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INSULATED ELECTRICAL CONDUCTOR

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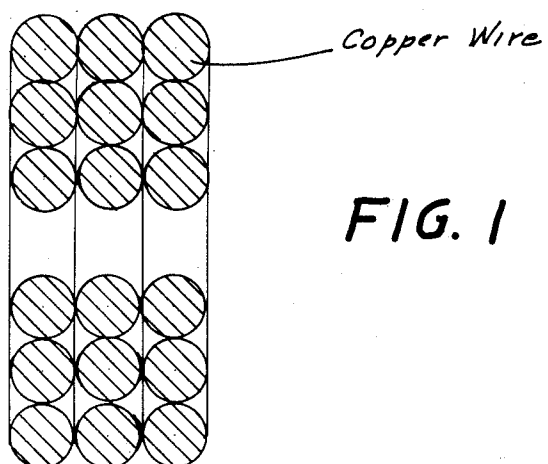


FIG. 1

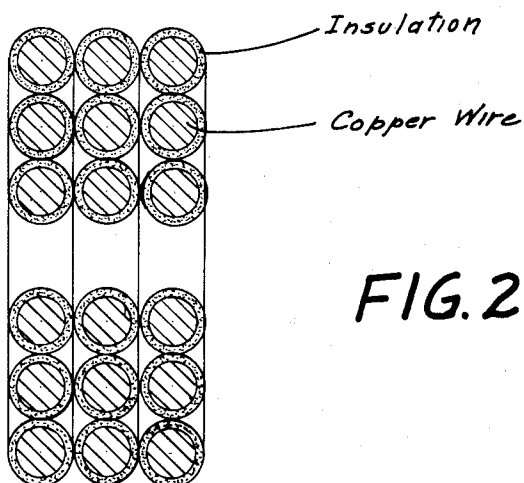


FIG. 2

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INSULATED ELECTRICAL CONDUCTOR

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8 Claims. (Cl. 148—6.3)

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This invention relates to insulated electrical conductors and improved processes for their production.

There are many known methods for insulating electrical conductors, such as extrusion of a coating of rubber, application of a coating of lacquer, and winding a layer of cotton, silk or other fibrous material about the conductor. Conductors thus insulated may be wound into coils or in other forms with the adjacent turns of the conductor being insulated by means of the insulating coating. It has been very difficult to reduce the minimum volume occupied by the insulation in wound coils, because of the inherent thickness of insulation produced by the processes mentioned above. For low voltage applications, enameled wire is generally used but the thickness of the enamel coating is not less than .0005", resulting in a tremendous factor of over design since the average enamel will stand several hundred volts per mil thickness without electrical breakdown, and this is not required for low voltage applications.

A further disadvantage of prior insulation has been the temperature limitation since the flexible insulation conventionally applied to wires cannot be operated above temperatures in the order of 100–125° C. at best. Flexible ceramic insulation has been applied to conductors for operation at temperatures up to 200° C., but the insulated wire thus produced is quite expensive and, again, the minimum thickness is often excessive when the operating voltage differential is low.

A further disadvantage has been the difficulty in coating unclean copper wire with insulation. The copper oxide film usually present on copper wire does not adhere to the copper to any great extent. Thus, while the insulation may adhere to the oxide film, it does not adhere firmly to the wire itself and will not withstand severe flexing. In some cases, the insulation will not adhere to oxide film.

It is an object of this invention to overcome the foregoing and related disadvantages. A further object is to produce a novel electrically insulated corrosion resistant conductor. A still further object is to produce thin flexible insulating coatings upon electrical conductors wound in coil form. A further object is to produce an improved insulated copper wire. Additional objects will become apparent from the following description and claims.

These objects are attained in accordance with the invention wherein there is produced a metal

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element protected by an adherent coating of a formed in situ metal phthalocyanine. In a more restricted sense this invention is concerned with a copper conductor insulated with a coating of copper phthalocyanine formed in situ, of thickness less than about .0005 inch. In one of its limited embodiments this invention is concerned with a Nichrome alloy conductor insulated with a coating of formed in situ nickel and chromium phthalocyanines. The invention is also concerned with processes for producing the insulated conductors mentioned above.

According to our invention we have found that novel insulating layers may be produced on metal surfaces by controlled reaction of the metal with an intermediate chemical which will react with the metal to form the phthalocyanine salt of the metal. While copper and other metal phthalocyanines are well known in the art, they have been produced en masse, in large particle sizes or in thick layers which possess very poor physical properties. They do not adhere to metal surfaces and the layers or particles per se are fragile and brittle. For these and other reasons the metal phthalocyanines have not to date been used as electrical materials.

According to our invention we form extremely thin, flexible and coherent metal phthalocyanine layers upon conductors by reacting the surface of the conductor with the vapors of a compound selected from the class containing phthalonitrile, phthalimide and substituted derivatives of these compounds, at a temperature between about 200° C. and 500° C.

The volume of the metal phthalocyanine formed on the metal surface is greater than the metal per se, since the density of the salt is less than that of the parent metal, and it would be expected that the coating should flake off. However, we have found that the layers formed in accordance with the invention are adherent and form a strong bond with the metal. The volume increase is sufficient however, to force the wires apart to an extent which makes possible entry of the vapors of the reactant material into the concealed portions, such as the interior of a coiled wire. A further advantage of the invention resides in the fact that the layers of the invention may be formed upon copper and other metal surfaces even though they are contaminated with an oxide film. Likewise a chloride film does not inhibit or prevent the reaction from proceeding smoothly and rapidly.

We have found that the coating produced in accordance with the invention will withstand

up to 150 volts without breakdown even though the thickness is less than about .0005" and generally less than about .0002". We have made the surprising discovery, as mentioned above, that our process is applicable to not only exposed surfaces but also to the inner or concealed surfaces of the conductor within coils and other conductor assemblies made with bare wire. A wound coil treated in accordance with the invention will be insulated between turns throughout its entire assembly even though it was originally wound with bare wire. This represents a tremendous improvement over prior insulation techniques, particularly for low voltage applications. For example, Litz wire may be produced simply and readily by insulating stranded bare conductors.

The metal conductors which may be insulated in accordance with the invention may be any which will form the metal phthalocyanine under the conditions specified heretofore. Among these metals are copper, tin, iron, lead, aluminum, magnesium, manganese, chromium, zinc and alloys thereof. The surface of these metals is preferably clean and, if possible, free from the oxides, since more adherent coatings are obtained on clean surfaces. The conductor may be in the form of a wire, a stranded wire, bar, plate, sheet, film or any other shape.

The process is adapted to batch and continuous operation with equally satisfactory results and possesses the further advantage that the reaction time required to produce even the maximum thickness of layer is very short.

Suitable chemical reagents for the process are phthalonitrile, phthalimide and other compounds such as the various ortho-cyano-benzonitriles which will react with metals in the vapor state. According to our process these intermediates are vaporized and held at a temperature between 200-500° C. and preferably between 300-400° C. In most cases the vapor is superheated, that is, heated above the boiling point of the compound. The vapor is preferably 100% reactant. However, if so desired, the reactant may be diluted with an inert constituent such as nitrogen. Oxidizing and reducing gases should not be present for optimum results. Solutions of the reactant in high boiling liquids are also of value.

The reactant used in accordance with the invention appears to be very stable in the vapor state in the absence of oxygen and very little loss of material is encountered.

The insulating layers produced in accordance with the invention possess the further advantage of bonding to resinous materials of the thermoplastic and thermosetting types, such as phenol-formaldehyde resins and polystyrene resins, respectively. Thus, foils for electrical condensers may be treated in accordance with the invention before incorporation in electrical condensers utilizing resinous dielectric materials. This reduces the tendency for the resin to separate from the electrode material at the junction therebetween with the consequent facilitation of the occurrence of corona discharges.

The invention will further be described with reference to the attached drawing in which,

Figure 1 shows a cross section of a coil of copper wire and

Figure 2 shows a cross section of the same coil after being insulated in accordance with the invention.

Referring more specifically to Figure 1, a cross section is shown in which the adjacent copper

wires touch each other at four points, more or less, on their surfaces. If this coil is treated in accordance with the invention, for example by being exposed at 350° C. to the vapors of phthalonitrile for two minutes, it will be provided with the insulation shown in exaggerated thickness in Figure 2 over the entire surface of the wire each wire being insulated from its adjacent wire by two thicknesses of the insulating compound. This is particularly valuable since one would ordinarily consider the interior sections of the coil as not enterable by the vapors of the reactant chemical. The insulation has the further advantage of extremely high temperature stability despite the fact that organic nuclei are present.

Likewise, metals other than copper may be treated such as the resistance alloy "nichrome." Thus a resistor structure may be wound and subsequently insulated by the processes described herein. It is therefore possible to make multilayer windings of resistance wire by very inexpensive and highly satisfactory means.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope hereof, it is to be understood that the invention is not limited to the specific embodiments hereof except as defined in the appended claims.

What is claimed is:

1. In a process for making a compact coil of insulated turns of wire, the steps of providing a tightly wound multilayered coil of bare metal wire having a surface of the class consisting of copper, tin, iron, lead, aluminum, magnesium, manganese, chromium, zinc, and alloys thereof; and adjacent turns of which contact each other; and exposing said coil of wire to the vapors of a compound selected from the class consisting of phthalonitrile, phthalimide and ortho-cyanobenzonitriles at a temperature between about 200° C. and 500° C., to form on the surface of the wire and between the individual turns a layer up to about 0.0005 inch thick of a phthalocyanine salt that forces adjacent contacting turns apart and insulates them from each other.

2. A process for breaking substantially continuous electrical contact between adjacent contacting turns of a tightly wound coil of bare Nichrome alloy wire and for forming an electrically insulating layer between such turns and upon all exposed surfaces of wire, which comprises exposing said coil of Nichrome alloy wire to the vapors of phthalonitrile at a temperature between about 300° C. and 400° C., until a layer of up to 0.0002 inch thick of phthalocyanine salt is formed upon the surface of the wire.

3. A process for breaking substantially continuous electrical contact between adjacent contacting turns of a tightly wound coil of bare copper wire and for forming an electrically insulating layer between such turns and upon all exposed surfaces of said wire, which comprises exposing said coil of copper wire to the vapors of phthalonitrile at a temperature of about 350° C. for approximately two minutes.

4. A tightly wound coil of wire composed of a metal selected from the group consisting of copper, tin, iron, lead, aluminum, magnesium, manganese, chromium, zinc and alloys containing such metals, whose adjacent turns are insulated from each other only by a layer of phthalocyanine salt formed in situ.

5. A resistance element comprising a tightly wound coil of Nichrome alloy wire whose adjacent turns are insulated from each other only by

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a layer of phthalocyanine salt formed in situ.

6. An electrical coil comprising tightly wound copper wire whose adjacent turns are insulated from each other only by a layer of copper phthalocyanine formed in situ.

7. In a process for making a compact electrical coil of insulated turns of wire, the steps of providing a tightly wound multilayered coil of bare copper wire all of the adjacent turns of which contact each other, and exposing said coil of copper wire to copper phthalocyanine-forming vapors at a temperature between about 300° C. and 400° C., until a layer of up to 0.0002 inch thick of copper phthalocyanine is formed upon the surface of the wire to force the individual turns apart and insulate them from each other.

8. A multilayered tightly wound coil of copper wire in which all the adjacent turns are in contact with each other but are electrically insulated from each other by a layer of copper phthalocyanine about 0.0002 inch thick formed in situ on the surface of the wire.

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on the surface of the wire.

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