March 29, 1966 L. E. LAWRENCE 3,243,752

ENCAPSULATED SUPPORTED COILS

Filed March 7, 1962 5 Sheets-Sheet 1

Fig. 1

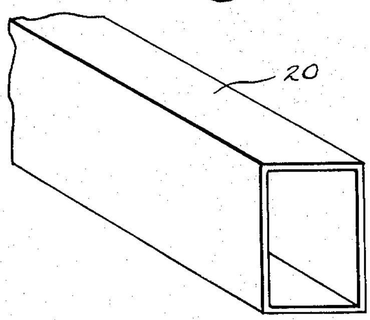

Fig. 3

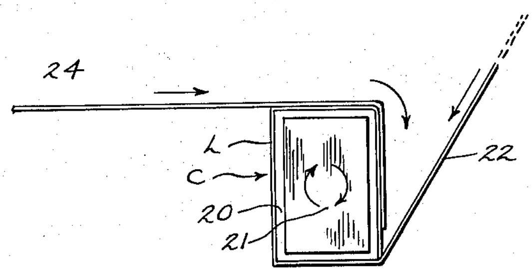

Fig. 2

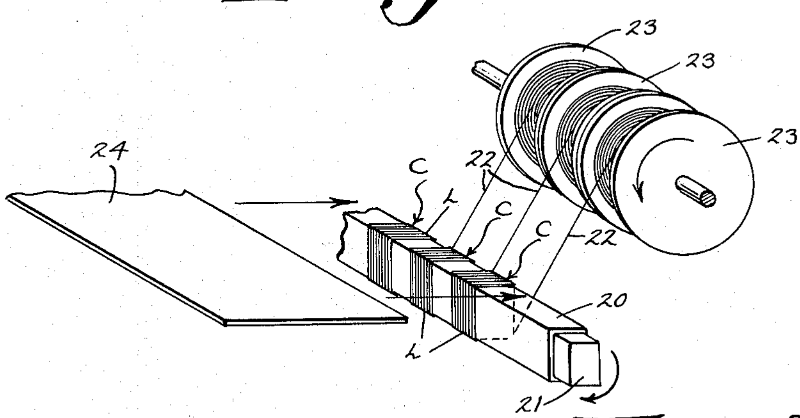

Fig. 4

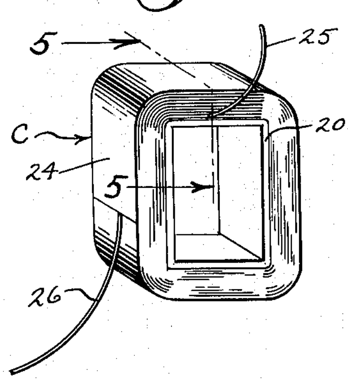

Fig. 5

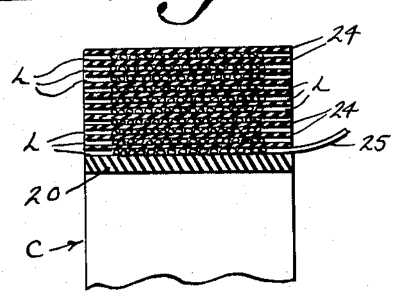

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Fig. 6

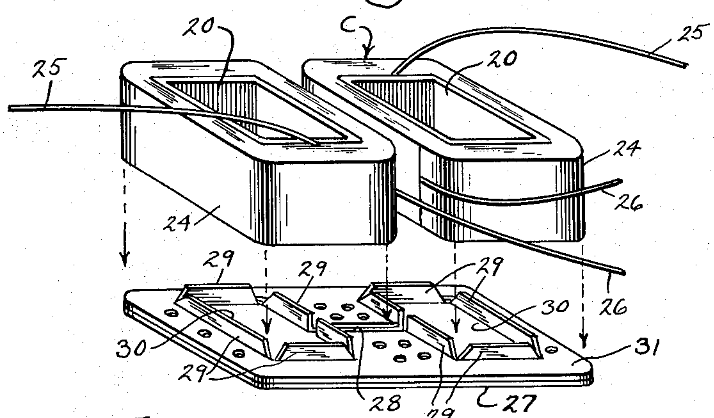

Fig. 7

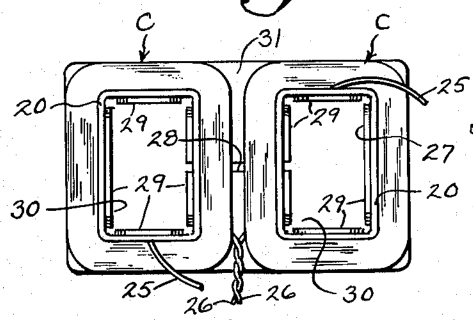

Fig. 8

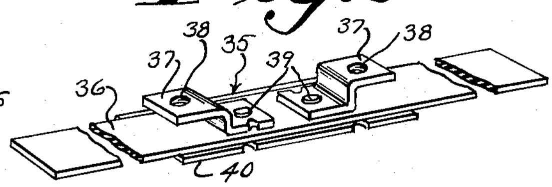

Fig. 9

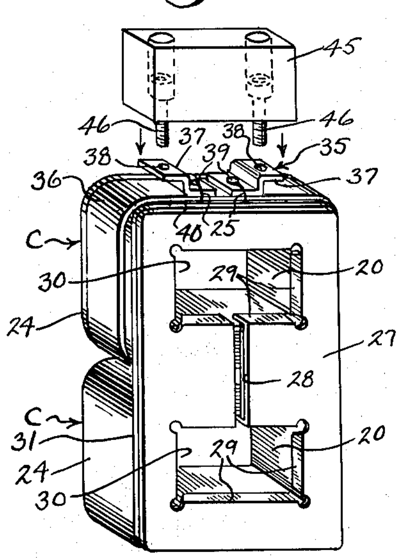

Fig. 10

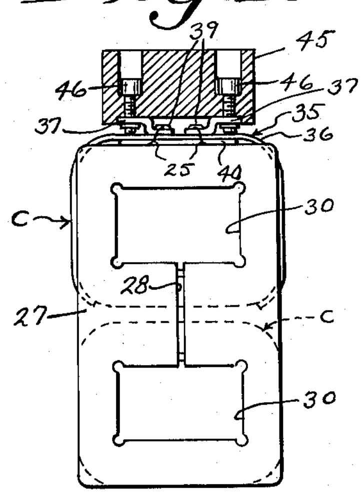

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Fig. 11

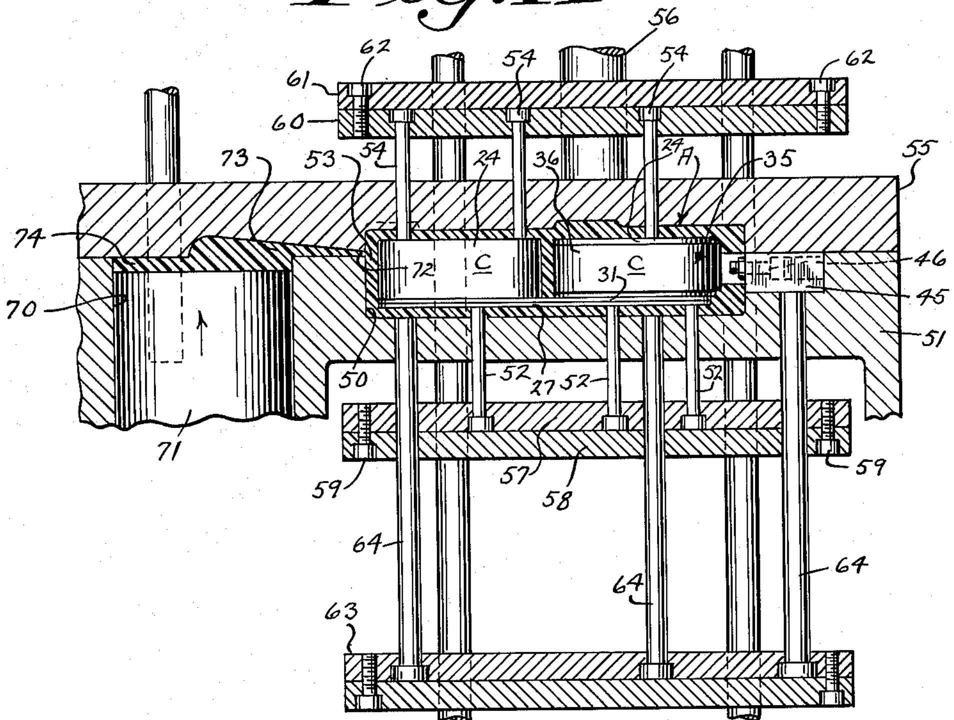

Fig. 12

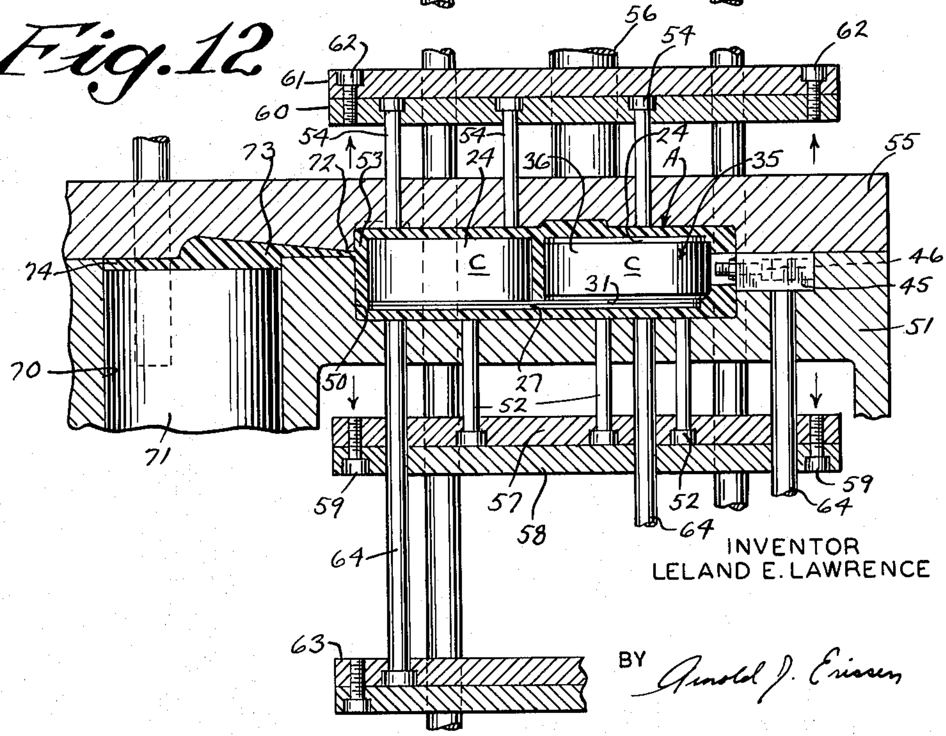

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Fig. 13

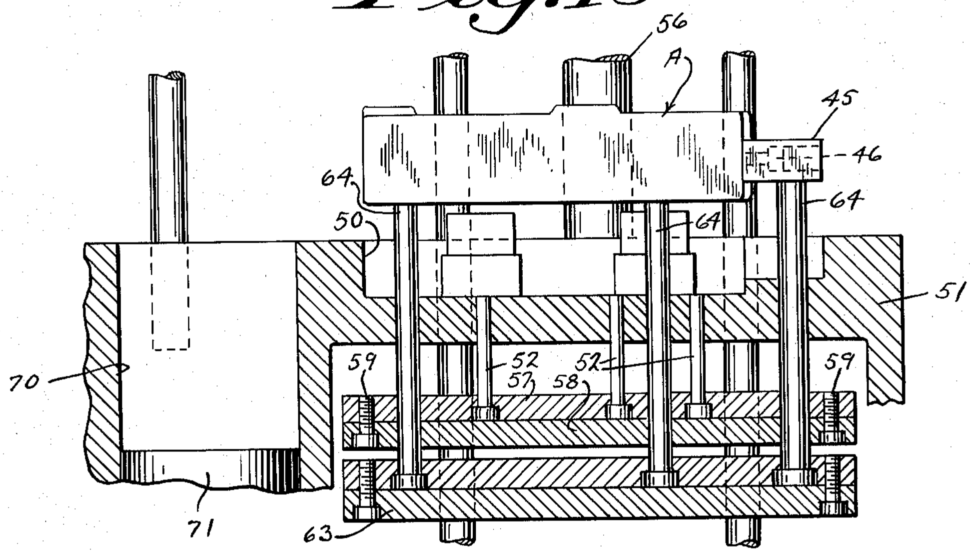

Fig. 14

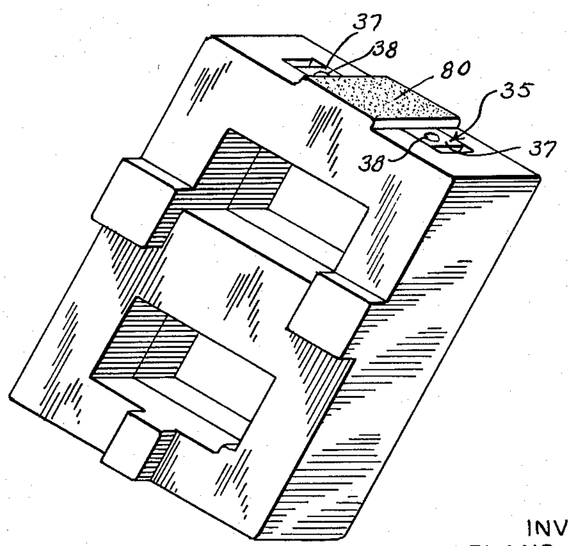

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Fig. 15

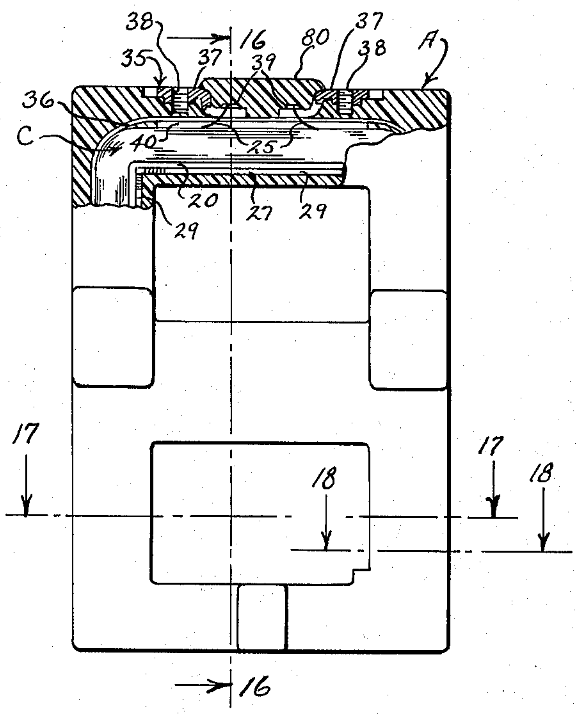


Fig. 16

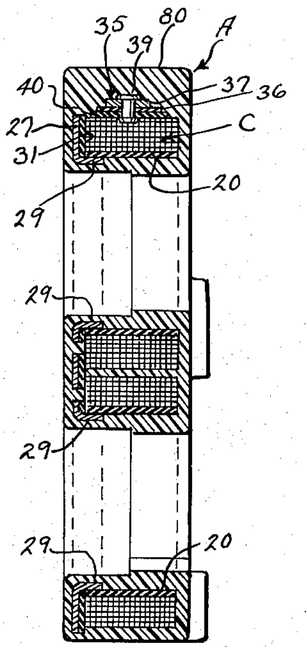


Fig. 18

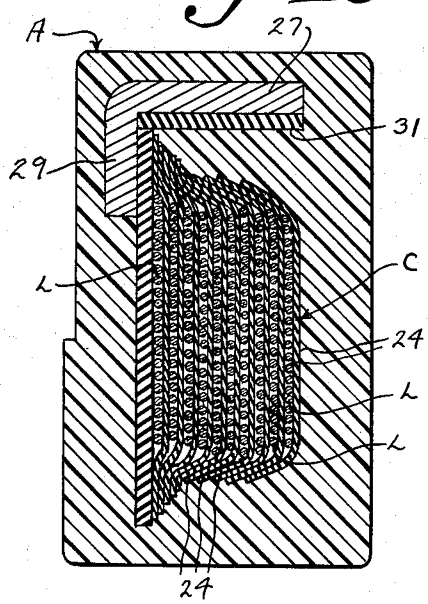
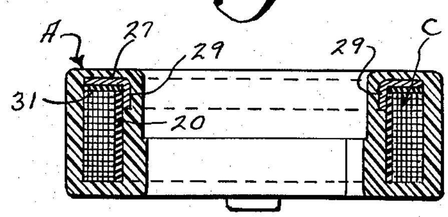


Fig. 17



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United States Patent Office

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3,243,752

ENCAPSULATED SUPPORTED COILS

Leland E. Lawrence, Wauwatosa, Wis., assignor to Allen-Bradley Company, Milwaukee, Wis., a corporation of Wisconsin

Filed Mar. 7, 1962, Ser. No. 178,094
3 Claims. (Cl. 336—205)

The present invention relates to the manufacture of electrical coil assemblies, and particularly to coils for use in electromagnetically operated devices, wherein the manufacture of such coils may comprise the steps of winding a predetermined number of insulated conductor turns on an insulating supporting tube, the turns being in juxtaposed, layer wound relation; interleaving strips of insulating paper, or the like, between the wound layers; affixing the conductor leads to a terminal strip; mounting a coil or coils on a locating and supporting plate, which may be adapted for use as a magnetic shunt, with a removable die insert to protect screw threads; and molding an encapsulating, insulating coating around the coil or coils and the supporting plate by means of transfer molding techniques, or the like, said coating being of such nature as to retain the respective turns and layers in close relative proximity without penetrating internally of the coil winding layers.

In coils of previous constructions vacuum impregnation with varnish, or more lately with an epoxy resin, has been used to hold the wire turns firmly in place to prevent vibration caused by alternating magnetic fields or mechanical shock. This method effectively holds the wire turns in place, but it has some disadvantages. Any coil so constructed contains a substantial amount of resin in the interstices of the winding which upon accidental overheating gives off quantities of heavy smoke which may condense on associated parts of the switch or other equipment nearby. Also, such a coil may drip resinous products of decomposition on associated or nearby equipment. Further, and this is particularly true of coils impregnated and cast with epoxy resin as encapsulating material, such coils tend to swell, blister and deform, in addition to exuding resinous material, so that they are often very difficult to remove from their associated structure for purpose of replacement. Also, in coils of this construction, the magnet wire in the coil which is generally insulated with some form of resinous coating, is subjected to the action of solvents in the varnish or of liquid epoxy resin for considerable time during impregnation and curing at elevated temperatures. This may tend to soften the insulation on the wire and reduce its effectiveness.

It is an object of this invention to produce a coil wherein the turns are held securely against vibration by compacting the winding under hydrostatic pressure during a molding process in which an encapsulating material is caused to surround the windings under fluid pressure until it cures to a solid mass.

It is another object of this invention to produce a coil which, containing no impregnating resin the intertices of the winding, and utilizing an encapsulating resin resistant to heat, gives off relatively small amounts of smoke, exudes little, if any, resinous material, and does not swell or blister objectionably when accidentally overheated.

Among other objects of the present invention is the provision of a pressure-molded coil assembly which is completely protected against mechanical damage and harmful atmospheres.

It is still another object of the present invention to provide a unique pressure molding technique which results in a coil assembly for use in electromechanical devices, and which assembly is encapsulated for protection against mechanical damage and the damaging effects of

deleterious atmospheric conditions, and wherein the coil or coils will not swell objectionably if subjected to overvoltage conditions which result in overheating.

It is a further object of the present invention to provide an electromagnetic coil assembly which is encapsulated with a molding material of high thermal conductivity capable of readily dissipating heat, and which further provides an effective seal for a coil or coils contained therein.

It is another object of the present invention to provide an electromagnetic coil assembly which includes a coil or coils which have been layer wound to provide a compact and neatly assembled construction adaptable for placement in molding dies wherein a pressure molding composition may be used to entirely encapsulate the assembly and to maintain the individual coil turns in juxtaposed relationship.

It is still another object of the present invention to provide a protective outer layer for a coil assembly of a molding composition applied by means of transfer molding techniques or the like, wherein said composition is in contact only with the end turns, so as to minimize any deleterious effects on the previously applied coil wire insulation.

It is another object of this invention to provide, as an integral part of a coil assembly, a mechanical support member which aids and facilitates manufacture of the coil assembly, adds to the mechanical strength of the coil assembly, and which may be adapted to provide a magnetic shunt path for controlling the shape of the pull curve of the magnet of which the coil assembly is a part.

It is a still further object of the present invention to provide a coil assembly which has such precision of dimension that the coil itself provides structural usage, such as support of certain components in the case of electrical motor starter or the like.

It is still another object of the present invention to provide a coil assembly which lends itself to clean, straightforward production techniques.

The foregoing and other objects and advantages of this invention will appear from the description following, which is set forth by reference to the accompanying drawings, in which there is set forth by way of illustration and not of limitation, a procedure of manufacture and a form in which this invention may be embodied.

In the drawings:

FIGS. 1–13 inclusive, are illustrative of a sequence of manufacture of an encapsulated coil assembly in accordance with teachings of the present invention, and wherein;

FIG. 1 is a perspective view of a preformed rectangular coil tube which serves as a support for the coil turns,

FIG. 2 is a diagrammatic view of portions of a winding apparatus and, in particular, illustrating the procedure for winding turns around the coil tube and interleaving of insulating paper strips between winding layers,

FIG. 3 is an end view of the coil tube relative to FIG. 2 with the supporting tube in sliding fit engagement with an elongated winding mandrel, and further illustrating the relationship of the layer wound coil turns and interleaving insulating paper strip,

FIG. 4 is a perspective view of a coil forming a part of the present assembly after having been removed from the winding mandrel and after having been sectioned from a coil tube comprising a series of axially spaced multiple wound coils,

FIG. 5 is a fragmentary, sectional view taken along lines 5—5 of FIG. 4 illustrating the layer wound arrangement of juxtaposed coil turns and interleaving insulating paper forming the basic construction of the coil,

FIG. 6 is a perspective, exploded view illustrating the step of seating cooperating coil members on a common support plate, which plate may be adapted for use as a magnetic shunt,

FIG. 7 is a top plan view of an assembly of twin coils seated on the support plate, and with the coils being connected in aiding series relationship by means of twisting their adjacent leads together,

FIG. 8 is a perspective view of a terminal assembly to be fastened to one side of the coil construction by means of adhesive engagement with the outermost insulating paper layer,

FIG. 9 is a perspective view of the coil assembly with the two remaining leads of the respective coils fastened to the threaded terminal members, and further illustrating the step of mounting a protective molding insert in threading engagement with openings in the terminal assembly,

FIG. 10 is a front elevational view of the coil assembly and its protective molding insert just prior to being placed in its respective cavity of a transfer molding machine,

FIG. 11 is a fragmentary view of a transfer molding machine illustrative of the means for interim support of the coil assembly during the period that the encapsulating molding composition is entering the die cavities,

FIG. 12 is a view similar to FIG. 11 of the apparatus and illustrating the step of withdrawing supporting molding pins after sufficient molding compound has been forced into the die to provide equal pressure upon all surfaces of the coil assembly to be encapsulated thereby,

FIG. 13 is a fragmentary view of the molding machine illustrating the steps of removing the finished, encapsulated coil assembly from its respective die cavity after the molding composition has been brought to final curing state,

FIG. 14 is a perspective view of the finished encapsulated coil assembly made in accordance with the teachings of the present invention,

FIG. 15 is an elevational view of the finished coil assembly having a portion broken away to more specifically illustrate the article in its final form, and with the protective molding insert removed from the terminal assembly,

FIGS. 16, 17 and 18 are views respectively taken along lines **16—16**, **17—17** and **18—18** of FIG. 15, and in which various details of the coil portions are more clearly disclosed.

As mentioned previously, the various steps in the preferred method of manufacturing the coil assembly of the present invention are disclosed in FIGS. 1–13, inclusive. With reference to FIG. 1, the coil members of the present coil assembly are wound on an insulating supporting tube **20**, which is preferably of rectangular configuration and may be die formed from gummed kraft paper. The tube **20** is arranged to receive steel winding mandrel **21**, slidable therein (see FIGS. 2 and 3) and having a portion extending from each end of the tube arranged for fastening to a chucking device of a winding machine (not shown). The tube **20** is preferably elongated to provide means for winding a series of axially spaced turns thereon. The wires **22** for each of the coil members, designated generally by the reference character C, are fed from supply bobbins **23** and are wound to form a layer of a predetermined number of juxtaposed convolutions on the coil tube **20**. As is disclosed in FIGS. 3 and 5, each of the layers L are flat and particular care is taken to prevent the individual turns from overlapping upon one another in order to maintain minimum size and to prevent damage during later pressure molding operations. The wires **22** are received from the manufacturer with an insulating coating and each layer is further insulated from its adjacent layer by means of a sheet **24** of kraft paper. The insulating sheet **24** is interleaved between the winding layers L and is inserted therebetween upon completion of a row of juxtaposed coil turns, as shown in FIG. 3. Winding of coil turns and insertion of the sheets L is continued in the manner above described until the designated number of turns have been wound to form the coils C.

In the present case, the assembly disclosed herein, for purposes of illustration, has particular application for use in electromagnetically operated motor starter and contactor devices, although it is within the scope of the present invention to utilize its teachings for manufacture of electromagnetic coils for use in any electromagnetically actuated device requiring a magnetic coil construction, or for that matter, in any device requiring a coil of compact size and wherein coil life is of importance.

After winding of the prescribed number of coil turns has been completed, each of the axially spaced coil portions C, wound upon the coil tube **20** are separated from one another. This is accomplished upon removal of the tube **20** from the mandrel **21**, by simply severing the tube **20** into its various sections at points intermediate the outer turns of each coil portion, such as by means of a band saw blade (not shown). Thus, the individual coil members take the form of the coil C as shown in FIGS. 4 and 5 with extending lead portions **25** and **26**, to provide a layer wound construction of juxtaposed coil wire turns L, separated from one another by means of the paper strips **24**.

The illustrated coil assembly A may comprise two identical coils C which are positioned, as shown in FIG. 6, upon a locating and supporting plate **27** which may be provided with a centrally located leg portion having an interruption **28**. Since the purpose of the interruption **28** is to prevent circulation of current which would otherwise flow as the result of alternating current flux linkage in alternating current coils, it will be apparent that this interruption may be made in the outer legs, if so desired. In the case of interrupting the center leg portion, there is an assumption made that the coils C are substantially identical in electrical characteristics. Placement of the interruption in the outer legs would prevent current flow through the plate should the series connected coils not be identical electrical properties. When the coil is to be used with direct current, no interruption is necessary. In the present embodiment, the support plate **27** has been further modified to provide upstanding flanges **29** respectively defining windows **30** in the support plate **27**. Thus, the upstanding flanges **29** act as a means for locating and providing additional support for each of coils C by extending inwardly of the bore of the supporting tube **20** of the respective coil. An insulating plate **31** is preferably placed between the coils C and the support plate **27**. The height of these upstanding flanges has a substantial effect on the shape of the "pull" curve when the supporting plate **27** is made of magnetic material.

After the coils C are mounted in place on the support plate **27**, the leads **26** are twisted and soldered together, as shown in FIG. 7, to thereby serially connect the twin coils C. It will be understood that the coils C must be connected to aid one another magnetically, but they may be connected in series or parallel as desired. Next, a terminal assembly, designated generally by the reference numeral **35** (see FIG. 8), is mounted at one end of the coil assembly by means of adhesive contact between an insulating paper mounting strip **36** and the outer paper strip **24** of the coil C. The mounting strip of paperboard **36**, or the like, serves as a support for oppositely spaced terminal members **37**, each having a tapped opening **38**. The terminals **37** are each fastened to the mounting strip **36** by means of rivets **39**. An insulating paperboard sheet **40** is interposed between the head of the rivets **39** and the coil C. The terminal assembly is fully disclosed in the subassembly view of FIG. 9.

FIG. 9 is also illustrative of the technique of providing a means for protecting the threads of the terminal openings **38** during molding. This is accomplished by means of mounting a protective molding insert **45** directly over the spaced-apart terminals **37**. Screws **46** are each threaded into respective tapped opening **38** of each of the terminals **37** until the insert **45** is brought into flush engagement with each of the terminals. As shown in FIG. 10, the respective screws **46** extend inwardly of the tapped openings **38** to further provide a means of preventing the molding composition from interfering with the terminal screws (not shown) which are later threaded into the terminals **37** as a means of connecting the coil with a source of power. The coil assembly, as viewed in FIG. 10, is now ready for placement in the die cavity of a transfer molding machine or the like. However, a group of assemblies, corresponding in number to the cavities in the die, are first preheated in an oven (not shown). This serves to drive off volatiles and moisture from the coils, which might prevent proper filling of the mold with the heated molding material or the possible formation of bubbles or blisters.

With reference to FIGS. 11–13, it will be apparent that the coil assembly, comprising the coils C mounted on the support plate **27**, and with the removable protective insert **45** attached thereto, is arranged for placement in the molding cavity **50** of the lower die block **51**. As illustrated in FIG. 11, the coil assembly is disposed with the support plate **27** resting upon retractable support pins **52** in a manner that permits the assembly to be supported in spaced relationship relative to the bottom surface of the die cavity **50**. The detail and operation of the support pins **52** are more fully described and claimed in the co-pending application of Roy A. Gill, Ser. No. 178,092, filed on Mar. 7, 1962, now abandoned, and assigned to the same assignee as the present invention. The technique described therein permits the molding composition **53** to totally encapsulate the assembly during the molding operation as hereinafter described. It will also be apparent that the upper support pins **54** cooperate with the pins **52** to clamp the coil assembly A therebetween during the initial molding period until sufficient molding composition has entered the die block cavities to support the assembly A. The upper block **55** is supported by means of the supporting actuator **56** fastened thereto.

The headed upper and lower support pins **52** and **54** are, in turn, respectively supported by the separable bar sections **57** and **58** held together in clamping relationship by means of the screws **59**. Thus, the headed support pins **52** are removably held in place with respect to the bar sections **57** and **58**. The same is true of the upper support pins **54**, which are clamped to the headed portion of the bar sections **60** and **61** fastened together by means of screws **62**. Each of the support pin bars are movable relative to one another by means not shown, and for purposes hereinafter set forth. A knockout bar **63** is also provided for supporting knockout pins **64** and is movable upwardly to eject the molded assembly from the die after it has been cured.

The remaining portions of the mold are conventional and comprise a centrally located transfer chamber **70** having a bore adapted to slidably receive plunger **71**, which is shown in its uppermost position in FIGS. 11 and 12 and in its withdrawn position in FIG. 13. In FIGS. 11 and 12, the coil assembly is shown within the closed upper and lower die blocks **51** and **55**, respectively, and with the molding material having been injected into the cavity **50**. The die is gated at **72** and is provided with runners which form a sprue **73** removable, along with a cull **74** after the die blocks are separated.

Thus, after the molding composition has been brought to liquefying temperature and injected into the die cavities **50**, with the coil assemblies A respectively supported therein, the preheated assemblies are uniformly encapsulated with the molding composition **53**. A suitable molding composition for this purpose is a mineral filled epoxy composition known as No. 3628 compounded by the Fiberite Corporation of Winona, Minnesota. When this particular material is used the pressure is maintained in the neighborhood of 50 to 100 pounds per square inch. The pressure may be lower or higher depending upon the size and strength of the winding wire **22**. This pressure range is quite low when compared to pressure utilized in conventional molding techniques. The important consideration concerning pressure lies in providing sufficient pressure for flow and coverage of the entire assembly A, including the plate **27**, and to compact the windings into a solid unit and, at the same time, avoid damaging the coil windings, terminals or connections therebetween.

The particular molding composition, above-described, contains no solvents or other material that might damage the original insulating coating deposited on the coil wire. However, the curing temperature would have an adverse effect if it were maintained for any length of time. It is desirable to use a composition, such as that mentioned above, which cures in a short time. It will be apparent that the selection of such molding materials is an important aspect of the present invention. In addition, no solvents or carriers are used which might volatilize during the heated molding operation and thereby leave voids which would interfere with the heat conducting characteristics of the pressure molded mass and compacted coil. Since there is no impregnating compound within the windings to swell when overheated, the ability of the finished molded coil to resist undesirable swelling and blistering when overheated is determined largely by the characteristics of the molding compound. The above-mentioned Fiberite Corporation composition No. 3628 is suitable in this respect.

The total mold and cure cycle for the above-mentioned composition is approximately 4 minutes, although it will be obvious to those skilled in the art that such period may vary with composition, preheat temperature, etc. In the present case, the composition has a usable flow period of approximately 60 seconds and the pressure is applied to the ram plunger **71** for a period of approximately 2.5 minutes. The retractable support pins **52** and **54** are maintained in clamping position relative to the assembly A for a period of from 12 to 35 seconds (depending upon ambient temperature, humidity, composition, etc.) to permit a desired amount of the composition to flow into the cavities **50**. The support pins **52** and **54** are then retracted to the position shown in FIG. 12. This will permit the material to fill the entire cavity, and thereby provide a uniform, non-interrupted encapsulating coating surface. No areas will remain which would otherwise require patching, filling or other attention.

As stated previously, the construction and operation of the retractable pins **52** and **54** are more fully described and claimed in the aforementioned co-pending application of Roy A. Gill, Ser. No. 178,092.

Upon completion of the 4 minute cycle, the die blocks **51** and **55** are separated. Removal of the assemblies A from their respective cavities is delayed for a period of 18 to 30 seconds, depending upon atmospheric conditions, to permit the encapsulating surface to cool and further harden. The knockout pins **64** are then moved to the position shown in the view of FIG. 13 by means of the knockout bar **63** to raise the hardened encapsulated coil assembly A upwardly from the cavity **50**, along with the insert **45** for removal thereof. The cull **74** and sprue **73** are also removed with the finished pieces, and are broken away from the pieces by hand. The ram or plunger **71** is then retracted for receipt of a new preheated molding composition preform. The knockout pins **64** are also retracted to the position shown in FIGS. 11 and 12, and the coil support pins **52** and **54** are extended outwardly from the blocks **51** and **55**, respectively, to the position shown in FIG. 11 for support of a new coil.

The interior surface of the coil molding insert **45** is preferably roughened to provide the complementary roughened surface 80 at the one end of the assembly A, as shown in FIG. 14 which more readily receives a printed identification or label. Inasmuch as the molding composition is of an epoxy type, it will be appreciated that the surfaces must be roughened or otherwise treated for receiving printing inks or adhesive. Thus the inherent roughness provided in this area during molding is of advantage.

It will be apparent from the enlarged cross section of FIG. 18 that the pressure molded assembly of the present invention provides an arrangement of coil windings in layer-wound relationship and which are compressed into a compact, tightly held body by means of an encapsulating molding composition, and wherein the said molding composition contacts only the coil ends so as not to affect the insulation normally coating the coil wire. From FIG. 18, it will be noted that the coil turns in the layers L are compressed towards one another in side-by-side contact. In coils wound with fine wire and insulated with relatively thin insulating paper layers 24, there is a tendency of the paper layers 24 to fold over the ends of the winding layers L to cover these windings, depending upon mold gating, and thereby help in preventing the composition to be in direct contact with the windings on the insulation thereon. There does not appear to be any appreciable effect upon the wire insulation though when the paper layers 24 are relatively thick and the wires are of relatively large diameter.

It will be further apparent that by utilizing the herein disclosed pressure molding technique, that the molding pressure acts to uniformly compact the conducting turns of the coil or coils into a relatively solid mass with adjacent turns in physical contact. It is well known by those familiar with the axioms of heat transmission that heat will be dissipated from a solid mass more readily than in instances wherein there may be occluded gas pockets between adjacent winding turns, as would be the case with conventional varnish impregnated coils (with or without vacuum). These materials generally contain volatile solvents, which when later evaporated leave gas filled voids acting as localized heat insulators.

In addition to the advantages of increased heat conduction accomplished by the techniques of the present invention, it will be further appreciated that the compact, pressure molded coil assembly also provides a substantially vibration-free construction wherein the adjacent turns will be prevented from rubbing against one another and wearing off the protective insulating coating and thereby shorting out certain sections of the coil. There is no impregnating varnish or resin in the interstices of the winding which might otherwise cause swelling or blistering if the coil should be accidentally overheated.

The coil assembly of the present invention is dimensionally stable and lends itself to clean, straightforward production techniques as hereinabove described.

Although the present assembly has been described with reference to a particular embodiment thereof, it is, of course, to be understood that this invention is not to be so limited, except as so defined by the appended claims.

I claim:

1. A pressure molded electrical coil comprising a plurality of layers of convoluted turns of an insulated conductor and defining a longitudinal opening therethrough, the conductor turns of a respective layer lying in substantial side-by-side relationship, said layers being separated from one another by means of interleaving insulating sheet material, a supporting and locating plate disposed adjacent one side of said coil and being formed to provide a window defined by upstanding marginal portions protruding partially into the longitudinal opening of said coil, an insulating plate disposed between said supporting plate

and said coil, a thermoset encapsulating compound surrounding said coil turns and said supporting plate to compact said turns and said sheets as a solid unit; said unit and said encapsulating material defining in their adjacent relationship a substantially distinct marginal line of demarcation.

2. A pressure molded electrical coil comprising two adjacent coil windings each having a plurality of layers of convoluted turns of an insulated conductor and each defining a longitudinal opening therethrough, the conductor turns of a respective layer lying in substantial side-by-side relationship, said layers being separated from one another by means of interleaving insulating sheet material, a supporting plate disposed adjacent one side of said coil windings and being formed to provide two coil winding windows, each defined by upstanding marginal locating portions protruding partially into the longitudinal opening of a respective coil winding, said plate further including an interrupted leg portion adjacent a window therein, whereby an electric current path will be interrupted in said plate where there is a voltage induced therein, an insulating plate disposed between said supporting plate and said coil windings, a thermoset encapsulating material surrounding said coil windings and said supporting plate to compact said turns and said sheets as a solid unit; said unit and said encapsulating material defining in their adjacent relationship a substantially distinct marginal line of demarcation.

3. A pressure molded electrical coil comprising two adjacent coil windings each having a plurality of layers of convoluted turns of an insulated conductor and each defining a longitudinal opening therethrough, the conductor turns of a respective layer lying in substantial side-by-side relationship, a supporting plate disposed adjacent one side of said coil windings and being formed to provide two coil winding windows, each defined by upstanding marginal locating portions protruding partially into the longitudinal opening of a respective coil winding, said plate further including an interrupted leg portion adjacent a window therein, whereby an electric current path will be interrupted in said plate where there is a voltage induced therein, an insulating plate disposed between said supporting plate and said coil windings, a thermoset encapsulating material surrounding said coil windings and said supporting plate to compact said turns as a solid unit; said unit and said encapsulating material defining in their adjacent relationship a substantially distinct marginal line of demarcation.

References Cited by the Examiner

UNITED STATES PATENTS

1,864,331	6/1932	Whitesmith	336—205
1,884,385	10/1932	Thordarson	336—197 X
2,411,810	11/1946	Sander	336—178 X
2,464,029	3/1949	Ehrman	336—96 X
2,478,633	8/1949	Lord	336—205
2,490,506	12/1949	Brouerman	336—185 X
2,724,869	11/1955	Merrill	18—59 X
2,754,569	7/1956	Kornei	29—155.57
2,775,742	12/1956	Bogue	336—96 X
2,856,639	10/1958	Forrest	18—59
2,930,011	3/1960	Wigert et al.	336—96
2,942,217	6/1960	Ford	336—205
2,960,755	11/1960	Bender et al.	29—155.57
3,030,597	4/1962	Piaia et al.	264—272 X

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