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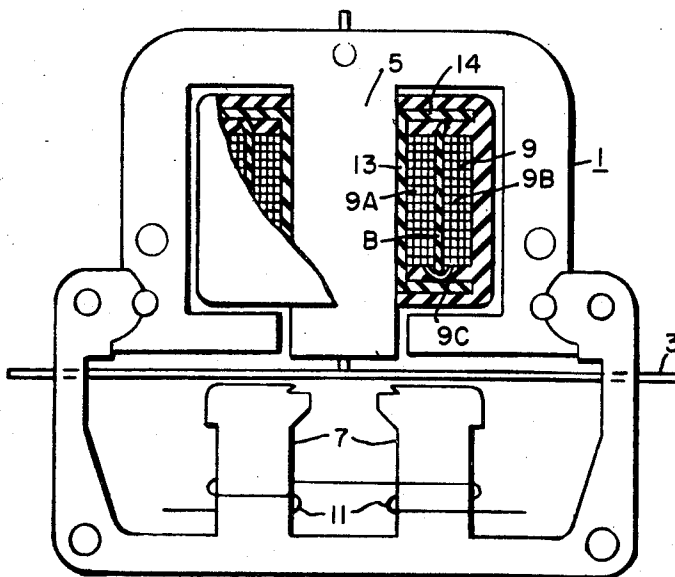
[54] **ENCAPSULATED ELECTRIC COIL HAVING BARRIER LAYER**
5 Claims, 6 Drawing Figs.
 [52] U.S. Cl. **324/137,**
335/225, 336/96, 336/190, 336/206
 [51] Int. Cl. **G01r 11/08**
 [50] Field of Search **336/96,**
205, 206, 190, 199; 335/224, 225; 324/137

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ABSTRACT: A random-wound electric coil has one or more barrier layers dividing the random-wound coil into two or more parts for the purpose of improving the resistance of the coil to electric surges.



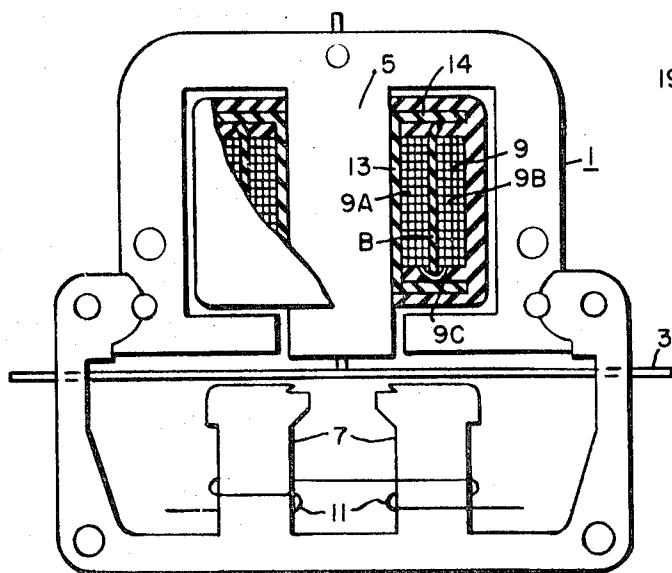


FIG. 1.

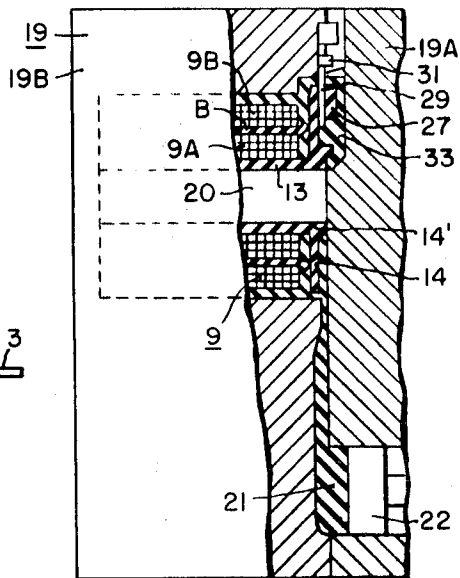


FIG. 2.

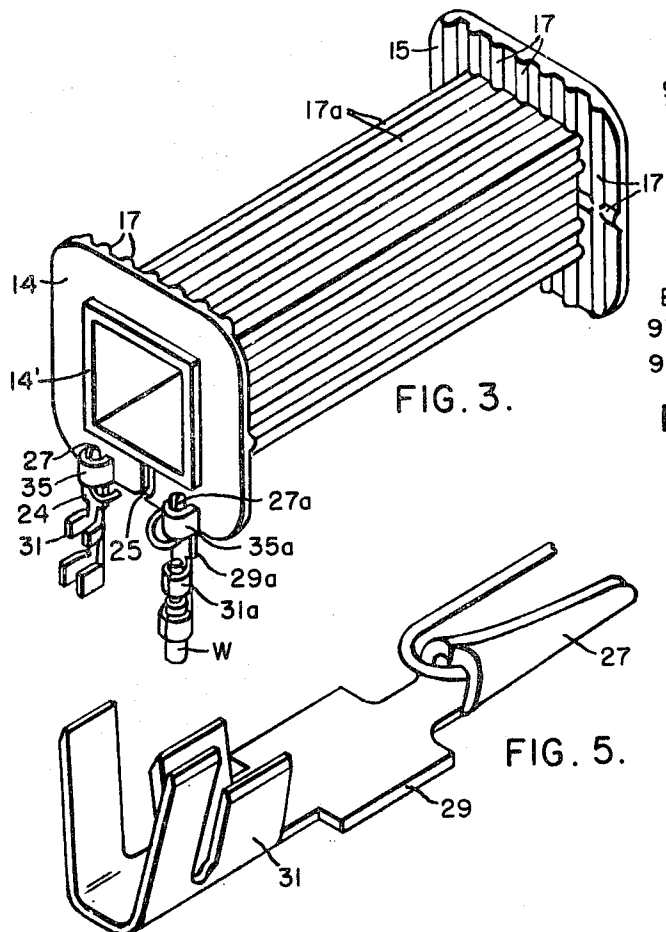


FIG. 3.

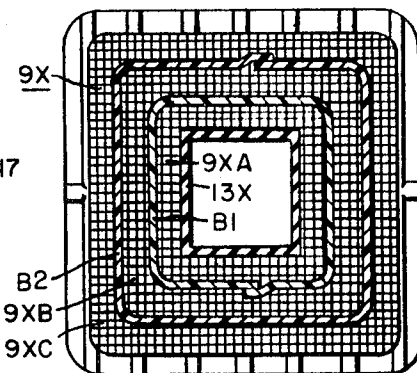


FIG. 6.

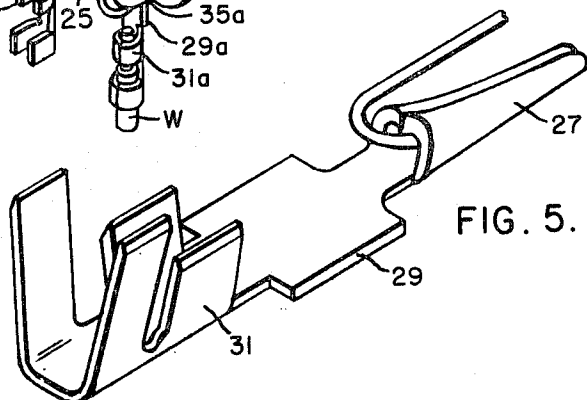


FIG. 5.

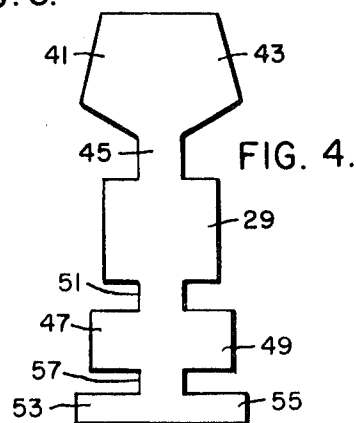


FIG. 4.

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ENCAPSULATED ELECTRIC COIL HAVING BARRIER LAYER

CROSS-REFERENCE TO RELATED APPLICATION

Reference is made to the copending patent applications of Thomas J. Daley, Ser. Nos. 659,216 and 659,217, now U.S. Pat. No. 3,496,504 filed Aug. 8, 1967, and directed to an encapsulating process and produce and to terminals respectively which are herein disclosed. The latter application is 3,496,504, patent 3,496,504. The Daley applications and the present patent application are assigned to a common assignee.

BACKGROUND OF THE INVENTION

This invention relates to a random-wound electric coil assembly and has particular relation to such an electric coil having a barrier embedded therein.

Coils have been constructed by applying a random winding to a spool constructed to facilitate the flow of insulating and encapsulating material directly into engagement with the winding. The resultant coil has exhibited excellent resistance to electric voltage surges.

SUMMARY OF THE INVENTION

In accordance with the invention, one or more insulating barrier layers are embedded in a random-wound coil for the purpose of dividing the coil into two or more parts. The coil is wound on an insulating spool and is encapsulated in insulating material which preferably directly engages end faces of the coil and interlocks with the ends of the barrier layer or layers. The barrier construction materially improves the surge resistance of the coil.

It is, therefore, an object of the invention to provide an electric coil having high surge resistance.

It is a further object of the invention to provide an encapsulated random-wound coil which has a barrier layer dividing the coil into sections.

It is another object of the invention to provide an improved process for constructing an encapsulated coil having high surge resistance.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects of the invention will be apparent from the following description taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a view in elevation with parts broken away of an induction watt-hour meter embodying the invention;

FIG. 2 is a view in elevation with parts broken away of the voltage coil employed in the meter of FIG. 1 associated with encapsulating apparatus;

FIG. 3 is a view in perspective with parts broken away of a spool employed for the coil of FIGS. 1 and 2;

FIG. 4 is a view in plan of a blank employed in forming a terminal assembly;

FIG. 5 is a view in perspective of a terminal assembly constructed from the blank of FIG. 5; and

FIG. 6 is a view in cross section of a modified coil embodying the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 represents an induction watt-hour meter having an electromagnet 1 which provides an air gap for an electroconductive disc or armature 3. The electromagnet 1 includes a magnetic structure generally formed of laminations of soft magnetic steel and providing a voltage pole 5 and current poles 7. A voltage winding 9 surrounds the voltage pole and current windings 11 are associated with the current poles 7. Structures of this general type are described in the Electrical Metermen's Handbook, 7th Edition, published in 1965 by the Edison Electric Institute of New York City. As pointed out in this Handbook, pages 673 and 674, the meter stator may have a 10 kilovolt impulse withstand level.

The voltage coil 9 has a large number of turns of small diameter electroconductive wire which is of the insulated or enameled type. As an example, a voltage coil designed for energization from 240 volt alternating current circuit may have 5500 turns of NO. 33 wire (American Wire Gage).

The voltage coil 9 is of the random-wound type wherein the turns are wound on a spool or bobbin having a central support 13 and a pair of flanges 14 and 15. The central support 13 is in the form of a tubular sleeve which may be of circular cross section, but more commonly has a rectangular cross section adapted to receive snugly a voltage pole 5 of rectangular cross section.

If the turns are wound on a spool with the end turns in direct engagement with the flanges of the spool, it will be found difficult to obtain the desired level of resistance to voltage breakdown. One of the principal breakdown points in a random-wound coil of conventional construction is between the start and finish layers or intermediate layers at the interspace of the enameled wire and the spool flange. If such a coil is encapsulated the forces generated during the encapsulation tend to reduce the start to finish distance and this reduction decreases the breakdown level.

Preferably the end turns of the coil are spaced from the flanges by a layer of insulating material which is molded into intimate contact with the end turns in the manner shown in the aforesaid Daley patent application. To this end the flanges may be provided with a large number of ribs 17 as shown in FIG. 3. These ribs space the end turns of the coil sufficiently from substantial portions of the flanges to permit the introduction of hardenable insulating material in liquid form into the spaces established by the ribs. The material may be a solid at room or ambient temperature which becomes liquid under the temperature and pressure conditions present during such introduction.

After the winding is applied to the spool the resultant structure is placed in a mold 19 having a cavity corresponding to the desired resultant outline of the coil. The mold includes a top 19A, a bottom 19B and a core 20 for the central support to prevent entry of encapsulating material into the central support. The mold also has an inlet 21 through which suitable encapsulating material may be introduced by a transfer ram 22. The encapsulating material is applied in liquid form through conventional runners and gates and is designed to harden in place to provide good insulation for the winding. Conveniently the encapsulant may be solid under ambient temperature conditions encountered by the meter during use, but may be liquid under the temperature and pressure conditions employed for encapsulation. Nylon and a thermosetting polyester resin are examples of suitable encapsulating materials. Preferably the encapsulating material is an epoxy resin provided with a filler such as fiberglass.

When the encapsulating material is applied in liquid form to the mold, it flows between the ribs 17 on the flanges into direct engagement with substantial portions of the end turns of the winding.

In a preferred embodiment the encapsulating material is forced into the mold under substantial pressure, such as 2000 pounds per square inch. Such pressure tends to compact the windings of the coil and to force the end turns away from the associated flanges. This has the effect of introducing a continuous layer of insulating material in direct contact or engagement with the end turns and located between the end turns and the associated flanges. The encapsulating material is now permitted to harden and if the material is of the thermosetting type, heat may be applied to expedite such hardening.

The elimination of air spaces resulting from the intimate contact of the encapsulant with the wire turns provides the additional benefit of reducing the harmful effects of corona. This elimination may be further assisted by utilizing the well-known vacuum molding techniques during encapsulation.

It will be noted that the encapsulating material together with the spool forms a complete encapsulation for the voltage

coil. If desired, the encapsulating material may be introduced between the turns and the central support 13 to increase the insulation between the turns and the voltage pole which is located within the central support. To this end ribs 17a on the outer surface of the central support may be provided to space adjacent coil turns from substantial portions of the support.

When the encapsulating material is applied it flows into the spaces between the ribs 17a of the central support and compacts the coil to form a substantial layer of insulation between the coil and the central support. For many applications these additional ribs 17a are not required.

Electrical connections to the coil are made through a double terminal arrangement. In a preferred embodiment the flange 14 is provided with a slot 25 through which the inner end of the coil extends. This end is secured to a solderless connector 27 located on one end of a sealing plate 29. Another solderless connector 31 is secured to the opposite end of the plate 29 and extends beyond the encapsulating material to receive an external electric lead. As shown in FIG. 2, the mold 19 has a pocket 33 which permits encapsulating material to flow around the solderless connector 27, and its connection together with part of the plate 29 while leaving the solderless connector 31 free to receive an external lead. The mold is of multipart construction and provides parting surfaces engaging the plate 29. Thus the plate 29 provides sealing surfaces engaging the adjacent parts of the mold. A similar terminal construction 27a, 29a, 31a is shown for the other end of the coil.

In order to hold the terminal assemblies during the molding operation, the flange 14 has two pockets 35 and 35a proportioned to receive the connectors 27 and 27a respectively.

The complete spool may be constructed in any suitable manner. Preferably the spool, including the central support 13, the flanges 14, 15, the ribs 17, the pockets 35, 35a, and the slot 25, is molded from a suitable insulating material which may be similar to that employed for encapsulation provided that it is capable of retaining its shape during the conditions of encapsulation.

The terminal assembly is constructed from a sheet of electroconductive material preferably copper containing, such as a sheet of brass having a thickness of 0.020 inches. From this sheet is cut or punched a blank having the configuration shown in FIG. 4. This blank has a rectangular central portion providing a seal plate 29. Two fingers 41 and 43 are attached to one end of the plate 29 through a neck 45 which is narrower than the adjacent dimension of the plate 29. The fingers 41 and 43 subsequently are bent or crimped into engagement with one end of the coil as shown in FIG. 5. This construction provides a solderless terminal 27 in a manner well understood in the art.

In a similar manner two fingers 47 and 49 are attached to a second end of the plate 29 through a neck 51. An additional pair of fingers 53 and 55 are connected to the fingers 47 and 49 through a neck 57. These two pairs of fingers are bent into U-shaped configurations to constitute the second solderless terminal 31. When the end of an insulated conductor or lead W is partly stripped and laid in the channels formed by the U-shaped configurations the fingers 47 and 49 may be crimped into engagement with the stripped portion of the lead and the fingers 53 and 55 may be crimped into engagement with the insulated portion of the lead. A solderless terminal of this type is well known in the art.

As previously pointed out the terminal 27 and the portion of the plate 29 is located within the encapsulation of the coil as shown in FIG. 2. Portions of the plate 29 are engaged by parting surface of the mold to form a seal for the encapsulating material.

The preferred embodiment as thus far specifically described provides an electric coil having good resistance to breakdown due to voltage surges. I have found it possible to improve materially the resistance to breakdown, by embedding one or more barriers in the coil. This improvement now will be described.

In FIG. 9 the coil 9 is divided into an inner part or section 9A and an outer part or section 9B separated by a barrier B. The part 9A is random wound and the winding then is discontinued until a barrier B is applied. The barrier B is in the form of one or more layers or sheets of unsaturated polyester resin or dielectric material. In a preferred embodiment the barrier is a single layer of a polyester film such as polyethylene terephthalate resin which is available on the market under the trade name "MYLAR." The thickness of the layer may vary over a substantial range with good results. Thicknesses in the range of 2.5 to 3.5 mils have been satisfactorily employed. Excellent results have been obtained from a single layer having a thickness of 3.5 mils (0.0035 inches). The adjacent ends of the layer may abut each other, but preferably they overlap.

The layer extends between the ribs 17 of the flanges 14, 15 of the spool and the edges adjacent the flanges are embedded in the encapsulating material as the encapsulating pressure compacts the turns of wire.

The wire from the inner part 9A is led around the barrier B at 9C and the outer part of the coil is then random wound. The division of the turns of the coil between the two parts may be selected from a substantial range. Assuming a 5500 turn coil, excellent results have been obtained with 2000 to 3000 turns in the inner part 9A. Preferably the turns are equally divided between the two parts 9A and 9B.

It will be noted that the barrier B assures a layer of insulating material which extends between the start and finish turns of the coil. This materially decreases the dependence of the coil surge resistance on the distance between the start and finish turns of the coil.

Further improvement in surge resistance results from the physical connections or interlocking of the barrier in the encapsulant adjacent the flanges 14 and 15.

Without the barrier at high voltages there is a tendency for the coil to fail along or near the interface between the copper and the insulation adjacent one of the spool flanges. It is desirable for the barrier to project well beyond the copper toward each flange of the spool into good interlocking relationship with the insulation between the copper and the flange. Preferably the length of the barrier is longer than the distance between the flanges, for example, 1/4 inch longer. When the barrier is applied over the inner part of the coil, the edges of the barrier rest against the ribbed flanges 14 and 15 and these edges, in effect, form shallow flanges (e.g. 1/8 inch flanges) between which the initial turns of the outer part of the coil are wound. This assures good projection of the barrier into the later-applied insulating material and good interlocking therewith.

Still higher surge levels may be attained by utilizing more than one barrier to divide the coil into more than two parts. Thus, in FIG. 6 a coil 9X and a spool having a central support 13X correspond to the coil 9 and spool of FIG. 1. However, in FIG. 6 two barriers B1 and B2 correspond to the barrier B of FIG. 1 and divide the coil 9X into an inner part 9XA, an intermediate part 9XB and an outer part 9XC. It will be understood that each of the parts is random wound and the three parts are connected electrically in series. The resultant coil is encapsulated in the manner discussed for the embodiment of FIG. 1. Each of the barriers in FIG. 6 is shown to have overlapping ends. The three parts may have different numbers of turns, but in a preferred embodiment they have equal numbers of turns.

The coil has been described as encapsulated, and may be injection, transfer or compression molded. The principles of the invention also may be applied to potted or impregnated coils.

It should be noted that the invention differs from the conventional layer-wound coil. On each side of a barrier in FIGS. 1 and 6 the coil parts are random-wound rather than layer-wound. Thus the invention retains the small size and simplicity of manufacture inherent in random winding. At the same time the invention provides uniformly high resistance of such coils to internal voltage breakdown.

I claim as my invention:

1. An induction meter comprising:

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an electromagnet having spaced voltage and current poles, and an electrically conductive disc mounted for rotation between said spaced voltage and current poles, a coil assembly on said voltage pole including an insulating spool having a tubular sleeve and first and second flange members disposed at opposite ends of the tubular sleeve, and only one electrical coil of insulated wire disposed about the tubular sleeve, said electrical coil having first and second axial ends disposed adjacent to but spaced from the first and second flange members, respectively, an insulating barrier member disposed to divide said electrical coil into first and second electrically connected concentric portions, with the turns of each of the first and second portions being random wound, said barrier member having a free length parallel with the axis of the spool which is longer than the distance between said flange members, and solid encapsulating means disposed about said electrical coil, including portions between the first and second axial ends of the electrical coil and the adjacent first and second flange members, respectively, 20

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with the insulating barrier member extending into the solid encapsulating means at each axial end of the electrical coil.

2. A meter as claimed in claim 1 wherein said barrier is a polyester material.

3. A meter as claimed in claim 1 wherein said barrier is polyethylene terephthalate resin.

4. A meter as claimed in claim 1 in combination with a second barrier layer of insulating material surrounding the second one of said parts, said coil having a third part comprising a plurality of turns of said electric wire random wound about the second barrier layer, the encapsulating material between each flange and the adjacent end of the coil being in interlocking engagement with the adjacent edge of the second barrier layer.

5. The induction meter of claim 14 wherein the turns of the electrical coil are substantially equally divided between the first and second portions by the barrier member.

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