

[54] ELECTRICAL COIL WITH SPACING BANDS

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336/205; 338/298

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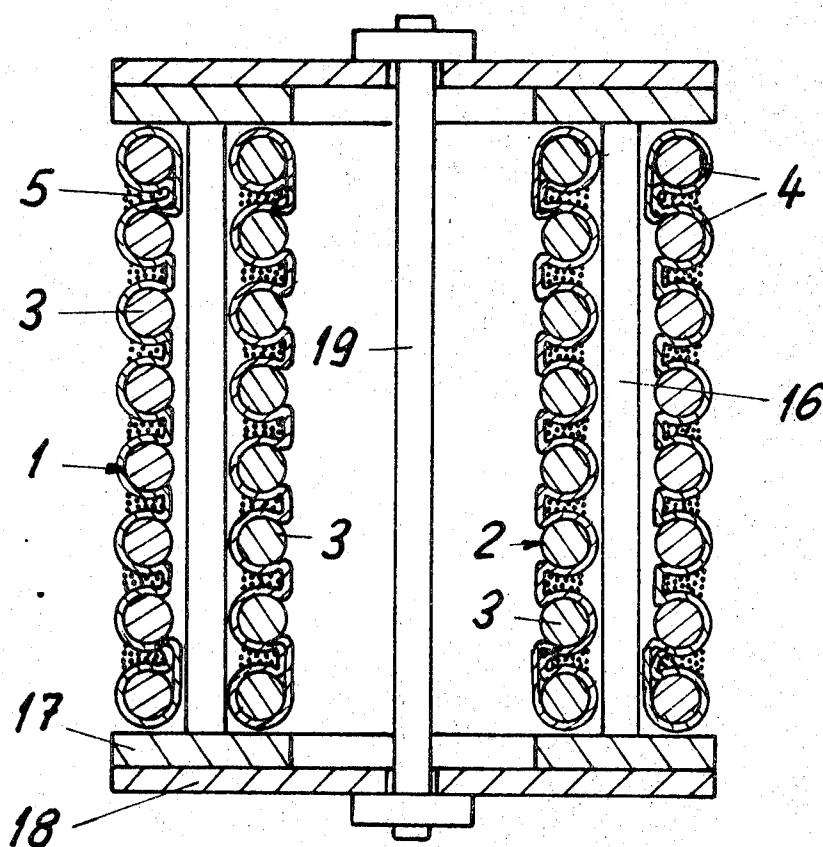
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[57] **ABSTRACT**

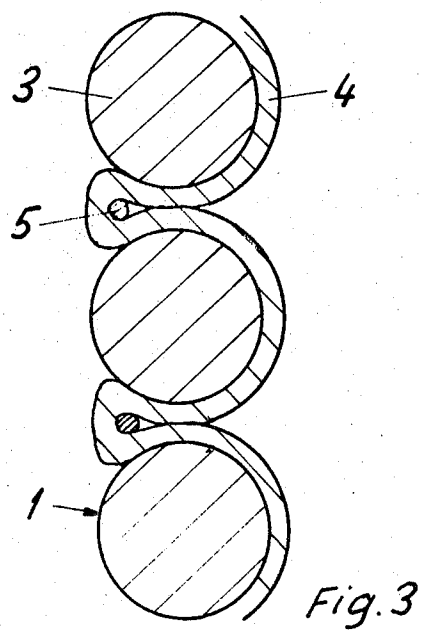
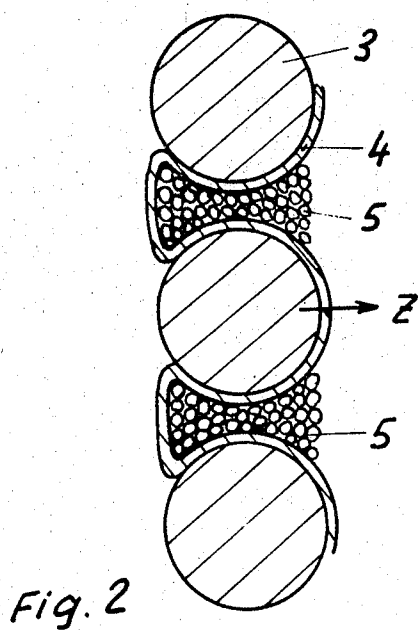
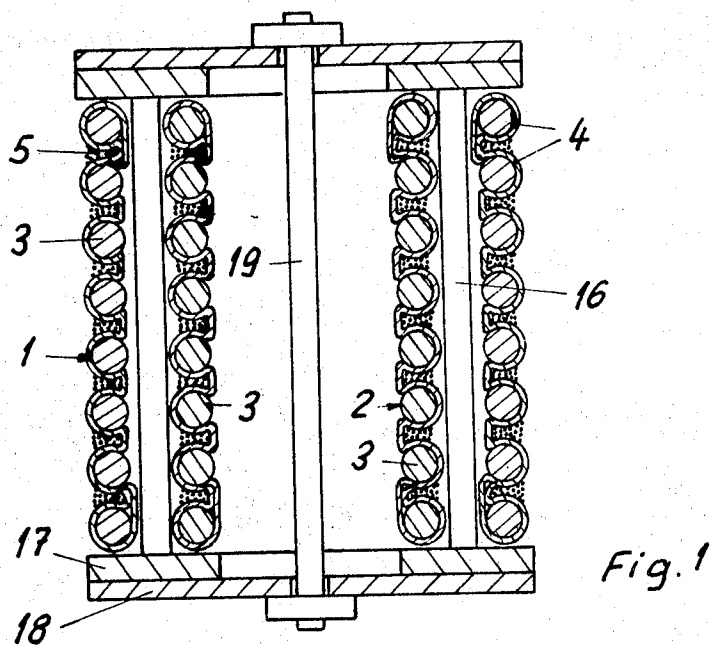
An electrical impedance coil which has a helical configuration has applied to the outer surface thereof a plurality of circumferentially spaced bands of insulating material and which extend longitudinally of the coil. A cord wrapping applied around the bands at the helical interspace formed between adjacent turns of the coil serves to draw in those portions of the bands into this interspace so as to lie between adjacent turns and the bands in conjunction with the binding-in effect produced by the cord wrapping serve to mechanically reinforce the coil against disruptive forces which occur when the coil is required to carry high currents.

A rotatable mandrel arrangement is provided in connection with manufacture of the coil, the mandrel serving to form the electrical conductor into helical form, and as a support for the supply rolls of the band material to be applied to the outer surface of the bands, after which the cord wrapping is applied as the mandrel is rotated.

6 Claims, 4 Drawing Figures



SHEET 1 OF 2



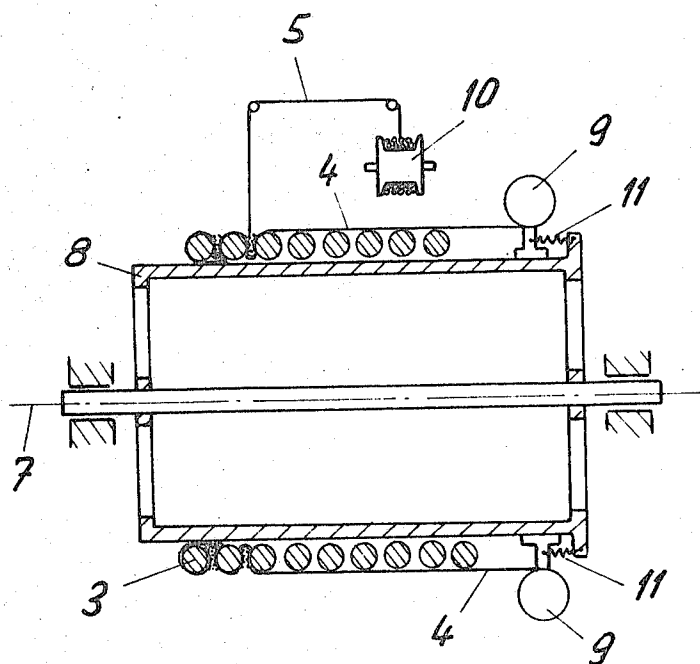


Fig. 4

ELECTRICAL COIL WITH SPACING BANDS

The present invention relates to an improved construction for an air-cooled electrical coil of the impedance, or "choke" type which is utilized as a wave block or to limit current flow in the case of a short-circuit condition on the line to which the coil is connected. The invention also is directed to a method for manufacturing the coil as well as an apparatus by which the method can be performed.

Electrical impedance coils must be so designed as to satisfactorily withstand the very high mechanical and thermal stresses which are imposed upon them as a result of the passage of the very high current flows which occur under short-circuit conditions. It is a well known fact that when a high current flows through a helically wound coil, the latter is subjected to the action of forces tending to expand it, in a manner similar to a helically wound tube when subjected to the flow of a fluid therethrough under pressure. Accordingly, the turns of the coil must be held against these dynamically induced expansion forces by applying a corresponding counterforce at the circumference of the coil. Moreover, the overall length of the turns of the coil tends to shorten under the effect of its own magnetic field created by the passage of current through it, as a result of which the coil is subjected to very high axially oriented compressive forces. If the turns of the coil are spaced apart by spacer elements in order to provide for free passage of cooling air between the turns, the tendency of adjacent turns to approach each other also leads to undesirable deflection of the conductor portions between the spacers.

The problem of mechanical short-circuit strength is also complicated by the fact that the mode in which the forces in an alternating current occur is a pulsating one and that, due to the strong magnetic fields which result from the high values of the short-circuit currents, strong eddy current flows are also induced in those supporting elements for the coil which are electrically conductive.

Electrical impedance coils are also customarily mounted in air, in contrast to a solid or liquid medium, a fact which also necessitates that, because of the relatively poor heat transfer characteristic of air, considerable attention must be devoted to the problem of cooling in addition to the previously mentioned problems of counteracting dynamically produced destructive mechanical forces as a result of the shortcircuit current flow.

Various attempts have already been made to solve these problems. For example, it is already known to maintain the turns of the coil at the desired mutual spacing by means of spacers inserted between turns in order to mechanically reinforce and stabilize the coil as well as increase the overall coolable surface area of the coil. To prevent these spacers from becoming loose or shifting their position it is known to secure them in place by means of teeth or grooves. This results in a multiplicity of expensive components requiring much time for assembly with the coil. Moreover, the conductor material is subjected to undesirable bending forces during assembly of the spacers with the coil, i.e. when they are introduced between adjacent conductor turns. Molding on the spacers directly necessitates complicated molding dies and also partial or complete embedding of the coil into a molding compound. The latter procedure worsens the problem of coil cooling so that

artificial venting becomes necessary in order to establish a satisfactory heat transmission characteristic. Transmission of heat is also rendered more difficult in those situations when the coil is applied on a sleeve of insulating material, even when the latter is provided with openings through the sleeve wall to increase the flow of circulation air over the coil.

In order to mechanically strengthen helically wound impedance coils against dynamically induced mechanical and electrical destructive forces, it is also known to wind onto the entire outer surface of the coil an insulating cylinder consisting of insulating fibers and to solidify the sleeve material by the application of impregnants. However, while this arrangement provides mechanical reinforcing it obviously hinders transmission of heat from the coil because of the solid nature of the sleeve, as well as its poor heat transmission coefficient. More recently, it has been proposed to fasten coil winding parts to electrical machines in that layered insulating materials were pressed between the individual coil components, or were wound around them and then hardened by means of a plastic compound. It has also been proposed to utilize individually casted or elastic cushion inserts as the spacer elements between turns of the coil. However, such spacers can, as a practical manner, be applied only by hand which results in a high cost of production.

The primary objective of the present invention is to provide an improved helical impedance coil construction which obviates the disadvantages of the previously known techniques and which can be produced at a comparatively low cost and in a continuous manner on a comparatively simply constructed winding machine.

The improved helical impedance coil structure is principally characterized in that a plurality of bands of insulating material distributed over the circumference in spaced relation extend longitudinally along the outer surface of the coil and the portions of these bands between adjacent coil turns are drawn in, so as to lie in the gap between the turns, by means of a cord wrapping also of insulating material. The bands and cord wrapping provide adequate mechanical reinforcement for the coil and the spacing between adjacent bands ensures an adequate flow of cooling air through the coil.

The method by which the improved impedance coil structure is produced resides principally in the features that after the helical coil is wound, the circumferentially distributed bands of insulating material are applied longitudinally along the surface of the coil, this being followed by application of the cord wrapping in a progressive manner starting at one end of the coil.

The apparatus by which the method is performed resides principally in the features of a rotatably driven cylindrical mandrel on which the helical coil is first formed, the mandrel having mounted thereon reels on which supply rolls of the band material are stored and fed to the coil surface, the reel supports being arranged for a sliding movement longitudinally of the mandrel and spring loaded so as to enable the band material to be placed under longitudinal tension, and there being also provided a reel on which a wound-up supply of the cord material is stored and fed to and wrapped around the bands.

The foregoing as well as other objects and advantages inherent in the overall invention will become more apparent from the following detailed description of preferred structural embodiments of the impedance coil

and an apparatus for carrying out the method of making the coil. In the accompanying drawings:

FIG. 1 is a vertical central section through a completed impedance coil structure in accordance with the invention, this particular embodiment consisting of a pair of concentrically arranged coils;

FIG. 2 is a vertical section of a portion of one of the coils depicted in FIG. 1 and drawn to a larger scale;

FIG. 3 is also a vertical section of a portion of a coil similar to FIG. 2 but illustrating a modification of the latter with respect to the spatial arrangement of the band material and cord wrapping between adjacent turns; and

FIG. 4 is a view in central longitudinal section through an apparatus by which the method for producing the coil in accordance with the invention can be performed.

With reference now to the drawings and to FIG. 1 in particular, it will be seen that the impedance coil structure depicted is constituted by an assembly of two concentric coils 1 and 2 connected electrically in series. Each coil constructed in accordance with the invention consists of a helically wound electrical conductor 3 so as to provide spacing between adjacent turns of the helix, a plurality of bands 4 of insulating material distributed around the outer surface of the coil in circumferentially spaced relation and which extend longitudinally along the coil, and a cord wrapping 5 also of insulating material applied to the bands 4 at a right angle to the latter and which serves to bind and draw portions of the bands into the interspaces between adjacent turns of the coil. Particularly suitable for the bands 4 and cord wrapping 5 are materials having a high tensile strength and an impregnable structure, such as fiberglass fabrics for the bands and fiberglass rovings from which the cord is made and which facilitate bonding of the bands and cord together, after application to the coil. Included in the assembly of FIG. 1 besides the two coils 1 and 2 are the usual auxiliary mounting components such as spacers 16 extending longitudinally in the annular gap between the inner and outer coils, annular plates 17 at which opposite ends of the spacers 16 terminate, and end plates 18 provided with centrally located openings for receiving a clamping bolt 19 for holding the entire assembly together. The electrical connections between the two coils are conventional and hence have not been included. While the FIG. 1 embodiment includes two coils, the invention can obviously be applied to single coil structures since each of the two coils is made in accordance with the invention.

FIG. 2 shows at a much larger scale a section of the coil structure depicted in FIG. 1 from which it will be seen more clearly that the band material 4 is relatively thin in relation to the distance between adjacent turns 3 of the coil, and that the greater portion of the interspace between adjacent turns is filled out by the cord wrapping 5. Also, it will be seen that the band material 4 is so drawn inwardly by the binding force applied by the cord wrapping that it reaches to the inner peripheral surface of the coil.

In the slightly different embodiment illustrated in FIG. 3, the distance between adjacent turns 3 of the conductor corresponds to substantially twice the thickness of the band material 4 so that the cord wrapping 5 accounts for only a very small part of the overall profile between adjacent conductor turns.

In cases where the compressive forces acting in an axial direction upon the coil are very great when a short-circuit current flows through the coil, the conductors 3 must be supported over their entire circumference by the cord wrapping 5 which act as bandages, in their overall effect. At the same time the cord wrapping 5 helps to absorb the explosive forces Z acting in the direction indicated in FIG. 2 on the conductor turns 3 when a short-circuit current flows which tends to expand the windings radially. It suffices to lead a correspondingly less number of the bands 4, dimensioned thicker in this case, over the surface of the coil while the cord wrapping 5 serves less to absorb the short-circuit forces than to draw the bands 4 into the gaps between adjacent turns of the coil.

In the embodiment of FIG. 2, the cooling air sweeps along as little as possible covered inner and outer sides of the coil, whereas, in FIG. 3 the cooling air, additionally has free passage between the conductor turns at the places on the periphery of the coil where there are no bands 4. Both embodiments thus provide adequate absorption of the forces occurring in the event of a short-circuit, in the axial and also the radial directions of the coil and under relatively favorable cooling conditions.

Relatively simple apparatus for applying the bands and cord wrapping to the coil is illustrated in FIG. 4. Here it will be seen that a cylindrical mandrel 8 is provided and arranged for rotation about the axis 7, and the conductor material is wound about the surface of this mandrel to establish the desired helical form for the coil. Reels 9 are provided at one end of mandrel 8 for mounting supply rolls of the band material 4. These are mounted on the mandrel in such manner as to enable them to slide in a direction longitudinally of the mandrel and a tension spring 11 having one end anchored in an end flange of the mandrel and the other end connected to the reel mount thus to enable the reels, and hence also the bands 4 which are distributed uniformly about the circumference of the coil to be kept under tension after the opposite ends of the bands have been secured to the end turn of the coil and while the cord wrapping 5 is applied from a supply spool 10 as the mandrel 8 is rotated thus to draw the band material into the helical gap between adjacent turns of the coil in a progressive manner beginning at the end of the coil remote from the reels 9. While only one cord wrapping 5 is illustrated, it is, of course, possible to utilize two or more such cords together in which event a supply spool would be provided for each cord.

After the band and cord material has been applied to the coil, these two materials which, as previously indicated are preferably made from fiberglass, or some other similar strong and impregnable material, are then glued together such as by use of solvent-free synthetic resins such as epoxy or polyester resins which upon solidification establish a strong bond between the bands and cord wrapping. These resins may be applied to the bands and cord wrapping either before or after application to the coil.

When winding the coil, it may be wound on the mandrel with a pitch greater than the final desired spacing between adjacent turns and then compressed to the final pitch after application of the bands and cord wrapping. It is also possible to wind the coil with its final pitch, in which event the bands 4 and coil wrapping 5 can be applied progressively as the coil is wound

rather than after completion of the coil winding operation.

I claim:

1. An electrical impedance comprising a helically wound conductor coil, a plurality of bands of insulating material distributed over the outer surface of said coil in circumferentially spaced relation and which extend in a generally longitudinal direction of the coil, and a cord wrapping of insulating material applied to said bands at the portions thereof between adjacent turns of the coil and which serves to draw in those band portions so as to lie in the gap between the adjacent turns.

2. A helically wound electrical impedance coil as defined in claim 1 wherein said cord wrapping and bands are bonded together.

3. A helically wound electrical impedance coil as defined in claim 1 wherein said cord wrapping and bands are made from fiberglass and are bonded together by

impregnation with a hardenable resin.

4. A helically wound electrical impedance coil as defined in claim 1 wherein said cord wrapping is constituted by a continuous cord member which extends from one end of the coil to the other in the helical space developed between adjacent turns of the coil.

5. A helically wound electrical impedance coil as defined in claim 1 wherein the thickness of said band material is considerably less than the distance between adjacent turns of the coil, and the interspace between coil turns is filled out by the cord wrapping.

6. A helically wound electrical impedance coil as defined in claim 1 wherein the distance between adjacent turns of the coil is essentially equal to twice the thickness of the band material so that the drawn-in portions of said material essentially fill out the interspace between the coil turns.

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