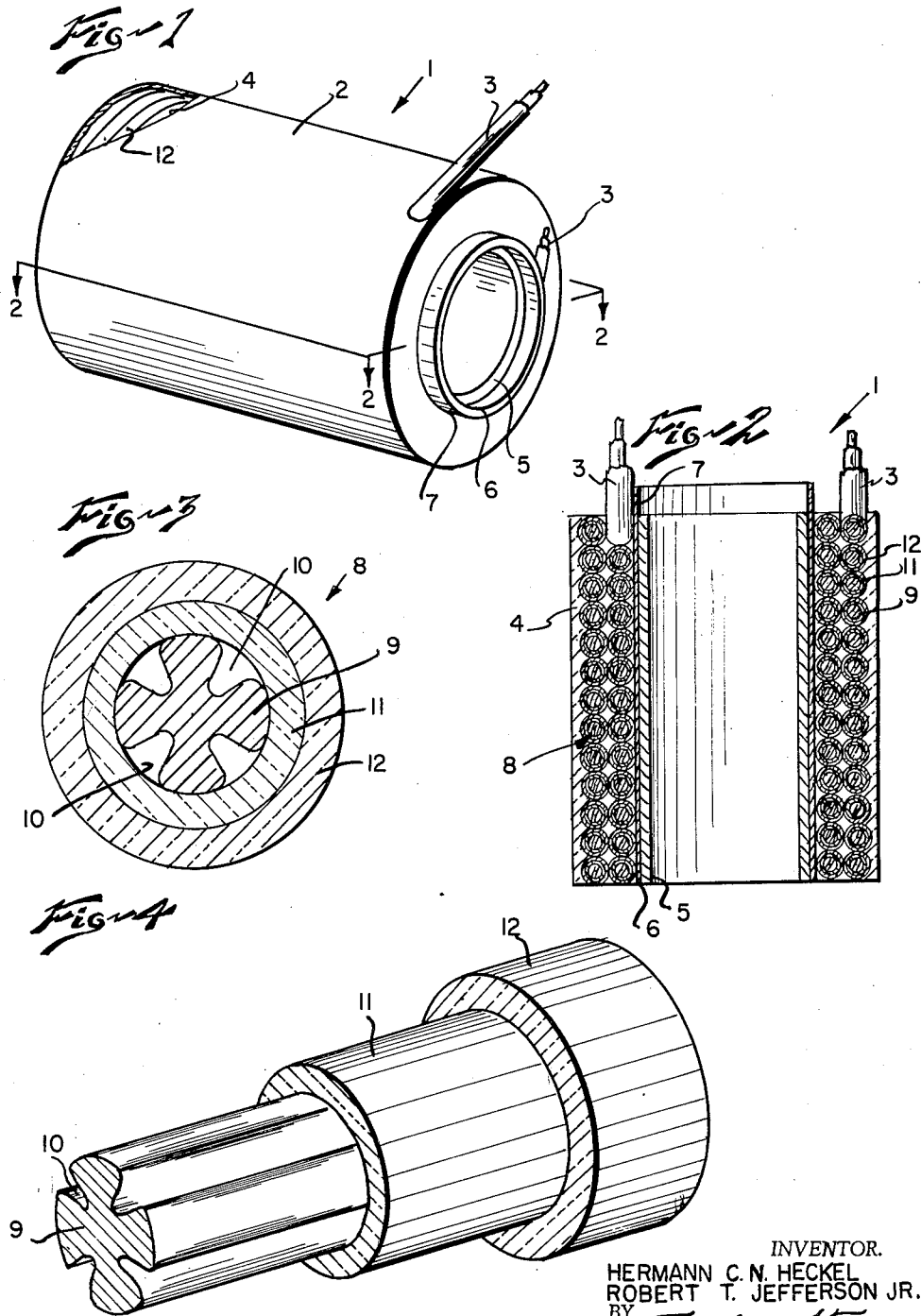


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ELECTRICAL COMPONENT HAVING A SERRATED CORE CONSTRUCTION
AND METHOD OF MAKING THE COMPONENT
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ELECTRICAL COMPONENT HAVING A SERRATED CORE CONSTRUCTION AND METHOD OF MAKING THE COMPONENT

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This invention relates to insulated electrical conductors for high temperature applications, for example, as coils which will withstand temperatures of 500° C. and above.

It has been found that it is desirable to provide for the free expansion and contraction of the conductor wire in electrical components which are designed for high temperature operation; this invention has as a particular object the provision of a wire which is notched about its periphery to provide for take-up of stresses in the insulated conductor when the conductor is subjected to considerable temperature change.

The notched wire employed in combination with the insulation is in effect serrated to form depressions in the wire, which depressions suitably extend longitudinally with the wire. Preferably the wire in its formation is drawn through a conveniently shaped die to yield the desired wire cross-section. Such section may have the shape of a gear, star or a generally cruciform configuration.

The insulation material which is provided is inorganic and suitably in two layers. The first layer is preferably of high softening point material and substantially inert chemically to reaction with the conductor at the temperatures of manufacture and operation. This inner layer is covered with a layer of lower softening point material which is usually sintered to the outer layer in electric component manufacture.

The inner insulation material and the conductor are relatively slidable to permit of free elongation, and of volumetric expansion, of the wire in all directions without the exertion of substantial stress on the insulation. This feature is emphasized by the provision of the serrated conductor since the frictional contact with the insulation is minimized.

Further, in a component such as a coil the serrations, as the conductor of the coil shrinks diametrically with temperature drop, provide cavities into which the insulation may extend without undue stress. This factor assists the cushioning effect provided by the insulation itself.

It is accordingly a primary object of this invention to provide a novel combination of electrical conductor and insulation material.

It is a particular object of the invention to provide novel methods of producing electrical conductors and electrical components.

The invention will be more fully understood by reference to the following detailed description and accompanying drawings wherein:

FIGURE 1 is a perspective view, with parts broken away, illustrating an encapsulated coil produced in accordance with the invention;

FIGURE 2 is a sectional view taken substantially on line 2-2-2 of FIGURE 1;

FIGURE 3 is a sectional view of the insulated electrical conductor utilized in the formation of the coil of FIGURES 1 and 2; and

FIGURE 4 is a perspective view of the conductor of FIGURE 3.

Referring to the drawings, the numeral 1 generally designates an encapsulated electrical coil, the body of which is designated at 2, and the coil is provided with encapsulating material 4. The coil is formed on a

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ceramic core 5. The ceramic core itself is provided with a layer of tape 6, suitably of a high softening point material, such as aluminum silicate. Such material is sold under the trade name of Fiberfrax. Tape 6 extends, as shown at 7, from one end of the coil to provide a hand grip for withdrawing the tape and the core 5 from the coil, should the same be desired. The conductors which form the coil are indicated generally at 8 in FIGURES 2 and 3.

As will be noted the copper conductor 9 is centrally disposed and is of a substantially cruciform shape, expansion cavities 10 being defined between the lobes of the conductor.

Surrounding the conductor 9 and in contact therewith is a body of fibers 11 which are suitably applied to the conductor in the form of continuous filaments of a high silica content material, such as silica fiber, mica or aluminum silicate. These fibers are substantially inert chemically to reaction with the copper and are so provided on the copper conductor that the conductor may expand and contract longitudinally within the layer formed by the fibers, without exerting material stress on the fibers.

Surrounding the layer 11 of silica fibers is an outer layer 12 of lower softening point fibers, also preferably wound on the structure in the form of continuous filaments. Suitably this material comprises a commercial E glass, for example, and preferably an E glass treated with methacrylate chromic chloride. A suitable composition for such glass is—

Constituent:	Percentage
SiO ₂ -----	53.5
Al ₂ O ₃ -----	14.5
B ₂ O ₃ -----	10.0
CaO -----	17.5
MgO -----	4.5

The sintering point of the above noted glass is about 825° C.

As may be noted most clearly from FIGURE 4 the serrations which form the expansion cavities 10 extend longitudinally of the conductor and provide for the expansion and contraction of the conductor in such manner that material stress is not exerted on the surrounding insulation.

To form the coil of FIGURE 2 with a conductor such as that shown in FIGURES 3 and 4, the coil is wound in the normal manner on the tape covered ceramic core. The coil is then fired at a temperature of about 825° C. to effect sintering of the glass of the fibers of the outer sheath. This sintering causes the glass of the fibers 12 to form a substantially continuous film around the coil. However, there is no material penetration of the fibers of silica indicated at 11 by the material of the outer layer since there is no true flow of this material. Actually there is no stiffening of the silica fibers by the entry of glass. Therefore, the fibrous material 11 retains a material degree of resiliency, and this, in combination with the provision of the expansion cavities 10, and the ability of the conductor to move longitudinally relative to the insulation material provides for the attainment of a crack-free structure in the finished coil.

The coil, as already noted, when heated to 825° C., results in a sintering of the material of the outer sheath. The time of exposure to this temperature is approximately 30 minutes. Thereafter the coil is cooled slowly to a temperature of about 650° C. As the temperature decreases to about 800° C. the glass of the outer sheath hardens and thereafter the conductor contracts much more than the glass, the contracting of the glass, in fact, being substantially insignificant.

As the conductor contracts the diameter of the coil decreases and tends to exert stress upon the surrounding

insulation. However, the fibers 11 exert a cushioning effect, inhibiting cracking of the glass of the outer layer.

Suitably the coil is maintained about a half hour at 650° C. and then is cooled slowly to 550° C. over a period of about an hour. To relieve strains which may have been set up in the glass the coil is held at 550° C. for about an hour and then cooled slowly to room temperature over a period of about two hours.

In this cooling there is substantially no significant contracting of the glass, either of the fibers in the layer 11 or of the coating or film formed by the sintered glass of the outer layer. The copper may also shrink freely in any direction without occasioning strains in the glass, because the conductor is not bonded to the glass. Further, the provision of a plurality of serrations uniformly disposed as in quadrature in FIGURE 3 aids the uniform contraction. In this connection it is to be noted that the sintered glass of the outer layer is milky white in contrast to glass which has been fully melted and appears quite clear.

The product of the operation thus described has visible turns of the coil which are adhered together but not mechanically well bonded by the film. However, the coil is sufficiently rigid for service conditions.

To completely encapsulate the coil the material 4 is provided in the form of a yarn and wound on the coil. The coil is then again heated to a temperature of about 875° C. to cause complete flow of the material 4, such that it takes the form illustrated in FIGURES 1 and 2. This material enters between the turns of the winding of the coil, extends over the turns, fully encapsulating the product, but it does not extend materially into the interstices of the fibers 11, and therefore does not penetrate to the conductor. Accordingly the fibers 11 remain somewhat resilient.

In the operation of the coil at temperatures of say 500° C., for example, conductor 9 may expand freely due to the serrations, and upon contraction when cooling the layer of fibers 11 provides a cushioning effect particularly between adjacent layers of the coil itself, inhibiting cracking, which normally occurs in the outer layer of insulation. Further the layer 11 also serves as a cushion when the coil is being heated and avoids any undue stress on the sintered glass continuous deposit.

The quantity of fibrous inorganic insulation material employed should be such that oxidation of the conductor does not occur and flexibility of the insulated conductor is not impaired. As a guide 1.2 grams per foot of the material of layer 11 and 1.5 grams per foot of the material of the layer 12 is satisfactory on a wire of a size of No. 18.

While the invention has been particularly described in connection with a cruciform shape, it will be apparent that other shapes, such as a star shape or a gear shape, could be employed. It is only necessary that the conductor be notched in such manner to provide for the expansion of the conductor freely in all directions.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and accordingly, it is desired to compre-

hend such modifications within this invention as may fall within the scope of the appended claims.

What is claimed is:

1. An article of manufacture comprising layers of electrical insulation material and an electrical conductor covered by but slippable relative to the insulation material, said conductor being notched longitudinally providing serrations in the conductor, an inner layer of said insulation material around said conductor being of a resilient fibrous material which is substantially inert with the conductor chemically, and an outer layer of siliceous fibers of a lower softening point than the material of the inner layer and the conductor and which outer layer may be sintered to provide a film of siliceous material over the inner layer and adhered to the inner layer, both said layers of insulation material being highly flexible whereby a coil can be wound from the insulated conductor and then heated to sinter said outer layer to form a fully insulated rigid coil wherein the outer layers of insulation material of adjacent turns of the wire are fused together but wherein the conductor is still slippable within said inner layer of insulation material and cushioned thereby.

2. An electric coil comprising turns of an electrical conductor in superposed relation, said conductor having longitudinally extending serrations therein spaced about the periphery of the conductor and at least two layers of inorganic insulation over the length of the conductor insulating the turns of the conductor and slippable upon the conductor to provide for volumetric expansion and contraction of the conductor, said insulation including an inner fibrous layer separating the conductor from an outer layer and being flexible and to cushion the outer layer and conductor in expansion and contraction changes of the conductor, and said outer layer also being fibrous and being flexible when applied over said inner layer and also being of a lower softening point than the inner layer and sinterable on said inner layer to adhere to the said inner layer without substantial penetration of the inner layer whereby upon sintering of the outer layer after the coil is formed a cross section of the coil will reveal a rigid unitary matrix consisting of the sintered outer layers in fused together relation and conductors distributed therein each surrounded by unsintered resilient fibrous insulation material and each conductor slippable and expandable in its pertaining unsintered insulation material.

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