

Nov. 13, 1928.

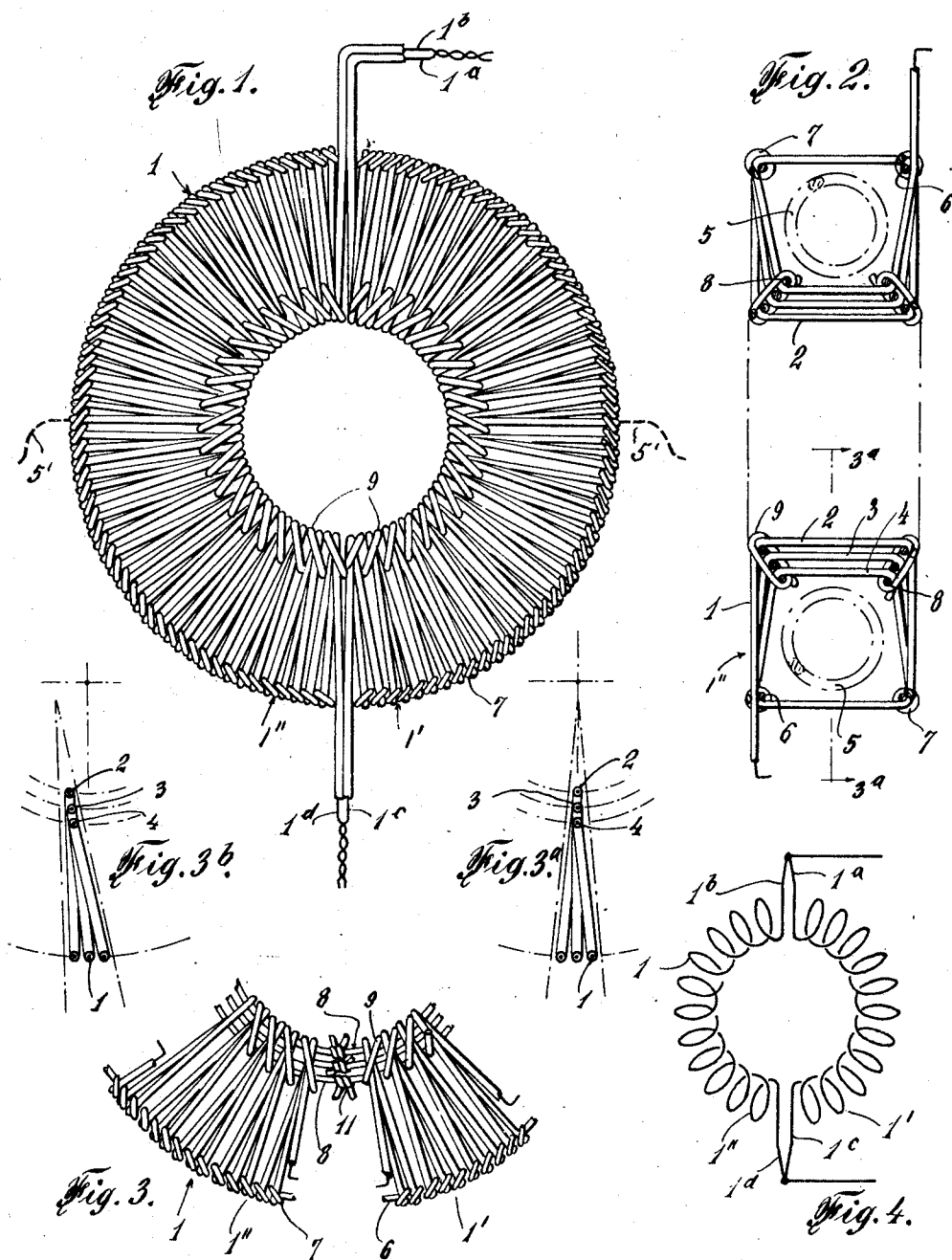
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A. D. CARDWELL

TRANSFORMER AND INDUCTANCE

Filed May 16, 1925

3 Sheets-Sheet 1



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Fig. 7.

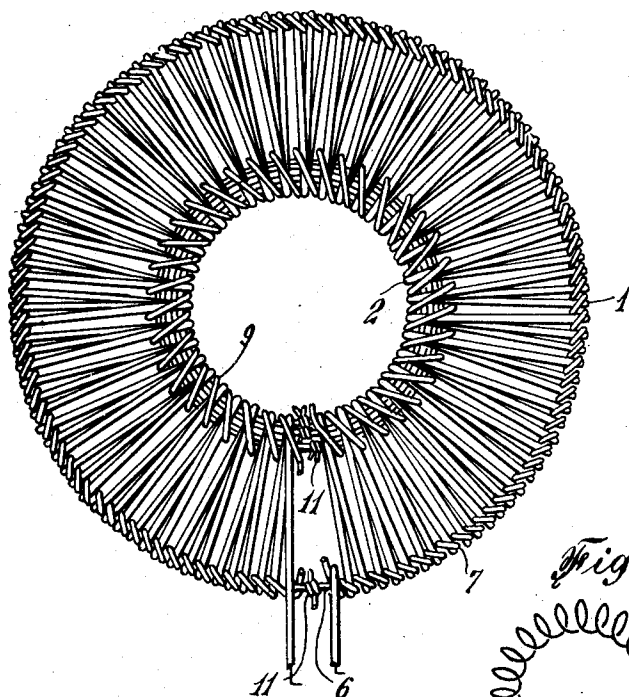


Fig. 8.

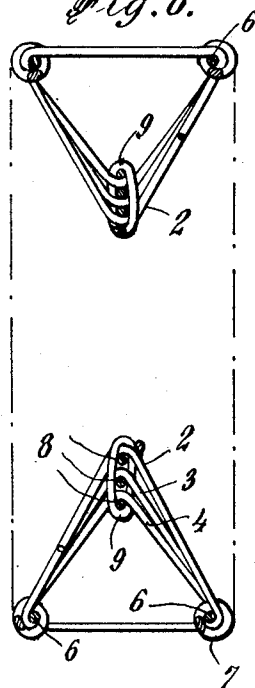


Fig. 11.

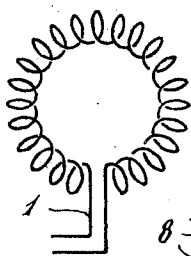


Fig. 6.

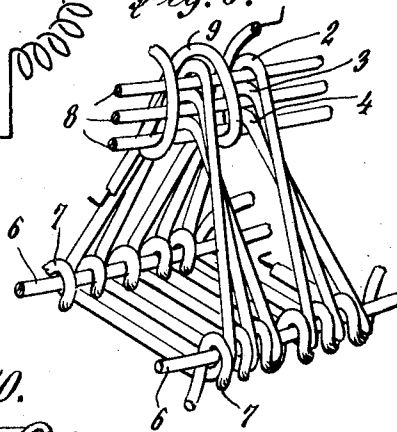


Fig. 5.

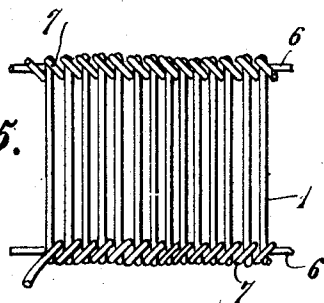


Fig. 9.

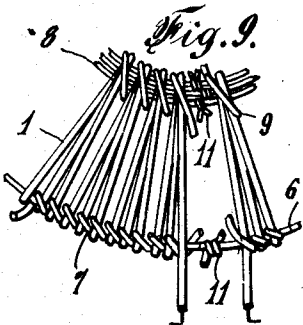
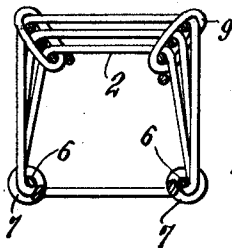


Fig. 10.



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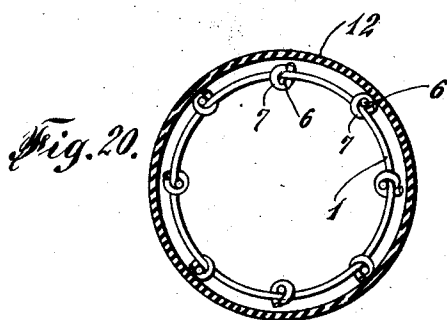
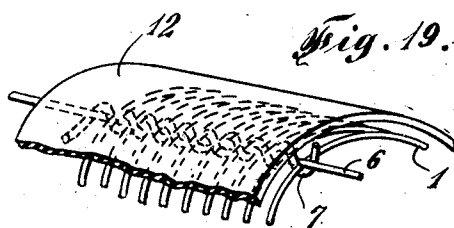
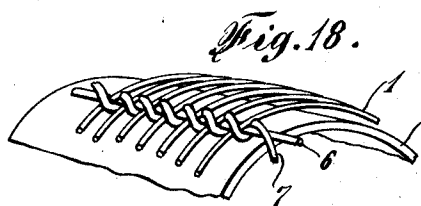
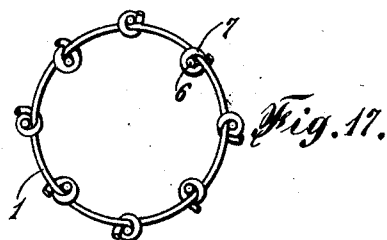
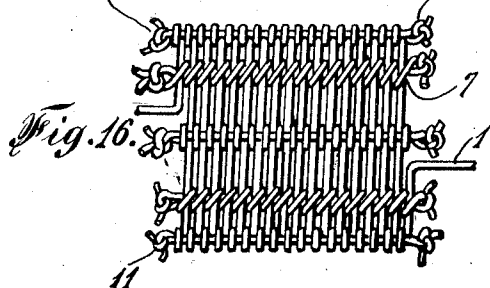
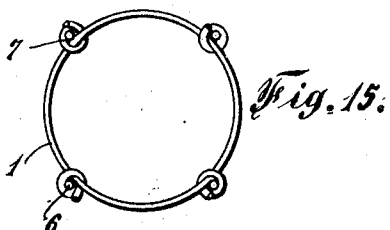
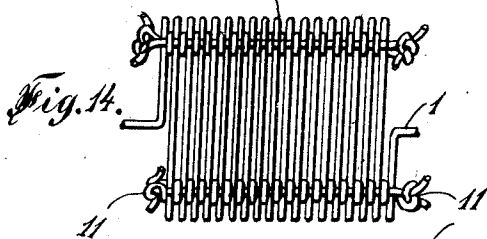
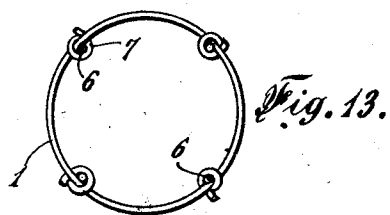
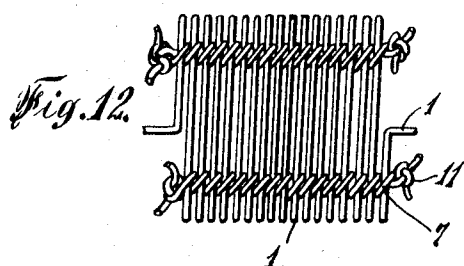
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TRANSFORMER AND INDUCTANCE.

Application filed May 16, 1925. Serial No. 30,666.

My invention relates to improvements in coils of wire for electrical purposes, such as in inductances, transformers, etc., and embodies advantageous features in coils in toroidal form.

One of the objects of my invention is to provide a coil or electrical element having conductor windings wound in such a way that the electrical current will pass through the coil in parallel on its opposite sides or halves, whereby the magnetic fields generated will be in conjunction, and the adjacent ends of the windings will be of the same electrostatic potential.

To carry out my invention one side or half of the coil may be wound as to the right or in a clockwise direction, and the other side or half of the coil may be wound as to the left or in counter-clockwise direction, with the corresponding ends of the windings adjacent or in close proximity and the ends of the conductors at adjacent ends of the coils joined electrically. The ends of the halves of the coil may be placed in relatively close proximity or juxtaposition without injurious effects because the ends which are close or abutting are of the same potential. The individual layers of wire as they progress in different directions around the halves or separate elements of the coil are of the same potential on one side as the wires that occupy the same symmetrical position on the opposite side of the coil. The greatest difference of potential is represented by the points of entrance and exit of the current which is at substantially diametrically opposite points of the coil. An advantage of the construction described permits the primary winding of a transformer to be brought out at points of equal potential on my improved coil used as the secondary, so that the lead wires for the primary will not introduce any serious electrostatic capacity in the secondary.

Another object is to connect the turns of a coil together in such a way as to space adjacent turns apart and retain the turns in relative positions, serving to reduce the distributed capacity of the coil.

The coil described may be used as the secondary of a transformer, or the primary, or both, or the coil may be used as an inductance without the primary coil.

My invention also comprises novel details of improvement that will be more fully hereinafter set forth and then pointed out in the claims.

Reference is to be had to the accompanying drawings forming a part hereof, wherein

Fig. 1 is a face view of a toroidal coil embodying my invention having turns or windings in opposite directions;

Fig. 2 is a cross section of Fig. 1;

Fig. 3 is a detail of part of Fig. 1;

Fig. 3^a is a detail section, taken on the plane of line 3^a, 3^a, in Fig. 2 with cords omitted;

Fig. 3^b corresponds to Fig. 3^a showing a different relation of the inner turns to the outer turns of a group;

Fig. 4 is a diagrammatic view of the toroidal coil of Fig. 1;

Fig. 5 is an edge view of an outer side of the coil;

Fig. 6 is a detail perspective, on an exaggerated scale, illustrating the manner of tying the turns of the coil;

Fig. 7 is a side view of a toroidal coil having turns or windings in a single direction and substantially in triangular cross section, spaced and retained in accordance with my invention;

Fig. 8 is a cross section of Fig. 7;

Fig. 9 is a detail side view of a portion of the coil of Fig. 7 substantially rectangular in cross section;

Fig. 10 is a cross section of Fig. 9;

Fig. 11 is a diagrammatic view of the coil of Fig. 7;

Fig. 12 is a side view of a straight coil having its turns or windings spaced by binding means, part of which is within the coil;

Fig. 13 is an end view of Fig. 12;

Fig. 14 is a side view of a straight coil having its turns or windings spaced by binding means, part of which is without the coil

Fig. 15 is an end view of Fig. 14;

Fig. 16 is a side view of a straight coil having its turns or windings spaced by binding means, part of which is without the coil and part within the coil;

Fig. 17 is an end view of Fig. 16;

Fig. 18 is a detail perspective view illustrating a core or tube within the coil of Fig. 12;

Fig. 19 is a detail perspective view illustrating a tube without the coil of Fig. 14; and

Fig. 20 illustrates the coil of Fig. 16 within an outer tube.

Similar numerals of reference indicate corresponding parts in the several views.

The coil, which preferably comprises insulated conductor 1, may be formed by winding the conductor with a suitable number of

turns to form the desired completed toroid or coil, the outer or peripheral portions of the turns being laid side by side to so remain. In the form shown in Figs. 1 to 4 the coil comprises two windings 1', 1'' of the conductor wire 1 wound in opposite directions, the turns of the windings 1' being shown in Figs. 1 and 4 as wound to the right hand or in a clockwise direction and the turns of the windings 1'' as wound to the left hand or in counter-clockwise direction with corresponding ends of the two windings opposing. The right and left hand windings may be made of the desired cross sectional shape and configuration, the corresponding ends of the two windings being brought together so as to oppose or abut and they are so retained by suitable means. The end portions 1^a, 1^b of the two reverse windings at one side of the coil are electrically connected, as by twisting the wires together, (Fig. 1), and the end portions 1^c, 1^d of said windings, on the side of the coil opposite the parts 1^a, 1^b, are electrically connected, as by twisting the wires together. In accordance with the construction described when the coil is included in an electrical circuit the current will pass in parallel through both coils, and will create magnetic fields which will be in the same direction inasmuch as the current progresses through one half of the coil in a clockwise direction and through the other half in a counter-clockwise direction. Hence, the electro-magnetic flux will be in conjunction and the electrostatic fields will be separated by the total dimension of the coil, as determined by the distance between the first and last turns of the respective halves. The construction enables the ends of the two halves of the windings to be put in close proximity without injurious effects because the abutting ends are of the same potential. The individual layers or turns of wire on one side as they progress around the toroid or coil are of the same potential as the turns of wire which occupy the same relative or symmetrical position on the opposite side of the toroid or coil. The greatest difference of potential is represented by the points of entrance and exit of the current to and from the coil which is at diametrically opposite sides of the latter. The coil described may be used as an inductance or an impedance, and also may be used as one winding of a transformer in conjunction with another winding thereof. When my improved coil is used in a transformer an advantage is attained in that one winding may be brought out through convolutions of the other winding at points of equal potential on the coil, so that the lead wires will not introduce any serious electrostatic capacity in the secondary, (see dotted lines 5', Fig. 1). A primary winding is indicated in dotted lines at 5 in Fig. 2. The winding 5 may be within or without the toroidal coil. The primary winding may be in

one direction only, or it may be of the split-parallel form described regarding coil 1, such as diagrammatically shown in Fig. 4, having the same magnetic and electrostatic characteristics. The cross sectional area of the turns or windings may be of any desired shape, such as rectangular, triangular, hexagonal, or the like, in either of the forms illustrated.

In order to provide the toroidal coil with a relatively large number of turns within a relatively small compass the diametrically inner parts of a given number of adjacent turns, say three of such turns, are located one within another in groups or series with the corresponding outer turns side by side.

As illustrated in Figs. 3^a, 3^b and 6 the inner turns 2, 3, 4 of a group of turns lie or are nested within one another, such that the inner parts of every third turn will lie at the inner circumference of the toroid, (each part 2 counting as number one in a group or series of three), with the corresponding inner portions 3, 4 of each group or series of three complementary turns nested or lying within the part 2 of the same group and within one another, with an air space between said turns, all within the area bounded by the first turn on the outer periphery of a given group, the last turn on the same periphery of the same group and the particular turn of the group at the inner circle of such group. Said area is shown within dotted lines in Figs. 3^a and 3^b. In Fig. 3^a the inner turns at 2, 3, 4 are substantially in a radius of the toroid, and in Fig. 3^b the turns incline from a radius. The construction is such that with the groups of turns arranged as described no turns of one group will rest on or lie within any turns of an adjacent group of turns. While the turns or convolutions of the conductor corresponding to the parts 3, 4 are concealed at the inner portion of the toroidal coil by the companion outer parts 2 the continuations thereof appear at the peripheral portion of the coil in full and appear more or less graduated from the inner circle to the outer periphery of the coil, on the radial-like lays. The turns may be formed in substantially rectangular form, as illustrated in Figs. 2 and 10, or in a substantially triangular form, as in Figs. 6 and 8, or the coil may be wound in other desired form.

In accordance with the construction described I am enabled to provide a coil having a relatively large number of turns or convolutions located at the peripheral portion in a single layer side by side, and the inner portions nested as may be required to preserve the substantially radial lines of the turns, and within a relatively small compass. While I have referred to the coil as comprising a series of three complementary turns 2, 3, 4, adapted to nest at the inner portions, which I find in practice to be a satisfactory and practical form

of toroid, it will be understood that two, three or more of such complementary nested turns in groups may be used according to the diameter of the toroidal coil and according to the closeness with which it is intended that the peripheral portions of the turns shall be located. Where the inner portions of several conductor turns are nested in groups, thereby forming substantially wedge shaped sets of turns, the several sets are placed in juxtaposition but not within one another by locating the inner turns side by side. By the means described the distributed capacity of the completed toroid is reduced to a minimum.

The turns of the element or coil may be retained in any desired way, such as by means of suitable binding connections. The turns may be tied together, or a cord or cords may be within or without the coil, serving to retain the turns or convolutions of the coil in normal or definite relation and serving as supporting means. The binding connections may be in the form of a non-conducting cord or strip. The binding may be independently attached to each of the turns or convolutions at the outer or peripheral portion of the coil and a binder may be attached to each series or group, (2, 3, 4) of turns or convolutions at the inner circle of the coil. At 6 the binding cord runs completely around within the outer portion of the coil and at 7 is another cord looped across each of the turns or convolutions at the outer part of the coil and around the binding cord 6, forming a bind or tie at each turn, whereby each looped portion of the binding is interposed between two turns at the outer periphery of the coil, thereby securing the turns together and spacing the turns apart. At the inner portion of the toroidal coil binding cords 8 pass around. As illustrated one cord is within the inner turns 4 and other cords between the turns 3, 4 and 2, 3, for spacing them apart, and a binding cord 9 is looped across each three turns or convolutions of wire and encloses three binding cords 8, preferably in a single loop, for each group or series of turns, whereby the wires of each group or series of turns are spaced from each other by cords 8 and each group or series of turns at the inner part of the coil is spaced from the adjacent groups by the cord 9. The cords 6 and 8 afford anchorages for the several loops of the binding cords 7 and 9. The fastening of the binding to the turns of the coil retains the turns in spaced relation, and the inner ends of the binding cords at the adjacent ends of the coil may be tied together at 11, to retain the coil in toroidal form for use. The spaces between the adjacent turns and sets or groups of turns will reduce the distributed capacity of the coil, and thereby increase its efficiency either as an inductance or as a transformer. One or more of the cords 8 may be omitted, in which case

preferably the inner cord 8 will be used. The same construction of tying and spacing the turns together may apply either to the secondary winding or to the primary winding 5, or to both.

A toroidal transformer or inductance constructed in the manner set forth will have numerous advantages. The fields are concentrated in a confined area and are entirely closed so that losses due to stray fields are reduced, stray signals passing through the coil will generate a current on one side equal and opposite to any current which may be generated in the windings diametrically opposite, so that any external field will be neutralized to minimize the effect of stray signals on the toroid. Conversely, any magnetic field generated by the turns on one side of the toroid will have an opposite field generated by the turns on the opposite side of the toroid, so that magnetic feed-back or undesirable magnetic coupling with any other circuit will be reduced. This will permit the concentration of comparatively large inductances in a small area without the disadvantage of having intense external magnetic fields, and also permit the use of comparatively large air core transformers or inductances without generating a large external magnetic field.

I have illustrated my improved parallel coil as of annular or ring-like contour, but it will be understood that the coil may have other desired configuration provided the ends of the coil oppose or are adjacent.

With respect to Figs. 1 to 10 I have set forth my improved binding as utilized in connection with a toroidal form of coil, whereby the turns or windings are spaced apart and retained. My improved binding, however, is not limited to the toroidal form of coil since the binding may be used with other shaped coils or windings as elements or parts of electrical instruments. In Figs. 12 to 20 I have illustrated my improved binding as utilized in connection with coils in straight form with cords or the like 6 passing along the coil or conductor 1 and the binding cords 7 looped across the turns of the conductor and around the corresponding longitudinally disposed cords 6, securing the turns or windings of the coil together and spacing them apart. In Figs. 12 and 13 the cords 6 extend longitudinally within the turns of the coil; in Figs. 14 and 15 cords 6 extend longitudinally along the outer surface of the coil, and in Figs. 16 and 17 some cords 6 are within and some cords 6 are without the coil, all of such cords being tied to the turns of the coil by the binding cords 7 which space the turns apart, and overlie or underlie the conductor 1. At the ends of the coils the respective complementary cords 6, 7 may be tied together, such as indicated at 11.

The coils of Figs. 12 to 17 will be sufficiently firm to be used without a core therein or a

cover thereon for various purposes. Said coils, however, may be used with an inner core or tube of suitable material, preferably of insulation, indicated at 12, the coil being spaced
 5 from the core or tube by the binding cord 7 that projects from conductor 1 either exteriorly or interiorly of the coil. In Fig. 18 the form of coil shown in Figs. 12 and 13 has a core or tube 12 therein and the longitudinal cords 6 and
 10 the underlying binding or looping cords 7 that project within the circumference of the windings beyond the conductor and cord 6 of the coil serve to space the coil from the tube or core. In Fig. 19 the coil is inserted with-
 15 in tube 12 and in this case the exteriorly disposed cords 6 and the overlying bindings 7 projecting beyond the conductor and cord 6 serve to space the coil from the inner surface of the tube. In Fig. 20 the tube 12 encircles
 20 the coil of Fig. 14 and is spaced therefrom by the exterior cords 6 and the looping cords 7, other cords 6 being within the coil. In the form of coil of Figs. 16, 17 and 20 a tube similar to 12 may be within the coil in the man-
 25 ner shown in Fig. 18, and a tube may or may not be around the coil.

Although in Figs. 1 to 10 I have hereinbefore referred to the conductor 1 as being an insulated conductor it will be understood that
 30 in all cases the conductor need not have an insulating covering, as where the binding or looping cords or elements 7 or 9 pass between adjacent turns of the coil, and also where the spacing cords or elements 8 are located be-
 35 tween nested turns of the coil, since such parts 7, 8 and 9 serve to separate the conductor turns in spaced relation, thereby insulating them from one another. The looping cords also serve to insulate the non-insulated con-
 40 ductor from tube or core 12.

I use the term "cord" in the specification and claims in a generic sense intending it to mean ordinary cord or twine in round or
 45 other cross section, or a strip of tape or ribbon-like element of insulating material, which may be used extending along the windings of the coil and as looping or binding the turns or windings of the coil as well as spacing them apart.

While I have illustrated and described the element or coil as provided with several cords extending along the same, it will be under-
 50 stood that such elements or coils may have one or more of such cords with the binding or bindings looped around the turns of the coil and the cord or cords, or around the turns of the coil only for spacing and binding the turns with the cords 6 or 8, or both, omitted. The element or coil may be made without the
 55 cords and binding, (Figs. 3^a, 3^b), and may be retained in toroidal form in any desired way.

While the elements 6 and 8 have been referred to as cords, they are employed to form ribs to which the windings are secured or
 60 lashed by the binding cords. These elements

6 and 8 may, of course, be of different sizes or diameters and they may consist of textile ma-
 terial or they may be in the nature of dielec-
 trics, such as rattan, rubber, or bakelite rods
 or strips. In using the ribs and binding
 70 cords, the cross sectional dimensions of the combined ribs and binding cords may be determined in order that when the coil is ap-
 plied to a support either internally or exter-
 75 nally of the coil, the coil will be held in effective spaced relation to the support. Furthermore, by the employment of the rib and bind-
 ing cord, the distance between the turns of the coil may be determined by the cross sec-
 80 tional area of the binding cord and, of course, the distance between the turns will be changed according to the diameter of the binding cord.

Having now described my invention what I claim is:—

1. A toroidal coil comprising a conductor having turns whose peripheral portions are located side by side and inner portions of groups of turns adjacent, means securing the
 90 outer turns together and spaced apart, and means securing said groups of turns together and spaced apart from other groups.

2. A toroidal coil comprising a conductor having turns whose peripheral portions are located side by side and inner portions of groups of turns adjacent, and means secur-
 95 ing turns of each group together radially and spaced apart with the groups spaced apart.

3. A coil for electrical purposes comprising a conductor having turns, a rib extend-
 100 ing at approximately right angles to the turns, and means between the several turns encircling the conductor and rib for securing the conductor to the rib.

4. A coil for electrical purposes comprising a conductor having turns, a rib extending axially of the turns of the coil, and a binder embracing a turn of the coil and rib for se-
 105 curing the turn to the rib and holding the turn of the coil in spaced relation to other turns of the coil.

5. An electrical element comprising a conductor having turns, a rib extending at ap-
 110 proximately right angles to the turns, and bindings looped across the turns and around said rib, holding the turns in spaced relation to one another.

6. A coil comprising a conductor having turns whose peripheral portions are located side by side circumferentially and whose turns are arranged in groups at the inner portions, a rib extending through the turns at the peripheral portion of the coil, means extending between the turns for securing the
 115 coil to the rib and spacing the turns apart, the turns of each group being spaced from each other, ribs extending between the turns, respective means for securing the turns of each group to a respective rib and in radial
 120 125 130

alinement and for holding the groups in spaced relation to one another.

7. A coil comprising a conductor having turns whose peripheral portions are located side by side circumferentially and whose turns are arranged in groups at the inner portions, a rib extending through the turns at the peripheral portion of the coil, means extending between the turns and around the turns of the coil and the rib for securing the coil to the rib and spacing the turns apart, the turns of the several groups being radially alined, and means for securing the said alined turns in spaced relation to each other and in spaced relation to turns of the other groups of the coil.

8. A coil for electrical purposes comprising a conductor having turns, a rib extending axially of the turns of the coil, a binder

embracing a turn of the coil and a rib for securing the turn to the rib and holding the turn of the coil in spaced relation to other turns of the coil, the cross sectional dimension of the rib and applied binder determining the distance that the coil will be held from a support to which the coil may be applied.

9. A coil comprising a conductor and turns adjacent, a rib extending axially across the turns, and a binder looped across said turns and around said rib and spacing said turns apart.

10. An electrical element comprising a conductor having turns, ribs extending across the turns in spaced relation to each other, and binders looped around the turns and around said ribs spacing the turns apart.

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