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L. E. FEATHER

3,467,932

TRANSFORMER CONSTRUCTION

Original Filed June 24, 1965

2 Sheets-Sheet 1

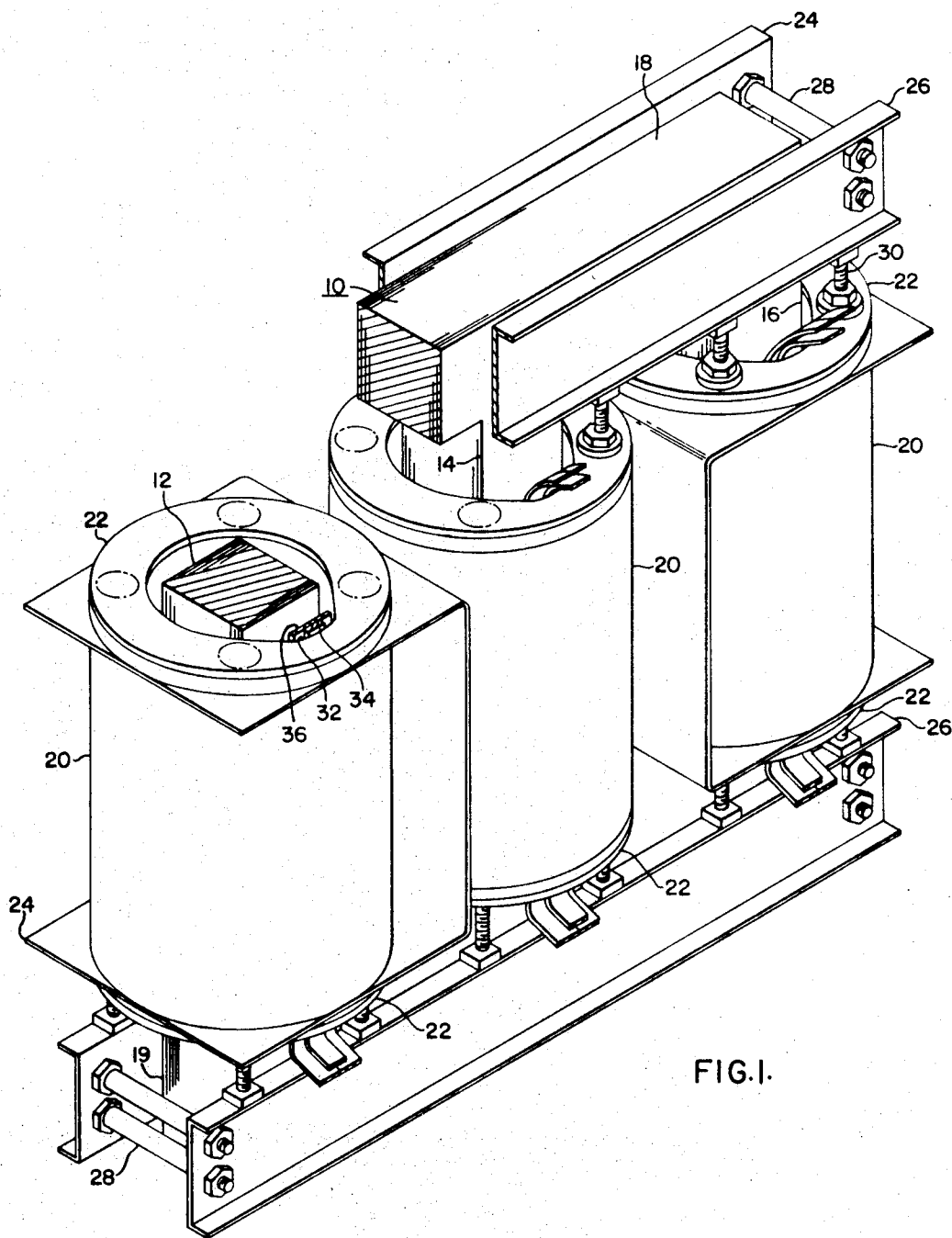


FIG. 1.

WITNESSES

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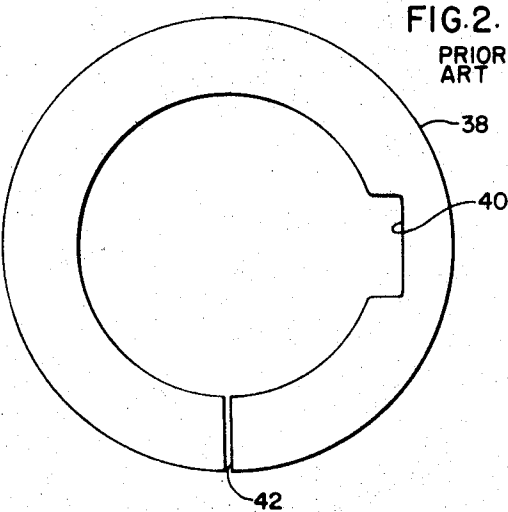
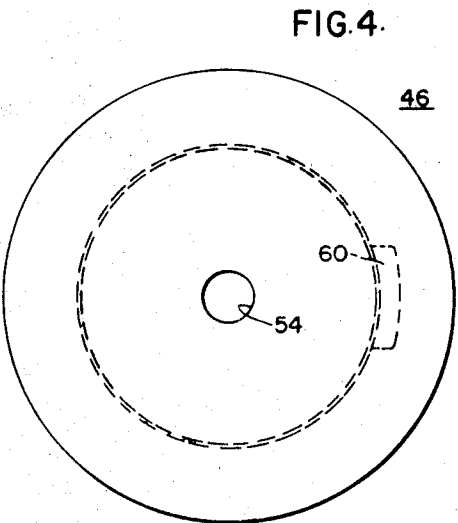
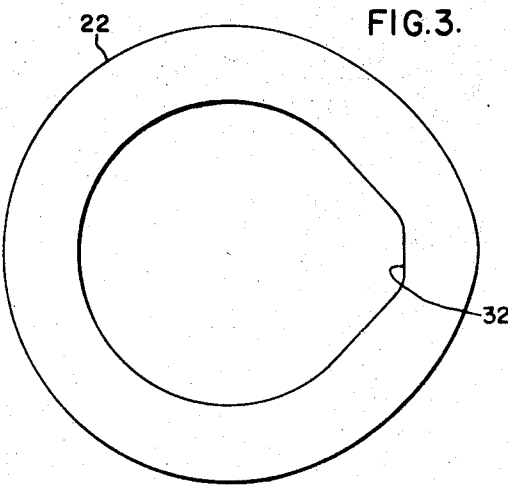
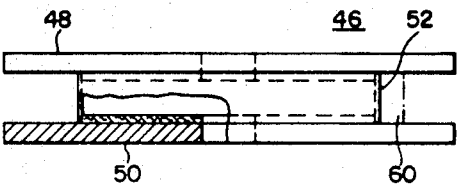
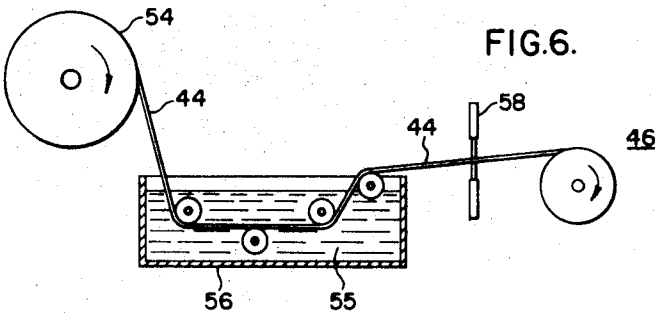


FIG. 5.



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3,467,932

TRANSFORMER CONSTRUCTION

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Int. Cl. H01f 27/30

U.S. Cl. 336—197

4 Claims

ABSTRACT OF THE DISCLOSURE

A transformer of the core-form type having a non-metallic pressure ring formed of a plurality of continuous turns of filamentary fibrous material impregnated with a bonding resin. The fibrous material forms 70 to 85% of the weight of the pressure ring. The resin bonding material is epoxy and the fibrous material, glass, is under a tension of 2 to 3 pounds. The ring is between pressure means and the winding and has a flexural strength of approximately 100,000 pounds for square inch.

This application is a continuation of application Ser. No. 466,787, filed June 24, 1965, now abandoned.

This invention relates to core-form transformers, and particularly to an improved core-form transformer comprising improved non-metallic pressure plates or rings.

In core-form transformers of the prior art the coils or windings are placed about the legs of a magnetic core. A frame member is usually attached to the upper and lower yoke portions of the magnetic core. A metallic pressure plate or ring is usually placed against the coils or windings at both ends of the coils or windings. Jack-screws are attached to the frames, which are attached to the upper and lower yoke members; these jack-screws are tightened down against the metallic pressure plates or rings to maintain the coils or windings under pressure to prevent movement of the coils or windings under short circuit conditions. The pressure plates or rings are usually made of steel and are from one half inch to an inch or more in thickness and are washer shaped and have about the same inside and outside diameter as the coils or windings to which they are applied.

These prior art steel pressure plates or rings have several disadvantages. The steel pressure plates or rings occupy space in the core openings thus increasing the necessary core dimensions. Insulation for the full line potential must be placed between the ends of the coils or windings and the metallic pressure plates or rings. Low voltage leads which must pass between the core and the pressure plates or rings must be insulated from the pressure plates or rings. Since the pressure plates or rings are usually made by flame cutting from steel plate, sharp points on the edges of the plates or rings serve as points for starting corona and electrical breakdown.

Furthermore, eddy current losses in the steel pressure plates or rings increase with increasing size of the transformer. In very large core-form power transformer units, these losses are frequently high enough to cause undesirable heating of the pressure plates or rings which will damage the transformer.

Accordingly, it is a principal object of this invention to provide an improved core-form transformer wherein the above referred to disadvantages of the prior art transformers are eliminated.

It is a further object of this invention to provide an improved core-form transformer wherein nonmetallic pressure plates or rings are provided between the ends of the coils and the core.

It is still a further object of this invention to provide an improved core-form transformer which incorporates non-metallic pressure plates or rings composed of filaments bound together into a solid mass with a suitable resin.

It is still a further object of this invention to provide an improved pressure plate or ring for use in core-form transformers.

It is still another object to provide an improved method of making a non-metallic pressure plate or ring for use at the ends of the coils in a core-form transformer.

These and other objects of this invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a partial perspective view of a core-form transformer incorporating non-metallic pressure plates as provided by this invention;

FIG. 2 is a plan view of a metallic type pressure plate as used in the prior art;

FIG. 3 is a plan view of the new non-metallic pressure plate or ring;

FIG. 4 is a plan view of a mandrel for manufacturing the improved non-metallic pressure plate or ring;

FIG. 5 is a side view of the mandrel shown in FIG. 4; and

FIG. 6 is a schematic view of the process used for providing the new pressure plates or rings.

Referring to the drawing in detail, FIG. 1 is a partial perspective view of a core-form transformer utilizing non-metallic pressure plates or rings. The transformer of FIG. 1 comprises a magnetic core 10 having three leg portions 12, 14 and 16, with an upper yoke portion 18 and a lower yoke portion 19 connecting the three leg portions to provide a closed magnetic circuit. The leg portions and the yoke portions of the core 10 are made up by stacking laminations of grain oriented silicon steel, having at least one preferred direction of orientation of grain structure. A coil 20 comprising a low voltage winding and a high voltage winding is placed on each of the core legs 12, 14 and 16 before the upper yoke portion 18 is placed in position. A pressure plate or ring 22 is placed adjacent the lower end and adjacent the upper end of each of the coils 20 during the assembly of the transformer. Frame members 24 and 26 are clamped to the upper yoke member 18 and to the lower yoke member 19 by means of bolts 28. The frame members 26 and 28 are provided with jack-bolts 30. The jack-bolts 30 are positioned in such manner that after the coils 20 and the pressure plates or rings 22 have been assembled in position on the legs of the core 10, the jack-bolts 30 are adjusted to apply pressure to the upper and lower pressure plates or rings 22. The jack-bolts 30 are positioned in such manner that at least four jack-bolts 30 apply pressure to both the upper and lower pressure plates or rings 22. The pressure plates or rings 22 each have a slot portion 32 provided therein for facilitating bringing out low voltage leads 34 from the windings 20. The low voltage lead 34 is insulated from the respective core legs by means of insulators 36. In a transformer of the type described it is necessary to provide pressure on the coils 20 to prevent movement of the coils under short circuit conditions, which occur during short circuit testing of the transformer or which might occur after the transformer is placed in operation.

The pressure plates or rings 22 as illustrated in FIG. 1 are made from non-metallic material, such as, glass fiber, roving or tape which is bonded with epoxy or polyester resin and the resin is heat cured to provide a solid rigid mass. The construction of the pressure plates or rings 22 will be described hereinafter.

In prior art transformers of the type illustrated in FIG. 1, it has been the practice to use pressure plates or

rings made from steel plate. These pressure plates or rings were flame cut from a solid steel plate to the proper dimension. A pressure ring or plate 38 such as used in the prior art devices is illustrated in FIG. 2. With this type of pressure ring it was necessary to flame cut a slot 40 from the ring to permit bringing the low voltage lead 34 out from the inside of the coil 20. It was also necessary to cut a slot 42 completely across the pressure ring 38 to prevent the pressure plate or ring 38 from acting like a shorted turn. With this type of pressure plate or ring it was also necessary to place full line potential insulation between the end of the coil 20 and the pressure plate or ring 38. It was also necessary to completely insulate the low voltage leads 34 from the pressure ring 38. Often, because the pressure ring 38 was cut from a solid plate by flame cutting, sharp points occurred on the edges of the rings or plates 38 which served as points for starting corona and electrical breakdown. Also, because of stray magnetic flux at the ends of the coils the eddy current losses were objectionable and caused undesirable heating of the pressure plates or rings 38 which tended to damage the transformer.

The pressure rings or plate 22 are constructed by winding continuous filament glass fiber, roving or tape 44 onto a mandrel 46 and impregnating the fiber, during the winding process, with a heat curable resin, such as epoxy or polyester resin. During the winding of the pressure ring or plate 22 the mandrel 46 is rotated at approximately 40 revolutions per minute. This speed of rotation applies a tension of approximately 2 or 3 pounds per strand to the fiber. After the plate or ring 22 has been wound to the proper size, the mandrel 46 on which the plate or ring 22 has been wound is then placed in an oven and the plate or ring 22 is cured at a temperature of approximately 130° C. for approximately 2 hours, followed by additional curing at 150° C. for 2 additional hours. After this curing the plate or ring 22 is removed from the mandrel 46.

Pressure plates or rings 22 constructed according to the above process have been tested for flexure at room temperature. This test was applied by laying the ring or plate 22 horizontally on four supports spaced 90° apart. A load was applied to four points on the top surface of the ring or plate 22 midway between the bottom supports. Plates or rings 22 tested in this manner indicated a flexural strength of approximately 100,000 pounds per square inch or more. It was found that pressure plates or rings 22 constructed in this manner, in addition to having good flexural strength also had good electrical insulating properties.

Typically, a pressure ring or plate constructed as described hereinbefore contains from 70 to 85% by weight of continuous filament glass fiber, roving or tape with the balance of the weight consisting of an epoxy or polyester resin.

FIGS. 4 and 5 illustrate a suitable mandrel for winding the pressure ring or plate 22 as provided by this invention. The mandrel 46 of FIGS. 4 and 5 comprises two steel plates 48 and 50 which are separated by a ring 52, which ring 52 defines the inside diameter of the pressure ring or plate 22. The maximum outside diameter of the pressure ring or plate 22 is defined by the maximum dimension of the steel disks 48 and 50. The mandrel of FIGS. 4 and 5 is provided with an aperture or opening 54 for mounting the mandrel 46 for rotation during winding of the fiber to provide the pressure ring or plate 22.

The process for constructing a pressure plate or ring 22 according to this invention is illustrated in FIG. 6. In FIG. 6 the reference character 54 illustrates a reel of fiber, such as continuous filament glass fiber, glass roving or glass tape 44. A container 56 contains a resin 55, such as an epoxy or polyester resin. The fiber 44 is drawn through the container 56 by rotating the mandrel 46 at approximately 40 revolutions per minute. It is emphasized that the fiber 44 and the resin 55 must be com-

patible so that the resin 55 will completely wet the fiber 44. As the fiber 44 is drawn from the container 56 excess resin is removed by wipers 58. After the fiber 44 passes through the wipers 58 it is wound on the mandrel 46 under a tension of approximately 2 or 3 pounds per strand until the desired build up of the pressure ring or plate 22 is obtained. After the required build up of the pressure ring or plate 22 is obtained then the pressure ring or plate 22 is cured on the mandrel 46 by heat, as described hereinbefore, to provide a solid rigid structure in the form of the pressure ring or plate 22. If it is desired to provide a slot 32 for bringing the low voltage leads out from the inside of the coils 20, before the winding process is started a spacer 60 is placed inside the mandrel, as illustrated in FIG. 4, to provide a slot 32. This spacer may be simply a block of some type fastened in position inside the mandrel to provide the required slot 32 as the filament is wound on the mandrel 46.

Alternatively, the slot may be provided by sawing, after the ring is removed from the mandrel. Such a sawn slot would be smaller than the slot 40 on the steel plate or ring because it would not be necessary to insulate the low voltage leads from the ring or plate.

From the description hereinbefore it is seen that this invention provides a pressure plate or ring 22 of insulating material which is very rigid and strong and which provides an electrical insulator between the ends of the coils 20 and the core 10 and in which eddy current losses will not occur, as in the prior art device. It is also seen that with the pressure plate or ring 22 as provided by this invention it is not necessary to provide full line insulation between the end of the coil 20 and the pressure plate or rings 22.

Pressure plates or rings 22 may be constructed according to this invention with dimensions within approximately the following limits, based on the transformers now being built. The inside diameter of the opening in the ring 22 may be 10 to 24 inches; radial width from the inside opening in the pressure plate or ring 22 to the outside diameter may be 3 to 15 inches; thickness of the pressure ring or plate may be ½ to 1½ inches. However, these approximate dimensions may vary with different ratings of transformers.

The term "epoxy resin" as used herein is intended to mean a complex epoxide resin comprising a polyether derivative of a polyhydric organic compound, e.g., polyhydric alcohol or phenols containing at least two phenolic hydroxy groups, said derivatives containing 1, 2 epoxy groups. The ethoxyline resins as defined are disclosed in various places in the art such as in Castan Patent 2,324,483 as well as Castan Patent 2,444,333, British Patent 518,057 and British Patent 579,698. U.S. Patents 2,494,295, 2,500,600, 2,511,913 and 2,691,007 disclose other examples of epoxy resin compositions. Curing of such compositions is readily accomplished by acidic (e.g., phthalic anhydride, etc.), or strongly alkaline materials (e.g., diethylene triamine, etc.).

The term "polyester resin" comprises a material comprising the reaction product of a polyhydric saturated or unsaturated alcohol and a saturated or unsaturated polybasic acid either with or without a modifying unsaturated monomer such as styrene, etc. Specific examples of the basic material are, for instance, diethylene glycol maleate, dipropylene glycol maleate, diethylene glycol fumarate, etc. Such materials are readily polymerized by peroxy catalysts such as benzoyl peroxide, tertiary butyl perbenzoate, etc.

From the foregoing, it is seen that the present invention has provided a transformer comprising non-metallic pressure plates or rings which overcome many of the disadvantages of the steel or magnetic type pressure plates or rings used in the prior art transformers of this type.

While the present invention has been shown and described in only one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible

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of various changes and modifications without departing from the spirit thereof.

I claim as my invention:

1. An electrical transformer, comprising:
a magnetic core having leg and yoke portions,
an electrical winding disposed in inductive relation
about a leg portion of said magnetic core;
non-metallic pressure rings disposed about said leg
portion of the magnetic core, between each axial end
of said electrical winding and a yoke portion of said
magnetic core; each of said pressure rings having a
substantially ring shape, with a central opening dis-
posed between first and second substantially flat
major opposed surfaces; each of said pressure rings
including a plurality of continuous tensioned turns
of filamentary fibrous material impregnated with a
resinous bonding means; said resinous bonding means
bonding the fibrous material into a coherent solid
mass; said fibrous material providing 70 to 85% of
the weight of said pressure rings, with the balance of
the weight being provided by said resinous bonding
means;
and means applying pressure to said pressure rings to
maintain said electrical winding under pressure.

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2. The electrical transformer of claim 1 wherein said pressure rings have a flexural strength of approximately 100,000 pounds per square inch.

3. The electrical transformer of claim 1 wherein the continuous tensioned turns of filamentary fibrous material in said pressure rings are under a tension of 2 to 3 pounds.

4. The electrical transformer of claim 1 wherein the filamentary fibrous material of said pressure rings is glass, and the resinous bonding means is an epoxy resin.

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