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INSULATING COMPOSITION

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This invention relates to sheet metal provided with an electrically insulating coating.

The invention is especially adapted to the provision of ferrous metal sheet for electrical purposes, i. e., core plate for transformers, dynamos, and the like adapted to avoid or minimize eddy, or Foucault, currents, for which reason it will be described with particular reference thereto, although it will be understood that the coated material is useful for other purposes also.

It is not necessary that the insulating coating on core plate be of particularly high ohmic resistance or dielectric strength. For the best results it is desirable that the assembled sheets be spaced slightly from one another. Varnish has been used for coating the plate, but in general it has not been wholly satisfactory because varnish coatings are more or less easily destroyed. A more serious disadvantage arises from the fact that the users of these materials prefer that the insulating coating be applied to the core plate before it is punched, and that after punching it is necessary to anneal the sheet. Such annealing, commonly at temperatures from 1200° to 1400° or 1500° F., destroys these varnish coatings, thus making it necessary to revarnish the sheet before it is assembled in the apparatus.

To overcome these disadvantages it has been proposed to use inorganic coating materials of which sodium silicate is a common example. While these compositions are incombustible, experience has shown that after the sheets are reannealed such coatings are of rather poor adherence and are not satisfactorily resistant to abrasion and other influences which destroy or remove them. Consequently the coating may be rubbed off to a greater or less extent so that the elements assembled from the core plate do not resist eddy current formation with as high efficiency as is desirable.

In consequence of these and other factors there has been a demand in the electrical trade for an insulating coating which may be applied before the core plate is punched, which remains satisfactorily adherent after annealing, and which affords satisfactory resistance to eddy currents.

It is among the objects of this invention to provide a coating for metal, especially core plate, which is strongly adherent to the sheet and is abrasion resistant, affords the insulation resistance necessary for performance of core plate, may be evenly, simply and cheaply applied, is not expensive, is resistant to removal by water, oil and similar media, and whose adherence is not seriously affected by heating, as by annealing.

The invention is predicated on my discovery that the difficulties encountered heretofore in the art may be minimized or overcome, and the objects of the invention attained, by applying to the metal a coating of an inorganic insulating material and a special binder, namely, phosphoric acid, or a water soluble phosphate, and heating to effect production of a bonded, adherent, and abrasion resistant coating.

While I do not limit myself to this theory, I now believe that the heating causes the phosphoric acid or the phosphate, referred to hereinafter as the phosphoric acid radical of the binder, to react with the underlying metal with production of, for example, an iron phosphate, thus actually bonding the metallic base to the coating composition, whereby the coating becomes tightly and strongly bonded to the base. The heating not only bonds the coating together and to the base, but also causes it to be converted to a form which is resistant to abrasion and to removal or destruction by oil, water, mineral spirits, and similar liquids with which the core plate may come into contact in normal use, and thereafter the sheet may be annealed without destroying the coating or reducing its insulation value.

In the preferred practice of the invention the binder used in diammonium phosphate

$$([NH_4]_2HPO_4)$$

However, other binders of the class mentioned may be used, such as phosphoric acid (H_3PO_4), monoammonium phosphate ($NH_4H_2PO_4$), normal ammonium phosphate ($[NH_4]_3PO_4$, the corresponding sodium salts, mixed salts, such as sodium ammonium acid phosphate

$$(NaNH_4HPO_4),$$

and other soluble phosphates, of which a variety are known and available.

Various inorganic materials may be used in the practice of the invention, but suitably this portion of the composition comprises a pigment, most suitably one which likewise reacts with the binder during the heating step, and an inorganic diluent, or extender, which serves as a massing agent. The inorganic material is not only insulating, but also acts to produce a space effect which is desirable in core plate. That is, the aim of coating core plate is to prevent eddy currents, which are very low in magnitude, from forcing current through, or inducing current in, the assembled sheets. These inorganic materials act to space the sheets slightly from one another, and this space effect is of material assistance in prevent-

ing the eddy currents from causing current flow in the sheets.

I now prefer to use chromic oxide as the pigment, but the invention is not limited to that material, it being possible to use iron oxides, aluminum oxide, ultramarine blue, zinc oxide, lithopone, red lead, barytes, titanium oxide, manganese dioxide, and, generally speaking, any inorganic material of similar nature which will not be detrimentally affected by the temperature to which the coating is heated, or at which the sheet is subsequently annealed, and which will react with the phosphate to form a bonded coating, and which will likewise supply the insulating properties necessary in a core plate coating. From the wide variety of pigments which are thus available it will be seen that various colors can likewise be given to the coating.

China clay is an example of suitable extending material, or massing agent, although a variety of other materials having similar function is available, such as asbestine, silica, and other well-known inert fillers.

Generally it is desirable to add water to the composition to prepare it for application to the sheets; the amount of water used will depend upon the particular mode of applying the composition to the sheet. The composition may be applied by any convenient method which will produce a thin uniform film, for example, by rolls, by spraying, brushing, or wiping, or in other ways, as by the use of coating machines, such as the Barord coating machines. After the coating has been applied the coated sheet is then heated to effect drying to bring about the bonding reaction between the phosphate, the metallic base, and the pigment.

Exact proportions applicable to all of the binders referred to and the inorganic materials named can not, of course, be given, because these are susceptible of material variation, depending upon the particular requirements of the finished coating, and upon the particular ingredients. There should be, of course, sufficient inorganic material to supply the desired insulation resistance, and enough binder present to suitably bond the composition to the underlying base by reaction therewith and with the inorganic pigment with production of a strongly adherent and abrasion resistant coating which is capable of being subsequently heated without seriously affecting its adherence and insulating properties. As an example of a composition suitable for the coating of core plate, there may be used 10 parts by weight of chromic oxide, 10 parts by weight of china clay, 15 parts by weight of diammonium phosphate, and 25 parts by weight of water.

The compositions are compounded by simply mixing or grinding to secure solution of the phosphate and dispersion of the inorganic ingredients. Apparently no reaction occurs between the ingredients before the composition is baked on the core plate.

The exact temperature at which the sheet is baked will depend upon the particular binder used and also upon the length of exposure. In general the higher the temperature the more rapidly the bonding is effected. With the phosphate binders whose use characterizes the invention a temperature of 400° F. or higher is usually necessary to achieve the desired result. A composition made in accordance with the foregoing example may be baked satisfactorily by an exposure of about one minute at 750° F., but with this and other compositions a lower temperature can be used provided the sheet is exposed for a longer time. The same temperature will usually suffice when phosphoric acid is used as the binder, but as showing an influence which the particular binder exerts, sodium phosphates generally require a temperature of the order of 1200° F. if short baking times are desired.

The coatings thus produced are not only tightly adherent and resistant to abrasion and the liquids with which such core plate may normally come into contact, but also, and this is of material importance, such coated sheet may be annealed after punching without destroying the coating or causing it to flake off, and without reducing its insulation value. Thus, such sheet may be annealed at 1200° to 1400° or 1500° F. with complete satisfaction; the coating remains tightly adherent and satisfactorily resists the actions to which core plate is ordinarily exposed in handling and use.

The coating contains a pigment which can chemically combine with the phosphate binder, and it is usually desirable to have present an excess over the amount equivalent to the binder. The portion not acted upon thus acts with the extender to fill the voids between the reaction products, and is useful in providing a coating possessing continuous insulation resistance and in providing also the space factor desirable in core plate finishes.

Coated sheets as provided by the invention do not adhere one to another during annealing, Hence the invention is applicable to prevent sticking of sheet steel during annealing.

According to the provisions of the patent statutes, I have explained the principle and mode of practicing my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. That method of forming an insulating coating upon metallic sheet which comprises coating the sheet with a composition containing a binder selected from the group phosphoric acid and phosphates, and containing also chromic oxide, and heating the coated sheet to a temperature to cause reaction between said binder, said chromic oxide and the underlying sheet.

2. That method of forming an insulating coating upon core plate which comprises coating the plate with a composition containing a binder selected from the group phosphoric acid and phosphates, and containing also chromic oxide and china clay, and heating the coated plate to a temperature to cause reaction between said binder, said chromic oxide and the underlying plate.

3. That method of forming an insulating coating upon core plate which comprises coating the plate with a composition containing, by weight, 15 parts of diammonium phosphate, 10 parts of china clay, 10 parts of chromic oxide, and 25 parts of water, and heating the coated plate to a temperature to cause reaction between said phosphate, said chromic oxide and the underlying plate.

4. An insulated metallic sheet adapted for use in electrical apparatus comprising a sheet of ferrous metal having an uniform, adherent, and abrasion resisting coating formed by heating thereon a coating composition containing a

binder of the group phosphoric acid and phosphates, and also a solid insoluble inorganic insulating compound reactive with said binder under the influence of heat.

5. An insulated metallic sheet adapted for use in electrical apparatus comprising a sheet of ferrous metal having an uniform, adherent, and abrasion resisting coating formed by heating thereon a coating composition containing a binder of the group phosphoric acid and phosphates, and also a solid insoluble inorganic compound reactive with said binder under the influence of heat, and an inorganic massing agent.

6. An insulated metallic sheet adapted for use in electrical apparatus comprising a sheet of ferrous metal having an uniform, adherent, and abrasion resisting coating formed by heating thereon a coating composition containing a binder of the group phosphoric acid and phosphates, and also chromic oxide and an inorganic massing agent.

7. An insulated metallic sheet adapted for use in electrical apparatus comprising a sheet of ferrous metal having an uniform, adherent, and abrasion resisting coating formed by heating thereon a coating composition containing a binder of the group phosphoric acid and phosphates, and also chromic oxide and china clay.

8. A composition for coating metallic sheet comprising an aqueous solution of a binder selected from the group phosphoric acid and phosphates, chromic oxide, and an inorganic extender.

9. A composition for coating metallic sheet comprising, by weight, about 15 parts of diammonium phosphate, about 10 parts each of chromic oxide and china clay, and 25 parts of water.

10. That method of forming an insulating coating upon metallic sheet which comprises coating the sheet with a composition containing a binder selected from the group phosphoric acid and phosphates, and containing also a solid, insoluble inorganic compound of insulating character and reactive with said binder under the influence of heat, and heating the coated sheet and thereby bonding said coating tenaciously to the sheet.

11. That method of forming an insulating coating upon ferrous metal core plate which comprises coating the plate with a composition containing a binder selected from the group phosphoric acid and phosphates, and containing also a solid, insoluble inorganic compound of insulating character and reactive with said binder under the influence of heat, and an inorganic massing agent, and heating the coated plate and thereby bonding said coating tenaciously to the plate.

12. That method of forming an insulating coating upon metallic sheet which comprises coating the sheet with a composition containing a binder selected from the group phosphoric acid and phosphates, and containing also a solid, insoluble inorganic compound of insulating character and reactive with said binder under the influence of heat, and heating the coated sheet to a temperature to cause reaction between said binder, said inorganic compound and the underlying sheet and thereby bonding said coating tenaciously to the sheet.

13. That method of forming an insulating coating upon ferrous metal core plate which comprises coating the plate with a composition containing a binder selected from the group phosphoric acid and phosphates, and containing also a solid, insoluble inorganic compound of insulating character and reactive with said binder under the influence of heat, and an inorganic massing agent, and heating the coated plate to a temperature to cause reaction between said binder, said inorganic compound, and the underlying plate and thereby bonding said coating tenaciously to the plate.

14. That method of forming an insulating coating upon metallic sheet which comprises coating the sheet with a composition containing an aqueous solution of a binder selected from the group phosphoric acid and phosphates, and containing also a solid, insoluble inorganic compound of insulating character and reactive with said binder under the influence of heat, and heating the coated sheet to a temperature to cause reaction between said binder, said inorganic compound, and the underlying sheet and thereby bonding said coating tenaciously to the sheet.

15. That method of forming an insulating coating upon ferrous metal core plate which comprises coating the plate with a composition containing an aqueous solution of a binder selected from the group phosphoric acid and phosphates, and containing also a solid, insoluble inorganic compound of insulating character and reactive with said binder under the influence of heat, and an inorganic massing agent, and heating the coated plate to a temperature to cause reaction between said binder, said inorganic compound, and the underlying plate and thereby bonding said coating tenaciously to the plate.

16. A composition for coating metallic sheet comprising a binder selected from the group phosphoric acid and phosphates, and a solid, insoluble inorganic compound of insulating character reactive with said binder under the influence of heat.

17. A composition for coating metallic sheet comprising a binder selected from the group phosphoric acid and phosphates, a solid, insoluble inorganic compound of insulating character reactive with said binder under the influence of heat, and an inorganic massing agent.

18. A composition for coating metallic sheet comprising an aqueous solution of a binder selected from the group phosphoric acid and phosphates, a solid, insoluble inorganic compound of insulating character reactive with said binder under the influence of heat, and an inorganic massing agent.

CHARLES H. COOK.