

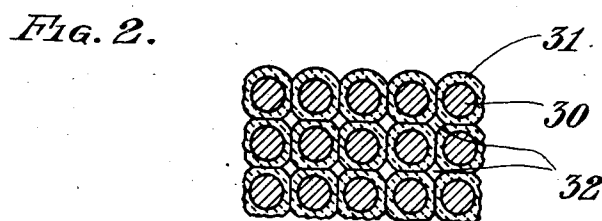
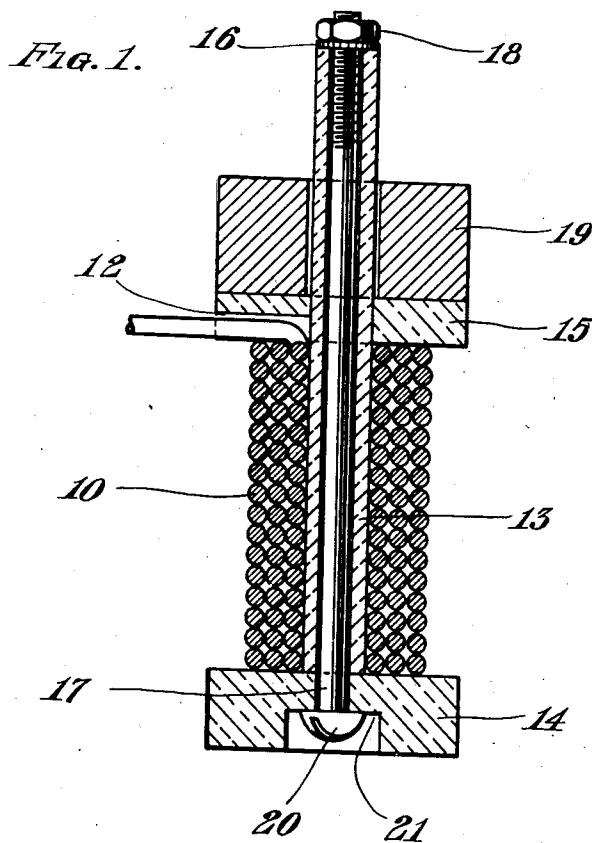
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ELECTRICALLY INSULATED ELEMENT

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ELECTRICALLY INSULATED ELEMENT

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5 Claims. (Cl. 175—21)

The present invention relates to electrically insulated elements, and more particularly to new and improved type of coils and to the method of manufacturing same.

My invention will be described in connection with coils as used for electromagnets, magnet poles of rotary electrical machinery and the like, the coiled wire of which is a conductor coated with a thermoplastic vitreous insulating medium and the adjacent turns and superimposed layers of the coil are bonded together by fusion of said insulating medium. It should, however, be understood that my invention is in no way limited to such use.

Coils in which the insulation of the conductor consists of a fused vitreous material have already been proposed. Such coils, however, proved unsatisfactory because the differential thermal expansion of their component parts caused high internal stresses in operation, and the vitreous materials used lacked flexibility to withstand such stresses without chipping and flaking. As a result, such coils rapidly deteriorated in operation, particularly if the coil was embedded in a solid matrix of the insulating medium.

The object of the present invention is to provide a new and improved coil in which the adjacent turns and superimposed layers of the coil are bonded together with an insulating medium.

Another object of the invention is to provide a coil in which the insulating coating of the conductor forms an elastic bond between adjacent turns and layers of the coil, and in which internal stresses are substantially or altogether eliminated.

These and other objects of the invention will appear as the specification progresses.

According to my invention, a coil consists of a wound conductor provided with an integral coating, and adjacent turns and superimposed layers of the coil are by interfusion intimately joined to each other by a bond formed of the coating, which bond is restricted to portions of the adjoining surfaces of the turns, whereby cavities or interstices are formed between adjacent turns and the layers, which extend throughout the entire coil.

By restricting, in accordance with the invention, the bond only to portions of adjoining surfaces of adjacent turns and superimposed layers of the coil, a compact and rigid and at the same time highly flexible structure is obtained, which precludes undue internal strains in the coil.

I preferably use for this purpose a coating consisting of a vitreous material or enamel in the

form of a ground or finely-divided frit, and of a suitable binder. Good results are obtained, for example, with a ground porcelain enamel or lead glass frit, and a suitable binder.

To obtain the best results, the vitreous material should constitute a major proportion (80% or more, by weight) of the coating. A coating of this type and the method of applying same to a conductor, is described in my copending application Ser. No. 325,043, filed March 20, 1940.

As described in said application, coatings showing high flexibility are obtained by the use as a binder of a compound selected from the group of organic materials known as "elastomers." Such binder materials if dispersed in a suitable suspension medium—to which the frit particles are added—are conditioned to exhibit high adhesive forces, and which to fully realize, the ground frit and the elastomer are deposited simultaneously by cataphoresis on the conductor. Suitable elastomers for such purpose are, for example, the acrylic ester resins, such as those known under the trade names of "Appretan A" and "Corial Bottom."

The coated conductor is then wound into a coil of the desired dimensions, after which it is subjected to heat treatment at a comparatively low temperature, to drive off substantially all of the binder, and a further heat treatment at a comparatively high temperature to fuse the coating.

To provide for the desired flexibility of the coil after the coating has been fused, in accordance with the invention, the fusion between coated adjacent turns and superimposed layers is to be limited to only portions of the coating. This I achieve, for example, by applying during the fusion and partial liquefaction of the coating compressive forces of a predetermined value to the coil, which bring into contact coatings of adjacent turns and cause an interfusion and flexible bonding of only portions of such adjacent coatings, thus providing for interstices between turns and layers.

The degree of compression to be applied depends on a number of factors, such as the resiliency of the conductor, the plasticity of the coating, the degree and duration of the heat treatment, etc. To obtain the object of the invention, the compression during the heat treatment should be sufficiently high to cause adjoining coatings to intermingle and coalesce but not so high as to cause the coatings to flow into each other to the extent as to prevent formation of the desired interstices; the formation of such in-

terstices or voids being an essential part of my invention.

The proper compression, which depends on the above enumerated various factors, may require a somewhat critical adjustment of the value of the compressive force. To avoid this, and in accordance with another feature of the invention, I embody within the coating particles of a non-thermoplastic insulating material, which do not melt or fuse or lose their identity during the heat treatment interfusing the adjacent portions of the coating of the coil. Particularly suitable for this purpose are particles of refractory insulating materials, such as silica, mica, aluminum oxide, magnesium silicate and the like.

In practice the above refractory materials prove to be somewhat soluble in the coating when it liquefies, the degree of solubility depending on the concentration and size of the particles and the temperature and duration of the heat treatment. To insure that a sufficient amount of discrete particles remain in the coating after the heat treatment, the coating should contain a large portion of refractory particles, for example 10% to 30% or more by volume, and such particles should be of the order of 200 mesh in size.

I have found that the desired bonding between the surface of adjacent coatings may be obtained by applying compressive forces along only one axis of the coil, for example, axially, (along the longitudinal axis of the coil), which compression may be effected by applying compressive forces at the two ends of the coil.

It should be noted that in case of axial compression the bonding is primarily between the coating of adjacent turns; however, all of the layers in turn are biased against each other by the inherent flexibility and resiliency of the structure, and a bonding along the complementary axis is obtained.

In certain instances it may be desirable to apply both axial and radial compression to the coil, in which case, however, the degree of compression along either axis is usually less than if axial compression alone is used. In general, compression along both axes, I have found, brings about a greater degree of uniformity of bonding in the coil structure.

Fusion of the coil under proper compression brings about a compact, coherent and stress-resistant structure in which adjacent portions of the wire coating are intimately bonded together. At the same time the bond is restricted to only small portions of the adjacently disposed coatings, and a coil structure comprising a multiplicity of voids or interstices between turns is obtained.

Furthermore, in view of the small area of bonding and the consequent large percentage of voids, a coil with a low distributed electrical capacity is obtained, which makes the coil particularly suitable for special applications, for example, for use at high radio frequencies.

In the drawing forming part of the specification,

Figure 1 illustrates a jig or fixture for compressing a coil during the heat treatment thereof, in accordance with one embodiment of the invention.

Fig. 2 is an enlarged view in cross section of a portion of a coil made in accordance with the invention, showing the bond and the interstices provided between turns and layers of the coil.

Referring to Figure 1, the fixture there shown, which is adapted for the axial compression of a coil during its heat treatment to interfuse the

adjacent portions of the coating, comprises a hollow core 13 consisting preferably of a refractory ceramic material, such as "Steatite," "Isolantite," porcelain or the like. At one end of the core there is provided a flange 14 preferably of ceramic material and provided with a countersunk bore 21, which flange 14 is positioned on the core by a bolt 17 passing through the core 13, and having a head piece 20 positioned within the bore 21 and a nut 18 with an interposed washer 16 pressing against the end of the core.

Disposed over the core 13 and slidably engaging the same is collar 15, preferably of ceramic material. The coil to be subjected to axial compression, shown in the drawing as 10, is disposed within a space bounded by the flange 14 and the collar 15. For taking out the beginning of the coil, the flange 14 is provided with a radial recess shown at 12.

Positioned on the collar 15 is an annular metal body 19 serving as a weight for compressing the coil 10 in accordance with the invention.

In making a coil in accordance with the invention the following procedure may be used: A wire conductor is provided with an integral coating, preferably of the type described in my copending application Ser. No. 325,043, referred to above. Such a coating may consist of a mixture of vitreous and refractory particles and an elastomer binder, for example 68% of porcelain enamel particles, 17% silica particles having a size of the order of 200 mesh, and 15% by weight of the elastomer "Corial Bottom."

The coated wire is then wound in conventional manner into a coil of the desired form. This may take place on a suitable mandrel of a winding machine, from which it is then transferred to the core 13, or core 13 may itself be used as the mandrel. In either case, as appears from the drawing, the coil occupies only a portion of the core 13.

The coil 10 having been thus provided on the core, the remaining components, i. e. flange 14, collar 15, weight 19 and bolt 17, are added to assemble the fixture into the structure above described.

The compression of the coil is effected by the annular member 19 and the degree of compression may be adjusted by correspondingly varying the weight of this member.

It should be well understood that the core 13 instead of being cylindrical in shape may have other geometrical cross sections depending on the desired shape of the coil.

The so assembled fixture is then placed in a suitable oven for heat treatment to interfuse limited portions of the coating; said heat treatment in its preliminary stages may also serve to bake the coating and to drive off substantially all of the binder in the coating. The temperature used and duration of the heat treatment depends on the material of the coating, the thickness of the coating, and the dimensions of the conductor and the coil. For example, in the case of a coil wound of a copper wire .016" in diameter having a coating approximately .0025" thick, which coating consists of the above illustrated constituents, using a porcelain core approximately .3125" in diameter and which coil consists of six (6) superimposed layers of twenty-six (26) turns each; a heat treatment at approximately 700° C. for approximately two (2) minutes has been found to be suitable.

For compressing the coil during the heat treat-

ment a weight 19 of approximately three and one-half (3.5) ounces is used.

The so heat-treated and compressed coil is permitted to cool and is then removed from the core. Such a coil is a self-contained unit which can be used by itself or assembled as a part of an electrical apparatus.

The coil is compact and coherent and an intimate bonding exists between adjacent turns as well as between the turns of successive layers. At the same time the coil is sufficiently flexible to obviate internal stresses and strains.

A portion of a coil in accordance with the invention is shown in cross section and on an enlarged scale in Fig. 2 in which the wound conductor is shown as 30 and the fused coating as 31.

It will be noted that the interfused bond between the coatings of adjacent turns, whether these turns are those of the same layer or of successive layers, extends over only a portion of the surface of the coatings whereby a series of interstices 32 are created which form substantially helical continuous ducts between the layers and turns extending throughout the length of the coil.

It should be understood that instead of the fixture shown in Fig. 1, equivalent structures may be used for the heat treatment, and simultaneously compression of the coil. In some cases it is advantageous to heat-treat and compress the coil within the device itself in which the coil is used. For example, the coil may be wound into the slots of an armature or about the poles of a motor, after which the so wound armature or pole is subjected to the heat treatment to fuse the coating. Compression of the coil may be achieved during such treatment, for example, by means of a suitable spring member which is either temporarily or permanently embodied within the structure. Such a procedure has also the advantage of providing an intimate bonding of the coil to the metal carrier.

While I have described my invention by means of a specific example and in a specific embodiment, I do not wish to be limited thereto, for obvious modifications will appear to those skilled in the art without departing from the spirit and scope of the invention.

What I claim is:

1. An electrical coil comprising a conductor wound into adjacent turns and superimposed layers, an integral coating of a thermoplastic insulating material on the conductor, a substantially high proportion of discrete non-thermoplastic insulating particles having a melting temperature higher than that of the thermoplastic material uniformly distributed throughout the coating, bonds formed between the adjacent turns and superimposed layers, said bonds

consisting of interfused portions of the thermoplastic material and extending over only part of the adjacently positioned portions of said coating.

2. An electrical coil comprising a conductor wound into adjacent turns and layers, an integral coating of a thermoplastic insulating medium on the conductor, discrete refractory particles uniformly distributed throughout the coating, and bonds formed between the adjacent turns and layers of the coil and consisting of interfused portions of the coating, said bonds extending over only part of the adjacently positioned portions of the coating, and substantially continuous interstices defined by the coating extending throughout the coil.

3. An electrical coil comprising a conductor wound into adjacent turns and layers, an integral vitreous coating on the conductor, a substantially high proportion of discrete refractory insulating particles uniformly distributed throughout the coating and bonds formed between adjacent turns and layers and consisting of interfused portions of the coating, said bonds extending over only part of the adjacently positioned portions of the coating, and substantially tubular and continuous interstices extending throughout the coil.

4. In the manufacture of electrical coils the process comprising the steps, providing on a wire conductor a coating comprising in a major proportion a thermoplastic insulating material and in a substantially large proportion particles of a refractory insulating material having a melting temperature substantially higher than that of the thermoplastic material, winding the coated conductor into a coil with a plurality of adjacently disposed turns, subjecting the coil to a heat treatment, and so compressing the coil during said heat treatment as to maintain only part of the adjacently disposed portions of the coating in contact with each other.

5. The method of manufacturing an electrical coil comprising the steps, providing on a wire conductor an integral flexible insulating coating consisting of particles of a vitreous material and of a refractory material and a volatilizable binder, the vitreous material constituting a major proportion of said coating and the refractory material being present in a substantially high proportion of the vitreous material, winding the coated conductor into a substantially cylindrical coil with a plurality of adjacently disposed turns, subjecting the coil to a heat treatment fusing the vitreous particles without substantially affecting the refractory particles and so compressing the coil during the heat treatment as to maintain only part of the adjacently disposed surfaces of the coating in contact with each other.

PRESTON ROBINSON.