Patented Aug. 29, 1933 1,924,311

UNITED STATES PATENT OFFICE

1,924,311

INSULATING MATERIAL

Albert A. Frey, Forest Hills, Pa., assignor to Westinghouse Electric & Manufacturing Company, a Corporation of Pennsylvania

No Drawing. Application January 6, 1931
Serial No. 506,967

10 Claims. (Cl. 175—21)

My invention relates to a liquid coating composition and more particularly to an inorganic insulating coating material of a refractory type.

The principal object of my invention is to provide metallic laminations with a coating material of a refractory type, which is capable of maintaining the laminations in spaced relationship during a subsequent annealing operation, and which will also serve as permanent insulating material when the laminations are assembled as a magnetic core for use in transformers and other electrical devices.

Another object of my invention is to provide a non-combustible, glass-like film upon metallic laminations, which shall be non-hygroscopic, insoluble in oil and weak acid and alkaline solutions, and which is capable of withstanding a high temperature.

A further object of my invention is to provide a liquid coating composition comprising a refractory material, an inorganic binder, and a suitable suspending medium.

A still further object of my invention is to provide a magnetic core for transformers or other electrical devices, the laminations of which are provided with a uniform, firmly-adherent film of insulating material having a high electrical resistance.

In preparing laminations of ferrous material such as iron-silicon or iron-nickel alloys which are utilized in the cores of transformers and dynamo-electrical machinery, it is the practice to anneal the laminations in hydrogen or other reducing gases, such as ammonia, or in an inert gas, such as argon or helium, to improve the magnetic properties. During this annealing process and especially during the annealing of iron-nickel alloys, it has been customary to coat the laminations with some suitable medium which will prevent the laminations welding or adhering together at the comparatively high annealing temperature which is employed.

In annealing iron-nickel alloys, the metallic laminations were coated with an aqueous suspension of magnesium hydroxide. The coated laminations were then baked in a drying furnace at a temperature of approximately 600° C., to dry the film and convert the greater portion of the magnesium hydroxide into magnesium oxide. A plurality of coated laminations thus coated were superimposed upon each other and placed in an annealing furnace. In the annealing operation, a current of hydrogen was passed through the furnace while the laminations were maintained at a temperature of approximately 1000° to 1300° C. During the annealing operation, the remaining magnesium hydroxide was converted into magnesium oxide which served to maintain the sheets in spaced relationship, thereby preventing the sheets from sticking together and permitting the hydrogen to pass between the laminations. Before utilizing the laminations in core plates, however, it has been necessary to remove the coating of magnesium oxide, and coat the cleaned laminations, with some suitable insulating medium, such as sodium silicate, or an organic varnish prior to assembly.

I have made the discovery that by applying an improved composition to the laminations, an insulating film may be formed thereon which will not only prevent the laminations from adhering together during the annealing operation, but the nature of the film formed during the annealing operation is such that it serves as an excellent insulating material, and consequently, the steps of removing the film after the annealing operation and the application of another insulating varnish are eliminated.

In practicing my invention, I mix together a refractory material, such as an oxide of aluminum, calcium, magnesium or iron or a mixture of two or more of such oxides or a refractory silicate, such as zirconium or aluminum silicate, which will not be reduced by hydrogen or the particular reducing gas utilized at the annealing temperature, with a small quantity of a binding agent such as sodium or potassium silicate, borax or the borates of alkali or alkaline earth metals, and a suitable vehicle, such as water, kerosene, or glycerol, in a ball or colloid mill, until the suspension has attained a paint-like consistency. This composition is then applied to the metallic laminations by any suitable means, such as by immersion, a spray gun, brush, or by passing the laminations between gelatin or felt-covered rolls, at least one of which passes through or is otherwise brought in contact with the insulating paint. The coated laminations are next air dried, or, if desired, the drying may be accelerated by means of a blast of heated air or the laminations may be passed through a drying oven maintained at a sufficient temperature to expel the major portion of the water of crystallization which may be associated with the binder or other ingredients which are present.

When sodium or potassium silicate are utilized as the binders, the temperature of the drying oven may be maintained at from 120° to 150° C., although it will be understood that the heating step is not absolutely essential because the

amount of water in the binder is not sufficient to materially affect the results. Since moisture, however, detrimentally affects the magnetic characteristics of ferrous alloys, it is sometimes desirable to remove the water of crystallization that may be present before performing the annealing operation. The coated laminations may then be stacked and annealed in the usual manner.

The following specific example will serve to illustrate and explain my invention: 40 pounds of aluminum oxide, and ½ gallon of commercial sodium silicate, having a specific gravity of 1.39, otherwise known as water glass, were mixed together and 2½ gallons of water were added, and the resulting suspension placed in a ball mill and mixed for 4½ hours, or until the suspension had attained a paint-like consistency. A strip of metal was immersed in this suspension, removed, and allowed to dry in air for two or three minutes. The insulating material thus produced forms a uniform coating over the surface of the metal which is very adherent; in fact, the coated metal can be bent repeatedly without the insulation giving any indication of cracking or peeling from the metal.

Although various proportions of aluminum oxide, sodium silicate, and water may be utilized, when the insulation is subjected to high annealing temperatures, I prefer to employ a composition comprising approximately 45% aluminum oxide, by weight, 15% sodium silicate, by weight, and 40% water, by weight.

The amount of water employed will be governed by the proportion of bond to pigment in the composition and by the film thickness desired on the annealed lamination. When less than 20% by weight of water is utilized, the paint will be too viscous to be readily applied, while if the composition contains more than 80% by weight of water, the consistency of the paint is so low that an effective coating will not be obtained unless a number of coats are applied.

The proportion of the sodium silicate may be varied from 2% to 30% by weight. Less than 2% by weight is insufficient to furnish proper binding properties for the refractory material so that a continuous adhering film is not formed upon the metal, but if a greater amount than 30%, by weight, of sodium silicate is employed, the refractory properties of the paint are destroyed because when the coating is utilized to prevent the laminations from adhering together at the annealing temperature, the fluxizing action of the sodium silicate upon the aluminum oxide forms a fusible silicate.

The composition should preferably contain 40% to 60% by weight of aluminum oxide. When less than 40% by weight of aluminum oxide is employed, the paint will not possess the requisite insulating properties and the laminations have the tendency to weld together during the annealing operation, although when the annealing operation is conducted at a temperature of less than 1200° C., it is possible to utilize less than 40% by weight of aluminum oxide. It is not desirable, however, to utilize more than 60% aluminum oxide, by weight, because a greater quantity will produce a heavier coating than is necessary for insulating purposes and, consequently the space factor will be reduced when the laminations are assembled.

In view of the foregoing examples, it will be apparent that the proportions of the ingredients may be widely varied, and I, therefore, do not desire to limit myself with respect to any specific example. In general, the proportion of refractory to bond in my coating composition is greater for coatings employed in high temperature annealing operations, while the reverse condition will generally be true for coatings utilized in low temperature annealing operations.

Iron, or calcium oxide, or highly calcined or fused magnesium oxide, or a mixture of two or more of such substances may be successfully substituted for all or a portion of the aluminum oxide, in my improved coating composition. Borax or borates of the alkali or alkaline earth metals may also be utilized as the binding agent. I prefer to utilize aluminum oxide as the refractory material because it is practically non-hygroscopic and does not hydrate readily in the calcined state when ground with water. It is insoluble in ordinary solvents and possesses satisfactory refractory characteristics. Furthermore, it is readily obtainable in the pure form, and may be easily ground to a very fine powder in a ball mill.

Although I have found that water is the most satisfactory vehicle or suspending medium for the pigment and binding agent in my improved composition, ethyl alcohol, glycerol, or suitable light oils, such as kerosene and linit oils, or a mixture of two or more of such substances may be substituted for all or part of the water. Various other binding agents may also be substituted for all or part of the sodium silicate, such as potassium, calcium or magnesium silicate, or a mixture of two or more of such silicates.

When a coating is applied in the manner specified and the laminations are assembled, it serves effectively as a spacing material during the annealing operation. If the annealing operation is conducted at 500° C. to 1300° C. and sodium silicate or other binder containing water of hydration is utilized, the binder will be completely dehydrated during the annealing process and a smooth hard film will be produced that has excellent insulating properties. During the annealing operation a portion of the refractory metallic oxide reacts with the silicate binder forming a complex silicate, thereby cementing the aluminum oxide particles together and to the metallic laminations.

If it is not necessary to anneal the metallic sheet material, the coating may be transformed into an insulation by heating the coating to a temperature of 500° to 1300° C.

My improved coating composition is especially valuable, however, when an annealing operation is required, because it not only functions as a separatory medium between the laminations during the annealing operation, but also provides an insulation between the laminations when they are assembled as core plates in electrical apparatus, such as transformers or dynamos. When magnesium hydroxide was utilized in former practice, it was necessary to remove the oxide which was formed and apply an insulating varnish before the laminations were assembled. My improved composition, therefore, eliminates the steps of applying and removing the magnesium hydroxide. Furthermore, when magnesium hydroxide was utilized, it was necessary to dry it at a temperature of approximately 600° C. before it could be utilized as a spacing material, whereas only a few minutes are required to dry my improved composition, or, if it is desired to remove the water of crystallization from the binder, the heating temperature necessary before annealing, will not ordinarily exceed 150° to 200° C.

My improved insulation is non-hygroscopic, adheres firmly to the metal, and is insoluble in weak acid or alkaline solutions. It is superior to a sodium silicate alone, because it is more firmly adherent at high temperatures, and is less expensive than organic insulation, and since it is non-inflammable, its use avoids the danger of fire or explosions.

While I have disclosed my invention in considerable detail and have given specific examples, it will be understood that the examples shall be construed as illustrative and not by way of limitation, and, in view of the modifications which may be effected therein, without departing from the spirit and scope of my invention, it is desired that only such limitations shall be imposed as are indicated in the appended claims.

I claim as my invention:

1. As an article of manufacture, magnetic sheet material coated with an insulating film containing particles of a refractory material in predominant amount cemented together and to the sheet material by a suitable binding agent.

2. As an article of manufacture, magnetic sheet material coated wth an insulating film comprising a refractory oxide as the major ingredient and a binding agent as a minor ingredient.

3. As an article of manufacture, magnetic sheet material coated with an insulating film comprising a predominant amount of aluminum oxide, and a silicate binder.

4. A magnetic core for electrical devices comprising a plurality of laminations of magnetic material, each of said laminations being coated with an adherent insulating film comprising aluminum oxide predominantly and a silicate binder.

5. The process of producing an insulating film upon a layer of sheet metal which comprises coating the sheet with a composition of matter comprising a major proportion of refractory free from carbonaceous material and a minor proportion of a binder and heating the coated sheet to a temperature of between 500° C. and 1300° C. to eliminate the water and bake the film.

6. The method of treating magnetic sheet metal which comprises coating the magnetic sheets with a film comprising refractory free from carbonaceous material and a binder, assembling a plurality of said sheets in superimposed relationship in a furnace and passing reducing gas through the furnace at a temperature of 1000° to 1300° C., said film serving to prevent the sheets from adhering together during the annealing process.

7. The process of treating iron or iron alloys which comprises applying a suspension of a refractory metallic oxide free from carbonaceous material in an aqueous solution of a soluble silicate to the iron or iron alloy, drying, and then annealing the coated metal at a temperature of from 500° to 1300° C.

8. The process of treating iron or iron alloys which comprises providing a suspension containing aluminum oxide and sodium silicate free from carbonaceous material, applying said suspension to the iron or iron alloy, drying and then annealing the coated metal at a temperature of from 500° to 1300° C.

9. As an article of manufacture, magnetic sheet metal coated with an insulating film comprising 40% to 60% by weight of refractory oxide and 30% to 2% by weight of insulating binder, on the basis of 20% to 80% liquid suspending medium.

10. As an article of manufacture, magnetic sheet metal coated with an insulating film comprising 40% to 60% by weight of aluminum oxide, and 2 to 30% by weight of inorganic insulating binder, on the basis of 20% to 80% liquid suspending medium.

ALBERT A. FREY.