United States Patent [19]

Horton, III

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[54] **ELECTRICAL INDUCTIVE APPARATUS**

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[52] **U.S. Cl.** ..... **336/205**; 174/117 FF; 336/206; 336/223

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

[58] **Field of Search** ..... 336/223, 206, 200, 205; 174/117 FF

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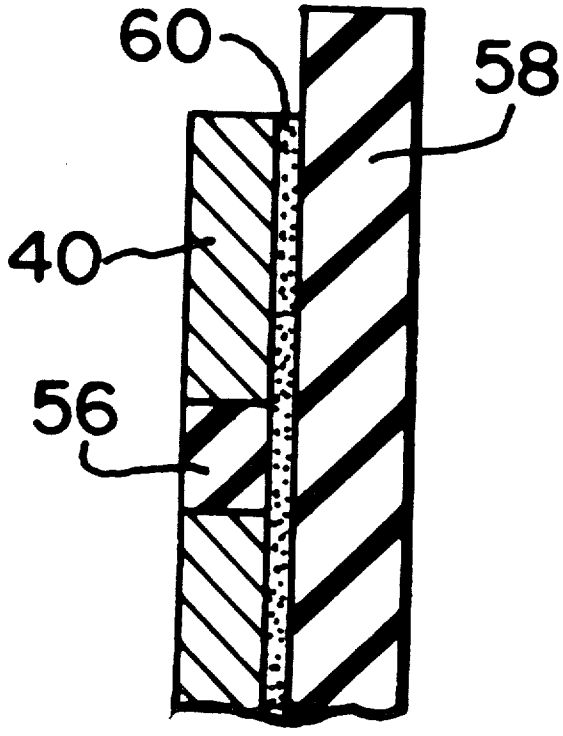
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Primary Examiner—Thomas J. Kozma
Attorney, Agent, or Firm—J. R. Hanway

[57] **ABSTRACT**

Core and coil assembly for distribution transformers. At least a portion of the coil is constructed of a plurality of metallic foil conductors which are bonded to a common piece of insulating material. The foil conductors are disposed in the coil to form coil sections which are axially displaced from each other. The insulating material extends between the coil sections to prevent relative movement of adjacent coil sections. Each foil conductor is first bonded to the insulating material and then spirally wrapped to provide the coil structure. In one embodiment, an insulating collar is positioned between adjacent foil conductors for extra mechanical strength.

1 Claim, 6 Drawing Figures



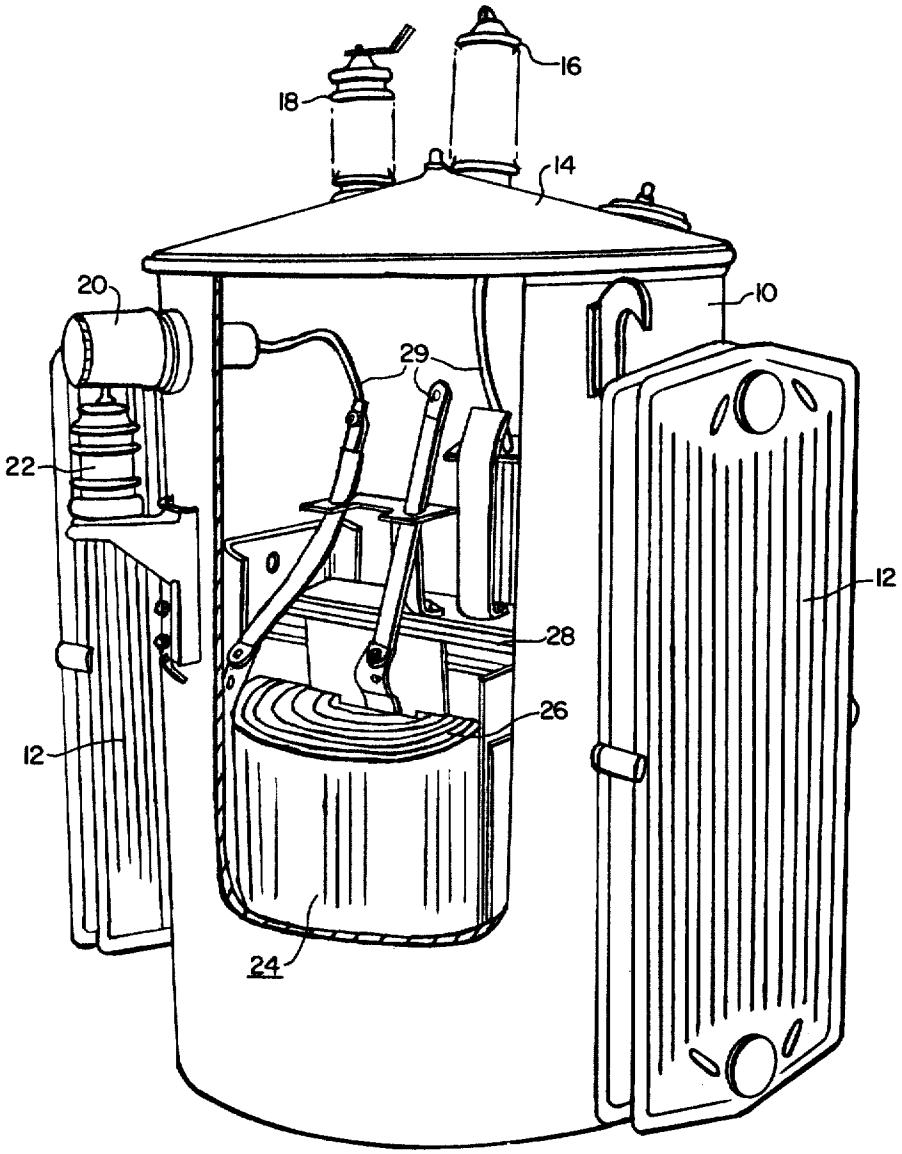


FIG. 1.

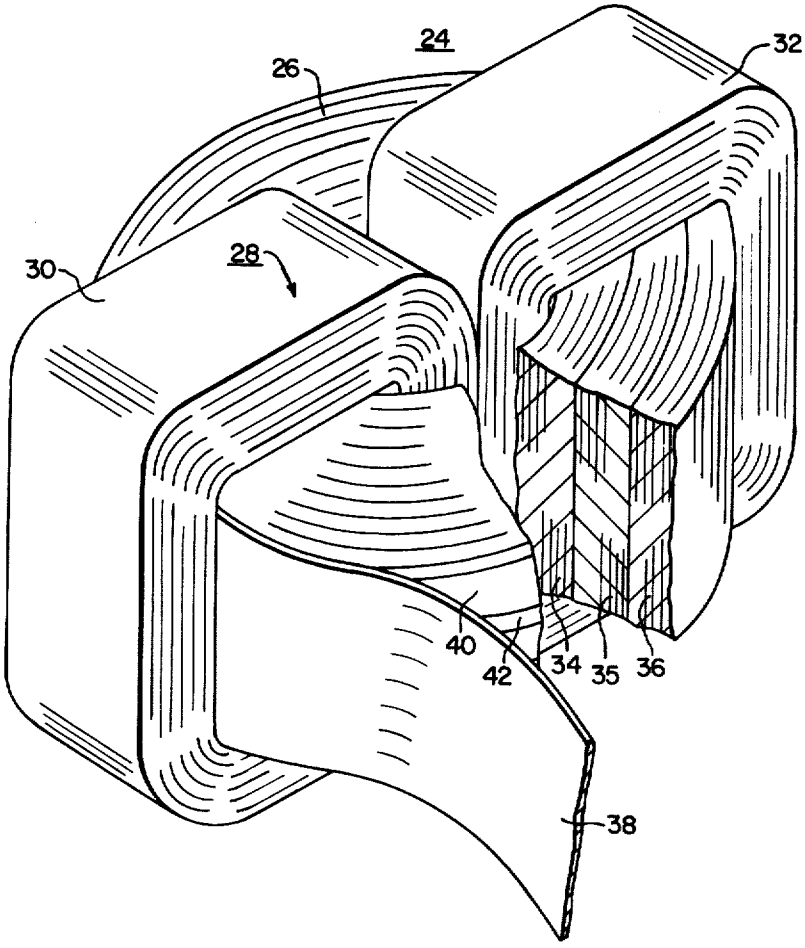
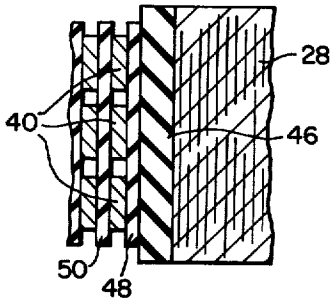


FIG. 2.

FIG. 4.



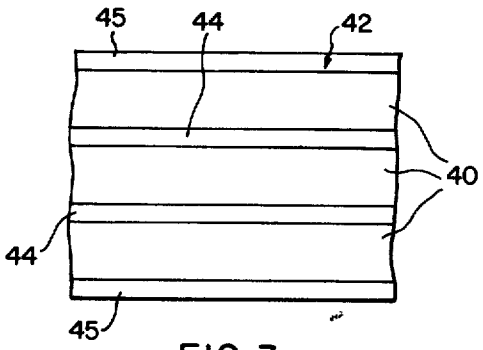


FIG. 3.

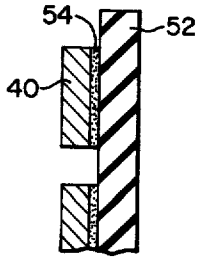


FIG. 5.

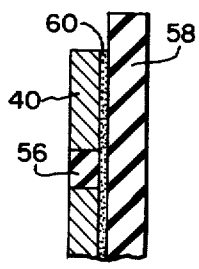


FIG. 6.

ELECTRICAL INDUCTIVE APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates, in general, to electrical inductive apparatus and, more specifically, to distribution transformers having foil conductors.

2. Description of the Prior Art

Distribution transformers which operate at relatively high voltages have coil structures which are suitable for construction from foil conductors. The physical integrity of a coil structure constructed with foil conductors has been found to be better than a corresponding winding structure constructed from strap conductors. This is due mainly to the fact that thin sheet or foil conductors can be supported over a larger surface area than relatively thick strap conductors. Thus, the ability of a transformer to withstand short-circuit stresses is enhanced by the use of foil conductors.

In some high-voltage winding structures, the use of a single sheet of foil which has a width substantially equal to the axial length of the winding structure, is practical. Such transformers exhibit very good mechanical integrity. However, as the voltage between layers increases, the insulation between the layers must be increased sufficiently to provide the required dielectric properties. As a result thereof, the space factor of the winding structure becomes undesirable when a single foil conductor is used. Using several foil conductors to form separate coil sections permits a reduction in insulating material and an improvement in the space factor. Windings and materials constructed in this manner are disclosed in U.S. Pat. Nos. 217,466 to J. L. Le Conte, 2,980,874 to J. W. Tarbox, and 3,477,126 to H. K. Price.

Winding arrangements used according to the prior art wherein multiple foil conductors are used in each layer are susceptible to destruction under short-circuit stresses. Under such conditions, the foil conductors tend to move to the center of the winding structure. Thus, the foil conductors at each end of the winding structure tend to move toward each other and, if moved sufficiently, or if adjacent conductors come into contact with each other, the winding structure is damaged. Therefore, it is desirable, and it is an object of this invention, to provide a transformer having a winding structure formed from a plurality of foil conductors which are suitably disposed within the winding structure to prevent axial movement thereof, and to provide a transformer winding structure which may be economically constructed to exhibit these desired characteristics.

SUMMARY OF THE INVENTION

There are disclosed herein new and useful arrangements for constructing the winding structure of a distribution transformer. A plurality of foil conductors are bonded to a single sheet of insulating material. The insulating and conducting members are spirally wound around each other to form the desired winding structure. By bonding the conducting foils to the insulating material, the construction of the winding is considerably simplified over construction techniques which require separate winding of each section of the winding. In addition, bonding the conductors to the insulating material prevents movement of the conductors during short-circuit stresses. In one embodiment of the invention, insulating collars having substantially the same thickness as the foil conductors are positioned between adjacent foil conductors and bonded to the insulating material. This provides a solid insulating material located between the conductors and enhances the mechanical strength of the winding structure.

BRIEF DESCRIPTION OF THE DRAWING

Other advantages and uses of this invention will become more apparent when considered in view of the following detailed description and drawing, in which:

FIG. **1** is a cut-away view of a distribution transformer constructed according to this invention;

FIG. **2** is a cut-away view of the core and coil assembly shown in FIG. 1 and constructed according to this invention;

FIG. **3** is a view of the foil conductor arrangement used in the core and coil assembly shown in FIG. **2**;

FIG. **4** is a partial, sectional view of the core and coil assembly shown in FIG. **2**;

FIG. **5** is a partial, enlarged view of the structure shown in FIG. **4** and constructed according to one embodiment of this invention; and,

FIG. **6** is a partial, enlarged view of the structure shown generally in FIG. **4**, but constructed according to another embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following description, similar reference characters refer to similar elements or members in all of the figures of the drawing.

Referring now to the drawing, and to FIG. **1** in particular, there is shown a distribution transformer constructed according to this invention. The transformer includes the tank **10**, the cooling radiators **12**, and the tank cover **14**. The high-voltage bushing **16** and the high-voltage lightning arrester **18** are mounted on the tank cover **14** and the tank **10**, respectively. The spin-top type low-voltage bushing **20** and the low-voltage lightning arrester **22** are mounted on the side of the tank **10**. The core and coil assembly **24** is located within the transformer tank **10** and is usually surrounded by a suitable cooling dielectric, such as mineral oil. The core and coil assembly **24** includes the winding structure **26** and the magnetic core structure **28**. The leads **29** extend from the winding structure **26** and are connected to the appropriate bushings, such as the bushings **16** and **20**.

FIG. **2** is a cut-away view of the core and coil assembly shown in FIG. **1**. The winding structure **26** is disposed in inductive relationship with the wound magnetic core **28** which consists of the core portions **30** and **32**. The winding structure **26** includes the inner low-voltage winding section **34**, the high-voltage winding section **35**, and the outer low-voltage winding section **36**. Each section includes at least one conductor which is spirally positioned around the center portion of the magnetic core **28**. The high-voltage winding section **35** may be constructed from foil conductors or from strap conductors. The layer **38** of insulating material is illustrated in a position which exposes the foil conductors **40** of the outer low-voltage winding section **36**.

FIG. **3** is a view illustrating the location of the foil conductors **40** on the insulating sheet **42** of the outer low-voltage winding section **36**. The inner low-voltage winding section **34** is constructed of similarly posi-

tioned insulating and conducting members. The insulating sheet **42** is constructed of a suitable material, such as kraft paper, and has a sufficient thickness to provide the desired dielectric strength between adjacent turns of the foil conductors **40.** The foil or sheet conductors **40** are separated by the space **44** to prevent electrical conduction between axially adjacent foil conductors. In addition, spaces **45** are provided by the extension of the insulating sheet **42** beyond the outer edges of the outside foil conductors **40.**

FIG. **4** is a partial, sectional view of the core and coil assembly **24** shown in FIG. **2.** The foil conductors **40** illustrated in FIG. **4** represent conductors contained within the low-voltage winding section **34.** The conductors **40** are separated from the magnetic core **28** by the additional insulating material **46.** The foil conductors **40** positioned between the insulating sheets **48** and **50** provide one conducting layer of the inner low-voltage winding section **34.** Additional conducting layers are provided by spirally wrapping the insulating sheet and the foil conductors **40** around the magnetic core **28.** The winding section formed thereby is essentially a three-section, foil-wound winding. Other numbers of sections may be used within the contemplation of this invention. The use of a single sheet of insulating material, such as the insulating sheets **48** and **50,** having a width substantially equal to the axial dimension of the winding structure provides sufficient mechanical support between the coil sections to prevent damaging movement of the conductors when they are subjected to high stress conditions.

FIG. **5** is an enlarged, partial view of a foil conductor **40** attached to an insulating sheet **52.** An adhesive material **54** is located between the conductor **40** and the sheet **52** to provide the desired bonding characteristics. The foil conductors **40** are first bonded to the insulating sheet **52** by a suitable method and then the composite material consisting of the insulating sheet **52** and the foil conductors **40** bonded thereto are wrapped around a suitable axis to provide a spirally disposed winding structure.

FIG. **6** is a view illustrating an arrangement constructed according to another embodiment of the invention. An insulating collar **56** is positioned between the foil conductors **40** and is similarly bonded to the insulating sheet **58** by the adhesive **60.** The insulating collar provides additional reinforcement of the foil conductors **40** and prevents relative movement therebetween. The insulating collar **56** may be constructed of any suitable material, such as kraft paper. In the embodiment shown, the thickness of the insulating collar **56** is substantially equal to the thickness of the conductors **40.**

The unique conductor arrangement and construction of the winding disclosed herein permits relatively easy construction of a foil-wound transformer. The foil conductors are bonded in the proper positions on the insulating sheet and then the entire conductor-insulation-adhesive structure is spirally wound to form the winding. A magnetic core is then placed into the winding. Since the conductors are fixed with respect to each other, the axial position of each conductor need not be controlled separately during the winding process. For example, in a three-section winding, at least three axial alignments are required during construction of the winding according to the prior art compared to only one axial alignment when constructed according to this invention.

In addition, bonding the insulating and conducting materials together permits the construction of a transformer which has less insulating material than prior art transformers, even with only one conductor. With normal winding techniques, the insulating material must have a greater thickness than that required for sufficient electrical strength in order to provide sufficient mechanical strength during the winding process. Due to the increased strength of the bonded insulating and conducting materials, the thickness of the insulating material may be just sufficient to provide the desired electrical properties without causing difficulty due to tearing during the winding operation.

Since numerous changes may be made in the above described apparatus, and since different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all of the matter contained in the foregoing description, or shown in the accompanying drawing, shall be interpreted as illustrative rather than limiting.

I claim as my invention:

1. A transformer comprising:

a magnetic core;

a primary winding disposed in inductive relationship with said magnetic core;

a secondary winding having a plurality of conducting layers disposed in inductive relationship with the magnetic core, with each of said conducting layers comprising at least two metallic foil conductors which are bonded to a common layer of insulating material; and,

an insulating member positioned between the foil conductors, with said insulating member having substantially the same radial thickness as the foil conductors.

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