to 250 mesh frit of fusion point of about 800° to 1200° F., 15 to 35 parts of 75 to 150 mesh frit of fusion point 1400° to 1600° F., 1 to 10 parts silica, 1 to 10 parts tabular alumina, 3 to 15 parts of acetone, up to 5 parts of a lower alkyl acetate, and up to 5 parts alcohol, all parts being by weight.

6. An insulating coating composition comprising 65 parts of frit of about 1200° F. fuse point and about 200 mesh size, 25 parts of frit of about 1500° F. fuse point and about 100 mesh particle size, 2 parts silica powder, 2 parts tabular alumina, and 5 parts acetone, all parts being by weight.

7. The method of providing an insulating coating to surfaces of portions of elements of electrical machines which comprises flowing over the surfaces a slurry of specific gravity in the range of 35° to 60° Baumé and comprised of 50 to 75 parts of a lower fusing 150 to 250 mesh frit of fusion point of about 800° to 1200° F., 15 to 35 parts of a higher fusing 75 to 150 mesh frit of fusion point 1400° to 1600° F., 1 to 10 parts silica, 1 to 10 parts tabular alumina, all parts being by weight, suspended in an organic liquid vehicle of boiling point in the range 50° to 100° F., followed by stopping the flow of the slurry and permitting the vehicle to evaporate, followed by heating the portion of the electrical machine to a temperature at least as high as the fusion point of the lower fusing frit to cause fusion thereof, without heating to a temperature to effect fusion of the higher fusing frit.

8. The method of claim 7 in which the element being coated is in a closed chamber and the slurry is caused to flow under pressure over the surface followed by circulation of dry air through the chamber, followed by evacuation of the chamber to seat the coating in place prior to the heating step.

9. The method of claim 7 in which the machine surface being coated is heated at a temperature at least as high as the fusing point of the lower fusing frit for at least an hour to anneal the metal thereof.

10. The method of claim 7 in which the slurry comprises 65 parts frit of about 1200° F. fuse point and about 200 mesh size, 25 parts of frit of about 1500° F. fuse point and about 100 mesh particle size, 2 parts silica powder, 2 parts tabular alumina, and 5 parts acetone, all parts being by weight.

11. The process of insulating the winding slots of an element of an electrical machine in which the element is composed of stacked punchings of sheets of steel material, the method also annealing portions of the punchings which have become hardened by the punching process, comprising flowing through the slots a slurry of specific gravity in the range of 35° to 60° Baumé and comprised of 50 to 75 parts of a lower fusing frit having a mesh 150 to 250 and a fusion point of about 1100° to 1250° F., 15 to 35 parts of a higher fusing 100 to 150 mesh frit of fusion point 1400° to 1600° F., all parts by weight, suspended in an organic liquid vehicle having a boiling point in the range of 70° to 100° F., followed by stopping the flow of the slurry and permitting the vehicle to evaporate, followed by heating the element to a temperature sufficient to fuse the lower fusing frit but to a temperature less than that required to fuse the higher fusing frit, followed by maintaining the temperature at such a value for a period of from one to two hours.

12. The process of insulating the winding slots of an element of an electrical machine in which the element is composed of stacked punchings of sheets of steel material, the method also annealing portions of the punchings which have become hardened by the punching process, comprising flowing through the slots a slurry of specific gravity in the range of 35° to 60° Baumé and comprised of 50 to 75 parts of a lower fusing frit having a mesh 150 to 250 and a fusion point of about 1100° to 1250° F., 15 to 35 parts of a higher fusing 100 to 150 mesh frit of fusion point 1400° to 1600° F., all parts by weight, suspended in an organic liquid vehicle having a boiling point in the range of 70° to 100° F., followed by stopping flow of the slurry and permitting the vehicle to evaporate, followed by heating the element to a temperature sufficient to fuse only the lower fusing frit, followed by maintaining the temperature at a value of about 1200° F. for a period of one to two hours.

13. An insulating coating composition comprising 50 to 75 parts of 150 to 250 mesh frit of fusion point of about 800° to 1200° F., 15 to 35 parts of 75 to 150 mesh frit of fusion point 1400° to 1600° F., all parts being by weight, suspended in an organic liquid vehicle of boiling point in the range of 50° to 100° F. and present in an amount to give a specific gravity of 35° to 60° Baumé.

14. An insulating coating composition comprising 50 to 75 parts of 150 to 250 mesh frit of fusion point of about 800° to 1200° F., 15 to 35 parts of frit of fusion point 1400° to 1600° F. of which up to 50% is about 200 mesh and the balance 75 to 15 mesh, 1 to 10 parts silica, and 1 to 10 parts tabular alumina, all parts being by weight, suspended in an organic liquid vehicle of boiling point in the range of 50° to 100° F. and present in an amount to give a specific gravity of 35° to 60° Baumé.

15. An insulating coating composition comprising solid particles of 65 parts of frit of about 1200° F. fuse point and about 200 mesh size, 25 parts of frit of about 1500° F. fuse point and about 100 mesh particle size, 2 parts silica powder, 2 parts tabular alumina, said solid particles being suspended in an organic liquid vehicle of a boiling point of 50° to 100° F. in an amount to give a specific gravity of 35° to 60° Baumé.

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CERTIFICATE OF CORRECTION

Patent No. 3,025,188 March 13, 1962

Everett P. Larsh et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, line 32, for "15" read -- 150 --.

Signed and sealed this 26th day of June 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patent