METHOD OF SEALING A MAGNETIC CORE

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FIG. 1

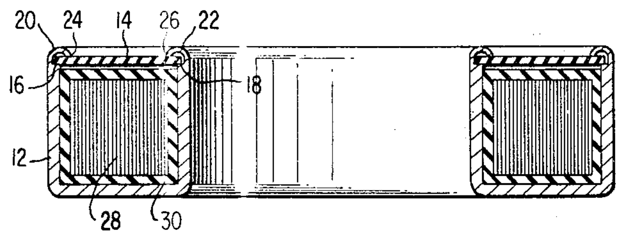


FIG. 2

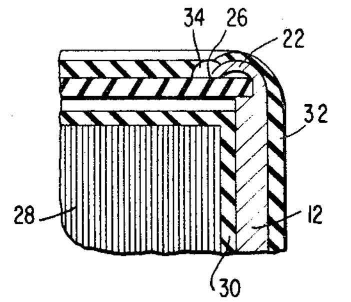


FIG. 3

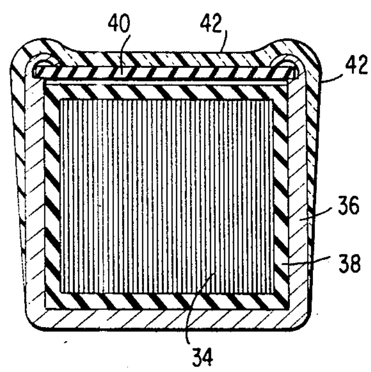


FIG. 4

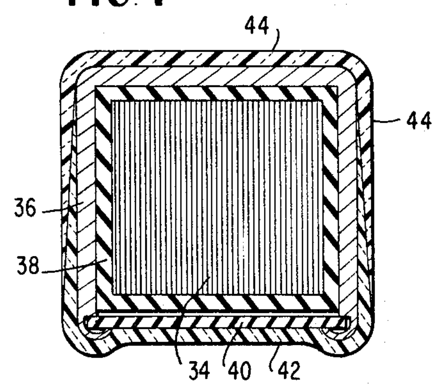


FIG. 5

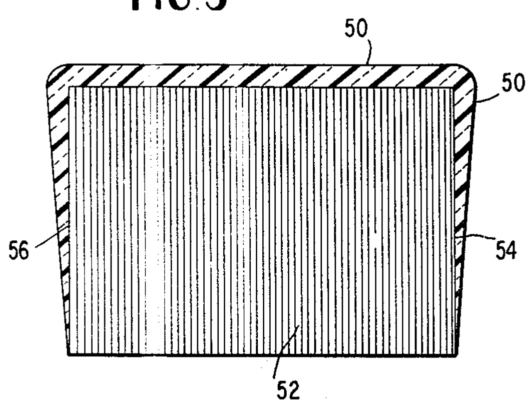
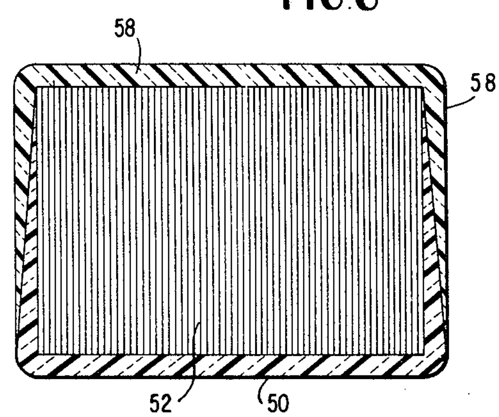


FIG. 6



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METHOD OF SEALING A MAGNETIC CORE

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U.S. Cl. 117—234 6 Claims

ABSTRACT OF THE DISCLOSURE

An electrical insulating material combining resin and a solid particulate filler to obtain thixotropic properties providing more uniform coating coverage in particular at product corner surfaces. In a specific embodiment, the material provides a resilient, matte-finish for non-slip application of coil windings. The electrical insulation material is prepared with a volatile liquid vehicle for spray-on application. In a method for sealing and insulating magnetic cores, the cores are heated above about 225° F. but not above about 425° F. to expand gases within the cores and/or within core encasements and permit gas escape before sealing. Sealing is completed while the magnetic core, and encasement if any, are at an elevated temperature. Curing of the coating is carried out by heating.

This invention is concerned with electrical insulation, magnetic cores and magnetic core manufacture.

Proper electrical insulation of magnetic cores, such as cores for saturable reactors and the like, prior to coil winding, has been a difficult problem and limiting factor in usage of special purpose cores. Uses for these cores are found in environments where it is increasingly difficult to prevent voltage breakdown between the windings and the core, or the metallic enclosure for the core. For example, coil windings in some applications carry in excess of 3000 volts and the wound core is required to operate under varying temperature conditions from minus 100° F. to 450° F. and higher. At such high temperature and high coil winding potentials, the difficulty is providing adequate voltage breakdown protection with a thin enough coating so that core measurements are not substantially changed and coil winding area is not substantially decreased.

In the past, spray-on enamels, and the like, for both boxed and unboxed cores have not provided consistent results. Further, it has been necessary to add polyester paints and other insulators in an attempt to obtain desired voltage breakdown protection. These coatings are not able to withstand temperatures in the 425° to 450° F. range without cracking and breakdown.

Fluidized coating of boxed cores, described in the patent to Goethe et al. #3,148,346, requires relatively high capital investment for equipment and has a number of inherent difficulties. These include holding the core during dipping, recoating steps to cover grip points, and a requirement for heavy coating thickness in order to obtain reasonable voltage breakdown protection. Further, fluidized coatings produce a hard finish which does not provide the desired support for coil windings. Neither the paint methods of prior practice nor the fluidized coating method provide adequate corner protection without increasing the average coating thickness such that loss of substantial coil winding space results.

It is an object of the present invention to provide electrically insulating coating for magnetic cores which can provide in excess of 3000 volt breakdown protection, can be applied using liquid spray techniques, is tough enough to resist pressures exerted by winding heavy copper wire on the core and still not crack, chip, or peel, provides a non-slip, resilient matte-finish for ease of handling and toroidal winding and exhibits good adhesion properties without brittleness. In addition the electrical insulating material of the present invention provides good edge coverage without excessive build-up of coating thickness on core flat surfaces, provides desired voltage breakdown protection from minus 100° F. and below to above 450° F. without physical or electrical degradation, is impervious to common solvents, acid, and alkali solutions, and is capable of sealing a core to prevent entrance of potting compounds and varnishes during vacuum impregnation.

Prior art coatings have a hard, glossy finish which do not effectively hold the coil windings within desired sectors. For example, when attempting to make coil windings in a 90° arc of a toroidal core, the windings spread out easily to a greater arc because of slippage on the hard, glossy finish. Also, while coatings of the prior art are adequate for flat surfaces they do not maintain coating thickness on corners as required. Corner coverage with these coatings is usually less than 50% of the coating thickness on the flat surfaces of the core.

An important contribution of the present invention for overcoming these problems has been development of a coating material exhibiting high thixotropic properties which permit economical spray-on techniques while at the same time providing product corner coverage of a thickness approaching that of the product flat surface coverage. The desired thixotropic properties are developed by a selection of a solid particulate material which is carried in colloidal suspension in the spray-on insulating material. This solid particulate material, in developing desired thixotropic properties, contributes to the formation of a matte-finish whch provides for non-slip winding of coil windings. Also, because of these properties, corner coverage provided is at least 80% of the average coating thickness on flat surfaces of a product.

The solid particulate material, referred to herein as a filler, should be inert, electrically insulating, temperature stable to at least 500° F., and have a particle size which develops desired thixotropic properties. One such suitable filler is silica i.e. substantially pure silicondioxide, amorphous in structure, with a particle size less than .02 micron in diameter or cross-sectional length.

In addition to carrying a solid filler as described above, provision is made for carrying pigmentation to color an insulating coating for coding, core identification, and appearance purposes. The invention teaches the use of a solid, pulverized, inorganic pigment which is temperature stable to 500° F. or higher. By temperature stable here is meant that the pigment remains solid and has color retention, i.e. does not oxidize at temperatures below 500° F. Examples of suitable pigments are molybdate orange and mercadmium red.

Selection of a suitable base for the solid filler and pigment is an important teaching of the invention. The base must be a fluid and temperature stable to about 500° F. Suitable synthetic resins include silicones, alkyds, epoxies, and silicone-modified alkyds and epoxies. Silicones or silicone modified high temperature resins are preferred because of the likelihood of silicone contamination of external surfaces of a boxed core. With silicones or silicone-modified resins, silicone contamination on a product does not inhibit bonding.

The fluid resin, pigment, and filler are mixed with a volatile liquid, such as aromatic hydrocarbons in proportions providing suitable viscosity for spraying. A high boiling point solvent should be included in the vehicle for carrying out the method of the invention. A boiling point for the solvent between about 225° F. and about 300° F. is preferred in order to prevent drying of the material on the heated product before proper flow of the coating.

A specific embodiment of a coating compound in accordance with the teachings of the invention includes the following percentages by weight:

	Percent
Silicone-fortified epoxy resin	About 30
Silica filler	About 5
Molybdate orange pigment	About 20
Xylol thinner	About 45

The mixture should have a viscosity within the range of 200–500 centipoises when measured immediately after thorough agitation of the mixture.

In further explanation of the invention, reference will be had to the accompanying drawings wherein

FIG. 1 is a sectional view of a boxed core,

FIG. 2 is an expanded sectional view of a portion of a boxed core showing the effects of gas expansion on electrical insulation applied in accordance with the prior art,

FIG. 3 is a sectional view of a portion of a boxed core sealed in accordance with the present invention,

FIG. 4 shows a cross-sectional view of a boxed core insulated in accordance with the present invention,

FIG. 5 shows a cross-sectional view of an unboxed core partially sealed in accordance with the present invention, and

FIG. 6 shows sectional view of a portion of the core of FIG. 5 sealed in accordance with the teachings of the present invention.

The boxed core of FIG. 1 includes a trough-like, nonmagnetic, metallic container **12** which can be toroidal, rectangular, or other configuration. The open end of the trough-like container **12** is covered with closure means **14** resting on shelf means **16** and **18**. Closure means **14** is held to the trough-like container **12**, for example by deforming portions of the container **20** and **22**, i.e. by folding over lip portions of the metal. Where closure means **14** meets trough-like container **12** an external juncture is formed at **24** and **26** between these two portions of the core encasement.

Within the encasement shown, a tape-wound magnetic core **28** is supported by cushioning material **30**.

FIG. 2 shows an expanded portion of a core, such as that shown in FIG. 1, at the juncture line **26** of that core. To the core of FIG. 1, an insulating coating **32**, applied in accordance with the prior art, has been added. Typical bubble or pinhole formation in the coating of prior art cores is shown at **34** above juncture **26**. Such bubbles or pinholes are formed during curing of the prior art cores, when the cores are subjected to a higher curing temperature than that existing at the time of coating the cores. They are caused primarily by expanding gas escaping along a juncture line between the closure means of the metallic container. Similar defects occur due to expanding gas from interstitial portions of unboxed cores. The result of such defects is a non-sealed or poorly sealed core for vacuum impregnation purposes and also a likely shorting path for voltage breakdown between coil windings and the magnetic core or its metallic enclosure.

FIG. 3 is a sectional view of a portion of a core in a rigid container. Core **34** is formed by placing electrically insulated magnetic sheet material in overlapping contact. The core is placed within non-magnetic metallic container **36** and is supported by cushioning material **38**. Closure means **40** covers the open end of container **36** to provide a rigid encasement for core **34**.

In carrying out the teachings of the invention the encased core is heated above about 225° F. but not higher than about 425° F. In a specific embodiment of the invention, the core is heated to a temperature such that a temperature of 275°, plus or minus 5°, is maintained at the time of subsequent coating and curing. Heating of the uncoated boxed core expands gases within the core box permitting escape of gases before the first seal coating has begun to solidify.

While the core is in a heated condition, as described above, junctures between closure means **40** and metallic container **36** on the exterior of the encasement are coated by spraying on electrical insulating material.

In practice, the electrical insulating material is sprayed on in a batch operation providing high volume production. The cores are positioned closure end up on spraying trays and the upper surface of the core is sprayed with electrical insulating material **42**. While in this position inner and outer diameters of the metallic container can also be sprayed. Normally the upper corners, and the inner and outer diameters are coated as shown in FIG. 3.

After spraying the cores are returned to an oven for partial curing, i.e. solidification of the spray coating **42** at a temperature above about 225° F. but not significantly higher than the temperature of the core when sprayed. By this is meant not heating to a temperature such that a sufficiently high pressure would result internally causing bubble or pinhole formation in the coating. Solidification of the sprayed-on coating seals the cores and the sealed cores are held in the above temperature range for approximately one-half hour after which the sealer coat will have cured sufficiently to prevent escape of any expandable gases within the container. The core is then raised to a temperature of about 300° F. to insure that the sealer coat is properly cured to withstand subsequent heating and cooling cycles.

The cores are turned after removal from a 300° F. oven and the remainder of the boxed core is sprayed with coating **44**, as shown in FIG. 4. This coating is solidified as described above. Plural coating can be applied with intermediate partial curing of previous coatings.

After all coatings are applied to the cores, the cores are returned to an oven between 425° F. and 500° F. for about one-half hour. This is the final hardening cure which bonds all coats together and prevents softening of the coatings if the part is heated to elevated temperatures during use.

Referring to FIG. 5, the coating of unboxed cores is similar to the coating of boxed cores except that sealing on a plurality of surfaces is required. Coating **50** applied to unboxed core **52** seals the interstitial openings at the upper end of the core between edge portions of the magnetic material and covers corner surfaces at the upper end of the core. At the same time, coating **50** can be extended to inner diameter **54** and outer diameter **56**. In a preferred embodiment, coating **50** is applied in a plurality of layers with intermediate partial curing of each layer as previously described. After partial curing of coating **50** the cores are turned. The cores are heated to a temperature above about 225° F. but less than about 425° F. This expands any gases between the insulated magnetic material and permits these gases to escape. While in this heated condition the core is sprayed with coating layer **58** and cured at a temperature of the core when applying layer **58**. Additional coats may also be applied by separate sprayings with intermediate curing, depending on the desired final coating thickness. The coating is cured at a final curing temperature between 425° F. and 500° F. for the purposes previously mentioned.

Whereas prior coating methods such as the fluidized coating method normally require coating thicknesses of .015 inch or greater, the present invention provides voltage breakdown protection in excess of 1000 volt potential with a coating thickness no greater than .007 to .010 inch.

In coating unboxed tape wound cores, the tape of the core should be wound tightly with a quality weld holding the inner and outer lap to the remainder of the core.

With the preheating temperatures and curing described above escape of gases from interstitial portions of a core will be avoided during the application of the coating. Curing of the coating, prevents any later escape of gases.

A single coating layer of the above-described insulation material of an average thickness of .004 inch will provide voltage breakdown protection of at least 500 volts.

The teachings of the invention are also applicable to applying voltage breakdown protection to other than tape wound cores such as powder metal cores. The procedures for preheating of the core and curing of the coatings described above are followed in coating such cores so that expandable gases from interstitial portions of the core do not impair the properties of the finish.

The use of silicone resins or other high temperature silicone-modified resins in the electrical insulating material described above provides better adherence to external surfaces of the core box materials which are ordinarily contaminated with silicone prior to the time of coating.

In preparing the electrical insulating material the fluid resin, pulverized pigment and sub-micron size filler are mixed with a vehicle, typically an aromatic hydrocarbon. A high boiling point solvent is included in the vehicle for spraying heated products in order to avoid drying of the spray-on material before proper coverage is obtained. The thixotropic properties provided by the filler maintain corner coverage without the running of the coating prior to curing experienced with prior art coatings. After curing, the material can have, by weight, about 5–8% filler, about 35–40% pigment, and the balance resin.

Other products and other materials than those specifically described above can be used in carrying the method of the invention in the light of the above teachings; for example one of the conventional coatings set forth earlier can be applied to a product after sealing as taught above. Therefore in determining the scope of the present invention reference will be had to the appended claims.

What is claimed is:

1. Method for sealing a magnetic core prior to winding coil windings on the core comprising the steps of

heating the magnetic core above about 225° F. but not higher than about 425° F. to cause expansion and escape of interstitial core gases, then

spraying an electrical insulating material in liquid form on the magnetic core while the magnetic core is above 225° F. but not higher than about 425° F., and

solidifying the electrical insulating material to seal the magnetic core by heating the magnetic core above about 225° F. but not significantly higher than the temperature of the magnetic core at the time of spraying.

2. The process of claim **1** in which the electrical insulating material is prepared in liquid form by mixing a fluid resin, which is temperature stable to 500° F. and a solid, particulate, inorganic filler, which remains solid at about 500° F., with a volatile liquid vehicle.

3. The process of claim **1** including the step of applying an additional electrical insulating coating to external surfaces of the sealed core.

4. The process of claim **2** including a final curing step in which the magnetic core is heated to a temperature between about 425° F. and about 500° F.

5. The method of claim **1** in which the electrical insulating material is prepared by mixing the following percentage weights:

about 30% fluid resin which is temperature stable to about 500° F.,

about 20% pulverized solid pigment which is temperature stable to about 500° F.,

about 5% filler comprising essentially silicon dioxide with a cross-sectional particle size of about .02 micron, and

the balance volatile liquid carrier including a solvent having a boiling point above about 200° F. but not higher than about 300° F.

6. The process of claim **1** including spraying a plurality of coats of the electrical insulating material to external surfaces of the magnetic core with intermediate partial curing of each coating at a temperature above about 225° F. but not higher than about 300° F. and, after completing spraying of the plurality of coats, curing the electrical insulating material between about 425° F. and about 500° F.

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U.S. Cl. X.R

29—602; 117—75, 104, 132, 213