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J. S. JOHNSON ET AL

2,669,601

INSULATED BUSHING

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Fig.1.

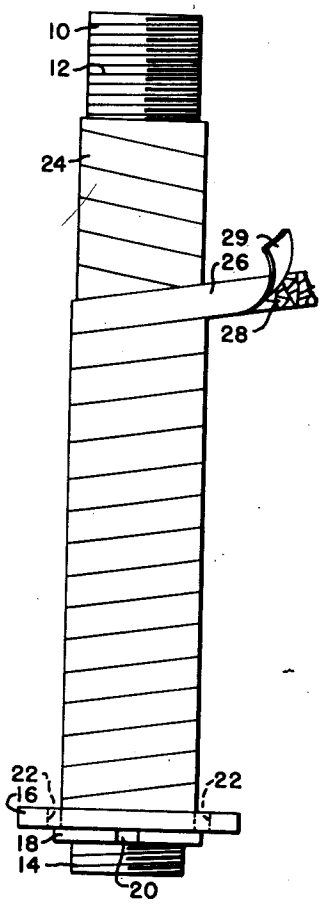
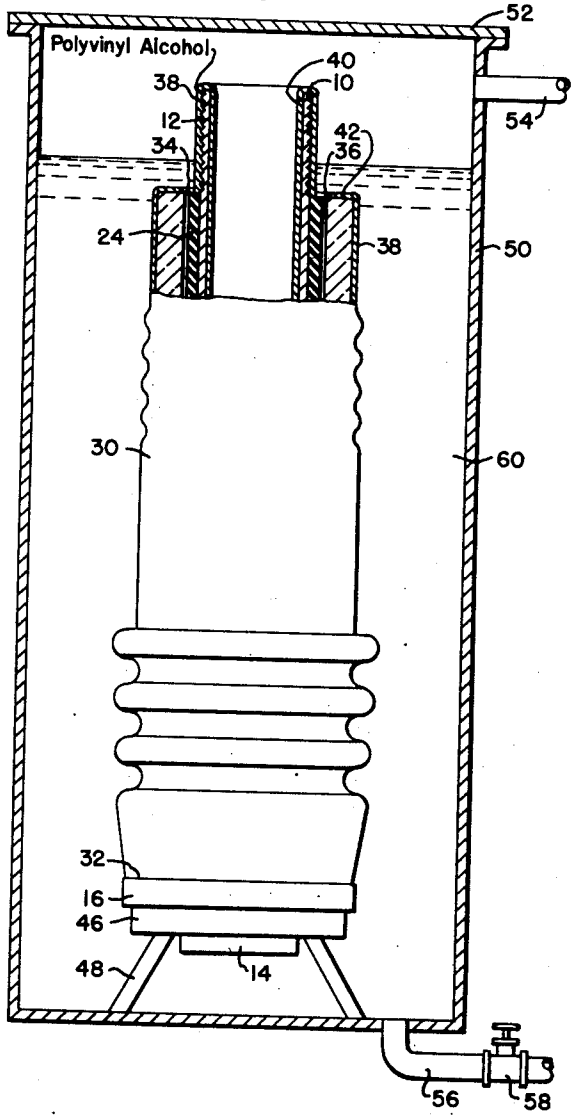


Fig.2.



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INSULATED BUSHING

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11 Claims. (Cl. 174—152)

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This invention relates to improved insulated bushings suitable for use with electrical currents having a high voltage and a high amperage.

At the present time the electrical industry employs large numbers of lead bushings in generators, switchgear and similar apparatus. For high voltage use the bushings are usually constructed with a central conducting stud and an exterior spaced porcelain sleeve sealed to the ends of the stud. The space between the porcelain sleeve and the stud is filled with oil in order to provide dielectric strength and to dissipate heat developed by the passage of electrical current through the stud. In many cases the space between the porcelain sleeve and the stud is partially filled with a wrapping of paper, but oil is necessary to insure proper operation of the bushings in service. The oil filling enables bushings to meet certain standards of impulse strength and withstand surges. Furthermore, it is necessary that bushings not generate radio interfering energy.

As the output of generators has gone up particularly with considerable increases in amperage, the size of oil-filled lead bushings must be increased correspondingly. The problem of providing an oil-tight seal between the ends of the porcelain sleeve and the stud becomes increasingly more difficult as the size of the bushing increases. This is due to the fact that during firing porcelain shrinks non-uniformly and erratic changes in dimensions occur, such changes increasing with size. Other disadvantages, such as fire hazard, cost and increased bulk of the apparatus, necessitated by the larger sized bushings has made it less and less desirable to use an oil-filled bushing. However, previous to the present invention, an oil-filled bushing construction was the only one known or available that would satisfactorily meet most requirements.

The object of the present invention is to provide an insulated electrical bushing of relatively small size that will handle electrical currents with adequate efficiency without the use of a liquid insulating medium.

A further object of the invention is to provide a bushing comprising a stud and a spaced porcelain sleeve in which the space is substantially completely filled with a mica tape and a solid thermoset resin.

A still further object of the invention is to provide a process for preparing a bushing in which the space between the porcelain sleeve and the stud is substantially completely filled with mica tape wrapping and a thermoset resin.

Other objects of the invention will in part be obvious, and will in part appear hereinafter.

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For a better understanding of the nature and objects of the invention, reference should be had to the following detailed description and drawing, in which:

Figure 1 is a view in elevation; and

Fig. 2 is a view in elevation, partly in section, showing the steps of preparing an insulated bushing in accordance with the invention.

We have discovered that highly efficient and unusually satisfactory electrical bushings capable of carrying a load that otherwise can only be safely carried by a much larger oil-filled bushing, may be prepared by filling the space between the conducting stud and a spaced porcelain sleeve thereon with a mica tape and a completely reactive thermosetting resin impregnant applied to the mica flakes.

In accordance with the present invention, the portion of the stud surrounded by the porcelain sleeve is wrapped with a mica tape or sheet in order to fill most of the space that would normally be present between the porcelain sleeve and the stud. The mica tape may be of any suitable width and may be applied in a sufficient number of layers to provide the required size or diameter to substantially fill the bore of the porcelain sleeve to be applied thereto. For most purposes, from 4 to 50 or more layers of mica tape, each layer of an average thickness of 7 to 10 mils, are sufficient.

It may be desirable to wrap one or more metallic condenser foils between the layers of mica tape to enable the potential stresses to be graded so that the insulation will function better in service.

For the purpose of the present invention, conventional mica tape materials are not suitable. Resin binders for mica flakes which have been employed heretofore, namely shellac, alkyd resins and asphalt, result in a tape that will not satisfactorily impregnate with the completely reactive resin compositions that have been found to produce satisfactory bushings. Any gas or air pockets in the mica tape will give rise to corona and be otherwise unsatisfactory. For the satisfactory practice of the present invention it is necessary to employ a mica tape in which the mica flakes are bonded to each other by a liquid binder. We have found particularly satisfactory a mica tape embodying a liquid resinous binder having a viscosity of 25 to 10,000 poises at 25° C. The binder may be composed entirely of one or more liquid resinous polymers having the desired viscosity, or it may be composed of a liquid mixture of a polymer and a liquid plasticizer, which mixture has the desired viscosity. The liquid resinous polymers are stable and relatively non-

volatile and non-depolymerizing at room temperature and at all operating temperatures of the bushings embodying them so that composite mica insulations prepared therewith may be handled, stored and used without significant loss or change in properties. Application Serial No. 161,231, filed May 10, 1950, and assigned to the assignee of the present invention, discloses liquid polymer binders and composite mica tapes prepared therewith suitable for use in practicing the present invention. Examples of such binders and tapes prepared therewith are set forth in the following table:

TABLE I

Polymer	Approximate Molecular Weight	Percent Bond in Tape
Polymethylmethacrylate	1,000	10.
Poly-α-methyl styrene	4,000	16.4.
Polystyrene	1,500	11.2.
Coumarone-indene	1,000	6.
Polyalphamethylstyrene	3,000	3 to 25.
Polymers of styrene and coumarone mixtures	6,000	8.

Reference should be had to that application, for example of other binders and methods of preparing mica tapes therewith.

Another suitable tape that may be employed in practicing the invention is one prepared with a binder composed of from 15% to 75% by weight of polystyrene of a molecular weight of between 30,000 and 250,000, and from 85% to 25% by weight of a plasticizer selected from the group consisting of liquid polycyclic hydrocarbons boiling above 270° C. and having a viscosity of from 0.5 to 5 poises at 25° C., selected from the group consisting of terphenyls hydrogenated at least 40%, monoamyl naphthalene, diamyl naphthalene and polyamyl naphthalene, and mixtures thereof. The hydrogenated terphenyl may be produced by pyrolitic decomposition of benzene as set forth in Patent No. 2,364,719, or it may be produced by reacting benzene and cyclohexyl bromide in the presence of aluminum chloride to produce dicyclohexyl benzene. A specific product that has been found satisfactory for the purpose of the invention is an isomeric mixture of ortho, meta, and para terphenyls hydrogenated approximately 55%, which mixture has a distillation range of from 345° C. to 425° C. and a viscosity of approximately 0.8 poise at 25° C.

Monoisoamyl naphthalene boiling in the range of 280° C. to 330° C., diamyl naphthalene boiling in the range of 330° C. to 365° C. and having a viscosity of 0.9 poise at 25° C., and polyamyl naphthalene boiling in the range of 355° C. to 400° C. and having a viscosity of 5.5 poises at 25° C., individually or in admixture may be employed in combination with polystyrene with satisfactory results. The following table sets forth the viscosities of a number of compositions produced in accordance with the invention.

TABLE II

Viscosity of various plasticized polystyrenes

Plasticizer	Plasticizer Content, Percent by wt.	Viscosity, poises at 25° C.		
		Polystyrene, M. W.=65,000	Polystyrene, M. W.=100,000	Polystyrene, M. W.=150,000
Hydrogenated Terphenyl—55%	75	5,220	9,500	19,000
Do	83.3	520	850	2,750
Polyamyl Naphthalene	83.3		75	
Do	75		600	
Do	50		5,000	

The mica tape to be employed in making bushings preferably has a backing comprising a sheet material to enable the mica flakes to be handled easier and wrapped more tightly about bushing studs. If desired, the mica flakes may be applied as a layer to the sheet backing, the liquid binder applied and then a top sheet superimposed to produce the strongest tapes.

The pliable sheet base material, for instance, may be rice paper or supercalendered rope paper or other paper. Such papers are available in thicknesses as low as of the order of 1 mil (0.001''). Furthermore, the sheet base material may comprise other materials such as glass fiber cloth, asbestos cloth, asbestos paper or cotton cloth. The asbestos paper may comprise ordinary milled asbestos admixed with small amounts of cellulosic fibers or it may be formed from asbestos that has been ball-milled to an extremely fine subdivision of the asbestos fibers, often called microfine asbestos. Synthetic resins either in the form of films or woven fabrics, such, for example, as nylon cloth or nylon film, may be employed as the sheet base material. Woven fabric from fibers prepared from linear polymethyleneterephthalate, or films from the same polymer are an excellent backing material. The preparation of these terephthalate polymers is set forth in Whinfield et al. U. S. Patent 2,465,319. Sheets of other synthetic resins, such as cellulose acetate butyrate or polyethylene may be employed as a base for the composite mica insulation. It is not necessary that both of the two base sheets applied on either side of the layer of the mica flakes be of the same material. Thus, the composite mica insulation may comprise a backing of paper and a superposed layer of asbestos paper, or asbestos and glass fiber fabric. Glass fiber cloth or asbestos paper may be employed respectively for the top and the bottom of the tape.

The mica flakes may be applied to the sheet backing by hand or in a conventional mica laying machine to any desired thickness of a layer thereof. Then the liquid resinous binder, preferably dissolved in a volatile solvent to provide a solution of a viscosity of about 10 poises and less, such solution having from 5% to 95% by weight of the polymer dissolved therein, is applied to the layer of the mica flakes in a quantity sufficient to wet them. The wetted layer of mica flakes is rolled to disperse the solution between the mica flakes and to distribute it uniformly and to wet the sheet base material. Additional layers of mica flakes may be applied and similarly wetted with the binder solution as required. A top sheet similar to the base or backing sheet may be applied, and the composite

sheet so produced rolled to insure good distribution of the solution of the binder. The sheet so produced is then heated to evaporate the volatile solvent, leaving only the liquid binder uniting the sheets and the mica flakes. If necessary, the sheet may be slit into suitable tape widths. The liquid binders have been found to wet the mica and to adhere to them to enable a relatively strong insulation to be secured. The composed insulation may be handled, cut, wrapped and processed without excessive separation or loss of the mica flakes. The liquid binders employed have been found not to impair the sheet backing material, such as paper, either in strength or in flexibility. The liquid binders will not evaporate or harden on storage.

Referring to Fig. 1 of the drawing, there is illustrated the step of applying the mica tape to a stud of an insulating bushing. The stud 10, composed of copper or other good conducting metal, is provided with threads 12 and 14 at its opposite ends. The copper metal forming stud 10 may inhibit polymerization of certain unsaturated compositions if left bare, so it is desirable to silver plate the stud or to coat it with a varnish such as a wire enamel, before processing it. At the one end, a collar 16 closely fitting the outside diameter of the bushing 10 is held in position by a spanner nut 18 with engageable slots 20 which nut is threadedly engaged with the thread 14. The collar 16 is adapted to fit closely one end of a porcelain sleeve to be employed with the stud 10. If required, threaded apertures 22 may be provided in the collar 16 for introducing a resin as will be set forth subsequently. Threaded caps (not shown) may be employed to close the apertures 22. A plurality of layers 24 of mica tape 26 are wrapped along the diameter of that portion of the stud to be enclosed by a subsequently applied porcelain sleeve. The tape 26 comprises mica flakes 28 and the sheet backing 29 united with the liquid binder as set forth hereinbefore.

After a sufficient number of layers 24 of the mica tape have been wrapped on the stud 10, the stud with the applied tape is heated and evacuated to remove gases and moisture therefrom in order to enable the impregnation of the tape with certain resinous compositions to be carried out to best advantage. Several alternative procedures are available in impregnating and assembling the bushing.

We have found that the procedure that appears most practical and has given very satisfactory results in service is the one illustrated in Fig. 2 of the drawing. In this preferred procedure a porcelain sleeve 30 is positioned upon the stud 10 with its wrapping 24 of mica tape. As illustrated, the lower end 32 of the porcelain sleeve 30 is in substantially liquid tight engagement with the collar 16. The threaded apertures 22 are not present or are capped in this procedure. If necessary a flexible gasket or the like may be interposed between the collar 16 and the lower end 32 of the bushing. The bushing 30 has an internal bore 34 slightly larger than the wrapping 24 of mica flakes, thereby providing a slight space 36 for clearance. The exposed surfaces of the assembly of the stud 10 and the porcelain sleeve 30 are coated with a readily removable protective material 38 to prevent the adhesion of subsequently applied resins to such threaded surfaces. As will be evident from Fig. 2 of the drawing, the protective material 38 is applied to the exterior portion of the porcelain sleeve 30, the threads 12 and 14 of the stud, the interior bore 40 of the stud, and the upper end 42 of the

porcelain sleeve. We have found that polyvinyl alcohol may be sprayed or brushed on the assembly to function as a protective compound. Numerous other strippable compounds may be applied, such, for example, as ethyl cellulose, cellulose acetate, asphalt and the like may be employed as a protective coating. Care should be taken, however, that none of the protective material 38 enters the space 36 or coats the bore 34 or the mica tape layer 24.

The partly assembled and coated bushing is placed upright on a supporting fixture 46 provided with legs 48, as shown in Fig. 2 of the drawing, disposed within a tank 50 provided with a sealable cover 52. Tank 50 is provided with a conduit 54 which may be connected to a suitable source of vacuum and a source of gas under pressure to enable the bushing assembly to be evacuated or otherwise treated. At the lower portion of the tank 50 is attached a conduit 56 provided with a valve 58 enabling an impregnating composition 60 to be introduced into a tank or to be withdrawn therefrom.

The bushing assembly shown in Fig. 2 of the drawing may have been previously heated in an oven to a temperature not exceeding 175° C., and preferably between 120° C. and 150° C., so as to drive off any moisture or volatiles from the mica tape wrapping 24. However, the tank 50 may be provided with a suitable heater for this purpose if desired. In either case after heating, and when placed within the tank 50, the bushing assembly is evacuated to an absolute pressure of not over 5 inches of mercury in order to withdraw any gases from the interstices of the wrapping 24. Thereafter a liquid completely reactive thermosettable resinous composition 60 is introduced through conduit 56 into the tank 50 to a level above the upper end 42 of the porcelain sleeve so that the composition 60 can enter the space 36. After the space 36 has been filled, a gas under pressure may be introduced through the conduit 54 to force the composition 60 into the wrapping 24 of the mica tape to substantially completely fill the voids and interstices thereof. Thereafter the composition 60 may be drained from the tank 50. The impregnated, partly assembled bushing may be heated in tank 50 or removed therefrom for heating in an oven to a temperature sufficient to cause the completely reactive composition to polymerize to a solid resin.

While a tape comprising mica flakes bonded with a liquid resinous binder gives excellent results in practicing the invention, we have found that mica flakes bonded with a volatile organic liquid may be employed successfully. Such volatile liquids form a temporary bond that holds the mica flakes and the backing together as a tape to enable the tape to be wrapped on the stud. Once wrapped, there is no need for a binder in the tape and it is permitted to evaporate either naturally or during heating. Examples of suitable organic liquids of a non-resinous nature are amyl naphthalene, benzene, toluene, xylene, ethyl lactate, butanol and higher alcohols, and naphtha. In preparing a tape, mica flakes laid on a sheet of paper are sprayed with the organic liquid and immediately wound into a tape roll while so wetted. The tape roll is put into a can or other vapor-tight container to prevent escape of the organic liquid binder. When required for taping a stud, a roll of tape is removed from the container and promptly wrapped on the stud. The tape is surprisingly strong and holds together well. Once the temporary organic liquid binder

is removed from the wound tape by heating and evacuation, impregnation with a completely reactive resin composition is easily effected.

Completely-reactive compositions suitable for use in the process may include any fluid polymerizable composition, ordinarily with a catalyst, that, upon being heated to a predetermined temperature, polymerizes entirely into a thermoset, relatively-hard resinous body. The fluid resinous composition may comprise a single polymerizable monomeric component such, for example, as diallyl phthalate, diallyl succinate, diallyl maleate, diallyl adipate, allyl alcohol, methallyl acrylate, diallyl ether, allyl acrylate, and allyl crotonate. It will be noted that such monomeric components comprise at least two unsaturated groups

$$>C=C<$$

capable of vinyl-type addition polymerization. Good results have been secured with only one monomer as well as mixtures of monomers containing two or more of these unsaturated groups capable of polymerization upon being subjected to heat. It will be understood that mixtures of any two or more of the polymerizable monomers, one having only a single >C=C< group and the other monomer two or more of such groups, for example, a mixture of 95% monostyrene and 5% of divinyl benzene, may be employed.

Numerous other completely-reactive multicomponent polymerizable compositions are known to the art. Such compositions include, in many cases, an unsaturated resinous component—particularly an unsaturated polyester resin—and an unsaturated polymerizable liquid monomer. Particularly good results have been secured by employing as the polyester resin the reaction product of an ethylenic dicarboxylic acid or anhydride thereof such, for example, as maleic acid, fumaric acid, maleic anhydride, monochloromaleic acid, itaconic acid, itaconic anhydride, citraconic acid and citraconic anhydride. The unsaturated dicarboxylic acid or anhydride or mixtures thereof are reacted with a substantially molar equivalent of a polyhydric alcohol such as ethylene glycol, glycerol, propylene glycol, diethylene glycol, or pentaerythritol or mixtures thereof. Castor oil has been employed successfully in reactions with maleic anhydride, and the resultant castor oil maleate ester admixed with a polymerizable unsaturated monomer, for example, monostyrene, in the proportions of from 10 to 95 parts by weight of the monostyrene and from 90 to 5 parts by weight of the ester. In the preparation of the unsaturated alkyd esters, an ethylenically unsaturated alpha-beta dicarboxylic acid or anhydride may be replaced with up to 95% of the weight thereof by a saturated aliphatic dicarboxylic acid or aryl dicarboxylic acid or anhydride, such, for example, as succinic acid, adipic acid, sebacic acid, phthalic acid, phthalic anhydride or the like. Also, mixtures of polyhydric alcohols may be employed. In some instances, epoxides have been employed in lieu of glycols, particularly in reactions with dicarboxylic acids instead of their anhydrides.

The unsaturated alkyd esters may be dissolved in a liquid unsaturated monomer having the group $H_2C=C<$. Suitable liquid unsaturated polymerizable monomers are: monostyrene, alphamethylstyrene, 2,4-dichlorostyrene, paramethyl styrene, vinyl acetate, methyl methacrylate, ethyl acrylate, diallyl phthalate, diallyl succinate, diallyl maleate, allyl alcohol, methallyl alcohol, acrylonitrile, methyl vinyl ketone, diallyl ether, vinylidene chloride, butyl methacrylate, allyl acrylate, allyl crotonate, 1,3-chloroprene, and divinyl benzene, as well as mixtures of two or more of any of these monomers.

An excellent completely reactive composition is one composed of a solution in from 90 to 50 parts of arylalkene polymerizable liquid monomer, such as monostyrene, of from 10 to 50 parts by weight of the alkyd reaction products of (A) an unsaturated acidic compound from the group consisting of maleic acid, maleic anhydride, fumaric acid, citroconic acid and citroconic anhydride in admixture with one or more saturated straight chain dicarboxylic acids having the carboxyl groups disposed at the end of the straight chain, the chain having from 2 to 10 non-carboxyl carbon atoms and not other reactive groups, and (B) a molar equivalent within +10% of an aliphatic saturated glycol having no other reactive group than the hydroxyl groups. The proportion of the unsaturated acidic compound in the (A) mixture of acids should be between 5% and 50% of the weight of the mixture. Suitable saturated dicarboxylic acids are adipic acid, sebacic acid, azelaic acid, suberic acid, succinic acid, decamethylene dicarboxylic acid and diglycolic acid and mixtures thereof. With the longer chain saturated dicarboxylic acids, as, for example, sebacic acid, the proportion of maleic anhydride, for example, may be higher than if the saturated acid were all succinic acid, to produce ultimate cured products of similar degrees of hardness. Examples of suitable (B) glycols for reaction with (A) the mixture of saturated and unsaturated acids are ethylene glycol, propylene glycol, diethylene glycol, 1,5-pentanediol and triethylene glycol. Mixtures of the glycols are suitable for producing the reaction product. The reaction of the (A) acidic compounds and (B) the glycols may be carried out by heating in a reaction vessel at temperatures of from 100° C. to 250° C. for from 24 hours to 2 hours to a low acid number of below 60.

The following are specific examples of the preparation of the unsaturated alkyd reaction products to be dissolved in the vinyl aryl monomer:

Example I

A mixture of 44 mole percent of adipic acid and 6 mole percent of fumaric acid was combined with 50 mole percent of propylene glycol and reacted with CO_2 sparging for about 4 hours at 140° C. in a closed reaction vessel after which the temperature was raised to 220° C. over a 4-hour period and the reaction was continued at 220° C. for 8 hours. A syrupy polyester resin was produced.

Another composition comprised the reaction product of 10 mole percent of maleic anhydride, 40 mole percent of adipic acid, and 50 mole percent of diethylene glycol.

Example II

A reaction product was prepared by reacting 30 mole percent of sebacic acid, 20 mole percent of maleic anhydride, and 50 mole percent of diethylene glycol under the same conditions as in Example I with a syrupy resin of low acid number resulting.

The unsaturated esters or alkyd resins of these two examples so prepared are dissolved in a monomeric compound having the group $H_2C=C<$, such as monostyrene or a simple substitution derivative of monostyrene, or a mixture of two or more monomers, as above described, to produce low viscosity, completely reactive solutions having

present from 10% to 50% by weight of the unsaturated ester. Particularly good results have been obtained by dissolving the unsaturated esters in monostyrene to produce solutions containing from 35% to 85% by weight of monostyrene and the balance, 65% to 15% by weight, composed of the unsaturated esters. Such solutions are solvent reactive compositions that will polymerize completely upon heating in the presence of one or more vinyl-type polymerization catalysts, such as benzoyl peroxide, lauroyl peroxide, methyl ethyl ketone peroxide, t-butyl hydroperoxide, ascaridol, tert-butyl perbenzoate, di-t-butyl diperphthalate, ozonides, peracids and similar catalysts, in an amount of from 0.1% to 2% and more, by weight. The proportion of the catalysts obviously may be present in amounts differing from these percentages. Accelerators such as metallic driers, for example, cobalt naphthenate; tin salts such as tin chloride; or azomethine or polyamine promoters, as set forth in Patent 2,450,552, may be added in small amounts not exceeding 2%, to the compositions.

After the completely reactive composition impregnated into the space **36** of the bushing assembly shown in Fig. 2 of the drawing has been polymerized, it will be found that the mica tape wrapping **24** and the space is filled with the solid thermoset resin. Thereafter the strippable protective coating **38** may be readily removed by immersing the bushing assembly in a suitable solvent for the composition. The thermoset composition will not be affected by conventional solvents. The bushing assembly may be thereafter completed by screwing on a suitable collar at the threaded portion **12** to abut the upper end **42** of the porcelain sleeve **30**.

An alternative procedure for impregnating the mica tape wrapping **24** and to fill the space **36** with thermoset resin that has been found to be advantageous is as follows: A porcelain sleeve **30** is slipped over the wrapping **24** until the lower end **32** of the bushing tightly abuts the collar **16**. Then a second collar similar to **16** is applied to the other end of the stud **10** and threadedly engaged with the threads **12** of the stud **10** so as to seal the upper end **42** of the bushing. The assembled bushing can then be heated, and evacuated through the threaded aperture **22** in the collar **16**. The completely reactive composition, such as **60**, may then be poured in through one of the apertures **22** to fill the space **36**. Vacuum may be applied to the other aperture **22** while the resin composition is being introduced, and when the space **36** is full, external pressure may be applied through the aperture **22** to force the composition into the interstices of the tape wrapping **24**. The bushing can then be heat treated to a temperature sufficient to polymerize completely reactive composition. It will be noted that this procedure does not require the application of the strippable protective composition **38**. This procedure is particularly advantageous for extremely large bushings which are difficult to handle and impregnate according to the procedure illustrated in Fig. 2 of the drawing.

Another procedural modification that has been found suitable is to subject the mica tape wrapped stud **10** of Fig. 1, without applying the porcelain sleeve thereto, to successive heating, evacuation and resin impregnation steps. The mica tape layer **24** will be saturated with the liquid completely reactive composition. The mica tape layer is then wrapped with a layer of an impervious sheet material, such as a polyvinyl alcohol sheeting, polytetrafluoroethylene tape or synthetic rubber. This tape wrapping prevents the loss or exudation of the liquid composition. The stud with this last-mentioned impervious wrapping is then placed in an oven and baked for a period of time sufficient to polymerize the thermosettable composition. Then the impervious sheet wrapping may be stripped. Ordinarily the mica tape wrapping in this latter expedient is applied in a quantity to approximate very closely to the dimensions of the bore **34** of the sleeve **30** to be applied thereover. When the sleeve **30** is slipped onto the stud, very little air space is present. In order to fit the bore of the porcelain sleeve the polymerized resin impregnated mica tape wrapped may be machined by turning in a lathe or grinding to size. It is not necessary that the space be filled, though it may be desirable to introduce a small amount of the liquid composition after the porcelain sleeve **30** has been put into place and to heat the bushing again to polymerize this small quantity of subsequently applied composition.

Suitable temperatures for curing the completely reactive compositions may be as low as 70° C. and as high as 150° C., or slightly more. Heating for one hour at from 80° C. to 100° C., followed by heating for several hours at a temperature of 125° C., will cure the reactive compositions of Examples I and II. The composition may be heated in any suitable manner including the use of a high frequency field.

Bushings constructed in accordance with the present invention will withstand much higher temperatures in use than is possible in oil-filled bushings employed at the present time. The electrical properties of the impregnated mica tape wrapping of the present invention reduces the possibility of corona taking place even at the highest operating voltages. Thus, bushings of a rating of 23 kilovolts and higher showed no corona on full voltage tests when constructed as disclosed herein. We have been able to greatly reduce the size of a bushing by employing the impregnated mica tape wrapping disclosed herein in place of the conventional oil-filled structures previously required. The bushings of the present invention avoid the problem of oil leaks and the like which have been a disadvantage heretofore. Furthermore, the use of an oil often results in the formation of sludges and the like that impair the functioning of the prior art bushings. The bushings of the present invention do not deteriorate in service due to temperature, atmospheric oxidation or other service conditions.

Since certain obvious changes may be made in the above procedure and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description and drawing shall be taken in connection with the accompanying claims and not in a limiting sense.

We claim as our invention:

1. A bushing comprising, in combination, a stud, an insulating porcelain sleeve of a lesser length than the stud and disposed about the outside of the stud, a space being present along the full length between the porcelain sleeve and the stud, a wrapping of a tape applied to the stud to substantially fill the space for the entire length of the porcelain sleeve, the tape comprising mica flakes and a sheet backing, and a body of thermoset resin filling the entire space and solidly impregnating the tape whereby no voids are present between the stud and the porcelain sleeve, the resin comprising essentially the product derived

by polymerizing a completely reactive, thermosettable composition comprising a liquid monomeric compound having the group $H_2C=C<$.

2. A bushing comprising, in combination, a stud, an insulating porcelain sleeve of a lesser length than the stud and disposed about the outside of the stud, a space being present along the full length between the porcelain sleeve and the stud, a wrapping of a tape applied to the stud to substantially fill the space for the entire length of the porcelain sleeve, the tape comprising mica flakes and a sheet backing, and a body of thermoset resin filling the entire space and solidly impregnating the tape whereby no voids are present between the stud and the porcelain sleeve, the resin comprising essentially the product derived by polymerizing a completely reactive, thermosettable composition comprising a liquid monomeric compound having the group $H_2C=C<$ and an unsaturated polyester dissolved in the liquid monomeric compound, the polyester having $>C=C<$ groups reactive with the monomeric compound to form an addition polymer therewith.

3. A bushing comprising, in combination, a stud, an insulating porcelain sleeve of a lesser length than the stud and disposed about the outside of the stud, a space being present along the full length between the porcelain sleeve and the stud, a wrapping of a tape applied to the stud to substantially fill the space for the entire length of the porcelain sleeve, the tape comprising mica flakes and a sheet backing, and a body of thermoset resin filling the entire space and solidly impregnating the tape whereby no voids are present between the stud and the porcelain sleeve, the resin comprising essentially the product derived by polymerizing a completely reactive, thermosettable composition comprising a liquid monomeric liquid arylalkene compound having an $H_2C=C<$ group and an unsaturated polyester dissolved in the liquid monomeric compound, the polyester having $>C=C<$ groups reactive with the arylalkene monomer to form an addition polymer therewith.

4. A bushing comprising, in combination, a stud, an insulating porcelain sleeve of a lesser length than the stud and disposed about the outside of the stud, a space being present along the full length between the porcelain sleeve and the stud, a wrapping of a tape applied to the stud to substantially fill the space for the full length of the porcelain sleeve, the tape comprising mica flakes and a sheet backing, and a body of thermoset resin filling the entire space and solidly impregnating the tape whereby no voids are present between the stud and the porcelain sleeve, the resin comprising essentially the product derived by polymerizing a completely reactive liquid polymerizable composition consists of (*a*) from 50% to 90% by weight of at least one monomeric arylalkene compound and (*b*) from 50% to 10% by weight of an unsaturated polyester derived by reacting by heating (A) a mixture of from 95% to 50% by weight of saturated acidic compounds and from 5% to 50% by weight of ethylenically unsaturated acidic compounds, the saturated acidic compounds composed of straight chain dicarboxylic acids having the carboxyl groups at the ends of the chains, the chains having from 2 to 10 carbon atoms, and no other reactive groups than the carboxyl groups, and the unsaturated acidic compounds being selected from the group consisting of alpha, beta-ethylenically unsaturated dicarboxylic acids and anhydrides thereof, and (B) a molar equivalent within ±10% of the mixture of acidic compounds of an aliphatic saturated glycol having no other reactive groups than the hydroxyl groups.

5. A bushing comprising, in combination, a stud, an insulating porcelain sleeve of a lesser length than the stud and disposed about the outside of the stud, a space being present along the full length between the porcelain sleeve and the stud, a wrapping of a tape applied to the stud to substantially fill the space for the entire length of the porcelain sleeve, the tape comprising mica flakes and a sheet backing, and a body of thermoset resin filling the entire space and solidly impregnating the tape whereby no voids are present between the stud and the porcelain sleeve, the resin comprising essentially the product derived by polymerizing a completely reactive liquid polymerizable composition consists of (*a*) from 50% to 90% by weight of monostyrene and (*b*) from 50% to 10% by weight of the polyester reaction product derived by heating from 6 to 10 mole percent of an acidic compound selected from the group consisting of fumaric acid and maleic anhydride, from 44 to 40 mole percent of adipic acid and 50 mole percent of propylene glycol.

6. A bushing comprising, in combination, a stud, an insulating porcelain sleeve of a lesser length than the stud and disposed about the outside of the stud, a space being present along the full length between the porcelain sleeve and the stud, a wrapping of a tape applied to the stud to substantially fill the space for the entire length of the porcelain sleeve, the tape comprising mica flakes and a sheet backing, and a body of thermoset resin filling the entire space and solidly impregnating the tape whereby no voids are present between the stud and the porcelain sleeve, the resin comprising essentially the product derived by polymerizing a completely reactive liquid polymerizable composition consists of (*a*) from 50% to 90% by weight of monostyrene and (*b*) from 50% to 10% by weight of the polyester reaction product derived by heating from 25 to 35 mole percent of sebacic acid, from 15 to 25 mole percent of maleic anhydride and 50 mole percent of propylene glycol.

7. A bushing comprising, in combination, a stud, an insulating porcelain sleeve shorter than the stud, the porcelain sleeve disposed about the stud, a space being present between the stud and the porcelain sleeve, a wrapping of mica tape applied to the portion of the stud embraced by the porcelain sleeve to substantially fill the major portion of said space for the entire length of the porcelain sleeve, the mica tape comprising mica flake and a sheet backing, and a thermoset resin solidly impregnating the mica tape wrapping whereby no voids are present in the tape wrapping, the thermoset resin comprising essentially the product derived by polymerizing a compound having at least two $>C=C<$ groups capable of addition polymerization.

8. In the process of preparing a bushing comprising a stud and a bored porcelain sleeve shorter than the stud to be applied about the stud with a space between the stud and the bore of the porcelain sleeve, the steps comprising wrapping with a mica tape that portion of the stud about which the porcelain sleeve is to be applied, the mica tape comprising a fibrous sheet backing, a layer of mica flakes applied to the sheet backing and a liquid binder uniting the mica flakes and the backing, the mica tape wrapping being thick enough substantially to fill the space between

the sleeve and the stud heating the stud and applied mica tape wrapping to a temperature not exceeding 175° C., evacuating the stud and applied mica tape wrapping to remove volatiles, impregnating the evacuated wrapping with a liquid, completely reactive, thermosettable composition comprising a monomeric compound having the group $H_2C=C<$, the liquid composition penetrating readily through the mica tape and filling all the interstices thereof, wrapping the impregnated mica tape with a flexible sheet of a material impervious to the fluid composition, applying heat to the stud with said last-mentioned wrapping thereon in order to polymerize the composition to a thermoset solid, thereafter removing the last-mentioned wrapping of impervious material, machining, if necessary, the solidly impregnated mica tape wrapping to a size smaller than the bore of the porcelain sleeve, placing the porcelain sleeve over the stud with its impregnated mica tape wrapping, thereafter filling the space between the wrapped stud and the porcelain sleeve with the liquid thermosettable composition and polymerizing the composition to a solid.

9. In the process of preparing a bushing comprising a stud and a bored procelain sleeve shorter than the stud to be applied about the stud with a space between the stud and the bore of the porcelain sleeve, the steps comprising wrapping with a mica tape that portion of the stud about which the porcelain sleeve is to be applied, the mica tape comprising a fibrous sheet backing, a layer of mica flakes applied to the sheet backing and a liquid binder uniting the mica flakes and the backing, the mica tape wrapping being thick enough to nearly fill the space between the sleeve and the stud, placing the porcelain sleeve about the stud with a collar attached to one end of the stud fitting against one end of the porcelain sleeve to provide a liquid tight seal therewith and to position the porcelain sleeve, the assembly of stud, collar and the porcelain sleeve forming an annular cavity within which is disposed the mica tape wrapping, the annular cavity having an opening at the end of the porcelain sleeve removed from the collar, heating the assembly to a temperature not in excess of 175° C., evacuating the assembly, introducing into the evacuated annular cavity a liquid, completely reactive thermosettable composition comprising a monomeric compound having the group $H_2C=C<$, the composition filling the cavity and impregnating the interstices of the mica tape wrapping, and heating the applied composition to thermoset it to a solid substantially completely filling the annular space between the porcelain sleeve and the stud, the porcelain sleeve, mica tape and thermoset composition cooperating to produce the electrical insulation for the bushing.

10. In the process of preparing a bushing comprising a stud and a bored porcelain sleeve shorter than the stud to be applied about the stud with a space between the stud and the bore of the porcelain sleeve, the steps comprising wrapping with a mica tape that portion of the stud about which the porcelain sleeve is to be applied, the mica tape comprising a fibrous sheet backing, a layer of mica flakes applied to the sheet backing and a liquid binder uniting the mica flakes and the backing, the mica tape wrapping being thick enough to nearly fill the space between the sleeve and the stud, placing the porcelain sleeve about the stud with a collar attached to one end of the stud fitting against one end of the porcelain sleeve to provide a liquid tight seal and to position the porcelain sleeve, the assembly of stud, collar and the porcelain sleeve forming an annular cavity within which is disposed the mica tape wrapping, the annular cavity having an opening at the end of the porcelain sleeve removed from the collar, applying a coating of a readily removable protective material to the portions of the assembly other than the annular cavity to prevent adhesive of subsequently applied resins to the protected portions, heating the assembly to a temperature not in excess of 175° C., evacuating the assembly, immersing the assembly into a body of a liquid resinous composition, completely filling the annular space between the porcelain and the stud, polymerizing the resinous composition, and removing the readily removable material from the assembly, the porcelain sleeve, mica tape and thermoset composition cooperating to produce the electrical insulation for the bushing.

11. In the process of preparing a bushing comprising a stud and a bored porcelain sleeve shorter than the stud to be applied about the stud with a space between the stud and the bore of the porcelain sleeve, the steps comprising wrapping with a mica tape that portion of the stud about which the porcelain sleeve is to be applied, the mica tape comprising a fibrous sheet backing, a layer of mica flakes applied to the sheet backing and a liquid binder uniting the mica flakes and the backing, the mica tape wrapping being thick enough to nearly fill the space between the sleeve and the stud, placing the porcelain sleeve about the stud with a collar attached to one end of the stud fitting against one end of the porcelain sleeve to provide a liquid tight seal and to position the porcelain sleeve, applying another collar member at the other end of the stud to provide a liquid tight seal against the other end of the porcelain sleeve, the assembly of collars, stud and porcelain sleeve defining an annular cavity between the porcelain sleeve and the stud, one of the collars having an opening therethrough leading to the annular cavity, heating and evacuating the assembly, introducing through the opening in the collar into the annular cavity a liquid completely introducing into the evacuated annular cavity a liquid, completely reactive thermosettable composition comprising a monomeric compound having the group $H_2C=C<$, the composition filling the cavity and impregnating the interstices of the mica tape wrapping, and heating the applied composition to thermoset it to a solid substantially completely filling the annular space between the porcelain and the stud.

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