March 19, 1957 P. T. NIMS 2,786,187

ELECTRICAL COIL

Filed April 6, 1950 4 Sheets-Sheet 1

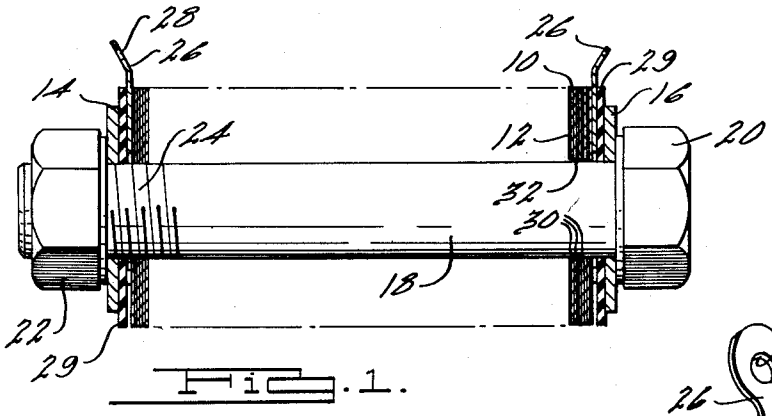


Fig. 1.

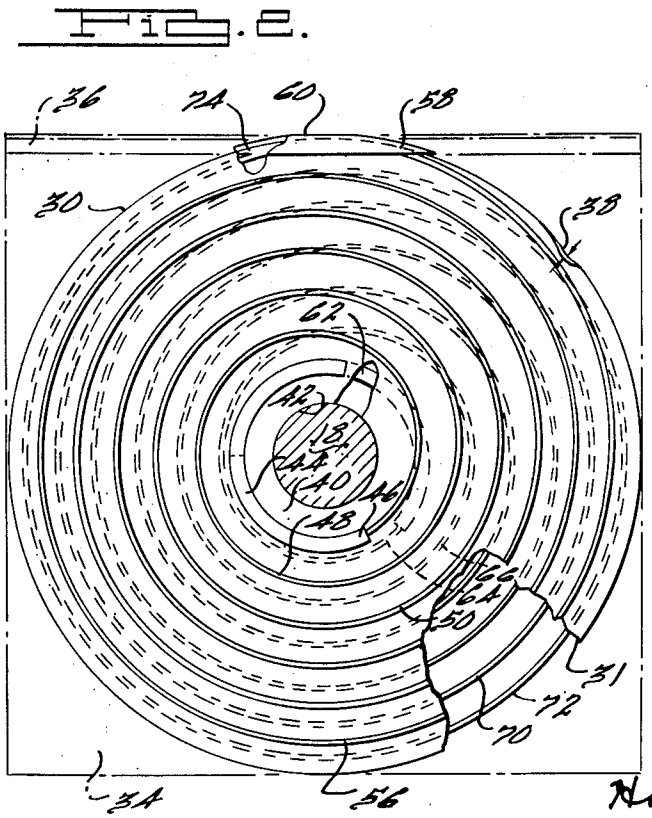


Fig. 2.

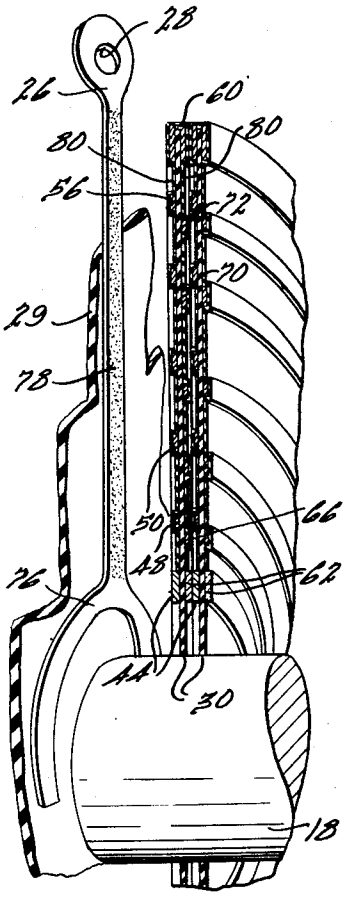


Fig. 4.

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ELECTRICAL COIL

Filed April 6, 1950 4 Sheets-Sheet 2

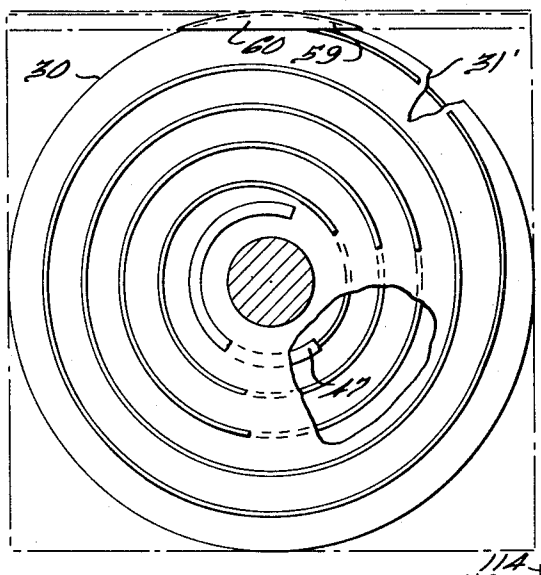


Fig. 3.

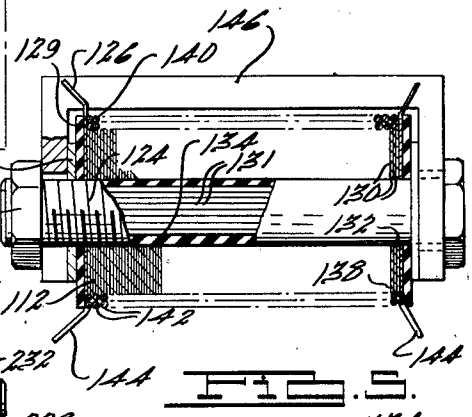


Fig. 5.

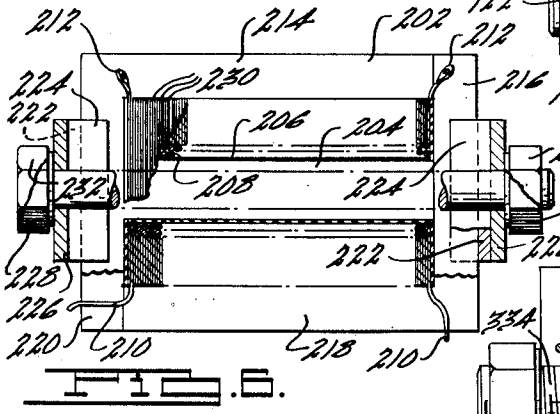


Fig. 6.

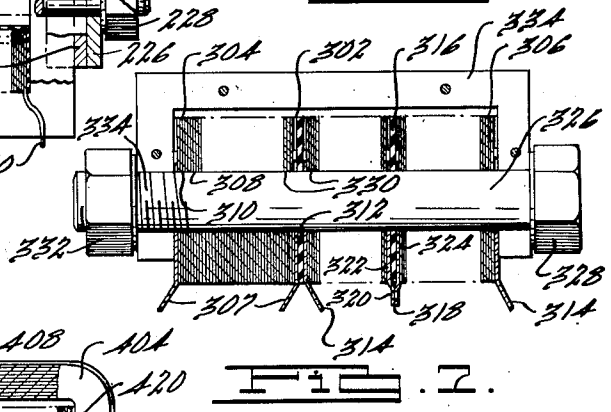


Fig. 7.

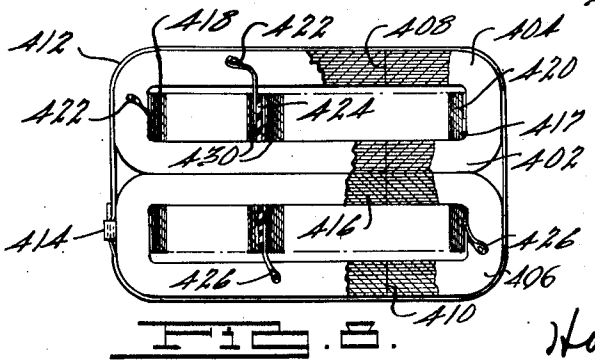


Fig. 8.

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ELECTRICAL COIL

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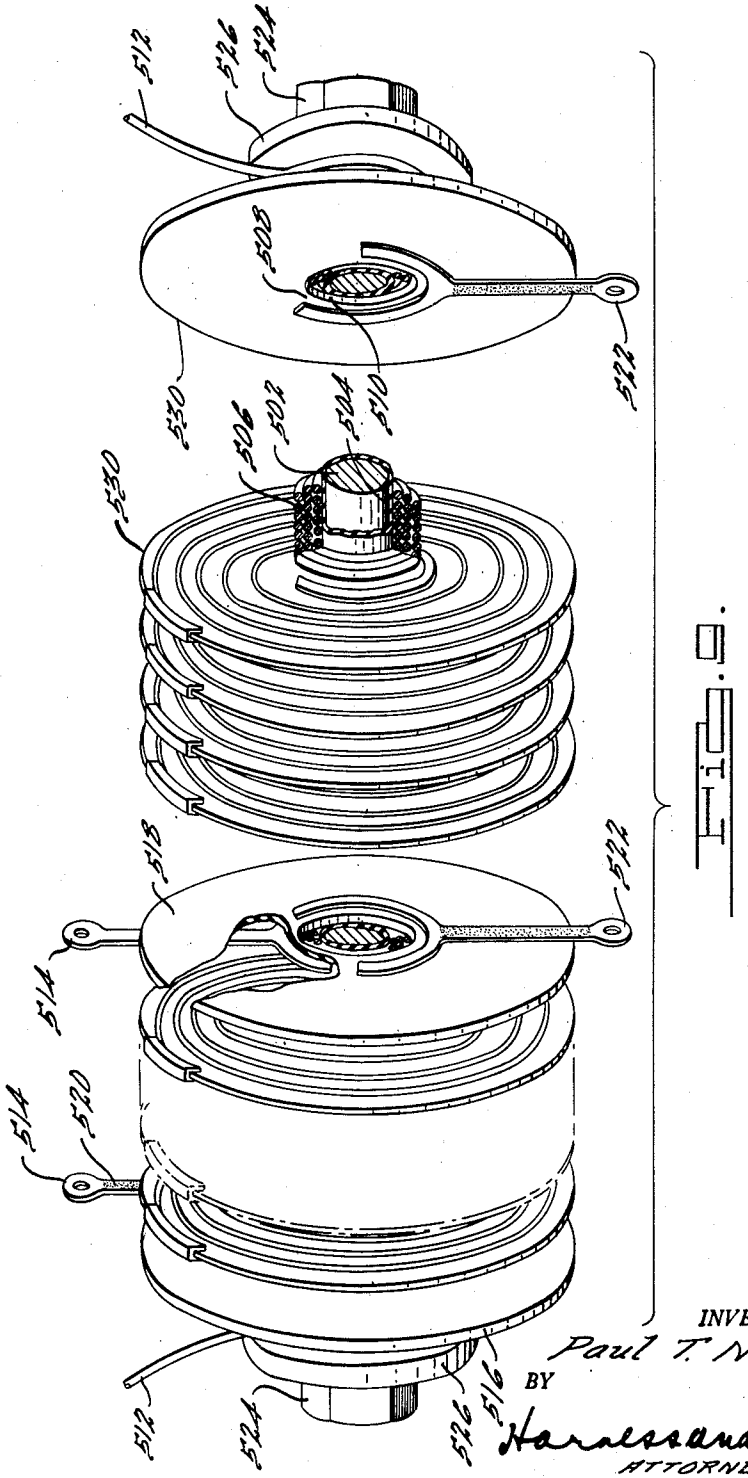


Fig. 5.

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ELECTRICAL COIL

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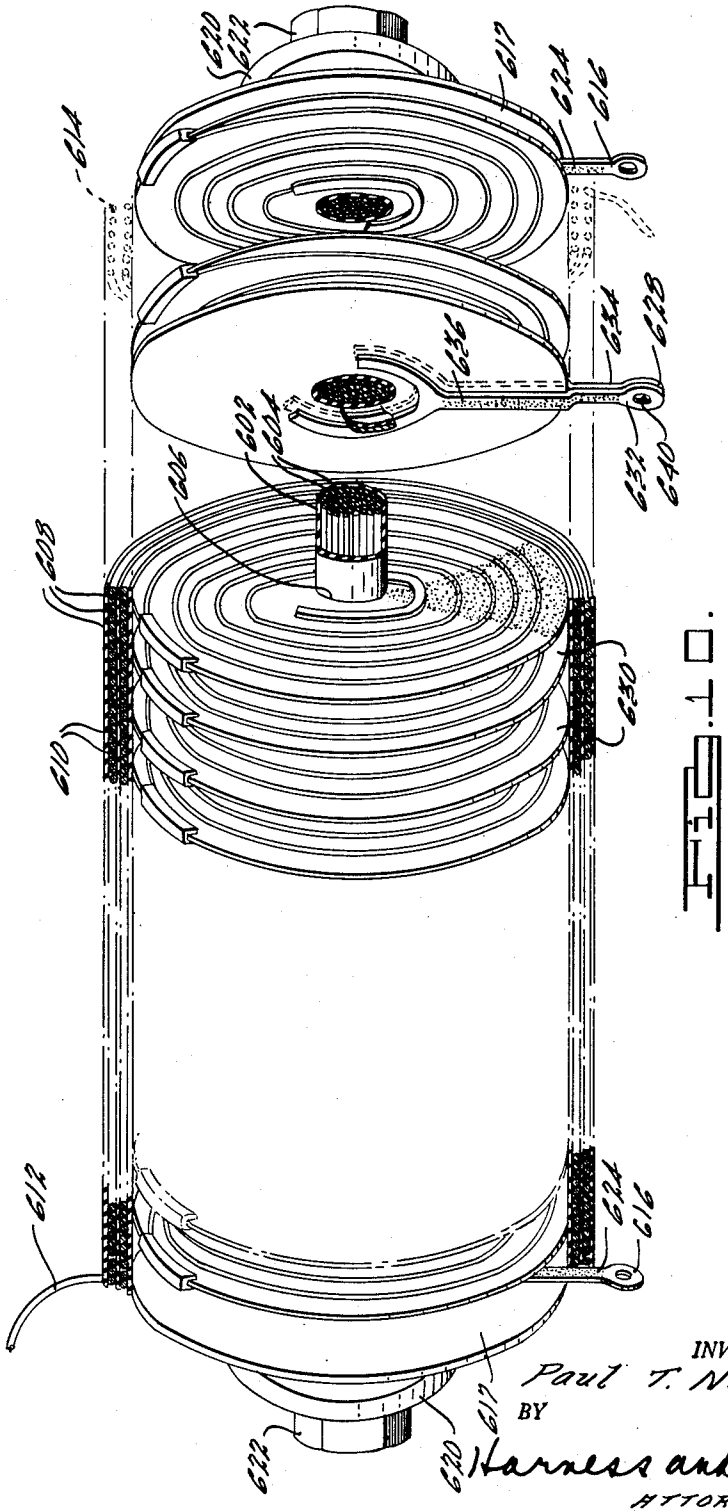


Fig. 1.

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2,786,187

ELECTRICAL COIL

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Application April 6, 1950, Serial No. 154,312

6 Claims. (Cl. 336—180)

The present invention relates to improved electrical coils and more particularly to coils fabricated of a multitude of individual parts as opposed to conventional wound coils of multiturn form having one or several continuous conductors which are substantially endlessly wound upon themselves to achieve the multiturn effect. Fabricated construction lends itself as well to coils employed for resistance effects as for inductive effects, the improvement in the former residing in the feature of substantial elimination of induction and in the latter the feature of low stray capacitance.

According to a further feature of the invention, a fabricated coil is provided in which the effective length of the resistance in one case and the effective number of turns in another case may be increased by a sub-multiple quantity or decreased merely by a simple addition or taking away of one or several of the multitude of the individual parts available as components.

According to still a further feature, provision is made to tailor a coil of parts previously constructed to any of a variety of strengths merely by aggregating an appropriate multitude of parts and assembling them in the quickly formed arrangement of a stack.

According to yet a further feature of the invention is the provision of a coil along the length of which there may later be conveniently interposed a number of tapping points without necessarily involving the unwinding of a coiled conductor down to the locations affected. Moreover, during initial assembly of the coil one or more tapping points may be provided as appropriate without the necessity of severing a conductor and interposing a permanently spliced tapping terminal.

According to another feature, provision is made whereby a coil may be fabricated from a stack of insulating sheets having margin portions mutually contributing to define insulating surfaces suitable for direct reception thereagainst of helically-wound continuous conductors and metallic core members as appropriate. That is to say, no further insulating layers need be interposed at the surfaces aforesaid such as presented in instances by outer margin portions, inner margin portions, or both.

According to still another feature of the invention a coil is provided in which a plurality of contacts cooperates to produce an uninterrupted electrical path between multiturn circuit elements, the appropriate contacting being at least initially effected by compression pressure. The plurality of points of pressure-contact tend to permit of ready interposition of taps and terminals at a variety of convenient locations respecting the coil and a comparative ease of reassembly without resort to mechanical fasteners or bonds being applied to the individual sets of contacts.

According to yet another feature, a coil is provided of which the final assembly as well as individual fabrication of the components, is suitable to high speed, fully automatic machine processes. Known coils may require one or several manual steps during formation which are not readily circumvented by or lend themselves to automatic operations. Instances of wound coil manufacture where

manual steps are taken include the interposition of insulation during laying of successive layers of the winding, the severing of the continuously wound conductor at coil end and the attachment of the oncoming end of the conductor to spool of origin of the next coil, and removal from the winding mandrel of finished coils and the insertion of the spool for the next contemplated coil onto the empty winding mandrel.

Other features, objects and advantages will either be specifically pointed out or become apparent when for a better understanding of the invention, reference is made to the following written description taken in conjunction with the accompanying drawings wherein:

Figure 1 is a sectional view of a coil constructed according to the present invention;

Figure 2 is a face view partially broken away of a component section of which the coil of Figure 1 may be formed;

Figure 3 is a face view of another section of somewhat modified form suitable for coil usage;

Figure 4 represents a fragmentary enlargement of the coil of Figure 1;

Figures 5, 6, 7 and 8 are sectional views showing further modified coils; and

Figures 9 and 10 are exploded views of other modifications in perspective.

As respects Figure 1, reference numeral **10** indicates a coil which may comprise a stacked body portion **12**, end washers **14** and **16**, and a core means **18** suitable to act in tension as a fastener. Core means **18**, which may be in the form of a highly resistive iron bolt has a head **20** at one end and a nut **22** suitably received by a threaded portion **24**. Broadly speaking, a rivet of these same proportions may be found to serve to advantage for the same purpose in certain applications. Mounted to an insulating layer **29** adjacent each washer there may be terminals **26** for the coil which are provided with a suitable aperture as at **28** for connection of the coil in a circuit. The body part **12** is formed of a plurality of individual component sections **30**, the inner margins of which define apertures mutually cooperating to define a central opening **32** through the coil suitable for reception of the core means **18**.

As respects Figure 2, the component section **30** may comprise a sheet or wafer **31** of an insulating material having a thickness dimension of small order, as is indicated at the turned back edge **38**. If sheet **31** happens to be initially in the form of a rectangle or square, it may be left in that form though it is preferable to remove the corners as at **34** and thickened edges as at **36** mounted to the corners and reduce wafer **31** to a substantial disc shape. The inner margin portions **40** of sheet **31** define an aperture **42** nakedly against which is received core means **18**. If the core means happening to be desired in a particular application is of polygonal formation, then perhaps only edges of the core means will engage the inner margin portions of sections **30** and broadly, the internal fit between sections **30** and the core means may be loose or snug as appropriate. In radial spacing to aperture **42**, a segment **44** of conducting material is carried by sheet **31**. Segment **44** has an end portion **46** from which a path of conducting material is extended in a relatively narrower form through a staggered path such as to execute a series of turns **48** and **50**, each successive one of which extends around the preceding turn. These turns are shown to be of substantial spiral configuration but within the broader aspects of the invention they may assume more of a rectangular or other spiral relationship. The portion **56** nearest the outer margin portions of sheet **31** progresses spirally outward to a connection with a portion **58** of an aggregation **60** of the electrically conductive material which passes over

the thickness of the edge of sheet 31 indicated in the dimension at 38, in order to effect a connection with a companion electrical path on the opposite side of sheet 31. As broken out at 62, a segment of conducting material is disposed on the opposite side of sheet 31 in a similar relation to aperture 42 as segment 44 just described. From a portion of segment 62 a path of the electrical conducting material may start at 64 and execute the first turn 66 of a series of turns completed by turns 70 and 72, the latter named turn of which connects to a portion 74 of the aggregation 60 of conducting material. It is to be noted that the two paths of conducting material are—in diaphonous view—of opposite spiral sense. Hence if segments 44 and 62 are energized, the magnetic field resulting from the path on each side of sheet 31 will tend mutually to contribute and produce a combined magnetic effect which will appear along the path defined by core means 18. Conversely, the creation of a magnetic field through core means 18 or a change in the strength of that field once created will tend to induce a voltage effective between segments 44 and 62.

As respects Figure 3, the component section 30 comprises a sheet or wafer 31' having electrical paths of a somewhat modified construction. The path on the face of the sheet nearest the observer spirals outwardly and connects to a common portion 59 of the connection forming aggregation 60 of material which leads across the edge of sheet 31' to the opposite face. The path of conducting material on the said opposite side of sheet 31' has a segment with a portion 47 connected in the same relative sense as was the near path such as to spiral outwardly in the same spiral sense and effect a connection at the outer margin of sheet 31' with the same or similar portion 59 of the aggregation 60 leading across the edge of the sheet. As shown, the electrical paths just set forth are in plan superimposed although as long as they are of the same spiral sense they may or may not be exactly superimposed. Regardless of the superposition so long as these paths are of the same spiral sense, when the segments adjacent the aperture of the sheet are energized, any magnetic field tending to be formed in the core means due to the influence of the electrical path on one side of sheet 31 will be counteracted by the path of the same spiral sense on the opposite side. The result of such construction is that a stack of such component sections if arranged to form a coil, will have little or no inductive effect and hence will readily lend itself to purposes and applications calling for a non-inductive resistance coil.

In Figure 4, details of the component sections 30 are shown enlarged for a better understanding of the coil of Figure 1. The apertures formed in sections 30 define an opening which directly receives the core means 18. It will be observed that the respective segments 44 and 62 of each section 30 are uninsulated as respects their exterior surfaces to the end that when sections 30 are stacked together, each segment 62 is exposed to come into a contact forming and conducting relation as respects the next successive segment 44. In order for an electrical current to pass from the segments 44 and 62 of any particular section 30, it must pass through successive turns 48, 50 and so on to terminate in a turn 56 which effects connection with the crossover path of conducting material 60. The electric current must then proceed radially inward by another series of turns from region 60 through turns 72, 70 and end in a turn 66 which effects connection with segment 62. Inasmuch as segment 62 of one section 30 is pressed into engagement with the segment 44 on the next successive section, the current then passes to the electrical path on the next section and by a series of turns progresses in a staggered path to the crossover connection for the said next section. A layer of insulating material 80, which may be varnish or other resin or plastic, is shown applied to all turns and portions of the electrical path with the exception of segments 44 and 62 on the sections 30. If the last coating of this insulating layer 80 is applied before the sections are compressed together by the fastener 18, then it may be found expedient to remove the core means altogether, the insulating layer providing thereafter the bond between the individual sections. The terminal 26 mounted to insulating layer 29 has a companion segment 76 adapted to be pressed into contact with a segment such as 44. The body portion of terminal 26 is provided with an insulating layer 78 which may be similar to layer 80 and serve to insulate terminal member 26 from the successive turns 48, 50, 56, and 60 of the section 30.

If the coil of Figure 4 is desired to be of the non-inductive type, such effect may be achieved by using the sections as disclosed in Figure 3 preceding. That is to say, the turns on the face of the coil on which segment 44 is mounted tend to oppose in effect the magnetic field created by the turns on the face of section 30 containing segment 62. Within the broader aspects, of course, this same non-inductive effect may be achieved by making the opposite faces of any one section of the opposite spiral effect shown in Figure 2, but by reversing the spiral paths on the next successive section 30, the result being that every other spiral path is of the opposite spiral sense. In the event that the spiral paths are to reinforce one another for their magnetic effect, the sections of Figure 2 are grouped together in a stack and drawn into compression as by core means 18. Since a multitude of these sections may desirably be used, it will be perceived that the resulting coil will be characterized as having low stray capacitance, which is to say that the greatest number of turns which can be adjacent one another are those of two adjacent discs. A conventional coil, on the other hand, has an entire layer adjacent to the next layer and this usually comprises many more turns. The voltage represented between these successive discs will be the additive voltage across the series of turns leading inwardly to the two segments 44 and 62 adjacent one another and returning outwardly to the next successive crossover portion 60. Each section 30 carries the electrical paths in mounting to its faces. That is to say, the electrical path may broadly be formed directly on sections 30 by printing, coating, electrodeposition or a combination thereof; it may be stamped out and then bonded or adhesively mounted to the sections 30 or it may be electroformed or sprayed down first and then mounted to the sections 30. It will be appreciated that in any of the foregoing cases the process admits of automatically handled steps not only as to fashioning of the paths on the sections but also the assembly of the sections into final coil form.

In Figure 5, a hollow fastener 118 which may be of a plastic or a resin, contains within chamber walls 134 a bundle of members 131 which may be soft iron or other wires effective to provide an appropriate magnetic path. The hollow fastener 118 may be in the form of a headed bolt having a threaded portion 124 on which is received a nut 122. The body member 112 is of stacked configuration comprising a multitude of sections 130 defining a central opening 132 in which is received fastener 118. An insulating sheet 129 held in place by a washer 114 mounts a terminal member 126 for the body section 112 of the coil. Around outer portion 138, which may be cylindrical, of body section 112 is wound a substantially endless conductor 140 defining a multiturn helical path 142 having end terminals 144. A yoke 146 is held by the ends of fastener 118 in order to define a substantially closed magnetic iron path through and around the coil. Either the stacked body portion 112 or the helically-wound portion 140 may receive an impressed power input and by virtue of the magnetic connection assisted by the core means 118 and 146, will tend to be magnetically connected to the remaining component of the coil and yield a transformer effect.

In regard to Figure 6, a core means 202 has a central portion 204 around which may be provided a cylinder

206 of insulation. Around cylinder 206 may be wound a substantially endless conductor 208 to produce a multiturn helical effect as between the end terminals 210 thereof. Terminals 212 are provided for a stacked body portion composed of sections 230. The apertures in sections 230 receive the wound component 208 and the central portion 204 of the core means. The core means may be of laminated construction comprising duplicate alternating layers. In one layer an E-shaped member 214 has the open ends thereof closed by a bar part 216. The next layer below the layer just described comprises an E-shaped member 218, the open ends of which are closed by a bar part 220 which is located at the opposite end of the coil from bar part 216. These layers, each of which has a central portion passing through the coil proper, are held together unitarily by opposed ears 244 formed on a bracket 222 disposed at either end of the coil. The brackets 22 are urged toward one another by a transverse strap 226 at the ends of which are received respectively a near bolt 228 and a far bolt 232. By means of the bolts and the strap the laminations of the core means are held together as a unitary body and also the stacked body section of the transformer coil may be compressed to afford intimate electrical contact as between the segments of each successive section.

In Figure 7, the coil shown has a body portion 302 which is stacked into components 304 and 306 comprising a multitude of sections 330. The apertures 308 of the individual sections 330 define a central opening 310. Between the components just set forth is an insulating layer 312. The terminals 307 to one side of layer 312 provide the end connections for component 304 and on the opposite side of insulating layer 312 the end terminals 314 provide the end connections for component 306. An insulating layer 316 intermediate terminals 314 provides a mounting for a tap 318 provided with an aperture 320 suitable for the connection of a tapping lead. Tap 318 comprises a member 322 on one side of layer 316 and a member 324 on the opposite side of layer 316 which are connected in the vicinity of opening 320. Core member 326, which is received in central opening 310 has a head 328 at one end and a threaded portion 334 at the other end on which may be received a nut 332. Core means 326 may desirably be formed of a highly resistive iron alloy. Adjacent the receptive ends of core means 326 noted are the lugs of a yoke 334 which completes a substantially closed iron circuit through and around the transformer coil just set forth. It is to be observed that in component 306 the tapping point 318 provides for an intermediate voltage.

In regards to Figure 8, core means 402 comprises laminated components 404 and 406. Along the line of separation 408 and 410 respectively, the laminated components each comprise two respective parts. These parts may be drawn together by means of a band going around their periphery as indicated at 412 which is connected on itself at 414. An insulating layer 424 is disposed between one part 418 of the body portion 416 and the other part 420. The paths of each of these portions are electrically separated by the layer 424. The body portion 416 may be considerably compressed to bring the section contacts together by means such as a tapered shim 417 between the end of the body portion and the core means 402. End terminals 422 are provided for body part 418 and end terminals 426 are provided for body part 420.

In Figure 9, a core means 502, which may be of highly resistive iron, is provided with an insulating cylinder 504 around which is wound a substantially continuous conducting element 506 which produces a helical multiturn effect. The wound conductor 506 is appropriately received in the apertures 510 formed by the inner margin portion 508 of each section 530. The wound conductor 506 provides end terminals 512 suitable for connection in a circuit. Other terminals 514 provide a separate electrical path for the circuit disposed between the insulating layer 518 and insulating layer 516. The layer of varnish, resin, or other insulation is indicated at 520 on these terminals. The varnished terminals 522 define another electrically separate circuit. The sections may be drawn together by application of pressure to washers 526 at the respective end thereof which may be accomplished by the fastener heads 524.

In Figure 10, the hollow fastener means 602 contains a plurality of elements 604 which may be soft iron wires. The hollow part 602 may be of a plastic or resin construction. Core means 602 is received in a central aperture 606 formed by the successive sections 630. Placed in cylindrical layers around sections 630 there may be provided insulating layers 608 disposed between layers of a substantially helically-wound conductor 610 having an end terminal 612. The helically-wound conductor may have an extension portion 614 as is appropriate. The end terminals 616 of the transformer coil are mounted to layers of insulation 617 which are drawn toward one another in compression by suitable washers 620 held by the ends 622. A coating of varnish or other insulation 624 may be applied to terminals 616 and a similar layer, of course, is indicated in application to the face of the respective sections 630. Tap 628 comprises two members 632 and 634 which have segments adjacent the core means and which at their outer ends are mutually joined adjacent the connection opening 640. These members are insulated as at 636. It will be observed that all of the stacked sections are electrically connected through the medium of tap 628 yet they still retain their electrically separate status as respects the outer wound conductors 610.

It will be observed that the inner and outer margin portions of the sections of the stacked coils above set forth provide a naturally insulated surface and the interposition of an insulating layer is purely optional as respects the introduction of a core means through the center of the body section or a wound conductor either centrally of the body part or along the external cylindrical surface thereof. Within the broader aspects of the invention the fastener, which could or could not serve additionally as the core means, may be dispensed with following final assembly of the coil and reliance placed on the adhesive effect of the varnish or plastic between the successive layers or sections involved. If the core means is not desirably to be eliminated then the fastener may be retained or else a substitute therefor made by a more appropriate core member which may or may not be as suitable strictly in a fastening capacity.

Variations within the spirit and scope of the above described invention are equally comprehended by the foregoing description.

What is claimed is:

1. In a coil, a stack of centrally apertured sheets of insulating material and including a first sheet, and other sheets facing the first sheet and adjacent thereto, a path of conducting material on the face of each said other sheet connecting two points by a series of turns, each succeeding turn extending around the previous turn, said first sheet having means forming a pair of paths of conducting material one on each side of the first sheet having circularly arcuate inner end contacts in radially spaced relationship with respect to the central aperture and coaxial with and overlappingly contacting similar end contacts provided on said other sheet paths, and having the other pair of end portions of the path means extending beyond the bounds of the first sheet and connected to each other.

2. In a coil, a sheet stack including a first sheet of insulating material and other sheets of insulating material facing the first sheet and adjacent thereto, a path of conducting material on the face of each said other sheet connecting two points by a series of turns, each succeeding turn extending around the previous turn, said first sheet having means forming a pair of paths of conduct-

ing material one on each side of the first sheet having circularly arcuate inner ends coaxial with and electrically contacting similar ends of said other sheet paths, and having the other pair of end portions of the path means extending beyond the bounds of the first sheet.

3. An electrical coil means comprising a stack of insulating wafers having a plurality of spiralled conducting elements mounted in interposition therebetween, said wafers having apertures defining an opening through the stack and having circularly arcuate aggregations of conducting material mutually coaxially arranged and mounted in radially spaced relationship with respect to the apertures and provided with contactingly overlapping portions and each with an end portion connected to the inner end of the spiralled conducting element, and core means disposed in said opening thereby being in radially spaced relationship with respect to said contact aggregations of conducting material.

4. An integrally stacked coil having a plurality of sandwiched sections comprising a pair of aligned insulating sheets presenting mutually opposing faces, one sheet of said pair having means forming a multiturn electrical path on its aforesaid face whereof each turn is radially spaced from every other turn, the other sheet of said pair having means forming a multiturn electrical path on its aforesaid face whereof each turn is radially spaced from every other turn, the innermost turn of each said path having a circularly arcuate end contact section disposed in the plane of such path and coaxial with the other end contact section so as to overlap with and electrically contact the same, and at least one insulating coating between respective portions of said electrical paths bonding together the paths and sheets to constitute an integral unitary sandwich in the coil.

5. In an electrical device, a centrally apertured discrete circular sheet of insulative material having a spiral path of conductive material on each face thereof surrounding the central aperture, the outer ends of the spiral path being interconnected across the edge of the sheet, there being a substantially semi-circular arcuate aggregation of conductive material at the inner end of each path arranged coaxially with respect to the other arcuate aggregation, and in combination therewith, an identical discrete sheet of insulative material juxtaposed on each side of the first-named sheet so as to be aligned in a stack therewith with at least a portion of the conductive arcuate aggregation on each side of the first-named sheet

being overlapped with and electrically contacting a like portion of the coaxial adjacent arcuate aggregation of conductive material on the juxtaposed sheet on that side, the respective spiral paths and connections forming a continuous multi-turn coil winding.

6. In an electrical device, a centrally apertured discrete circular sheet of insulative material having a spiral path of conductive material on each face thereof surrounding the central aperture, the outer ends of the spiral path being interconnected across the edge of the sheet, there being a substantially semi-circular arcuate aggregation of conductive material at the inner end of each path arranged coaxially with respect to the other arcuate aggregation, and in combination therewith, an identical discrete sheet of insulative material juxtaposed on each side of the first-named sheet so as to be aligned in a stack therewith with at least a portion of the conductive arcuate aggregation on each side of the first-named sheet being overlapped with and electrically contacting a like portion of the coaxial adjacent arcuate aggregation of conductive material on the juxtaposed sheet on that side, there being an insulating coating adhering to each side of the first-named sheet so as to coat the spiral path on such side and being cohered with a like coat provided on the juxtaposed sheet at that side and constituting substantially the sole means holding the discrete sheets together as a stack.

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