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J. P. HAUGHNEY ET AL
EMULSION INSULATING VARNISH AND METHOD OF COATING
AN ASSEMBLY OF ELECTRICAL CONDUCTORS
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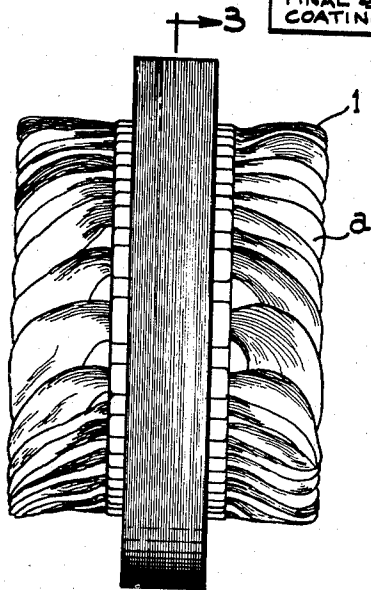
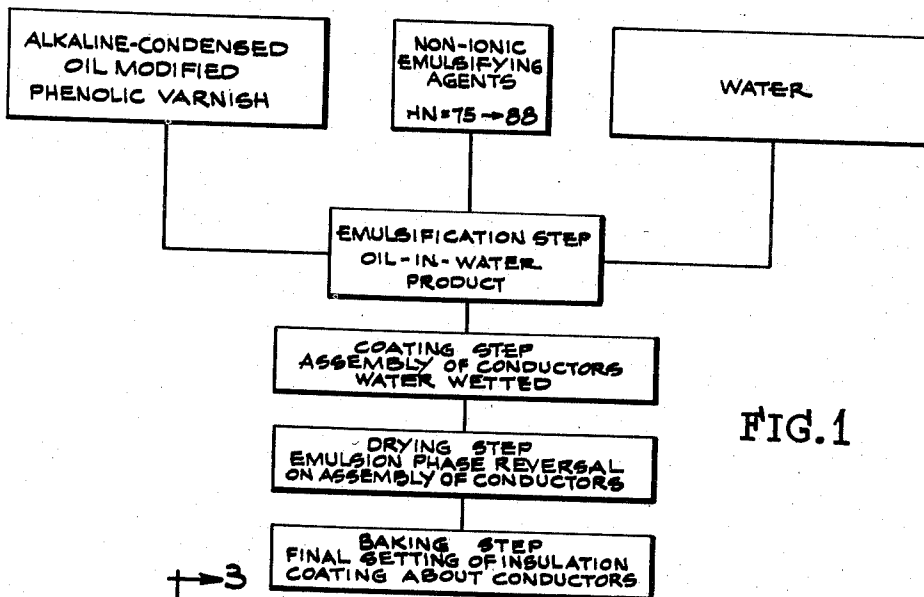


FIG. 2

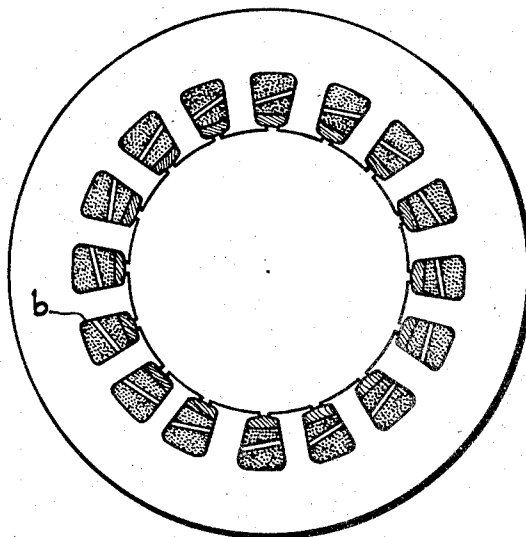
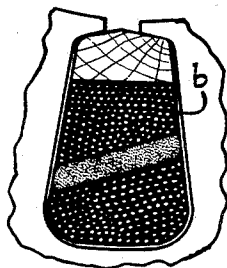


FIG. 3

FIG. 4



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EMULSION INSULATING VARNISH AND METHOD OF COATING AN ASSEMBLY OF ELECTRICAL CONDUCTORS

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4 Claims. (Cl. 117—232)

This invention is concerned with a novel method of coating an electrical conductor with a nonconductive coating and an article of manufacture resulting from the method.

More particularly, this invention is concerned with a method of insulating conductors which reduces to a point of practical elimination fire hazard heretofore inherent in application of liquid coatings to form insulation about an assembly of electrical conductors. Heretofore, fire hazard was constantly present in the manufacture of coils, stators, rotors, etc., in the operational step where nonconductive coatings are applied from solvent suspension to the assembly to prevent shorting in, and contribute strength to, corresponding electrical devices.

Tremendous losses in industrial fires have created a demand for such coating and method. Heretofore, all insulative coatings for similar use were confined to that class which were thinned with volatile hydrocarbon solvents for application; for example, toluene. Although a representative number of commercial laboratories were assigned the problem of overcoming fire hazard in this application, none were successful in producing an acceptable water-based, or water-thinned noncombustible insulator coating.

It is the primary object of this invention therefore, to provide a liquid coating composition capable of depositing a durable insulating solid film on and about an assembly of electrical conductors which material while in a liquid stator and in condition for application is noncombustible.

It is equally an objective of this invention to provide a noncombustible liquid coating which, when applied and heat-cured about a plural number of electrical conductors, will have satisfactory insulative quality for use in electrical equipment.

A further object of this invention is to provide an emulsion coating composition of the oil-in-water type which will be stable as to the emulsion for a period of time commensurate with that normal in the manufacture, shipping, storage and use of solvent reducible insulation coatings.

These and other objects of the invention will become further apparent as the description of the improved method and composition is developed in conjunction with the drawings.

Figure 1 is a flow sheet showing the general steps involved in the practice of the invention.

Figure 2 is a view of an electric motor stator showing the armature and windings with the rotor shaft removed.

Figure 3 is a sectional view of the stator along the line 3—3.

Figure 4 is an enlarged view of a fragmentary portion of an armature slot showing an assembly of conductors in place therein.

The coating of this invention is applied to an assembly of conductors as seen in Figure 2. The coating permeates in and about the windings 1. Exteriorly the windings are coated as about conductors 1 at *a* and interiorly in the windings as observed in Figures 3 and 4 at *b*.

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The following examples are generally selected as illustrative. However, they are representative merely and not uniquely demonstrative of the invention and are not to be construed as limitations upon the scope of the invention except in the light of correlative limiting comment.

EXAMPLE I

One mol of tertiary butyl phenol and one and a quarter mols of formaldehyde were condensed in the presence of 15 parts of caustic soda in 250 parts water at 140° F. for one hour. The syrup formed was neutralized with dilute HCl and the water decanted off. The residue was water washed twice and the resin heated to distill off residual volatiles present at 300° F. and room pressure. A brittle solid resin was recovered.

EXAMPLE II

Forty-five gallons of China-wood oil were heated 325° F. and 300 pounds of a resin similar to that described in Example I were cooked into the oil for a time of thirty minutes (to a long string) maintaining the temperature. The hot liquid was allowed to cool to 250° F. and thinned by addition of 120 pounds of high flash naphtha having a kauri-butanol number of 85. Four parts 24% lead naphthenate drier may be added at this time, or preferably just prior to use.

EXAMPLE III

Three hundred and eighty parts of a vehicle as illustrated by Example II, are weighed out into a mixing vessel equipped with a high speed agitator. Twenty parts of a nonionic emulsifying agent having a hydrophilic number of 88 (a polyoxyethylated nonyl phenol containing about 30 ethoxy (OCH₂CH₂) groups in the molecule sold under the trade name of Igepal CO-880) are stirred into the drying oil modified phenol-aldehyde resin varnish. One hundred parts of water are added, slowly with good agitation, over a five minute time interval. At the end of this first addition an oil-in-water emulsion results. An additional 100 parts of water may be added at a relatively rapid rate. After thorough mixing an additional 75 parts of water are stirred in to complete the emulsion. Other additives may be employed to accomplish specific objectives. For example, preservatives to ward off bacterial action may be incorporated in the emulsion system, foam preventatives, etc. Protective colloids are to be avoided, very small amounts are permissive and none desirable.

EXAMPLE IV

The stator of an electric motor of one-half horsepower size was immersed in the emulsion of Example III and moved by conveyor through the tank at such a rate that the unit was submerged for from five to ten minutes after being preheated to a temperature of 140° F. Thereafter, the unit was drained and air dried for an additional ten to twenty minutes before entering a drying zone at a temperature of 200° F. for one hour. Subsequently, the unit was heated to 275–300° F. six to eight hours to cure the insulation coating about the assembly of conductors provided by the non-volatile solids of the emulsion insulator vehicle. Upon testing the insulative quality of the coating it was found to exceed 1200 volts/mil in dielectric strength or quality.

As previously stated, the above examples are illustrative only. The invention contemplates a method of encapsulating an assembly of electrical conductors (motor stators and rotors, generator stators and rotors, transformers, etc.) by initially wetting the assembly with water. This is contrary to the prior art approach wherein the aim is to avoid moisture and other conductive matter. The water is the continuous phase of an oil-in-water emulsion wherein the disperse phase contains as the essential component a drying oil modified alkaline con-

densed phenol-aldehyde resin varnish. For optimum fire-retardant benefits, the amount of volatile hydrocarbon solvent should be kept at a minimum, due regard being given to ease of handling during emulsification. The presence of solvent is not essential, once the massive varnish phase is comminuted into microscopic disperse form. To provide adequate solvency the kauri-butanol number of the solvent should be kept at a value of at least 85 to insure proper resin solution therein.

After the assembly of conductors has been thoroughly water wetted, the electrical unit is allowed to dry. During drying, water, and solvent if any, evaporate and the elements of the conductor assembly become coated with the insulative varnish plus the emulsifier from the aqueous phase which is compatible with the organic insulative coating. Subsequently, the water, which may be residually held, and solvent is hastened in removal by a preliminary heating to about 200° F. It is also helpful, in some instances, to preheat the conductor assembly before application of the emulsified insulator varnish.

The heat-reactive varnish is then cured out by baking. The time and temperature of curing depend in part upon the phenolic resin, the nature of the drying oil modification, the size of the conductor assembly and other factors apparent to those familiar with the art. Illustratively, a transformer capable of being held in one hand is cured out in thirty minutes to two hours at 300° F. using a system similar to that described in the examples above.

By the above method, an insulated electrical conductor assembly is provided having good dielectric strength. Dielectric strengths of at least 1000 volts per mil are common. The insulation coating will normally contain the highest amount of phenol-aldehyde alkaline condensed resin soluble in oil that economics will allow. The coating is novel over prior art insulation coatings in that it contains a minimum of at least 3% by weight of the resin of a non-ionic surface active agent characterized by a hydrophilic number of from 65 to 90 or more. Larger quantities of non-ionic surfactant may be used, possibly as high as 20%, without seriously interfering with the dielectric quality or durability of the insulation.

A great number of variations may be made in the oil modified phenolic resin varnish or disperse oil phase as well as the aqueous phase. Further light upon these variations is set forth in the following paragraphs.

The disperse oil phase

The disperse phase of the emulsion insulator varnishes of interest to the present invention may be widely varied in composition, and the compositions generally are well known in the art of electrical conductor insulators. They may be identified as heat reactive drying oil modified alkaline condensed phenol-aldehyde varnishes.

The useful drying oils for modification of the phenol-aldehyde resins include the drying oils having an iodine number of at least 120 and may be of either isolate or conjugate double bond structure.

China-wood oil (tung oil) is a preferred oil for the present purpose. From a practical viewpoint cooking and handling of straight wood oil offers some control problems and it is expedient and common practice to dilute the wood oil with other oils less reactive in the varnish kettle. Use of 100% China-wood oil is not precluded, but it may be reduced in purity with oiticia oil, dehydrated castor oil, linseed oil, perilla oil, chia, soya sunflower and safflower seed oil and fish oils to name a few. By this means properties of application characteristics may be accommodated to specific application problems as is well known in the art.

The resin forming the oleoresinous varnish insulator is preferably an alkaline catalyzed, heat hardenable, oil reactive phenol aldehyde condensate wherein one mol of the selected phenol is condensed in the presence of from 1 to 1.5 mols of aldehyde in an aqueous reaction medium

containing from 10 to 20% of an alkaline catalyst. Caustic soda is useful. Other alkaline reacting substances may be substituted therefor. The temperature of condensation reaction may be varied from room temperature (6-8 days' reaction time) to 200° F. (15 minute reaction time) depending upon the alkaline catalyst and the production facilities available.

The final hardening of the phenol-aldehyde condensation may be accomplished by neutralizing (actually acidifying) the phenol-aldehyde condensate, removing water, water washing and distilling off water and other volatile substances at 300° F., more or less, until a brittle resin is formed.

The phenol commonly used is monohydric and is preferably alkyl substituted with, for example; methyl, ethyl, butyl, tertiary butyl groups, or it may be aryl substituted; for example, p-phenyl phenol is useful. Among other useful phenols are the cresols and xylenols, etc., as is well known in the art.

The aldehyde is most often formaldehyde, but acetaldehyde and other aldehydes have been used to produce a wide variety of permutations and combinations of oil reactive, heat-hardenable, alkaline catalyzed phenol-aldehyde resins useful in making oil modified phenolic varnishes suitable for use in electrical conductor insulation.

The oil modified varnish is produced by cooking the phenol-aldehyde resin into oil at temperature varying from 225° to about 350° F. For example, 325° F. for thirty minutes is often used.

Superior insulative varnishes are made from straight China-wood oil modified alkaline condensed phenol-aldehyde resins, but as previously indicated, may be further modified by reduction of the wood oil and replacement with other drying oils. It is also common practice and within the workable scope of this invention to reduce the phenolic resin, not only with oil content increase, but by inclusion of other resins including rosin, esters of rosin, terpene resins, hydrocarbon resins, gilsonite, etc. In the present application reduction of the phenolic resin with other resins should not exceed about 45% as a maximum.

For the present purposes, we also prefer not to deviate appreciably in oil length of the varnish from 10-15 gallon length vehicles. While 8-25 gallon length varnishes are useable, the longer oil lengths have objectionably slow cure and shorter length varnishes of the class described are difficult to control during manufacture. The oil length of a varnish is the number of gallons of oil used to modify 100 pounds of the resin component.

Generally, the higher the aldehyde to phenol ratio of the resin, the greater the quantity of drying oil or non-phenolic resin that may be included in the disperse phase of the compositions of interest.

The usual variety of volatile organic solvents may be a part of the above oil modified phenolic resins to produce varnishes for our present purposes. The solvent may be aromatic or aliphatic solvent and include diluent. Xylene and mineral spirits are illustrative. However, as the present product is aimed primarily at overcoming the fire hazard attendant in the coating operation with prior art compositions, the quantity of volatile solvent and its chemical nature should be at a minimum, never using an amount greater than 40% of the total varnish. In some instances, where flow considerations are minor, the entire absence of volatile organic solvent has not rendered the compositions as herein described inoperative in use. The presence or absence of solvent is a practical question of flow of the varnish, or viscosity, in regard to the ease of emulsification and the equipment for emulsification available. Obviously, the less solvent used the less the fire danger inherent in the product. The solvents should have a kauri-butanol number of at least 85 to insure solvency for the resins.

The above serves primarily as a review of the varnish

insulation field of the prior art and is intended, merely, as a foundation for the terms as used herein.

The aqueous phase

The major portion of the present aqueous phase is water and needs little consideration. Usual tap waters having some hardness have served the purpose without attendant difficulty. Distilled water is useful, but not essential. Contaminated waters are to be avoided for obvious reasons.

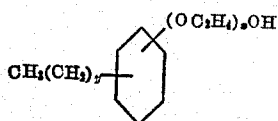
The sole essential component completely soluble in the aqueous phase is present in minor proportion ranging broadly from 3 to 20% and preferably comprises from 4 to 10% by weight of a non-ionic detergent having a hydrophilic number (HN) of from 65 to 90.

Three percent by weight of the disperse phase of non-ionic agent is a practical minimum, for when less than this quantity is used, phase inversion occurs. That is, the dispersed oil phase becomes the continuous phase and the water phase becomes the disperse phase. When this happens, the composition becomes unsuited to encapsulation of an assembly of electrical conductors including coils, stators, rotors, etc., to which use the present invention is presently of greatest importance. A quantity above 15% of surface active agent interferes with film quality, as well as causes unnecessary increase in cost of the composition. Four to five percent of an agent having an HN from 75 to 88 is quite satisfactory.

Another physical classification, referred to as the HLB or hydrophile-lipophile balance (see: Calculation of HLB Values of Non-Ionic Surfactants by William C. Griffin, Journal of the Society of Cosmetic Chemists, volume V, No. 4, December 1954), is applicable to definition and ranges in value from 13 to 18.

There is especial correlation between these identifying HN and HLB numbers when applied to polyoxyethylated non-ionic surfactants. The HN is closely related to the percentage of ethylene oxide present in the non-ionic agent when the nucleus thereof is an aryl phenol. Thus, those having HN's from 65 to 90 contain from 65 to 90% ethylene oxide groups by weight in the molecule. The HN is also related to HLB in accordance with the following: $HN = (HLB) \times 5$. The relation between the hydrophile number (HN) and hydrophile-lipophile balance (HLB) is also applicable to emulsifying agents other than those containing ethylene oxide units. For example, independent of the class of chemical structure of the emulsifier, if the requirement of the vehicle is, for example, an HLB of 10 or an HN of 50, then the best emulsifier of the class selected for that particular vehicle will be one having a value of 10 or 50 in accordance with the system of nomenclature used. However, though that particular emulsifier is best of its particular class, it may not necessarily be the best of all chemical classes having that particular HN number for the purpose. Emulsifying agents of the non-ionic class preferred in the present application are derived from treating alkyl phenols with low molecular weight alkylene oxides (e. g., ethyl and propylene oxide) to form polyoxyethylated (or propylated) alkyl phenols having molecular weights of at least 400.

The useful non-ionics of the preferred class may be illustrated structurally as follows:



Where

$x=10$ to 40

$y=6$ to 20

Molecular weight 400-2000

(The value of x determines the HN number of the surface active agent and is inherent in the HN designation.)

Of this group, those most commonly available are produced from octyl and nonyl phenol and sold under a variety of trade names. Mixtures of various ones of the polyoxyethylated non-ionic surfactants having HN's from 65 to 90 may also be used for the purposes of this invention.

While it is not an essential of this invention, one may also include minor amounts (less than 1% is satisfactory) of anionic surface active agents. The alkyl esters of succinic acid salts of which Aerosol OT is best known are exemplary in order to promote further the wetting of the metal of the electrical conductor by the aqueous phase. Successful coatings of electrical conductors can be accomplished, however, without use of anionic agents.

Minor amounts of other additives, for example, rust inhibitors including such materials as triethanolamine, minute traces of oxalic acid, etc., may be included to meet specific problems.

Protective colloids normally essential components of the aqueous phase of emulsion coating compositions are detrimental in the present combination and preferably should be avoided. This for the reason that dielectric quality of the final product is generally diminished by their presence. Thus, while agents of low HN numbers are operative with the usual varnish emulsions when a protective colloid is present, it is found possible to eliminate them for the present purposes when the HN number is above 65.

Thus, having illustrated the invention specifically by example and generally by physical metes and bounds description, what we claim is:

1. A method of insulating an assembly of electrical conductors which comprises initially wetting said assembly with the aqueous phase of an oil-in-water emulsion wherein the disperse oil phase comprises a liquid drying oil modified alkaline condensed phenol-aldehyde varnish, and the continuous phase comprises a major proportion of water and not less than 3%, based on the weight of said varnish solids, of a non-ionic surface active agent having a hydrophilic number of from 65 to 90, evaporating the volatile solvent and water to wet the conductor with the said resin and curing the said oil modified resin on and about the surface of said conductor assembly at an elevated temperature after having wetted the same with said resin.

2. A method of insulating an electrical conductor assembly which comprises wetting the surface thereof with the continuous phase of an oil-in-water emulsion the disperse phase of which comprises a 10-15 gallon length conjugated drying oil modified alkaline condensed phenol-aldehyde varnish containing not more than about 40% of volatile hydrocarbon solvent therefor, a continuous aqueous phase and a non-ionic surface active agent having a hydrophilic number of from 75 to 88 as the essential emulsifier present, evaporating the water to reverse the emulsion phase, wetting the conductor assembly with the dispersed oil phase, and curing the varnish-oil phase about the conductor to form an insulating coating having a dielectric strength of at least 1000 volts per mil.

3. The product of the process of claim 1.

4. The product of the process of claim 2.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,839,434

Joseph Paul Haughney et al.

June 17, 1958

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

Column 1, line 43, for "a liquid stator" read -- a liquid state --.

Signed and sealed this 9th day of September 1958.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents