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Baier

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[54] **ELECTRICAL CHOKE COIL OF THE AIR CORE TYPE**

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[52] **U.S. Cl.** **336/65**; 336/197; 336/205; 336/209

[51] **Int. Cl.** **H01f 27/30**

[58] **Field of Search** .... 174/122 R, 122 G, 122 C; 336/96, 205, 197, 65, 68, 206, 207, 209; 317/61.5

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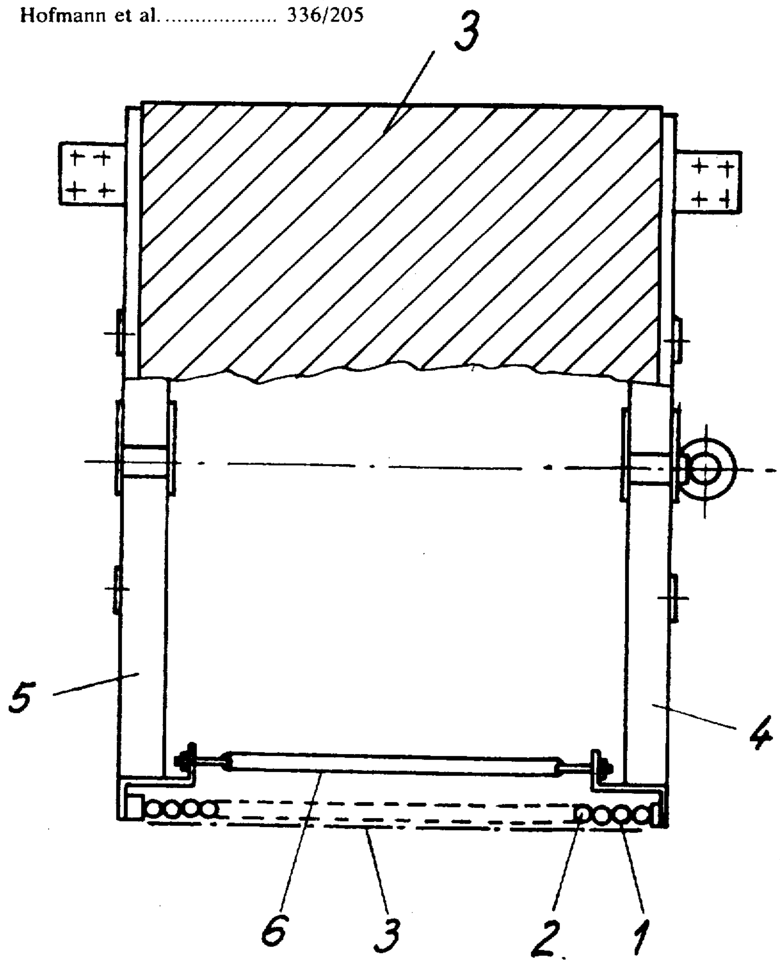
[57] **ABSTRACT**

An electrical choke coil of the air-core type formed by a helically wound insulated electrical conductor. The coil turns are substantially contiguous and are adhered to each other so as to bond all of the coil turns into an integral whole. The adhering agent is an epoxy-resin of the free air-curable type with which the insulation on the conductor is impregnated, and the conductor insulation includes a first layer of glass-mica tape and a second layer of glass-fibre tape. Spider type supports are located at each end of the coil and these are held against the coil ends by tensioned straps of insulating material extending between the supports. A tape of insulating material is wound onto the exterior surface of the coil to form a binding layer which further protects the coil against radial expansion.

2 Claims, 5 Drawing Figures



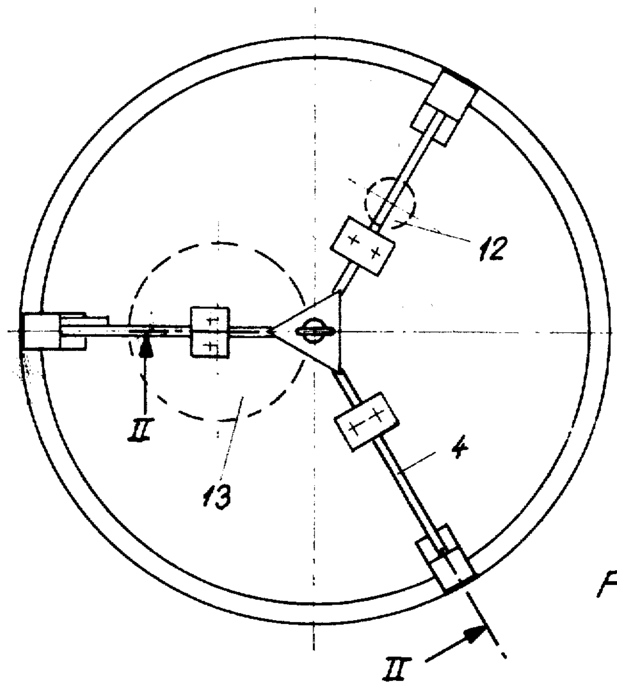


Fig. 1

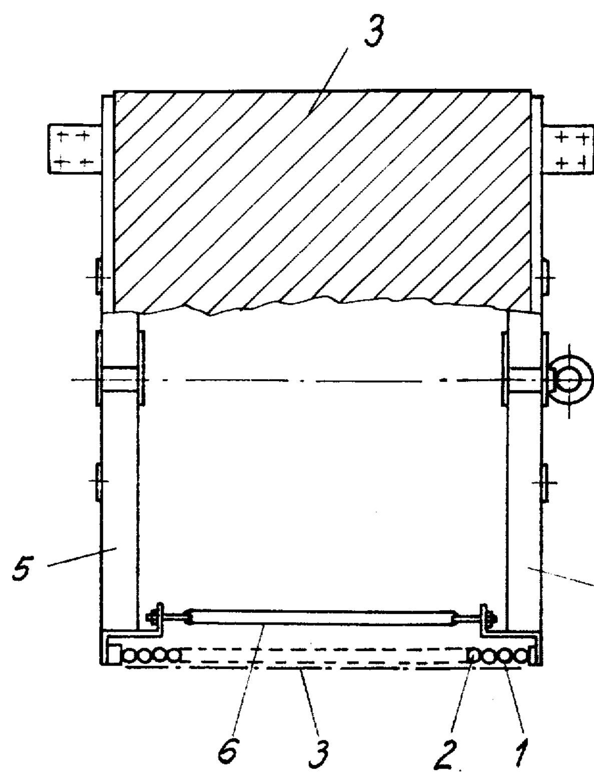


Fig. 2

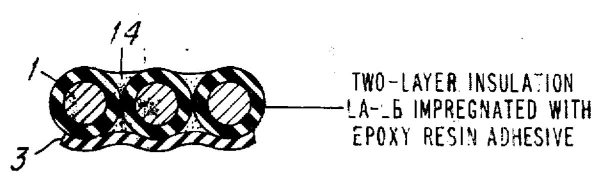


Fig. 2a

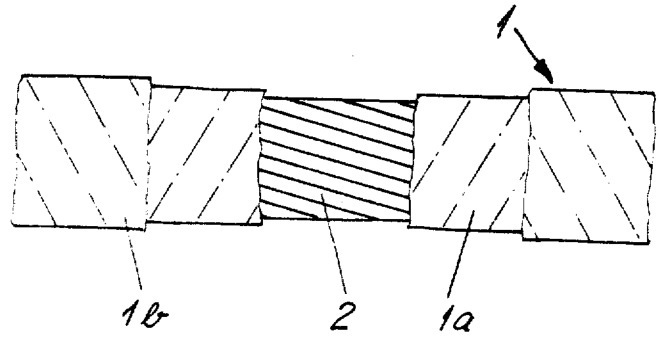


Fig. 3

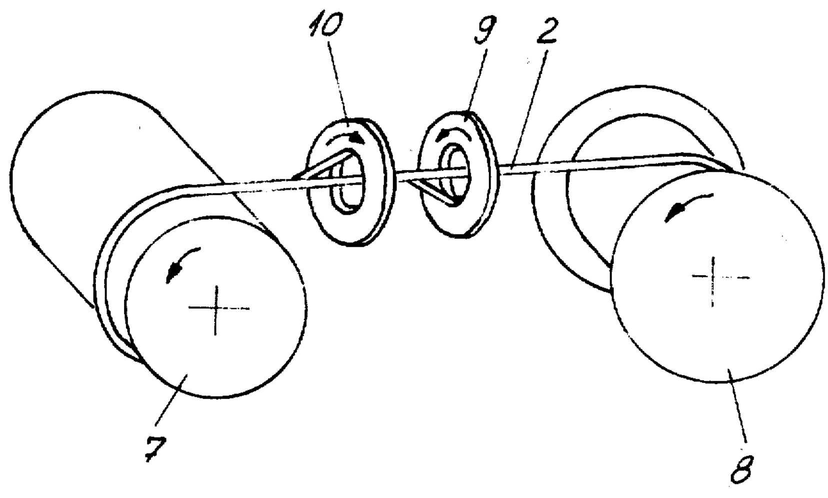


Fig. 4

ELECTRICAL CHOKE COIL OF THE AIR CORE TYPE

This invention relates to an improvement in the construction of electrical choke coils of the helically wound air-core type and also to a novel method and apparatus by which the coil is made.

Electrical choke coils of the air-core type have many uses in the electrical field. They are used as line traps in carrier communications, as current-limiting reactors and as smoothing chokes. Since in the case of a short-circuit, the total short-circuit current flows through the coils, the coils must be dimensioned and constructed in such manner as to enable them to withstand the very high mechanical and thermal stresses which arise therein during short-circuit conditions. Flow of high order currents through the coil result in the creation of mechanical forces in the cylindrically configured coil which tend to expand the coil diameter in the same manner as results from an increase in internal pressure within a tube. Hence, means are required to bind and restrain the coil turns from expanding in a radially outward direction. In addition to the radially outward acting mechanical forces, the magnetic field produced by the high order short-circuit current results also in the creation of a compressive force on the coil turns which acts in an axial direction. When the choke coils are constructed such that spacer members are located between adjacent turns of the coil to provide for circulation of cooling air between them, this axially directed compressive force may lead to bending of the conductor parts located between the spacer members.

The problem of assuring adequate mechanical strength for the coil during short-circuit current conditions is further complicated by the fact that the presence of a pulsating magnetic field in the case where alternating current flows through the coil results in the generation of strong eddy-current flows in whatever metallic support elements for the coil are utilized.

Also, since choke coils are usually of the air core type, the inherently poor heat transfer characteristic of air calls for additional attention to the cooling problem, under normal operating conditions.

Different expedients have been considered as solutions to the above-referred to problems. As already discussed, in order to effect an increase in the conductor cooling surface, an air gap has been maintained between adjacent turns in the coil by use of spacer members which are held securely in place to avoid loosening or shifting by means of serrations or slots but this is a most costly and time-consuming operation. Moreover, due to the presence of the gaps between turns, mounting of the spacer members can lead to bending of the conductor material as a result of the bending stresses imposed, and conductor bending also often takes place as a result of the above-referred to axially acting forces on the conductors during short-circuit conditions as a result of the high current flows. On the other hand, direct casting of the spacer members necessitates use of a complicated casting jib.

A common construction arrangement is to locate the helical coil between two insulating cylinders. This arrangement has, however, the disadvantage that for different coil diameters and different conductor dimensions, insulating cylinders of varied dimensions are required which, in fact, is quite complicated. Furthermore, due to the presence of a number of air-traps adjacent the conductor surface, the heat dissipation factor of such coils is very poor.

The principal object of the present invention is to provide an improved construction for choke coils of the air core type which do not suffer from the disadvantages of past constructions, i.e. coils which will stand up under short-circuit current conditions and which will also provide better cooling. The improved air-core choke coil structure is characterized by a helical winding of an insulated electrical conductor and wherein the individual turns of the coil which lie closely adjacent to each other are adhered together by an adhesive so as to bond the individual coil turns together into an integral whole capable of withstanding all forces to which it is subjected during operation.

The coil can be manufactured by first providing the bare conductor material with an insulating layer, then winding the conductor helically into the desired cylindrical form and then bonding the individual turns together. The adhesive material, e.g. an epoxy resin, can be impregnated into the insulating material before winding it onto the bare conductor, or the complete coil after winding can then be impregnated with the epoxy resin and then cured so as to harden it and complete the bonding operation. For the conductor material itself, the use of Aldrey-alloy is advantageous. For conductor insulation, a two-layer construction is preferred, the first layer being a winding of glass-mica tape for insulation and the second layer being a winding of glass tape for mechanical protection.

If desired, the choke coil having its insulated turns adhered together can also be provided with an outer binding of electrical insulating tape to further improve the resistance of the coil to radially outward expansion forces created by the short-circuit current.

Also, spider type supports can be provided at each end of the choke coil, these spiders being drawn together under tensional force by means of one or more circumferentially distributed axially extending straps of insulating material, preferably made from glass fiber which are tensioned.

Apparatus for performing the method by which the improved choke coil structure is produced preferably includes a rotary cylindrical mandrel on which the conductor is wound helically to form the coil, a supply roll of the bare conductor and a conductor-taping station intermediate the conductor supply roll and the mandrel for winding on at least one layer of insulating tape to the conductor, the particular taping station to be illustrated including a first station for winding on a glass-mica tape to the bare conductor for insulation and a second station thereafter winding on a glass-fibre tape for mechanical protection. The tapes can be impregnated with an epoxy-resin or plain tape can be used, in which case an impregnating station is provided to receive the choke coils after they have been wound on the mandrel.

The foregoing as well as other objects and advantages inherent in the inventive concept will become more apparent from the following detailed description of a preferred mode for carrying out the invention and the accompanying drawings wherein:

FIG. 1 is a top plan view of a choke coil designed to function as a "line trap" and which is constructed in accordance with the invention;

FIG. 2 is a view in longitudinal section through the coil taken on line II—II of FIG. 1;

FIG. 2*a* is an enlarged section detail of a portion of the coil structure;

FIG. 3 is an enlarged view of a portion of the conductor structure and the insulating layers thereon; and

FIG. 4 is a somewhat diagrammatic view in perspective of apparatus by which the choke coil can be made.

With reference now to the drawings and to FIGS. 1, 2 and 3, the line-trap choke coil is seen to be comprised of a closely wound helix of an electrical conductor **2** having insulation **1** applied thereto, the coil turns being essentially contiguous i.e. touching each other as shown in FIGS. 2 and 2*a* and being adhered together by means of an adhesive **14**. The conductor insulation consists of two superposed layers **1***a* and **1***b* as shown in FIG. 3, the inner layer **1***a* being a winding of glass-mica tape on the bare conductor for electrical insulation purposes and the other layer **1***b* being a winding of glass-fibre tape which is utilized for mechanical protection. As shown in FIG. 4, the two layers of tape are wound on helically in opposite directions, one being wound on clockwise and the other counter-clockwise.

Adhesion of the contiguous turns of the coil can be effected by means of an adhesive, e.g. an epoxy-resin, with which the insulating tapes **1***a* and **1***b* are impregnated prior to winding on; alternatively, the adhesive **14** can be added after the coil is wound by impregnating the completed coil with the epoxy-resin by an immersion process, and then curing so as to harden the resin and transform the coil into a compact and rigid self-supporting cylinder.

For the conductor material, "Aldrey" aluminum alloy is preferred. This is an alloy consisting of approximately 0.5 to 0.6 Si, approximately 0.4 to 0.5 Mg, the remainder being Al. In the case where operating currents of very high magnitude are involved, concentrically arranged coils, each constructed as above described, can be used, the coils being connected in parallel. In such case, in order to obtain an equal distribution of current, the number of turns of the outer coil should be less than that of the inner coil.

In order to reinforce the coil structure against expansion in a radial direction when subjected to currents of short-circuit magnitude, an outer wrapping of an electrically insulating tape **3** can be applied to the surface of the coil as depicted in FIG. 2 and which thus performs a binding function.

For the purpose of avoiding use of metallic parts within the coil itself, spider type support structures **4** and **5** are applied to opposite ends of the coil and these are held against their corresponding ends of the coil by means of straps **6**, one for each leg of the spider, made from glass-fibre and which are stressed in tension.

Because of the space-saving arrangement established within the finished coil structure, the tension straps **6** being located adjacent the outer ends of the spider legs, ample room remains within the coil to accommodate a lightning arrester **12** and line tuning equipment **13**, as depicted in FIG. **1**.

Apparatus constructed in accordance with the details depicted in FIG. **4** for forming the choke coil include a cylindrical mandrel **7** which is mounted for rotation about its axis by drive means, not shown, the insulated conductor being would helically on the mandrel as the latter is rotated, a supply spool **8** for the bare conductor **2**, and conductor taping station located intermediate the supply spool **8** and mandrel **7** which includes a first

taping station **9** wherein a first layer **1***a* of glass-mica tape is wound helically onto the bare conductor in a counterclockwise direction and a second taping station **10** where a second layer **1***b* of glass-fibre is wound helically onto the first layer **1***a*. The driving mechanism for the mandrel **7** and tape winders at stations **9** and **10** are properly synchronized so that successive turns of the tape layers **1***a* and **1***b* will have the desired amount of overlap as the conductor is fed through the taping stations. After the coil has been formed on the mandrel, it can then be removed from the mandrel and impregnated with the epoxy-resin by immersion and thereafter cured to effect hardening thereof. The details of this last component have not been included since they are well known to the art.

The epoxy-resin can be selected from the known group of such compositions which are curable in the open air and can be pigmented with a coloring agent, if desired, to increase their thermal-radiation characteristic.

Tests conducted on a choke coil constructed in accordance with the invention show that although the coil is completely enclosed with an insulation, which corresponds to Class-F, the thermal characteristics thereof are not disadvantageously affected in comparison with those of a coil made with a bare electrical conductor and wherein the individual turns of the coil are separated from each other by spacer members. Comparative measurement with a known coil of the latter type indicate a smaller temperature rise as compared to a line-trap coil **II** made according to the present invention. However, there is a shift in the mean temperature rise dependent upon whether the coil is operated in a vertical or horizontal attitude.

Coil Axis

		Vertical	Horizontal
I	1500 A	81°C	63°C
II	1600 A	48°C	79.5°C

I claim:

1. An electrical choke coil of the air-core type comprising a helically wound insulated electrical conductor, the insulation on said conductor comprising an inner layer of glass-mica material applied to the conductor and an outer layer of glass-fibre material, the individual turns of said helical coil being in touch with each other and bonded together into an integral whole by application of an electrically insulating adhering agent thereto, a binding layer of electrical insulating tape applied only to the outer surface of said coil for reinforcing the coil structure against radial expansion when subjected to currents of short-circuit magnitude, support spiders engaging each end of said coil, and tensioning straps of electrical insulating material extending between said support spiders inside of said coil for holding said support spiders against the coil ends under tension.

2. An electrical choke coil of the air-core type as defined in claim **1** wherein the insulation layers on said conductor are impregnated with an epoxy resin which when cured serves as said adhering agent for bonding together the individual turns of said coil.

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