Jan. 8, 1929. 1,698,650

E. F. PARKS

TOROIDAL COIL

Filed Aug. 31, 1925 2 Sheets-Sheet 1

Fig. 1.

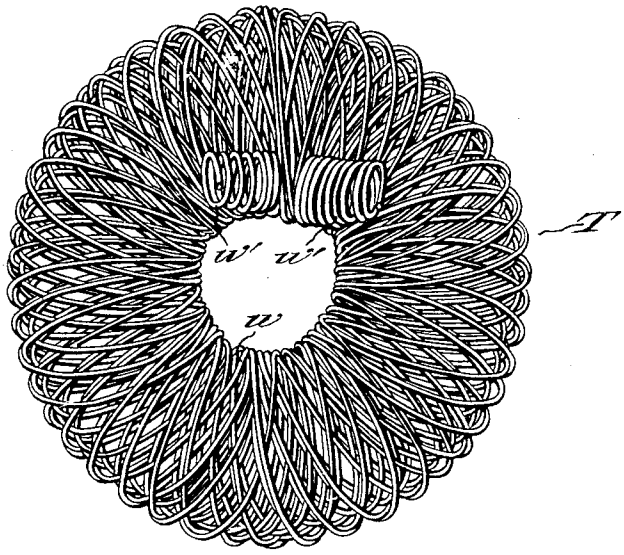

Fig. 2.

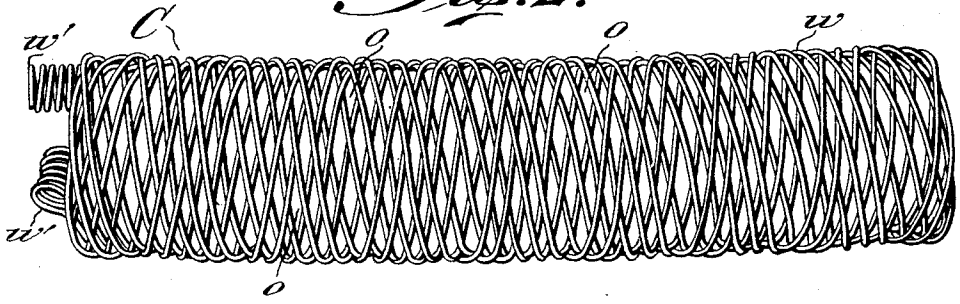

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Fig. 3.

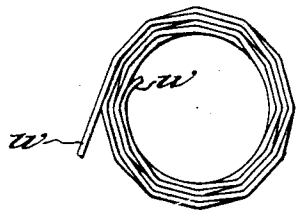


Fig. 4.

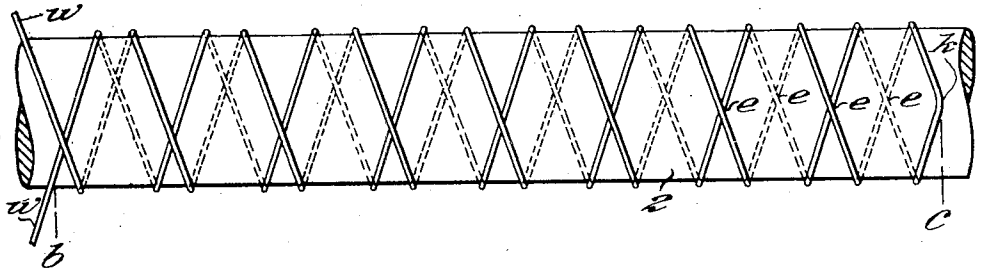
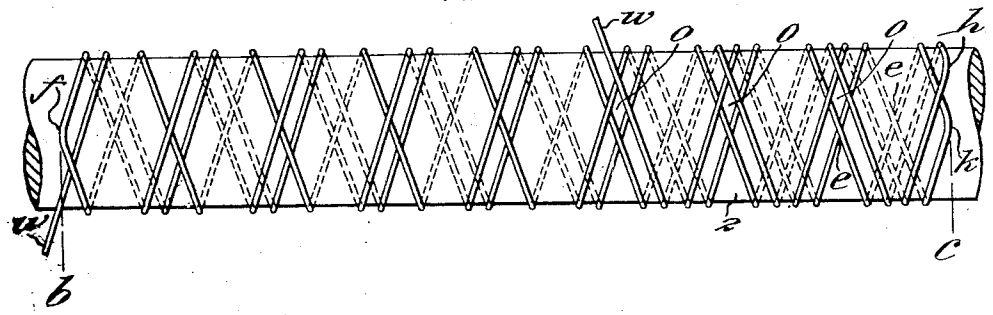


Fig. 5.



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Patented Jan. 8, 1929. 1,698,650

UNITED STATES PATENT OFFICE.

EDWARD F. PARKS, OF PROVIDENCE, RHODE ISLAND, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE NEW ENGLAND TRUST COMPANY, TRUSTEE, A CORPORATION OF MASSACHUSETTS.

TOROIDAL COIL.

Application filed August 31, 1925. Serial No. 53,639.

This invention relates to electrical coils and particularly to toroidal or doughnut-shaped coils for use with radio apparatus and for other purposes.

One object of the invention is to provide a toroidal or similarly shaped coil which is self-sustaining without the use of a core, flanges, disks or other supporting means, and which is capable of resisting considerable strain and stress without becoming deformed or distorted.

Another object of the invention is to provide a toroidal coil in which the windings of wire or other conductor are disposed to form a skeleton structure and to mutually cooperate to brace and stiffen the coil against distortion or disintegration.

Another object of the invention is to provide a coil of the type specified in which the windings are disposed and arranged to obtain the maximum electrical effect with a low distributed capacity and minimum high frequency resistance.

Another object of the invention is to provide a coil of the type specified which can be produced by machine winding whereby to render it economical to manufacture.

Another object of the invention is to provide a method of producing a coil of the type specified which can be performed without the use of special formers or complicated apparatus, and without requiring particular skill or expertness on the part of the workman.

Further objects of the invention are set forth in the following specification which describes a preferred form of the coil and a preferred method of producing it, as illustrated by the accompanying drawings. In the drawings:

Fig. 1 is a view of one form of coil embodying the invention;

Fig. 2 is a view illustrating the initial arrangement of the windings of the coil before it is bent or formed into a tore;

Fig. 3 is an end view of the windings of the coil showing a plurality of turns laid one over another;

Fig. 4 is a more or less diagrammatic view illustrating the method of disposing the turns of wire or other conductor in winding the coil; and

Fig. 5 is a similar view illustrating a later stage in the winding of the coil.

The advantages of the toroidal or "doughnut" form of coil for radio telegraphy and telephony are well known to those versed in the art. This type of coil provides a closed magnetic field or, in other words, the magnetic field of the windings is confined to a predetermined area which prevents undue influence on adjacent circuits, on elements of the same circuit, or on adjacent coils. Moreover, it is not readily influenced by outside magnetic fields. In multi-stage radio frequency circuits its use eliminates inductive feed-back, and rejects interference influences from adjacent electrical apparatus or circuits. In radio receiving sets of the so-called neutrodyne type its use reduces the magnetic linkage so that neutralizing is more readily accomplished without mounting or associating the coils at critical angles. Through its use the selectivity of a set may be greatly increased by eliminating signal energy picked up from nearby stations, and thus distant stations can be worked at wavelengths approximating those of locals with greater freedom from interference. Besides the above mentioned advantages of this type of coil for radio work it may have other applications not herein specifically stated.

The present invention embodies broadly the principle of winding wire or other conductor helically of a straight axis with the turns or convolutions spaced at a distance apart to provide an openwork or lattice-like structure in which each turn extending in a given direction crosses at an angle a previously wound turn extending in the opposite direction, so that all of the convolutions are tied or bound at the crosses and thus held from lateral displacement to provide a firm, stable mechanical structure of generally cylindrical contour which, after being removed from the winding mandrel, may be shaped or formed into a ring or tore without materially affecting the mutual relationship of the turns; the resultant coil being of true toroidal form, possessing great mechanical strength and stability, and having the turns so disposed as to obtain the maximum electrical efficiency.

As before mentioned, a particular object of the present invention is to provide a toroidal coil of strong and stable structure, and a method of producing the same which lends itself to economical manufacture. To this end I employ any suitable mechanical means

for winding the wire or conductor which constitutes the turns or convolutions of the coil, and preferably I wind it on a straight spindle or arbor 2 such as shown in Fig. 4. The spindle 2 is rotated and the strand of wire or other conductor fed thereto and guided or traversed longitudinally thereof either by hand or by suitable instrumentalities such as usually provided in winding machines of well known construction. In feeding the wire *w* to the mandrel or spindle 2 it is guided longitudinally thereof to dispose it in helical convolutions with a space between the adjacent parallel turns. This method of winding, known in the art as "universal" wind, or as a cross-wind, is distinguished from an ordinary spool wind in several particulars. In the first place, the parallel turns are not contiguous, that is, the wire is not laid in a close spiral as in a spool wind, but is disposed in open helices. Furthermore, the turns of the winding in the different layers bear a definite relation to each other, and in the present example each turn in each layer builds up on, or overlies, a corresponding turn in a previously wound layer, this system being known in the art as honeycomb or lattice winding. Such a method of laying on the turns of wire is shown and described in U. S. Letters Patent No. 1,490,040, granted April 8, 1924, to Morton W. Sterns. Either the honeycomb wind, so-called, or a variation thereof, as described in U. S. Letters Patent No. 1,490,041 of even date to the same inventor, may be employed for producing the present improved toroidal coil and a complete understanding of the system will be obtained from the following brief description as applied to Figs. 4 and 5 of the accompanying drawings.

In Fig. 4 the mandrel 2 may represent the winding machine spindle which is rotated by power-operated means not herein shown, and a reciprocating guide is usually employed for traversing the wire longitudinally of the spindle, although this is not herein shown as in some cases the wire may be guided by hand. In starting to wind the coil the wire *w* is fed to the rotating spindle 2 and traversed thereon from the point *b* to point *c* which define the ends of the windings. As the wire is traversed from *b* to *c* it is deposited on the mandrel 2 in spiral convolutions or helical turns which are disposed at an angle to the axis of the mandrel. In the present example of the winding the winding spindle 2 makes approximately eight revolutions while the wire *w* is being traversed from *b* to *c*, and consequently there will be eight turns in the length of the coil or, technically, an "eight wind". This is an arbitrary selection, however, as the pitch or lead of the wire may be made greater or less in accordance with the diameter on which it is being wound or in proportion to the length of coil to be produced; the prime consideration being to lead the wire at such a pitch as to insure against the turns slipping out of place.

As the wire *w* reaches the end of the coil at *c* its direction of traverse is reversed to lead it back to the starting point *b*, a sharp bend or "knuckle" being formed at *k* where the wire starts back in the opposite direction. As the wire traverses back in this direction a second series of reverse turns or helices will be formed with the wire crossing the previously laid turns at a sharp angle on opposite sides of the spindle at the points *e*, *e*, etc. It will be noted by reference to Fig. 4 that the crossing points *e* of the wire advance slightly circumferentially of the spindle 2, from one end of the coil to the other and back again, this being effected by causing an increment of motion in its traverse over the speed of rotation of the winding spindle, or in the technique of winding a "gain" of the traverse with respect to the rotation of the spindle. Stated briefly, the traverse of the wire is not in direct ratio to the spindle revolutions, but has a "gain" thereover which is designed for a purpose as later explained.

As the wire is traversed back, upon reaching the starting point *b* its direction of feed is again reversed at the bend or "knuckle" *f*, as illustrated in Fig. 5. The wire is then traversed back toward the point *c* again, but instead of being laid on over the first series of turns, it is disposed at one side thereof, and preferably with an appreciable space between the turns. This system is termed an "open wind" and in the present example the ratio of the traverse to the rotation of the winding spindle is plotted or calculated to produce a definite disposition of each series of turns of the winding in a given layer so that they substantially overlie or fall in the same plane as corresponding turns extending in the same direction in an adjacent under layer. This system of winding is explained in detail in the patent first above referred to and while not essential to the coil of the present invention it is preferable as making for certain electrical advantages. With the open wind as exemplified in either of the patents to Sterns, the turns of the coil are spaced apart and separated by air gaps whereby to increase the dielectric effect, and particularly to reduce the distributed capacity of the windings as well known in the art.

Referring to Fig. 5, as the wire reaches the point *c* in its traverse to this end of the coil once more, it is reversed again at *h*. At this point it will feed back with the turns spaced apart from the previously laid turns extending in the same direction and the winding continues in this manner until the wire has formed a network of crossing turns with diamond-shaped openings *o* therebetween, as partially indicated in Fig. 5 and shown more graphically in Fig. 2. This network or lat-

tice-like covering of wire on the mandrel may, for convenience, be considered a layer of the winding and in some instances may constitute the complete coil. In most cases, however, the winding is continued to deposit one or more additional layers overlying the first. These subsequent layers may be constituted by a continuation of the wire in the first layer or, in other cases, a new length of wire may be employed to form a secondary winding.

In the example herein illustrated the wire is continued in overlying layers, see Fig. 3, in which the turns are superimposed, with each turn extending in a given direction directly overlying, or disposed in substantially the same axially-intersecting plane, as the corresponding turn extending in the same direction in an under layer. This latter precise disposition of the turns of wire with respect to each other results in the true cellular or honeycomb structure, but is not essential to the present invention. That is, the turns of the different layers need not be arranged one directly over or in alinement with another, but it may be offset or staggered or even wound in a more or less haphazard manner. It is the crossing of the turns which makes for a firm, stable mechanical structure and this may be accomplished in other manner than the precise arrangement shown and described in the present example of the invention.

Throughout the claims the word series is used to indicate a single traverse of the conductor from one end to the other of the mandrel. In other words it indicates a single helix of spaced turns, of which two are shown in Fig. 4 with the turns running in opposite directions so as to cross each other at the angle referred to which is necessary to maintain the turns of adjacent series from slipping in respect to each other.

After the winding has been completed with one or more layers as desired, the cylindrical structure is slipped off from the winding mandrel 2, with the convolutions retaining their inherent form and relation as illustrated in Fig. 2. In this view, taken from a photograph, no attempt has been made to illustrate the several layers of the windings or the convolutions at the back of the cylinder, since they fall in the same planes, although certain under turns show at the ends due to the perspective of the camera. The mandrel on which the winding is performed may be of the collapsible or contracting type to facilitate its withdrawal from the windings, or a layer of paper or tube of pasteboard may be applied to the spindle before winding so that it may be easily slid off therefrom and then removed from the interior of the coil. The ends of the wire are usually left in suitable lengths projecting from one end of the coil to form connecting leads as indicated at w' in Fig. 2.

The cylindrical coil C shown in Fig. 2 as produced by the above described method of winding is relatively flexible along its length yet firm and stable as regards its general structure and the arrangement of its network of convolutions. It is bent or shaped into a ring or tore T by bringing its ends together in the manner illustrated in Fig. 1. The shaping of the coil to this toroidal form may be conveniently accomplished by bending it around a rod or other cylindrical form, and the ends are usually bound or caught together by ties or a lacing of cord. If desired, the completed coil may be dipped in paraffin, varnish, shellac or any other adhesive binding agent to unite and amalgamate the windings, but this treatment is not necessary as the coil has a very considerable inherent strength and stability after it has been shaped to the toroidal form.

It will be understood, of course, that the wire in the coil is insulated, usually with a wrapped covering of cotton, silk, or both, and therefore the surface of the wire is relatively rough. It has been found therefore that the multiple crossing of the turns of wire at a sharp angle creates a binding and gripping effect which prevents displacement of the individual convolutions and also stiffens and reinforces the whole structure. The completed coil is thus proof against becoming distorted or deformed in use or under rough handling and thus its form is preserved, and the desired relative disposition of its turns or windings retained. For these reasons it is mechanically and electrically superior to other known forms of toroidal coils. First, it requires no supporting core, reinforcing disks or braces and no taping or wrapping, the elimination of all supporting insulation in the field of the coil greatly reducing the loss factors; and secondly, its turns being spaced apart or non-contiguous, the distributed capacity is reduced to practically nil, and minimum high frequency resistance secured.

As another most important feature of improvement the present coil can be wound automatically by machine at a high rate of production whereby to economize in its cost of manufacture. No special formers or complicated apparatus are required to produce the improved coil, and no particular skill or expertness is necessary in its manufacture.

In the present illustration of the invention a preferred form of coil is shown and described and certain details of the method of winding specifically stated. It is to be understood, however, that the coil may be embodied in other forms and the steps in its method of manufacture be varied considerably without departing from the spirit or

scope of the invention. The coil may be bent to various shapes as comprehended within the meaning of the term toroidal, for instance, of horseshoe or half ring form. Therefore, without limiting myself to the exact embodiment of the invention or to the precise method of producing the same as herein set forth, I claim:

1. A toroidal coil composed of series of turns of spirally wound conductor having the convolutions of adjacent series disposed in divergent planes to cross each other at an angle sufficient to prevent slippage of the turns where engaged at the crossings.

2. A toroidal coil comprising several series of helical turns arranged with the turns in each series spaced at a distance apart and crossing the turns of an adjacent series at a sufficient angle to provide a stable openwork structure.

3. A toroidal coil comprising a plurality of series of helical convolutions of conductor wound with the turns of adjacent series crossing each other at a sufficient angle to be self-supporting and disposed in a hollow ring or tore.

4. An electrical coil comprising helical turns of conductor wound back and forth along a common axis whereby the turns of adjacent series cross each other at an angle providing inherent rigidity, said coil being shaped substantially to the general form of a tore.

5. A toroidal coil composed of several series of helical turns of conductor extending in opposite directions to cross each other at an angle with the turns of one series substantially overlying the turns extending in the same direction in an underlying series and forming a lattice-like structure having diamond-shaped openings between the turns.

In testimony whereof I affix my signature.

EDWARD F. PARKS.