

Jan. 28, 1969

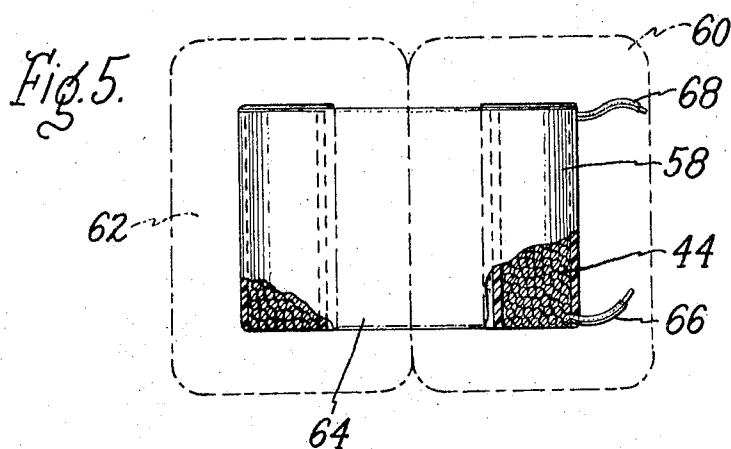
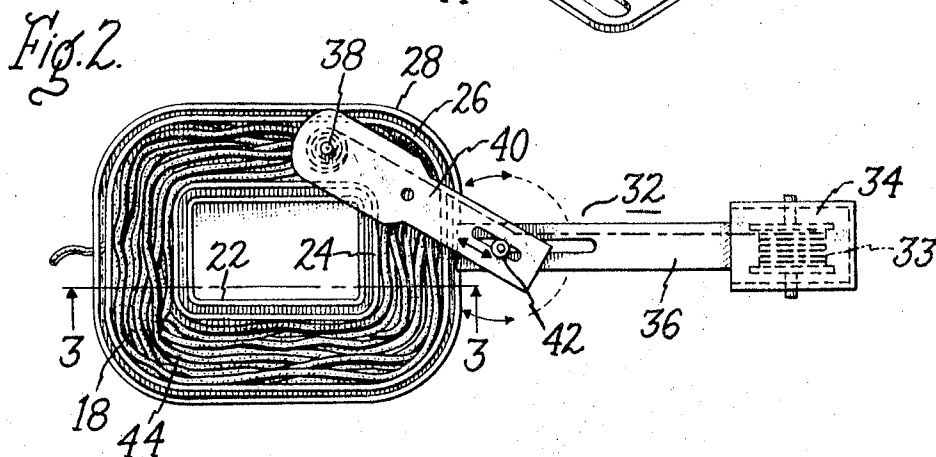
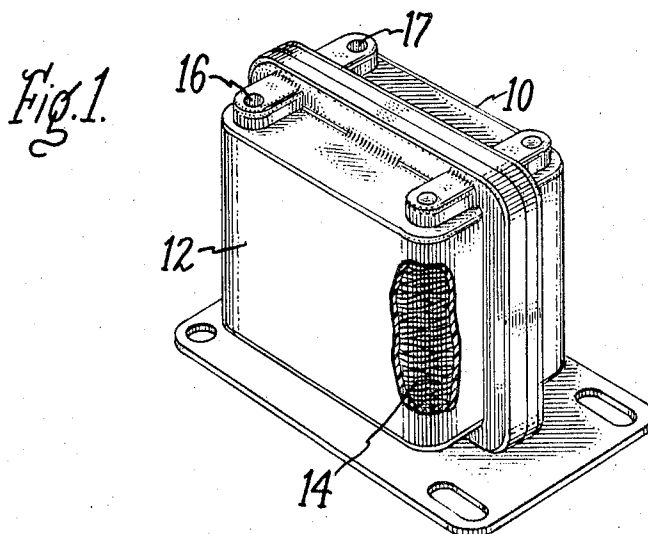
R. L. DAVIS, JR

3,425,014

AXIALLY RANDOMLY WOUND COILS

Filed Nov. 29, 1967

Sheet 1 of 2



Inventor,
Reuel L. Davis, Jr.,
by *Francis K. Doyle*
His Attorney.

Jan. 28, 1969

R. L. DAVIS, JR

3,425,014

AXIALLY RANDOMLY WOUND COILS

Filed Nov. 29, 1967

Sheet 2 of 2

Fig. 3.

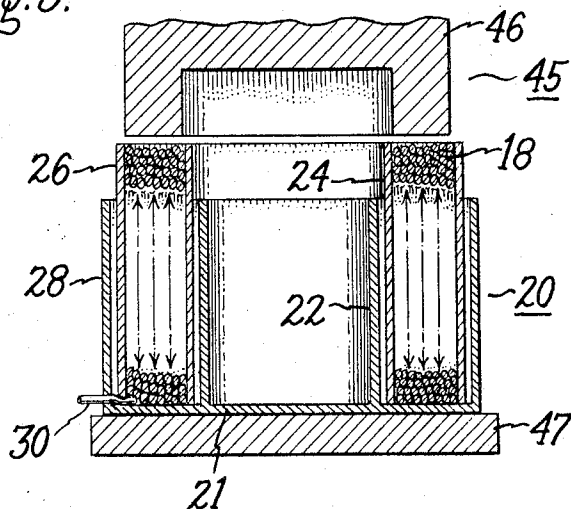
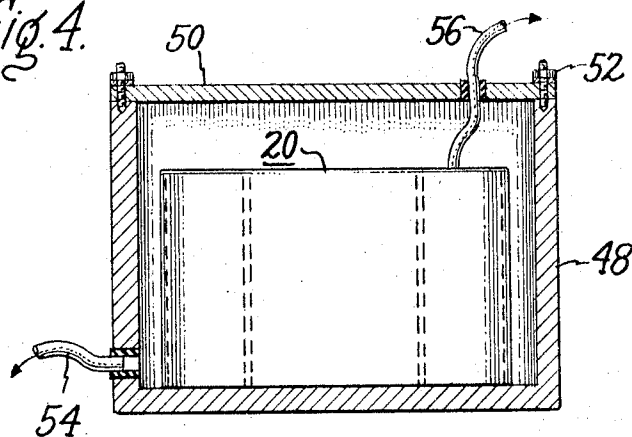


Fig. 4.



Inventor,
Reuel L. Davis, Jr.
by Francis X. Doyle
His Attorney.

1

2

3,425,014

AXIALLY RANDOMLY WOUND COILS

Renel L. Davis, Jr., 2032 Evergreen Drive,
Hendersonville, N.C. 28739

Continuation-in-part of application Ser. No. 446,687,
Apr. 8, 1965. This application Nov. 29, 1967, Ser.
No. 697,542

U.S. Cl. 336-96

2 Claims

Int. Cl. H01f 27/28

ABSTRACT OF THE DISCLOSURE

A winding assembly having a plurality of conductor turns encapsulated to form a tubular winding which has inner and outer walls. The plurality of turns start at the first end of the assembly and randomly fill the radial space between the inner and outer walls as the turns progress from the first end of the tubular assembly to the second end.

This application is a continuation-in-part of application Ser. No. 446,687, now abandoned, filed Apr. 8, 1965 for Randomly Wound Coils which was a division of application Ser. No. 160,171, filed Dec. 18, 1961, now Patent 3,212,172, for Method of Forming Coils and Coils Formed Thereby, all of which are assigned to the same assignees as this invention.

This invention relates to coils such as transformer coils and the like, and more particularly to coils which are randomly wound in an axial direction.

It is well known in the coil making art to wind coils for use in transformers or the like electrical apparatus on some type of a winding form. In general, the coil is found in layers along the form, the wire from one end of each layer usually being returned to the beginning of the lower layer and the next layer being wound in the same direction as this lower layer. Due to the voltage drop through the wire, when the coil is utilized in electrical apparatus and such apparatus is energized, a voltage gradient or difference is developed between adjacent turns in adjacent layers of the coil. That is a, voltage gradient is developed between the first turn in one layer, such as a lower layer, and the last turn in the next adjacent or upper layer. This voltage gradient, during the use of the coil, is generally substantially greater than the voltage gradient between adjacent turns in a single layer of the coil. In winding such coils, it is usual to use an insulated wire, the insulation of the wire being sufficient to protect the adjacent turns from the voltage gradient developed therebetween, but it is not sufficient to provide the necessary insulation between the different layers of the coil. In order to provide the necessary insulation between adjacent layers, it has been the general practice in the coil winding art to provide paper insulation, or the like, between the different layers of the coil. A construction of this type is disclosed, for example, in Patent No. 2,985,950.

As will be understood this type of construction is relatively expensive, both from the standpoint of materials used, and from the time and labor which is necessary to construct the coil. Further, as will be understood, coils which have been constructed in this manner are dependent upon their layer insulation to prevent breakdown between the layers when the coils are subjected to high impulse voltages. It will be understood that impulse voltages are large voltages which are suddenly impressed on the electrical apparatus and which substantially increase the voltage gradient between layers of the coils over that existing during steady state normal operating condition. As is well known, any weakness in the layer insulation or the subsequent deterioration of the layer insulation during

use of the coil will result in short circuits developing between various layers of the coil from impulse voltages, or from normal operating voltages, which will eventually cause the breakdown of the coil.

It has long been recognized as desirable to provide coils which are wound of insulated wire in which the various layer insulation could be eliminated, that is, it has been recognized as desirable to make coils in which all the turns of the coil are contiguous to all the turns which are adjacent thereto. As used throughout the specification and claims, the term "contiguous," when relating to turns, will mean that the adjacent turns are in substantial contact with each other, and that no additional insulation is provided between such adjacent turns. It has generally been considered impractical to provide coils in which all the turns are contiguous to all adjacent turns thereto because of the commercial and economic problems involved. As will be understood, the amount of insulation which would be necessary on each turn of the wire, to provide the necessary insulation for the voltage gradient between layers, would make the wire extremely expensive, while at the same time increasing overall size of the coil such that the overall dimensions of a coil formed therefrom would be substantially larger than present day coils which are formed from the usual insulated wire and provided with layer insulation between the various layers of the wire.

It is therefore one object of this invention to provide a new and novel coil where the use of layer insulation has been eliminated.

A further object of this invention is to provide a novel economical coil wherein all turns of the coil are contiguous to all adjacent turns.

It is a further object of this invention to provide a novel, randomly wound coil.

In carrying out this invention in one form, a coil is provided in which the various turns of the coil are randomly wound in an axial direction with all turns of such coil being contiguous to all adjacent turns.

The coil is made by the method of providing a cavity, such as a mold or the like, in the shape desired for the specific coil, and then randomly spinning or otherwise laying turns of wire, progressively axially into such cavity. After the cavity is filled with wire the wire is compacted, in any desired manner, within the cavity to form a tight, axially, randomly wound coil. The formed coil may then be encapsulated with any desired type of insulating material, or taped to provide a solid, randomly wound coil, progressive in an axial direction.

The invention which is sought to be protected will be particularly pointed out and distinctly claimed in the claims which are appended hereto. However, it is believed that this invention and the manner in which its various objects are obtained, as well as other objects and advantages, will be better understood from the following description when taken in connection with the accompany drawings, in which:

FIGURE 1 is a perspective view of a transformer, partly in section, showing one use of the novel coil of this invention;

FIGURE 2 is a top view of one form of cavity which may be used in making the coil of this invention, showing one method of placing the wire forming the coil into such cavity;

FIGURE 3 is a sectional view taken substantially along the line 3-3 of FIG. 2 and showing one method of compacting which may be used in making the coil of this invention;

FIGURE 4 is a schematic representation of one means for encapsulating the formed coil made by this invention; and

FIGURE 5 is a side view of a finished coil, partly in section, according to this invention.

Referring now to the drawings, in which like numerals are used to indicate like parts throughout, and referring specifically to FIG. 1, there is shown an instrument transformer, for example a potential transformer 10, provided with a primary and secondary coil and core, in a manner well known to those skilled in the art. The potential transformer is shown as broken away in one side of the casing 12 thereof to show a section of a randomly wound coil 14 which may be made according to the method disclosed in application Ser. No. 160,171, now Patent No. 3,212,172. As will be understood, the coil 14 is the primary coil of the potential transformer 10, and is provided with the voltage of the line to be measured through leads which terminate at connecting points 16, 17 shown on top of the transformer 10. Inasmuch as the primary coil 14 is subjected to the high primary voltage being measured, it will be understood, that the voltage gradient which could be developed between layers, were a substantial number of turns provided in each layer, would be relatively large and, therefore, it would be necessary to provide layer insulation between the various layers to prevent this voltage gradient from breaking down the insulation which is provided about each of the turns of the coil. In a manner hereinafter specified, the use of the layer insulation is eliminated by winding the coil randomly from one end to the other in an axial direction in substantially the same manner as the applied voltage progresses across such coil. By means of a coil wound in this fashion, each turn is contiguous to all adjacent turns and each adjacent turn is substantially subjected only to the voltage gradient of the normal turn-to-turn voltage gradient. Therefore, the need for layer insulation has been completely eliminated.

Referring now to FIGS. 2 and 3 of the drawings, the method of making the randomly wound coil of this invention, as disclosed in application Ser. No. 160,171, now Patent No. 3,212,172, will be described. As shown in FIGS. 2 and 3, a cavity 18 is provided, the cavity being formed in any desired shape, a rectangular shape being shown in this instance. The cavity is formed in a mold 20, which has a base 21 and an upstanding central member 22, by placing a central winding member 24 over the mold center member 22 and a winding can 26 within the outer upstanding member 28 of the mold 20. Thus, the cavity 18 comprises portions of the inner surface of the base 21 of the mold 20, the outside surface of the central winding member 24 and the inside surface of the winding can 26. The central winding member 24 and the winding can 26 are shown as fitting closely against the adjacent surfaces of the central member 22 and the outer member 28. Of course, it will be understood that these may fit as snugly or loosely as desired, since the central winding member 24 and the winding can 26 are used as spacer and winding members. Further, an opening 30 is provided in both the winding can 26 and the upstanding portion 28 of the mold 20, such that the end of the wire to be used to form the coil may be taken outside of them old 20, in the manner indicated in FIG. 3.

As can be seen, especially from FIGURE 3, the central member 22 of mold 20 extends in a vertical direction along the axis of the coil. As the wire is spun or wound into the cavity 18, it builds progressively in the axial direction, beginning at the bottom of cavity 18. As will be apparent from FIGURE 3, the first few strands of wire will cover the bottom of cavity 18, extending from the inner to the outer surface of the mold 20. In the usual coil, the strands or turns are wound along the arbor or coil form, which corresponds to inner or central winding member 24 forming layers which build progressively in the radial direction. However, by this method, the coil is randomly wound and builds progressively in the axial direction as can be seen in FIGURE 3. It is this axial progression that provides a coil which progresses in substantially the same manner as the applied voltage thus

eliminating layers, as such, and dispensing with the need for layer insulation.

The assembled mold, with the center section 24 and the winding can 26 in place thereon, is then placed into a winding machine, such as machine 32, which is provided with a reel of wire 33 mounted in the member 34. The winding wire extends from the member 34 along stationary arm 36 and to a rotary feeding member 38 on the movable arm 40. The winding machine is indicated only in a schematic manner in the drawing. As indicated in FIG. 2, the wire is fed from the feeding member 38 on movable arm 40 into the cavity 18 formed in the mold 20. The movable arm 40 is caused to move in a lateral and oscillatory manner about the pivot point 42, so as to lay the wire 44 within the cavity 18.

After a sufficient quantity of wire has been randomly wound into the cavity 18 by means of the winding machine 32, generally up to the height of the winding can 26 and the center piece 24, as indicated in FIG. 3, the machine is stopped and the mold is removed to a press, such as press 45 schematically indicated in FIG. 3. In the press 45 a ram member 46 is moved into contact with the winding wire 44 while mold 20 is supported on member 47 of press 45 and causes the wire to be forced tightly into the cavity 18, thereby solidly compacting the winding to form a coil which is substantially the height of the mold 20. As will be understood, inasmuch as the wire is randomly wound within the cavity 18 in an axial direction, the various turns of wire do not lay on top of each other in the manner usually found in a coil, but they are randomly dispersed at various angles throughout the entire coil in the manner indicated in FIG. 2. After the compacting step this random winding aids in supporting the coil in the same shape in which it has been formed.

After the compacting step has been provided, for example by means of the press 45 indicated in FIG. 3, the formed coil within the mold 20 may then be placed in an encapsulating machine, such as, for example, machine 48 shown in FIG. 4. As will be understood, before the mold is placed into the encapsulating machine 48 the center piece 24 and the winding can 26 are removed. Inasmuch as the coil has been firmly compacted it will maintain its shape, thereby leaving spaces between the center piece 22 and the upstanding outer portion 28 of the mold 20 and the formed coil, such that the encapsulating material may be brought into the mold on each side of the formed coil. As indicated in FIG. 4, after the mold with the formed coil is placed into the encapsulating machine 48 the top 50 is placed thereon and hermetically sealed thereon, for example, by means of bolts 52. A vacuum is then formed within the machine 48 by means of a vacuum pump (not shown) which removes the air from within the machine 48 through the vacuum pipe 54. After a sufficient vacuum has been obtained within the machine 48, the encapsulating material is caused to flow into the machine by means of the tube 56. The encapsulating material flows through the tube 56 and into the mold 20 as indicated, to surround the formed coil and fill all the voids within the mold 20. After a sufficient amount of encapsulating material has been poured into the mold 20 so as to completely surround the formed coil, the encapsulating material is stopped and heat is then applied, as necessary, to cure the encapsulating material to thereby firmly encase the coil within such encapsulating material.

As shown in FIG. 5, after the encapsulating material has been cured the coil may be removed from the mold and will thereby provide a solid, well insulated coil 58 which is randomly wound in an axial direction from the wire 44. The coil 58 does not have any layer insulation and will easily withstand the voltage gradients which may be caused within such coil when subjected to impulse voltages in use. In FIG. 5 the coil member 58 is shown as being provided with two separate cores 60 and 62, shown in phantom view, which are inserted within the window opening 64 of the coil, the window opening of course

5

6

having been formed when the coil was made by the center piece 22 of the mold 20. Also as shown in FIG. 5, the lower end of the wire 44 forming the coil 58 is brought out through the base of the member as shown in the mold in FIG. 3, and forms one terminal 66 of the coil 58 while a second lead 68 from the top end of the coil forms the other terminal of the coil. From the above it will be clear that a novel, randomly and axially wound coil has been provided in which the windings of the coil progress in a random fashion from one end of the coil axially to the other end in substantially the same manner in which the applied voltage progresses across the coil. As will be understood all turns of the coil will be contiguous to all adjacent turns.

While the preferred coil has been described in this specification, it will be understood by those skilled in the art that various changes may be made in such coil without departing from the scope of this invention. For example, while the coil of this invention has been shown as being encapsulated, after forming, in an insulating material, it will be obvious to those skilled in the art that depending upon the use desired of the coil, the coil may be merely provided with a supporting form, or it may be taped to aid in supporting and to provide the desired external insulation. Thus, while the preferred embodiment of the present preferred coil of this invention has been described in detail hereinbefore, it is to be understood that the scope of the invention is considered only as limited in the manner set forth in the claims appended hereto.

What is claimed as new and which it is desired to secure by Letters Patent of the United States is:

1. A winding assembly for electrical inductive apparatus comprising; a plurality of conductor turns; bonding means encapsulating said plurality of conductor turns to form a tubular winding assembly having an inner wall

forming a window opening and an outer wall, and extending axially between first and second ends, said plurality of conductor turns starting at the first end of said winding assembly and randomly filling the radial space between the inner and outer walls as the turns progress from the first end of said tubular winding assembly to the second end.

2. A potential transformer comprising a magnetic core, a primary winding, and a secondary winding, said primary and secondary windings being disposed in inductive relation with said magnetic core, said primary winding comprising a plurality of conductor turns, bonding means, said bonding means encapsulating said plurality of primary turns to form a tubular primary winding assembly having an inner wall forming a window opening and an outer wall and extending axially between first and second ends, said plurality of primary turns starting at the first end of said tubular primary winding assembly and randomly filling the radial space between its inner and outer walls as the turns progress from the first end of said primary winding assembly to its second end.

References Cited

UNITED STATES PATENTS

790,581	5/1905	Lovejoy	336—190
873,780	12/1907	Peterson	336—190 XR
2,275,967	3/1942	Keillor et al.	336—190

LEWIS H. MYERS, *Primary Examiner*.

T. J. KOZMA, *Assistant Examiner*.

U.S. Cl. X.R.

339—190