

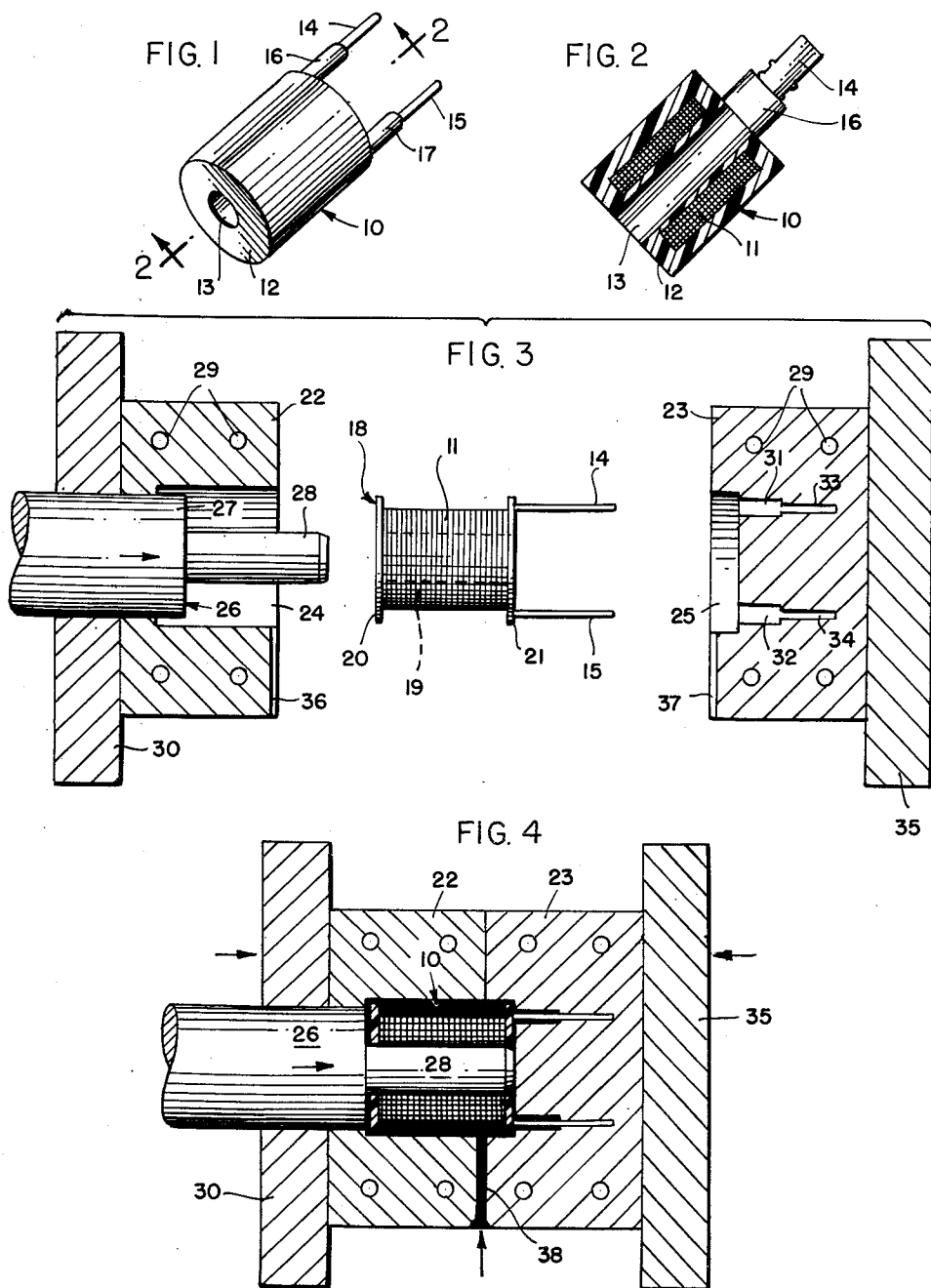
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ENCAPSULATED COIL AND METHOD OF MAKING

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ENCAPSULATED COIL AND METHOD OF MAKING

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This invention relates to electric coils, and more particularly to an encapsulated coil and method of making the same.

The technique heretofore employed in the manufacture of encapsulated electric coils has been to wind a coil of wire onto a spool or bobbin comprising a center hollow core equipped at its ends with laterally extending flanges. After the coil has been wound between the flanges, terminals mounted upon one or both of the flanges, and the ends of the coil connected to the respective terminals, the product is then dipped into a dielectric maintained in liquid form to completely coat the exposed surfaces of the spool and wire and a portion of the terminals. After such bodily dipping of the coils into the dielectric, which may be carried out by first positioning the coils on vertical shafts provided by a movable carrier, the spools and carrier are withdrawn from the dielectric, and the coating is subjected to heat or is otherwise cured to harden the same.

This technique has been followed in commercial practice irrespective of whether the bobbin or coil form is made of paper, plastic or other material, and regardless of the configuration of the coil form—that is, tubular, polygonal, etc. It will be apparent that mounting the coil upon vertical shafts provided by the carriers has been advantageous, for such shafts substantially fill the respective openings through the center cores and thereby prevent to a large extent the entrance of the liquid dielectric thereinto, for such openings must be unobstructed to receive iron cores.

Even though this practice has been followed exclusively, it has a number of serious disadvantages, among which is the relatively long time cycle required to mount the coils in the carriers, dip the same into the liquid dielectric, thereafter cure the dielectric and remove the coils from the carriers. Another disadvantage results from the wastage of dielectric material that necessarily attaches to dipping or submerging operations. Furthermore, the end product is crude in appearance, but more important, has a dielectric coating of uneven thickness that has voids throughout and that has only the most tenuous bond with the coil form. Such disadvantages, it will be appreciated, adversely influence the electric characteristics of the completed coil.

Accordingly, an object of this invention is to provide an encapsulated electric coil of improved character, that overcomes the disadvantages inherent in the prior art structures. Another object of the invention is in the provision of an encapsulated coil form and method of making the same, having a dielectric coating of predetermined and uniform thickness, and which has a neat, finished appearance. Still another object is in the provision of an electric coil and method of making the same, wherein a bobbin having a coil of wire wound thereon is encapsulated with a dielectric material so intimately bonded to the bobbin that substantially no distinction exists therebetween, whereby an integrated encapsulation of the entire wire coil is afforded.

Still a further object of the invention is to provide an encapsulated coil and a method of making the same, wherein a coil of wire is wound upon a thermoplastic coil form or bobbin, and in which a thermoplastic dielectric is molded thereabout at a temperature sufficient to melt the coil form—the coil form and encapsulating dielectric being

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of the same or analogous material whereupon the dielectric and coil form unite, with the result that a unitary or integral encapsulation of the electric coil is provided. Additional objects and advantages of the invention will become apparent as the specification develops.

An embodiment of the invention is illustrated in the accompanying drawing, in which—

FIGURE 1 is a perspective view of an encapsulated electric coil embodying the invention; FIGURE 2 is a longitudinal sectional view taken along the line 2-2 of FIGURE 1; FIGURE 3 is a longitudinal sectional view of the cavity portions of an injection mold, and illustrates one step in the method of making the encapsulated coil; and FIGURE 4 is a longitudinal sectional view similar to that of FIGURE 3, but showing the mold sections in closed position and with the dielectric material being inserted into the cavities thereof.

The electric coil illustrated in FIGURES 1 and 2 embodies the invention, and is denoted in its entirety with the numeral 10. This specific coil, which is exemplary only, comprises a wire coil 11 defined by winding an electric wire conductor upon a mandrel thereafter removable therefrom, or upon a coil form or bobbin in a manner well known in the art. Surrounding the wire coil 11 is an encapsulating body 12 of dielectric material. The encapsulating body of the structure shown in FIGURE 2 has a central opening or passage 13 extending therethrough, which is adapted to receive a magnetic core where such is necessary. Extending outwardly from the encapsulating body are a pair of terminals 14 and 15 which are electrically connected to the ends of the wire coil 11, and are partially covered by the encapsulating material as shown at 16 and 17. It will be understood that the terminals, as separate structural components, could be and often are omitted and leads (such as the ends of the wire coil) used instead.

It will be apparent that the electric coil 10 in the form shown in FIGURES 1 and 2, is a simple inductance whereby the terminals or leads 14 and 15 are the only electrical connections that need be made thereto. In the event, however, that the component is a transformer rather than inductance, either an auto winding or a plurality of wire coils defining conventional primary and secondary windings will be provided. In either case, additional leads or terminals will be necessary, and these will be connected to the various wire coils.

It will be noted in the specific structure shown that a substantially integral encapsulating body 12 surrounds the wire coil 11, thereby completely enclosing the same. Not only is there no discontinuity throughout the encapsulating body, but it has a uniform thickness. That is to say, in any selected area of the coil where it is desired to have the same amount or thickness of coating over the entire extent thereof, such thickness can be and is provided. In many instances, it may be advantageous to vary the coating thickness from location to location on the electrical component or to have certain parts uncoated (the terminals 14 and 15, for example), and such arrangements are readily and accurately afforded. The point of importance is that the encapsulation can be controlled precisely both as to thickness and location, in contrast to the non-uniformity inherent in the prior art structures. Further, it is also an attractive product, as is made apparent by the FIGURE 1 illustration. Moreover, since there are no voids throughout the encapsulating body, and because it has a uniform thickness, the electrical performance of the coil is much superior to those which have such shortcomings.

The method for encapsulating the wire coil 11 is shown in FIGURES 3 and 4, and the starting product comprises the wire coil 11 which may be wound upon a spool or bobbin 18 defining a coil form having a central

hollow core 19. Quite commonly, as is illustrated, the bobbin may have end flanges 20 and 21 formed integrally therewith or separately secured thereto. The wire coil 11 is wrapped about the center core 19 between the end flanges in a conventional winding operation, and the terminals 14 and 15 are riveted or otherwise rigidly secured to the flange 21 with the respective ends of the wire coil connected thereto. The method is applicable in connection with bobbins that do not employ end flanges, and also with self-sustaining wire coils.

The bobbin 18 is formed preferably of a material that will soften and commence to melt at ordinary injection molding temperatures (which may vary through a range of about 300° to 800° F.), such as the thermo-plastics which have good dielectric properties. Examples of these are nylon, cyclocac, styrene, cellulose acetate, buterate, acrilac, etc.

The partially completed coil, as shown in FIGURE 3, is placed within an injection mold that comprises separable mold sections 22 and 23. These mold sections provide, respectively, cavity sections 24 and 25—the first of which is cylindrical in the specific illustration and has an opening of lesser diameter communication therewith that slidably receives a holder 26, comprising a piston or rod 27 having a centering pin 28 of reduced diameter extending outwardly therefrom through the center of the cavity section 24. The piston at the opposite end thereof (not shown) is arranged with some suitable means for applying force thereto for urging the same toward the right (as viewed in FIGURE 3) to properly position the coil within the cavity and thereafter maintain it in such position against the pressure exerted by the incoming fluid. Affixed to the mold section 22 is a backing plate 30 that has a central opening therethrough which also slidably receives the piston 27.

The cavity 25 in the mold exemplification shown, has the same diameter as that of the cavity 24 but is relatively shallow with respect thereto. Communicating with the cavity 25 is a pair of stepped passages or recesses 31 and 32 adapted to receive the terminals 14 and 15 therein. The portions of the passages that are adjacent the cavity section 25 are relatively wide with respect to the terminals, but the stepped end portions 33 and 34 thereof are dimensioned so as to snugly receive the terminals therein. A backing plate 35 is affixed to the mold section 23.

The injection mold thus defined in terms of the components thereof pertinent to the instant invention, may otherwise be conventional and functions to receive fluid material in the cavity thereof to mold the material into a predetermined configuration. The material may be inserted into the mold through the passage defined by the passage segments 36 and 37 provided, respectively, by the mold sections 22 and 23. Ordinarily, the mold will be cooled as by means of liquid circulation through coolant passages 29. The mold sections are adapted to be brought together as shown in FIGURE 4, to define a unitary molding cavity, and such operation with respect to the coil will now be described.

First, the bobbin 18 with the wire coil 11 wound thereon, and with the terminals 14 and 15 suitably mounted on the flange 21 in electrical connection with the ends of the coil, is positioned with the passage 13 therethrough aligned with the centering pin 28 and with the terminals 14 and 15 aligned with the respective passages 31 and 32. The mold sections 22 and 23 are then moved into closing relation as shown in FIGURE 4, and the centering pin 28 is caused to move into the passage 13 to hold the coil and insert the terminals 14 and 15 thereof into the passages therefor in the mold section 23. After the mold sections are closed, a fluid material designated in general with the numeral 38, is inserted therein through the composite passage defined by the sections 36 and 37. The mold is maintained in closed condition until the fluid material cures, and sufficient force is applied to the holder 26 to assure shrinkage of the fluid in the right direc-

tion. Thereafter, the mold is opened to permit removal of the finished coil product.

The curing time within the mold (which is of relatively short duration) depends upon the specific materials employed, the temperature of the incoming fluid and the temperature at which the mold is maintained. It will be understood that the mold itself may be cooled, as is conventional practice, by the flow of coolant through the passages 29 thereof to maintain the temperature relatively constant.

As a specific example using a nylon material (DuPont Zytel resin 101) having a melting temperature of about 483° F., this material was injected into the mold cavity at a temperature of 560° F., and the mold was maintained at a temperature of about 100° F. by the circulation of water through the coils thereof. The curing time with these conditions was twenty-one seconds.

The encapsulating material welds itself to the coil form to provide a unitary encapsulation of the wire coil; and where the bobbin and encapsulating material are plastics of the same general characteristics, there is a coalescence of the bobbin and dielectric so that when the curing time has elapsed, the bobbin and encapsulating material are integral as shown in FIGURE 2, whereby one is substantially indistinguishable from the other.

It will be appreciated that the mold cavity may have various configurations depending upon the shape and size of the end product to be formed therein, and the shape of the cavity may be altered whenever it is desired to have an encapsulating coating of greater thickness at one point along the coil and at another point or points therealong. As stated hereinbefore, the coil may be cylindrical, as in the form shown, or it may be polygonal; and in such event, the configuration of the mold will ordinarily but not necessarily conform thereto. Furthermore, in some instances, a self-sustaining wire coil may be encapsulated by the technique disclosed that, in all events, turns out pieces quickly which are accurately and properly encapsulated and which does not result in the wastage of encapsulating material.

It is apparent from FIGURE 4 that the fluid material fills the enlarged portions of the passages 31 and 32, and thereby encloses or encapsulates a part of each of the leads, or terminals if they are used. The centering pin 28 and piston arrangement maintain the coil in a centered relation within the mold cavity so that the fluid material can completely and uniformly surround the same, and also takes up the shrinkage thereof. As a result, the encapsulation of the wire coil has a uniform thickness throughout any selected area which leads symmetry to the electrical characteristics of the coil, resulting in improved performance thereof. Furthermore, an attractive product is formed, and the time cycle necessary to accomplish the encapsulation is substantially reduced from that heretofore required. Moreover, the wastage of fluid dielectric is obviated.

While in the foregoing specification an embodiment of the invention both as to a method and structure is described in considerable detail for purposes of making an adequate disclosure thereof, it will be apparent that numerous changes may be made in those details without departing from the spirit and principles of the invention.

We claim:

A coil assembly comprising a coil of wire completely enclosed in a continuous, unitary, thermoplastic envelope having a center bore, said coil being axial with said bore and separated from it by a wall of substantially uniform thickness, with the outer layer of turns of said coil being embedded in said envelope, said assembly being formed by winding a coil of wire on a preformed thermoplastic spool having a tubular central segment and a laterally extending end piece integral with each end of said tubular segment and extending radially beyond said coil, mounting said wound spool on a mandrel that fills the center

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opening, enclosing said wound spool in a mold cavity and injecting fluid thermoplastic of the same composition as said spool into said mold at a temperature high enough to fuse portions of said end pieces, cooling to the solidifying temperature of said thermoplastic and ejecting the resultant encapsulated coil assembly from the mold cavity.

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