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3,822,147

**INSULATED ELECTRICAL CONDUCTOR AND COILS FORMED THEREOF**

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16 Claims

**ABSTRACT OF THE DISCLOSURE**

A metal conductor coated with multiple layers of a cured polyaromatic, polycarboxylic aromatic imide resin and a cured phenoxy resin. The layers are superposed and may be arranged so as to provide an inner layer of imide resin and an outer layer of phenoxy resin, an inner layer of phenoxy resin and an outer layer of imide resin, or both inner and outer layers of imide resin with a mediate layer of phenoxy resin sandwiched therebetween. Magnet wire made in accordance with the invention has special utility in oil-filled transformers.

**BACKGROUND OF THE INVENTION**

**Field of the Invention**

This invention relates to an improved insulated conductor and more specifically to an improved magnet wire which has special utility in the form of coils for oil-filled transformers.

**DESCRIPTION OF THE PRIOR ART**

Magnet wire comprising a metal conductor coated with a layer of a cured polyaromatic, polycarboxylic aromatic imide resin has heretofore been proposed. A layer of such a resin has been proposed as an outer layer on a magnet wire having a base insulation comprising a thermoset polyester, i.e., U.S. Pat. No. 3,022,200 entitled "Magnet Wire and Method of Making the Same" dated Feb. 20, 1962, and a magnet wire having a base insulation comprising an epoxy resin, i.e., U.S. Pat. No. 3,528,852 entitled "Dual-Coated Electrical Conductor" dated Sept. 15, 1970. Additionally, a resin of the same type has been proposed as a base insulation material under a layer of epoxy resin and an outer layer over a base insulation of oleo resinous or acrylic resin material.

In the design of oil-filled transformers, great demands are placed upon the type and quality of insulation materials. Because of the nature of this application, the insulating material must be compatible with oil and possess excellent hydrolytic stability. Presently, oil-filled transformers utilize magnet wire insulated with single layers of Formvar, epoxy or acrylic resin materials.

Today's transformers are being subjected to frequent overload conditions and sudden overvoltage line surges placing more demands upon the insulation of the magnet wire used. Recent market analyses have shown that it is not uncommon for transformers to be operated as much as 100% above their rated loadings, for example, a 25 kva. transformer during peak loading could be distributing as much as 50 kva. While the normal operating temperatures of these transformers was considered to be about 120° C., the temperatures of these transformers during peak requirements have been estimate to be as high as from about 160 to about 180° C.

Under these conditions, the physical properties of the insulation as evidenced by the resistance to deformation under high temperatures and pressures and the resistance to "crazing" and the chemical stability of the insulation, particularly its resistance to hydrolysis, and the electrical properties of the insulation, are required to be improved. Formvar, epoxy and acrylic insulations have a limited

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resistance to deformation under heat and pressure, thus resulting in continued danger of shorts between neighboring conductors. Formvar insulations also tend to easily darken and discolor the oil of the transformer when exposed to moderately high temperatures. Epoxy insulating materials have traditionally been plagued by their relatively poor physical properties as evidenced by "crazing" which reduces their dielectric integrity. Two types of crazing occur. One type of crazing can be caused by selective solvents that craze the film when the film is wet. Another and more serious type of crazing is so-called "dry crazing" that exists in film when manufactured. Severely crazed insulation provides questionable insulation under high impulse voltages such as that encountered during lightning surges. Acrylic resins are relatively poor insulating materials at room temperature and the electrical losses are significant at higher temperatures.

As an electrical conductor, aluminum is more economical than copper at today's metal prices. However, aluminum, be it E.C. grade or the so-called "alloys," is inherently softer than copper and has a low tensile strength compared to copper. This means that an aluminum conductor can be more easily stretched and can be more severely damaged during the winding of coils. This cannot help but cause more severe "hot spots" in aluminum windings and requires still better turn insulation to compensate for this phenomenon.

For these reasons, it is desirable to produce an improved magnet wire for use in oil-filled transformers.

**SUMMARY OF THE INVENTION**

It is therefore the primary object of this invention to provide an improved magnet wire.

Another object of this invention is to provide an insulation system which does not craze and has improved resistance to deformation under heat and pressure and improved electrical properties.

Another object of this invention is to provide an improved insulation system comprising a layer of a cured polyaromatic polycarboxylic aromatic imide resin and a layer of a cured phenoxy resin.

Another object of this invention is to provide an improved magnet wire which is useful in oil-filled transformers and which is competitive in cost to similar magnet wires insulated with Formvar resins.

Yet another object of this invention is to provide a coil of an improved magnet wire comprising a conductor coated with a layer of a cured polyaromatic, polycarboxylic aromatic imide resin and a layer of a cured phenoxy resin.

A further object of this invention is to provide an improved magnet wire for use in oil-filled transformers having multiple layers of resinous insulation materials which can be applied in one continuous operation by conventional methods and baked and cured at the same conditions without any layer of insulation suffering from degradation.

In the broader aspects of this invention, there is provided an improved insulated metal conductor having a layer of a cured polyaromatic, polycarboxylic aromatic imide resin and a layer of a cured phenoxy resin. The phenoxy resin can be applied as the inner layer, the outer layer or sandwiched between an inner layer and an outer layer, both of a polyaromatic, polycarboxylic aromatic imide resin. The invention also includes coils formed of magnet wire of the invention and an oil-filled transformer having as a part thereof such a coil.

**DESCRIPTION OF THE PREFERRED EMBODIMENT**

The magnet wire of the invention comprises a metal conductor coated with a layer of a cured polyaromatic,