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METHOD OF MAKING SPIRAL ELECTROMAGNETIC COILS

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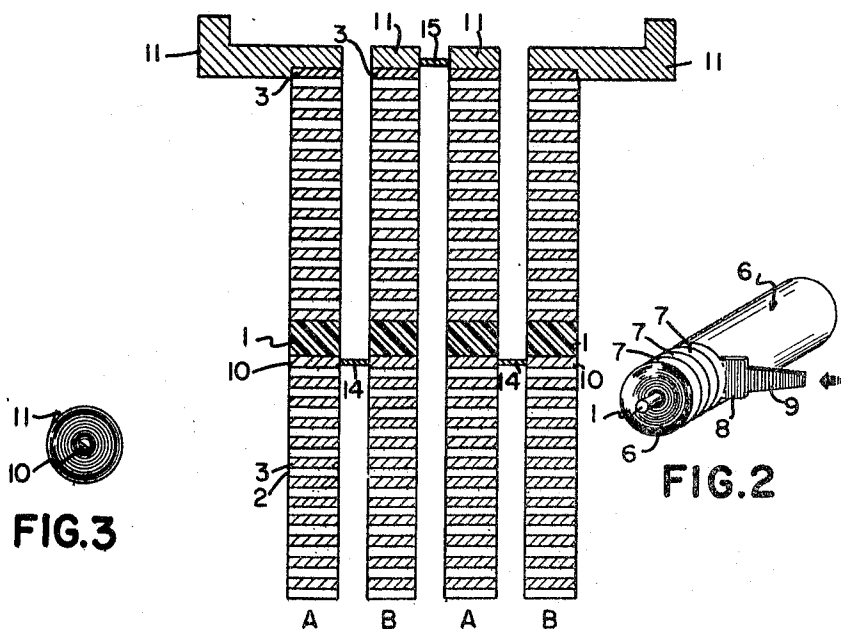


FIG.3

FIG.4

FIG.2

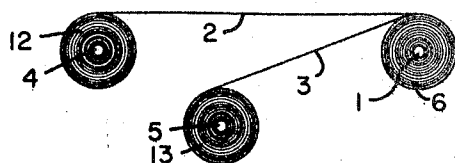


FIG.1

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METHOD OF MAKING SPIRAL ELECTRO-MAGNETIC COILS

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2 Claims. (Cl. 29—155.57)

This invention relates to coils, particularly for electrical purposes, in which the turns of the coil are ordinarily spaced apart by an insulating material, and to the manufacture of such coils.

Such coils are ordinarily made by winding wire of round cross-section in wide layers on a core. The round wire gives a poor space factor, yet the use of wire of rectangular cross-section is not feasible on automatic machinery because of the difficulties due to twisting of the wire, which is especially difficult if the wire is extremely fine.

I have discovered, however, that very effective coils can be made by winding wide foil sheets in layers separated by an insulating material, for example a sheet of paper, and then slicing the resultant piece into thin wafers, each of which will be in effect a spiral coil of rectangular wire, the turns of which are separated by the insulating material.

These spiral coils can be impregnated with wax, resin, plastic or other insulating materials before slicing, and can be used directly, as in a high frequency coil, or enclosed partly or wholly in magnetic material, or placed on a magnetic core. The spirals can be stacked together, separated from one another by a thin wafer of insulating material or by an insulating film, with the spirals being connected in series if a large number of turns is desired, with some of the coils acting as primaries, the others as secondaries if the resultant device is to be a transformer. One spiral can be a primary, the next a secondary, and so on if tight coupling is desired, or all the primary spirals can be together, and all the secondaries together, if looser coupling is wanted.

In slicing the wound layers into coils, the turns may become shorted, but the shorts can be removed by etching in an acid which dissolves the metal, the etching being continued long enough to dissolve out the shorted metal but not long enough to remove much of the unshorted metal in the interstices of the coil. However, I have found that if the cutting tool is extremely thin and sharp, and if its rate of progress into the coil is kept at a critical value with respect to the rotation of the wound piece, the slicing operation can be carried out without producing any shorts, and hence without the necessity of etching.

The coils produced are superior to conventional wire-wound coils because of the thinner insulation which can be used between layers, the rectangular cross-section of the conductors, and the thinness of the conducting material. The manufacturing cost of the coils is, moreover, much smaller than that for conventional coils of similar characteristics and the manufacture is more readily adaptable to completely automatic machinery.

Other features, advantages and objects of the invention will be apparent from the following specification, taken in connection with the accompanying drawing, in which:

FIG. 1 shows a sheet of metal foil and a sheet of paper being wound on a core together;

FIG. 2 shows the wound cylinder being sliced into wafers;

FIG. 3 shows a resultant single wafer-like coil; and

FIG. 4 shows in radial cross-section a means of connecting the wafer-like spiral coils.

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In FIG. 1, a cylindrical core 1, which may for example be of wood, is rotated to wind thereon the paper sheet 2 and the metal foil sheet 3, the direction of rotation being shown by the arrow. The sheets 2 and 3 can be unwound from separate spools 4, 5 and wound together on the core 1, by rotating the latter, which may be set in a chuck for that purpose. The rolls 12, 13 of paper and foil, respectively, can turn about the shafts 4, 5, which may be fixed. The paper used can be paper of the insulating type used in condensers, generally called kraft paper, and can have a thickness, for example, as small as 0.0003 inch or even less. The foil is also thin, about 0.00025 inch; aluminum foil being satisfactory for many purposes. The gains from the method of winding are such that when aluminum foil is used, the resistance of the finished coil is about the same as that obtained by using copper in the conventional wire windings. When copper is used with the wafer-coils described in the present application, the coil characteristics are far superior to those of wire-wound coils. Copper foil, however, is not generally obtainable in sizes as thin as the thinnest aluminum foil. Where aluminum foil is used as the conductor, a length of copper foil is generally used in overlap contact to the aluminum foil at the ends of the latter, to facilitate soldering the connections. If the copper foil overlaps the aluminum for several turns, a firmer joint between the copper and aluminum is provided.

The wound cylinder 6 is then impregnated with wax, by being set into a container of melted wax for about 24 hours in air, then for about 48 hours in vacuum. It is then allowed to dry.

The wax is preferably one whose melting point is above the temperature to which the coil is brought by the friction of slicing. Waxes melting at 240° F. have been found satisfactory, and they can be heated to 275° F. during impregnation. Various resins and plastics can be used instead of wax, for example polyethylene, polystyrene, and polyvinyl plastics. In addition to its insulating effect the impregnation holds the wound cylinder 6 together and keeps it from unravelling.

When the coil is wound to the desired size on the cylinder and impregnated, the resultant wound cylinder 6 is then sliced into wafers 7 with the razor blade 8, which may be mounted on a metal arm 9, attached to a tool holder in a lathe, the wound cylinder 6 being set into the chuck of the same lathe and in position to be cut by the tool, which should be set at right angles to the longitudinal axis of the cylinder 6. In one example, the cylinder 6 was 3 inches long, and was cut into wafers about 0.013 inch long.

For best results in cutting the wound cylinder 6 into wafers 7 without shorted turns, the lathe cross-feed should not be advanced, for each revolution of the wound cylinder 6, more than a distance equal to the combined thickness of one sheet of foil plus one sheet of paper, that is, the radial distance between the center line of two adjacent turns of foil.

As shown in FIG. 3, each resultant wafer-coil 7 will have one contact 10 at its inner end and one 11 at its outer end. The core 1 is shown removed in the coil of this figure. If the coils A, B, shown in radial cross-section in FIG. 4 are stacked so that their windings are all in the same direction, the inside contact 10 of one will be connected to the outside contact 11 of the next, if they are desired to be connected in series-aiding relationship. However, if alternate coils A, B, are reversed so that their windings are in opposite directions, then the coils can be connected together by connecting the inner metal contact terminals 10, 10 of one pair of coils together, through the wire 14, the outer metal contact terminals 11, 11 of the next pair together, through the wire

15 and so forth, the two metal terminals 11, 11 at the outside ends of the stack of coils being left free for connection to an external circuit.

Coils connected in the foregoing manner would of course be in series, although parallel connections can be used where desired. Although the coils A, B, are shown wound on a core which is a circular cylinder, the core can also be a square, a rectangle, or of any other desired shape. Coils in which paper insulation is used and impregnated with wax after coiling have been described in the specific example, but the paper can be eliminated if a plastic insulating coating is used over one side of the foil surface. Wound paper can be used for the core if desired.

The core shown in FIG. 4 is of insulating material and of diameter small compared to that of the outside diameter of the coils A, B. The core can be made of larger diameter, if desired. Moreover, the insulating core I can be removed and a core of iron or other ferromagnetic material inserted.

The foil can be insulated before winding, if desired, by spraying with a thin layer of glass or ceramic frit, the coil being heated sufficiently after winding to melt the foil and seal the unit together. Although a razor-blade type cutter is very effective, a rotating wheel cutter can also be used, the wheel being driven in a direction opposite to that of the rotation of the wound cylinder 6.

The foil used is too thin to form of itself spaced turns which are self supporting, but when wound as described herein with paper or other insulating material between turns, the resultant unit is completely self-supporting.

Instead of connecting the coils A, B in FIGURE 4 together by wires 14, 15, they can be connected by twisting the terminals 10, 10 or 11, 11 together.

What I claim is:

1. The method of making spiral electromagnetic coils, said method comprising: winding an insulated sheet of foil onto a core, then rotating the resultant winding while advancing a thin knife blade into it, in which the knife blade is advanced the radial distance between the center lines of adjacent turns, for each rotation of the resultant winding.

2. The method of making spiral electromagnetic coils, said method comprising: winding a sheet of foil and a sheet of insulating material simultaneously onto a core with the sheet of foil and the sheet of insulating material in register with each other to form a wide spiral winding, and rotating said resultant wide spiral winding while advancing a thin knife blade into it to cut through said foil and said insulating material to form narrow spiral coils therefrom, in which the knife blade is advanced the radial distance between the center lines of adjacent turns, for each rotation of the resultant winding.

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