United States Patent [19]

Roadstrum

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[45] **Feb. 20, 1973**

[54] **ELECTRICAL COIL**

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[22] Filed: **Feb. 24, 1970**

[21] Appl. No.: **13,539**

[52] **U.S. Cl.** **336/84,** 335/213, 336/129, 336/189, 336/200, 336/205, 336/232

[51] **Int. Cl.**.....**H01f 27/28**

[58] **Field of Search**.....336/205, 206, 189, 190, 191, 336/232, 84, 87, 200, 225, 232, 115, 129

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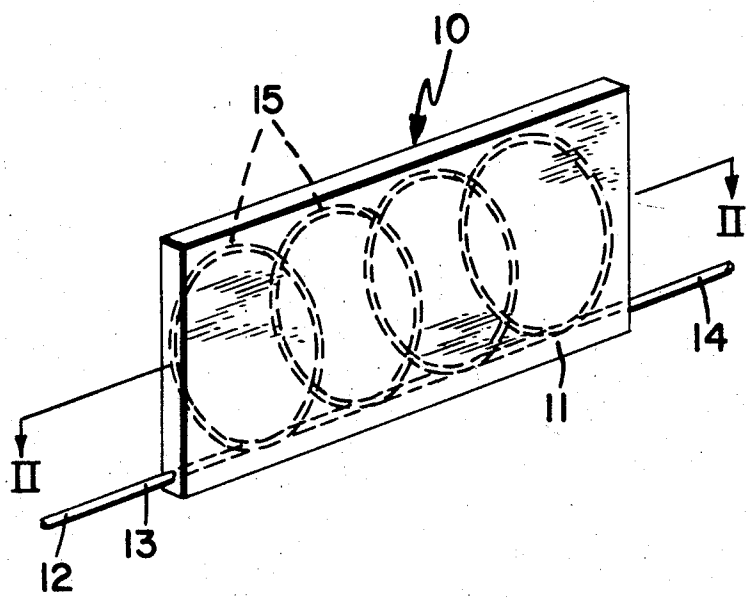
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[57] **ABSTRACT**

An electrical coil having a strand of conductive material formed into a series of loops lying substantially in the same plane to produce a field substantially perpendicular to the plane.

9 Claims, 24 Drawing Figures



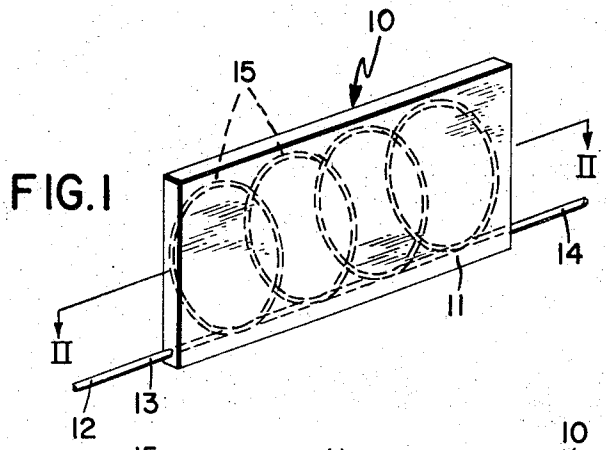


FIG.1

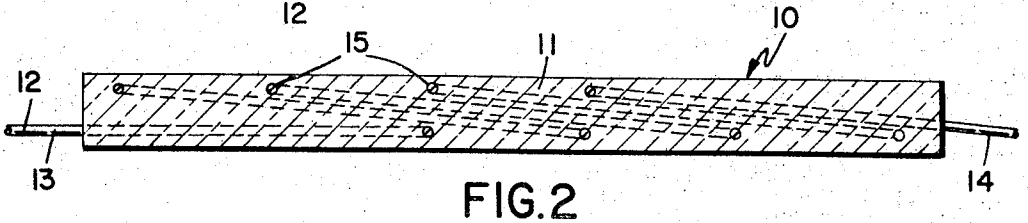


FIG.2

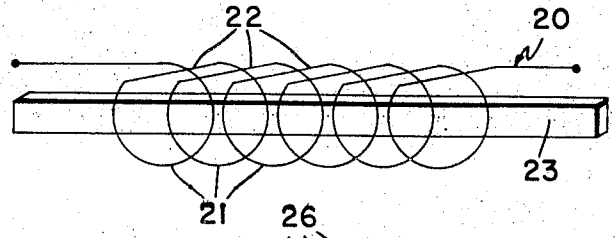


FIG.3

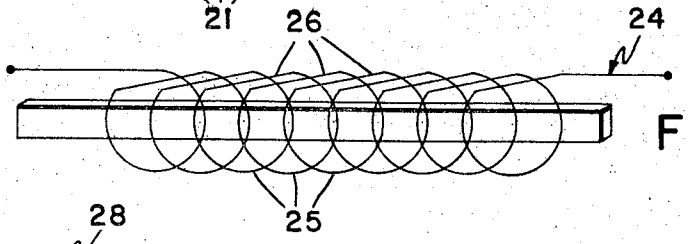


FIG.4

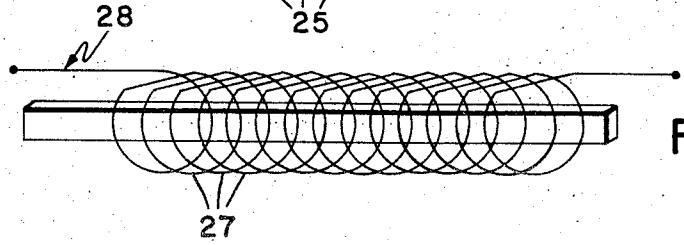


FIG.5

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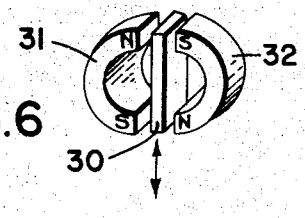


FIG.6

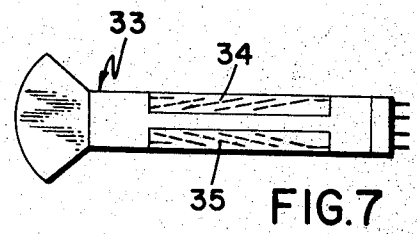


FIG.7

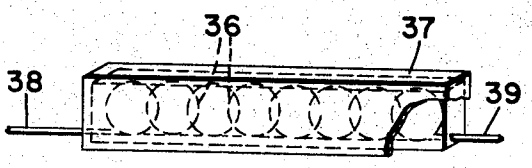


FIG.8

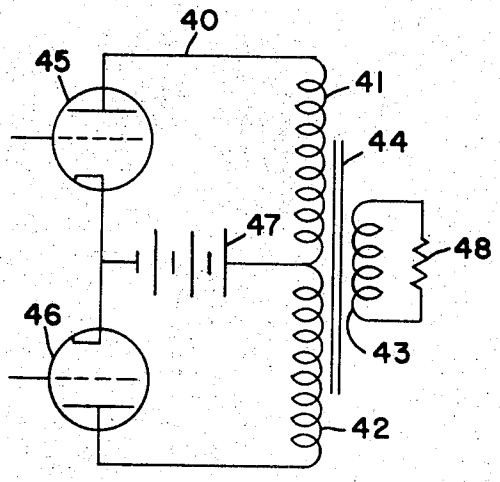


FIG.9

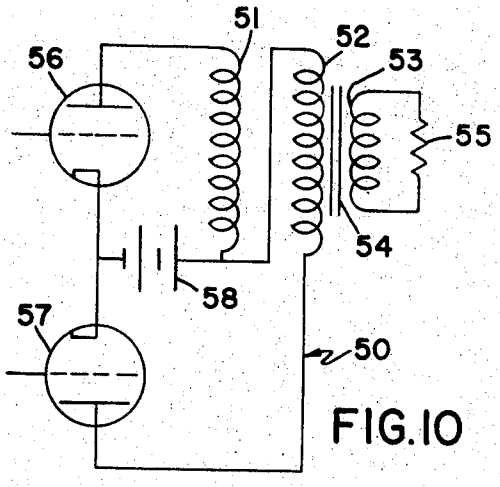


FIG.10

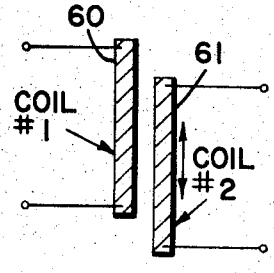


FIG.11

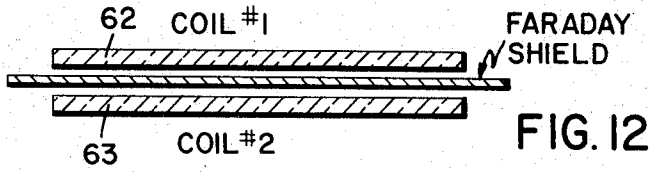


FIG. 12

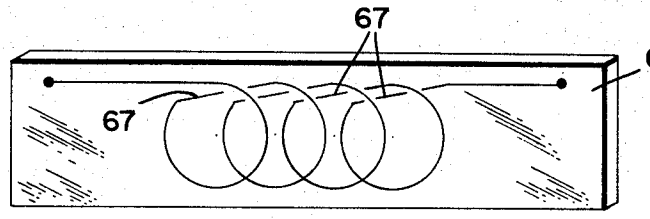


FIG. 13

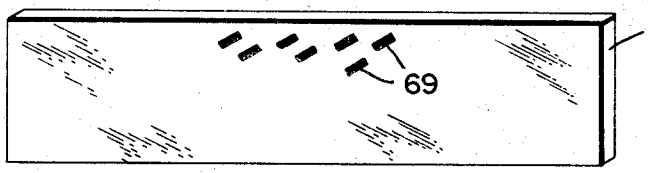


FIG. 14

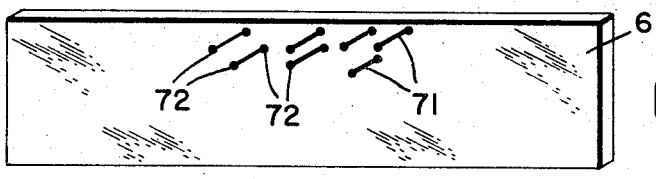


FIG. 15

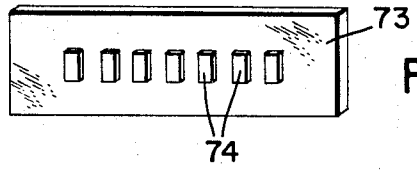


FIG. 16

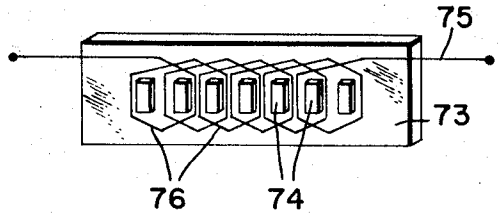


FIG. 17

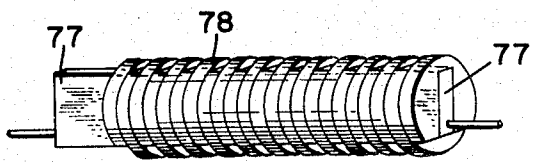


FIG.18

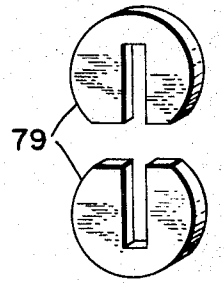


FIG.19

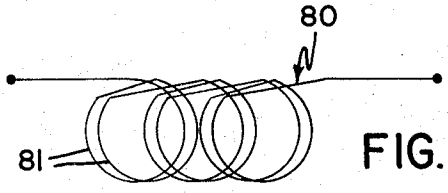


FIG.20

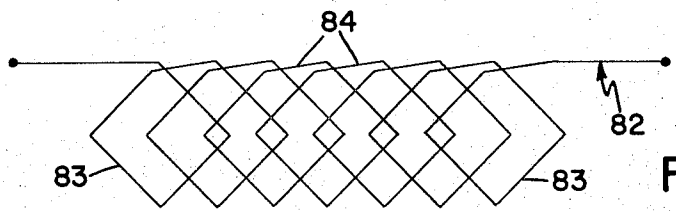


FIG.21

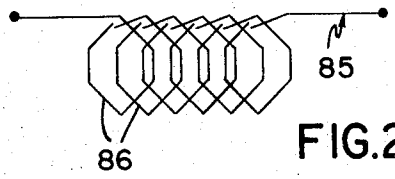


FIG.22

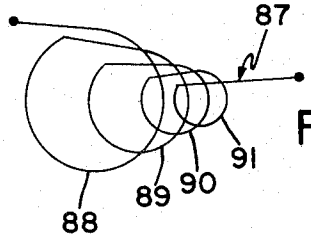


FIG.23

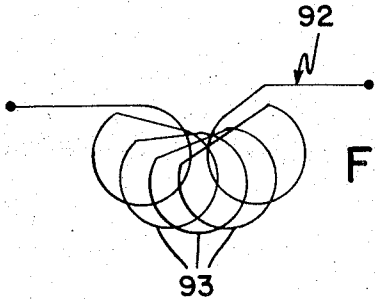


FIG.24

ELECTRICAL COIL

BACKGROUND OF THE INVENTION

In the manufacture of electronic circuits, it has become common practice to produce them in a flat form which may be used as part of a complete electronic device as a readily-replaceable board. Although most electronic elements lend themselves to flat construction, the element that has produced the most difficulty in the past has been the inductive reactance or electrical coil. Because the coils of the past have been formed in three dimensions (usually as a closely wound helix), the bulk of these elements has inhibited the progress of making electronic equipment as a flat board. These and other difficulties experienced with the prior art devices have been obviated in a novel manner by the present invention.

It is, therefore, an outstanding object of the invention to provide an electrical coil which can be used in the manufacture of electrical components and assemblies, which are easy to manufacture, which have reduced bulk, in which the interconnection systems are simplified, in which testing is simplified, which facilitate the use of printed or etched circuitry, and which simplifies the design and layout of circuitry.

Another object of this invention is the provision of a coil which is flat and in which the turns are normal to the coil axis.

A further object of the present invention is the provision of an electrical coil which adapts itself readily to ease of manufacture.

It is another object of the instant invention to provide an electrical coil which is readily designed for use in flat circuitry.

A still further object of the invention is the provision of an electrical coil which lends itself to the use of unusual core and loop arrangements.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

SUMMARY OF THE INVENTION

In general, the invention consists of an electrical coil having a strand of conductive material formed into a series of loops lying substantially in the same plane. Each loop overlaps the loop preceding it and the loop following it in the series and means is provided insulating the strand from itself at points of crossing.

BRIEF DESCRIPTION OF THE DRAWINGS

The character of the invention, however, may be best understood by reference to one of its structural forms, as illustrated by the accompanying drawings, in which:

FIG. 1 is a perspective view of an electrical coil embodying the principles of the present invention,

FIG. 2 is an enlarged sectional view through the coil taken on the line II—II of FIG. 1,

FIGS. 3 through 5 show various modified forms of the coil,

FIG. 6 shows the use of the coil of the invention in a device using permanent magnets,

FIG. 7 shows the use of the coil with a kinescope,

FIG. 8 shows the use of the coil with a shielding device,

FIG. 9 shows the use of the coil principle in an electronics circuit,

FIG. 10 shows the use of the principle of the coil in another electronics circuit,

FIGS. 11A and 11B show the manner in which the coil can be used in a variable transformer,

FIG. 12 is a sectional view of two coils having a shield to minimize capacitive coupling,

FIGS. 13, 14, and 15 show a method of printing that can be used to make up a coil embodying the principles of the invention,

FIGS. 16 and 17 show a method of constructing a modified form of the invention,

FIG. 18 shows a modified form of the coil,

FIG. 19 shows laminations used in the coil of FIG. 18, and

FIGS. 20 through 24 show various modified forms of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1, wherein are best shown the general features of the invention, the electrical coil, indicated generally by the reference numeral 10, is shown as having a main body 11 formed of a nonconductive material which, for the purposes of illustration, is shown as being transparent plastic. This main body is generally rectangular in shape and is relatively thin, so that it has a plate-like configuration. Encapsulated in the main body is an electrically-conductive strand 12 formed of copper or similar electrically-conductive material. An end 13 of the strand extends from one end of the main body 11, while the other end 14 extends from the other end of the body. Visible within the main body are loops 15 which lie substantially in the same plane. Each loop overlaps the loop preceding it and the loop following it in the series of loops. Means for insulating the strand 12 from itself is provided and in the preferred embodiment this consists of the material of which the main body 11 is formed by virtue of the fact that the strand portions are spaced where they cross.

In FIG. 2 it can be seen that, in order to cause the loops 15 to lie in a flat plane, it is necessary that each loop be slightly inclined to the general plane of the main body 11 and that, in order for the material from which the main body is made to act as insulation, the position of the wires are kept separate from one another. It will be understood, of course, that, in some versions it may be desirable to coat the conductive material in order to allow the strands of the loop to contact one another for ease of manufacture and assembly.

FIGS. 3, 4, and 5 illustrate the manner in which the loops can be arranged with different spacing within the principles of the invention. In FIG. 3, the electrical coil 20 consists of loops 21, the junction between adjacent loops consisting of straight portions 22. The coils are mounted on a supporting insulating strip 23. In FIG. 4, the coil 24 consists of a series of loops 25 joined by straight portions 26 wherein the loops are much closer together than those shown in FIG. 3. In FIG. 5, the loops 27 of the coil 28 are spaced even closer together than those in FIG. 4. Placing them closer together, of course, has the effect of increasing the mutual inductance and the overall inductance of the electrical

coil, depending also, of course, on the total number of loops.

In FIG. 6, an electrical coil 30 of the type shown in FIG. 1, lies between two permanent magnets 31 and 32 to form a system which can be used in a loudspeaker, for instance. The alternating current audio signal is applied to the coil to cause the coil to move physically between the poles of the magnets to produce the physical motion necessary in the loudspeaker for producing the audible sound.

In FIG. 7, a kinescope 33, such as the tube of a television set, is shown associated with two electrical coils 34 and 35 of the type shown in FIG. 1. In this case, the coils are used to produce an inductive field in the body of the tube in such a manner as to control the stream of electrons passing along the tube to produce the visual image at its face.

FIG. 8 shows the manner in which a coil 36 of the type shown in FIG. 1 can be enclosed in a metal housing 37 for shielding. Leads 38 and 39 extend from the housing for electrical connection to the coil which lies within. The housing 37 can be of a box-like or plate-like configuration exactly conforming but larger than the shape of the main body of the coil.

In FIG. 9, an electrical circuit 40 is shown being used with three coils 41, 42, and 43 of the type shown in FIG. 1 with a core 44 extending between them. The coils are associated with electron tubes 45 and 46 and a power source 47, while the output coil 43 is connected to a load 48. The circuitry is similar to conventional circuits but, of course, the use of the flat coils makes it possible to provide a flat configuration to the entire circuitry.

FIG. 10 shows another circuit 50 being used with coils 51, 52, and 53 of the type shown in FIG. 1. A core 54 lies between the coils 52 and 53 and a load 55 is connected across the coil 53. The coils 51 and 52 are associated with electron tubes 56 and 57 as well as a source 58 of power.

FIG. 11 shows the manner in which two coils 60 and 61 can be used to provide a variable transformer. The coils are mounted so as to be physically adjustable relative to one another with their flat sides facing.

FIG. 12 shows another method of shielding between two coils 62 and 63, both of which are constructed similar to that in FIG. 1. A Farraday shield 64 is interposed between the two plate-like coils.

FIGS. 13, 14, and 15 show various layers of a printed-circuit electrical coil formed in accordance with the invention. In FIG. 13, the body 65 of insulating material is shown as carrying the loops 66 having straight portions 67 which are interrupted where they are crossed by another portion of the loop. FIG. 14 shows insulating patches 69 to be printed on the same body 65, the coils being omitted for clarity of understanding.

FIG. 15 shows the body 65 carrying printed thereon jumpers 71 of conductive material having enlarged ends 72 which extend past the patches 69 and make contact with the broken ends of the straight portions 67 associated with the loops 66 in FIG. 13. It can be seen that all of the elements of the coil are produced on the same body successively by the printed circuit method so that the result is in an electrical coil which is quite thin and which is made by the printed circuit method.

FIG. 16 shows a portion of an electrical coil having a body 73 to which are applied core elements 74 made by the printed circuit method or other method and making use of iron powders or laminations. In FIG. 17 it can be seen that to the body 73 has been added a strand 75 formed into overlapping co-planar loops 76. The core elements 74 are located in spaces provided by fairly wide spacing between adjacent loops.

In FIG. 18 is shown a method of providing an electrical coil 77 with a suitable core. The coil is of the type shown in FIG. 1, but the core 78 is made up of a plurality of laminations or elements 79 formed of suitable sheet steel and cemented in place in interlocking relationship around the coil. FIG. 19 shows the specific shape of the elements 79 and shows how they are arranged alternately on the coil.

In FIGS. 20 to 24 are shown various modifications of the loop arrangement. FIG. 20, for instance, shows a coil 80 having loops 81 which are arranged in closely adjacent pairs with rather wider spaces between pairs in the series. FIG. 21 shows a coil 82 having loops 83 which are generally square in shape but are provided with straight portions 84 connecting the loops. In FIG. 22 is shown a coil 85 whose loops 86 are hexagonal in shape. In FIG. 23 a coil 87 is provided with a series of loops 88, 89, 90, and 91 which are successively smaller as one progresses along the series from one end of the strand to the other; this, of course, could result in an inductance field of a desired peculiar shape. FIG. 24 shows a coil 92 having a series of loops 93 which are arranged in the same general plane, but the centers of which form a curve, so that the inductive field would be in the shape of a cluster. This coil would be similar to the coil shown in FIG. 1, but with a curve in the plane of the plate-like main body.

It can be seen, then, that the present invention involves a new form of coil or inductance which can be employed advantageously in many ways with or without core materials. It can be used by itself or in situations requiring coupling with other coils. It can be used open or shielded. It is very useful in the production of electronic or electrical components and assemblies in a two-dimensional form or in a form that is as limited in its third dimension as is possible or practical consistent with other electrical or mechanical requirements. Such flat components and assemblies can ease manufacture, reduce bulk, simplify interconnection systems, simplify testing, facilitate use of printed or etched circuitry, speed design and layout, and have other advantages. This coil can be configured in a practical manner in a variety of ways for obtaining a desired inductive field. The coil can be easily constructed by winding the strand of wire in essentially one plane with a circular motion combined with a longitudinal motion in the same plane. This produces a form similar to the forms in the old Palmer method of penmanship in which circles were inscribed on a paper while the arm was moved uniformly along the line on the paper. Naturally, where the coil crosses itself, it is necessary that the coil wire be insulated or that some means be taken to prevent the conductor from touching itself at these points. Such means can include inclining the planes of the loop of the coil slightly out of the plane of the coil or by making a slight detour of one wire around the other. The density of the coil winding so constructed

can be easily varied by changing the rate of longitudinal motion compared to the circular motion forming the coil turns, and this procedure will produce the varied results shown in FIGS. **3**, **4**, and **5**. The longitudinal motion described need not be constant, but can be omitted or its rate changed in some other manner so that two or more turns of the coil can be placed more or less side-by-side (as shown in FIG. **20**).

In accordance with the invention, the coils can be wound of wire or formed of other conducting material and deposited as they are formed on a surface of paper, insulating board, ceramic, or other suitable material, which material can be rigid or flexible. Adherence to the surface can be brought about by the use of a sticky matrix material on the surface, by heat softening the surface itself, by casting onto the surface material as it is formed, or by continuous or spot-applied adhesive of any suitable kind. If a flexible surface, such as paper, is used, it is then possible to bend the coil into any desired shape as, for instance, in forming it around the neck of a cathode ray tube.

Alternately, such coils can be wound of wire or other conductor material stiff enough to stand in whatever shape is desired without support or with support at the ends or at selected points. It can also be manufactured with one or more strips of plastic or other material continuing longitudinally along the coil and embedding or otherwise supporting a part or parts of each turn or some of the turns. Such strips can contain powdered or other core material to enhance the coil's inductance or its coupling to other coils. When the alternative method shown in FIGS. **13**, **14**, and **15** is used, the coils are formed by printing or etching techniques. A circuit board or surface can be printed or etched or otherwise processed omitting one conductor at each of the coil crossings. An insulating paint or other substance can be applied to the intermediate crossing area and then a third step can be used to print or mount or form over the insulated area a crossing conductor and bonding it by suitable means to the end of the conductor to make a continuous coil.

It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such as properly come within the scope claimed.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent is:

1. An electrical coil, comprising

a. a strand of conductive material formed into a series of loops lying substantially in the same plane to produce a field substantially perpendicular to the plane, each loop overlapping the loop preceding it and the loop following it in the series, the center lines of the loops lying in a straight line, and

b. means insulating the strand from itself at points of crossing.

2. An electrical coil as recited in claim **1**, wherein the series of loops is encapsulated in a flat plate of plastic.

3. An electrical coil as recited in claim **1**, wherein a core envelops the series.

4. An electrical coil as recited in claim **1**, wherein the series is associated with another similar series lying in a spaced plane.

5. An electrical coil as recited in claim **4**, wherein the two series lie on opposite sides of an electron-stream device for the purpose of controlling the stream.

6. An electrical coil as recited in claim **4**, wherein a shielding element is mounted between the two series to permit an adjustment of the mutual inductance between them.

7. An electrical coil as recited in claim **4**, wherein a core extends between the two series, and wherein the number of coils in the series are selected to provide a transformer.

8. An electric coil as recited in claim **1**, wherein each loop is in the shape of a polygon.

9. An electric coil as recited in claim **4**, wherein the coils are movable relative to each other to change the magnetic coupling between them.

* * * * *