May 7, 1963 T. N. SAATY 3,089,106

PRINTED CIRCUIT COIL

Filed Aug. 15, 1960 2 Sheets-Sheet 1

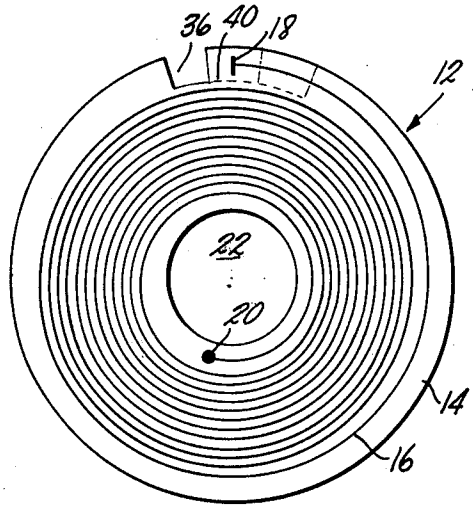


FIG. 1.

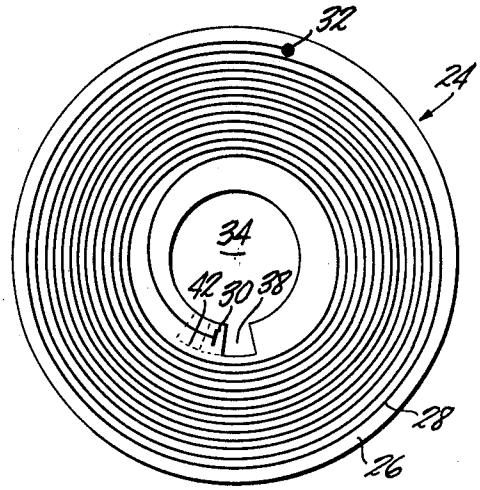


FIG. 2.

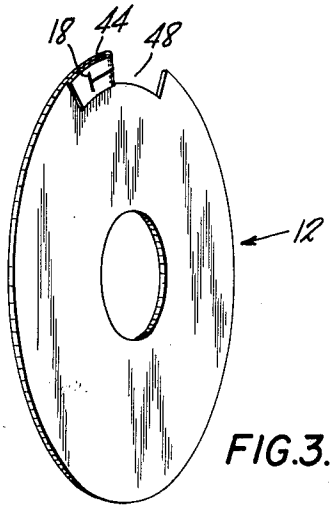


FIG. 3.

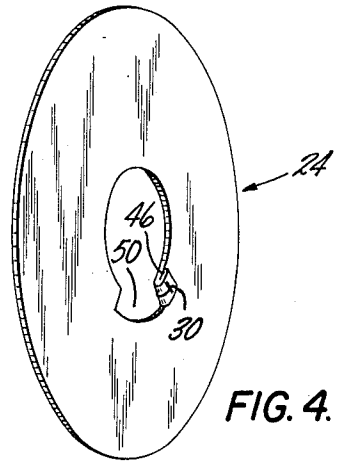


FIG. 4.

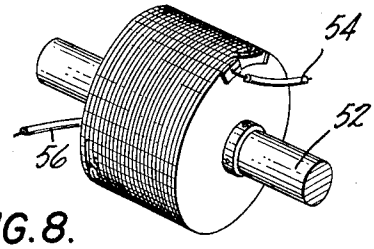


FIG. 8.

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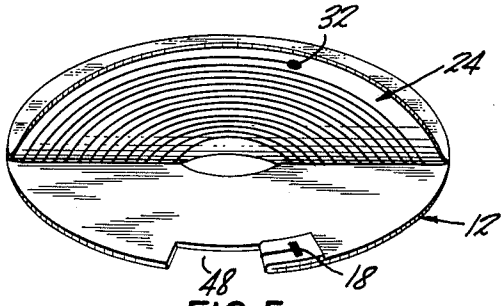


FIG. 5.

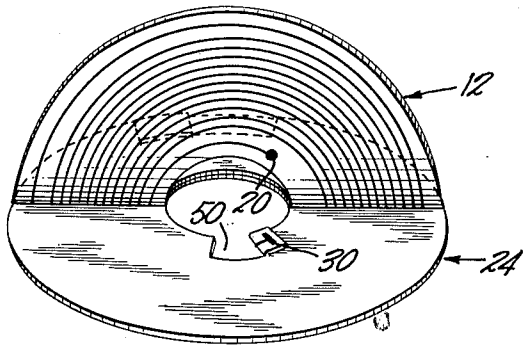


FIG. 6.

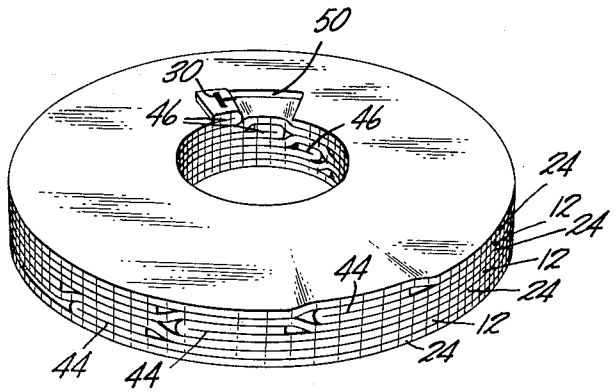


FIG. 7.

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PRINTED CIRCUIT COIL

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5 Claims. (Cl. 336—200)

The present invention relates to a novel coil and a method of making it, and in particular to a novel inductance coil and improved method by which it is made.

Although a number of ways have been developed for producing coils, the standard system involves winding an electrically conductive wire or ribbons of metal onto a core tube, spindle or special bobbin by means of an automatic or semi-automatic machine. The procedure is difficult and expensive requiring compensation for temperature changes, variation in wire diameters allowed during drawing and caused by tension on the wire during the winding step, and other variables, and in each instance depending upon the type of coil being made, and the nature of the bobbin, core, or spindle, a special complicated, and expensive machine must be used to wind the wire.

Another difficulty in winding coils is the difficulty in adhering to specifications and the desire to achieve a high degree of precision. For instance, if the number of turns is specified, a large variation in resistance can be expected and if resistance is specified, a large variation in the number of turns can be expected. Or, if finer wires are used, a higher tolerance is required to keep the cost within reasonable limits.

Essentially the present invention comprises printing, on a suitable backing, an electrical circuit in some geometrical form simulating a coil winding, and assembling a number of the backings so that the printed circuits are superimposed one upon another and preferably electrically connected in series. The circuits may be laid out in the form of a helix onto flat disks, and the disks may then be placed in series on to a core of magnetic material, but it is apparent that other arrangements may be used. The particular arrangement used depends upon the application, but in each instance, the printed circuits are formed and arranged so that the assembly simulates a conventional coil winding, having the desired specifications, such as number of turns, resistance, and dimensions.

For the purpose of the present invention, the term "printed circuit" shall be deemed to have the common meaning used in the art, and shall include all circuits where the components are laid down simultaneously onto a backing material, as distinguished from circuits wherein the components are assembled sequentially. In other words, the term shall include all circuits produced by methods including printing with metallic ink on a suitable backing material, etching a laminated surface, spraying through a mask, electro deposition, or other comparable methods of obtaining "printed" circuits.

A principal advantage of the invention is that the manufacture of coils and windings is considerably facilitated, and made less expensive, but an additional advantage is in the precision that may be obtained using the concepts of the present invention. For instance, with respect to the latter, present methods of printing surfaces are capable of laying down lines as fine as two thousandths of an inch in width, spaced as little as one thousandth of an inch apart. A further advantage is that an extremely compact winding or coil may be obtained.

Other objects and advantages will become apparent upon further consideration of the application, and the accompanying drawings, in which:

FIGURES 1 and 2 are printed elements for a coil of the present invention;

FIGURES 3 and 4 are the elements of FIGURES 1 and 2 modified for assembly as a coil;

FIGURES 5 and 6 illustrate the manner in which the elements of FIGURES 1, 2, 3 and 4 may be assembled;

FIGURE 7 illustrates an assembly of a multiple number of printed elements; and

FIGURE 8 illustrates the assembly of FIGURE 7 mounted on a core.

Referring to FIGURE 1, there is illustrated a printed element 12 according to the invention comprising a backing member 14 and a printed circuit 16 of electrically conductive material, wherein the circuit 16 is printed in the form of a helix which converges in a clockwise direction from an outer leading terminal 18 to an inner terminal 20. The element is circular in shape, having a circular cutout area 22 adjacent the inner terminal 20, but the shape of the element may be modified depending upon the application. Also the printed circuit, although illustrated in the form of a helix, may be modified with respect to shape and dimensions depending on the application contemplated. Further, the particular element shown is useful for core windings, but if a core is not used, the cutout area may not be necessary.

The particular materials used in the element are not important, and in general, the backing member is composed of an electrical insulating material, such as paper, and certain plastics and other comparable materials. The material used in the printed circuit is any material capable of conducting an electrical current, and its particular composition depends upon the manner in which the circuit is printed, and the characteristics desired.

Referring to FIGURE 2 an element 24, complementary to element 12 of FIGURE 1, is illustrated having a backing 26, and helical circuit 28, wherein the circuit diverges or extends outwardly in a clockwise direction from an inner leading terminal 30 to an outer terminal 32. In this instance, the inner terminal is adjacent a cutout portion 34 through which a core may be inserted.

In both FIGURES 1 and 2, cutout areas or notches 36 and 38 are provided positioned adjacent the leading terminals 18 and 30 of the elements 12 and 24. Additionally the elements are cut back along lines 40 and 42 so that the tabs 44 and 46 bearing the terminals 18 and 30 may be folded back in the manner illustrated in FIGURES 3 and 4, providing extended cutout areas or notches 48 and 50.

FIGURES 5 and 6 illustrate the manner in which elements formed as shown in FIGURES 3 and 4 may be superimposed upon each other. Note in FIGURE 5 that the outer leading terminal 18 of element 12, folded back as shown in FIGURE 3, makes contact with the outer terminal 32 of element 24. In FIGURE 6, the inner terminal 30 of element 24, folded back as shown in FIGURE 4, makes contact with the inner terminal 20 of element 12. Following this, the elements of FIGURES 5 and 6 are combined to form the coil illustrated in FIGURE 7, having the elements 24 and 12 superimposed in the manner shown.

From the above, it is apparent that cutting the backings 14 and 26 along lines 40 and 42 and folding back the formed tabs 44 and 46 serves two functions, one to provide contact between the superimposed elements and second, to provide cutout areas in alternate elements to compensate for the double thickness resulting from the folding over of the tabs. By suitably dimensioning the elements, so that each successive pair of elements is rotated slightly, the folded over tabs will be caused to occupy different areas about the circumferences of the assembled coil, as illustrated in FIGURE 7. In the coil shown, the terminals 18 and 20 of formed element 12, FIGURE 3, are 180° apart, whereas the terminals 30 and 32 of formed element 24, FIGURE 4, are slightly

less than 180° apart, going in a clockwise direction from inner terminal **30** to outer terminal **32**, the lesser angle being that calculated to shift the next successive pair of elements an amount necessary to avoid any overlapping of folds.

FIGURE 8 illustrates the elements mounted on a suitable core **52** with leads **54** and **56** connected to the appropriate terminals.

The coils according to the present invention may have a number of uses. For instance, choke coils or impedance coils providing a reactance effect in an electrical circuit are within the scope of the invention. Similarly, transformer coils may be manufactured as well as form-wound armature coils and field coils for electrical machines. Similarly, coils for solenoids and for heating elements may be manufactured using the principles of the present invention, and for each and every one of the uses, it is apparent that the present invention provides extremely useful concepts.

Many variations would be apparent to those skilled in the art. For instance, the circuits may be printed using a number of shapes and dimensions, and the elements may be stacked in any desired number depending on the characteristics involved. Also, as indicated above, the shape of the backing member and the materials used may be varied. Further, other methods are available for providing contact between the stacked disks, and the above relates to only one method used, and accordingly, it is intended that the present invention be limited only as described in the following claims.

I claim:

1. An electrical coil comprising a stack of flat discs each having an electrical winding printed thereon in the form of a spiral having a multiple number of turns, the windings of adjacent discs being of opposite hand, alternate discs having fold-back tabs at the outer terminals of their windings and other alternate discs having fold-back tabs at the inner terminals of their windings, the

fold lines for said fold-back tabs extending substantially radially of the respective discs, the respective terminals being carried by the fold-back tabs so as to connect the windings of adjacent discs, successive of said inner fold-back tabs being angularly oriented with respect to each other and successive of said outer fold-back tabs being angularly oriented with respect to each other.

2. An electrical coil as set forth in claim 1 in which all of the discs have center holes to accommodate a magnetic core therein.

3. A printed disc comprising an insulated backing, an electrical winding printed on one side thereof in the form of a spiral having a multiple number of turns and a fold-back tab at one end of the terminal foldable along a line substantially radial of said disc, the terminal being carried by the fold-back tab.

4. A printed disc comprising an insulated backing, an electrical winding printed on one side thereof in the form of a spiral having a multiple number of turns and a fold-back tab at the outer terminal of the winding foldable along a line substantially radial of said disc, the terminal being carried by the fold-back tab.

5. A printed disc comprising an insulated backing, an electrical winding printed on one side thereof in the form of a spiral and having a multiple number of turns and a fold-back tab at the inner terminal of the winding foldable along a line substantially radial of said disc, the terminal being carried by the fold-back tab.

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