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J. A. VICTOREEN

COIL AND METHOD OF MAKING SAME

Filed April 28, 1924

2 Sheets-Sheet 1

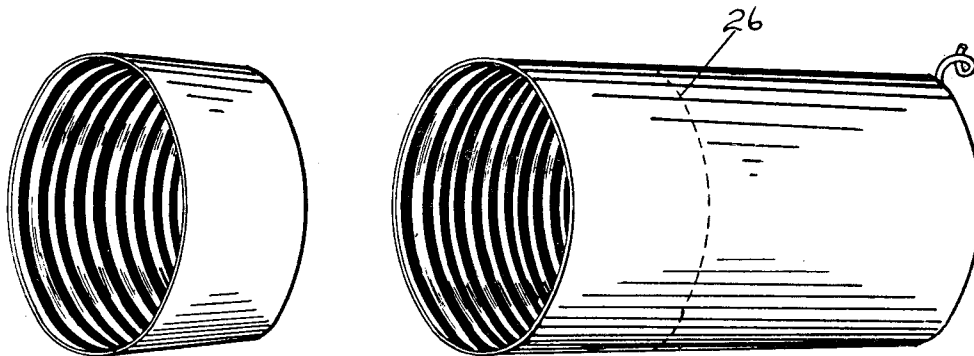


Fig 2

Fig 1

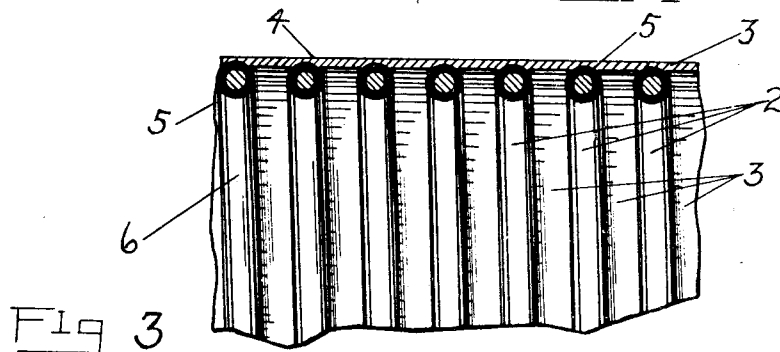


Fig 3

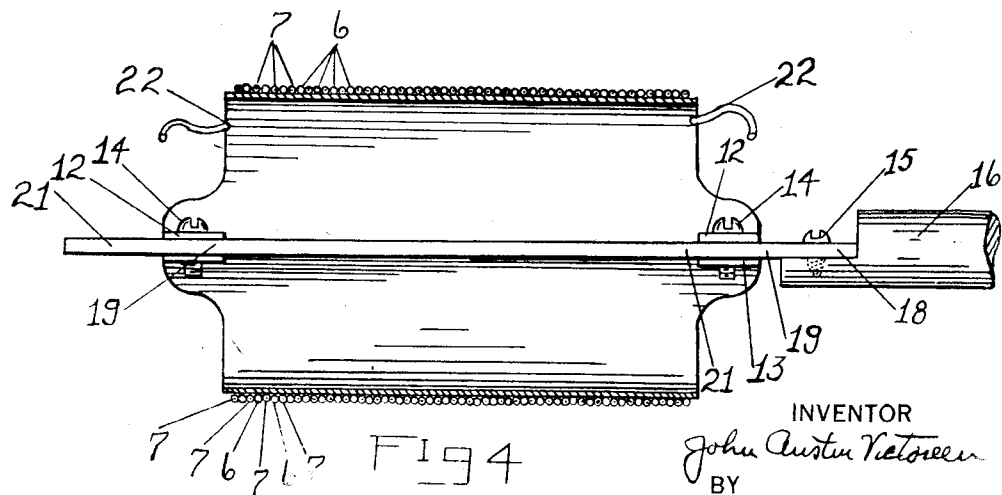


Fig 4

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2 Sheets-Sheet 2

Fig. 8

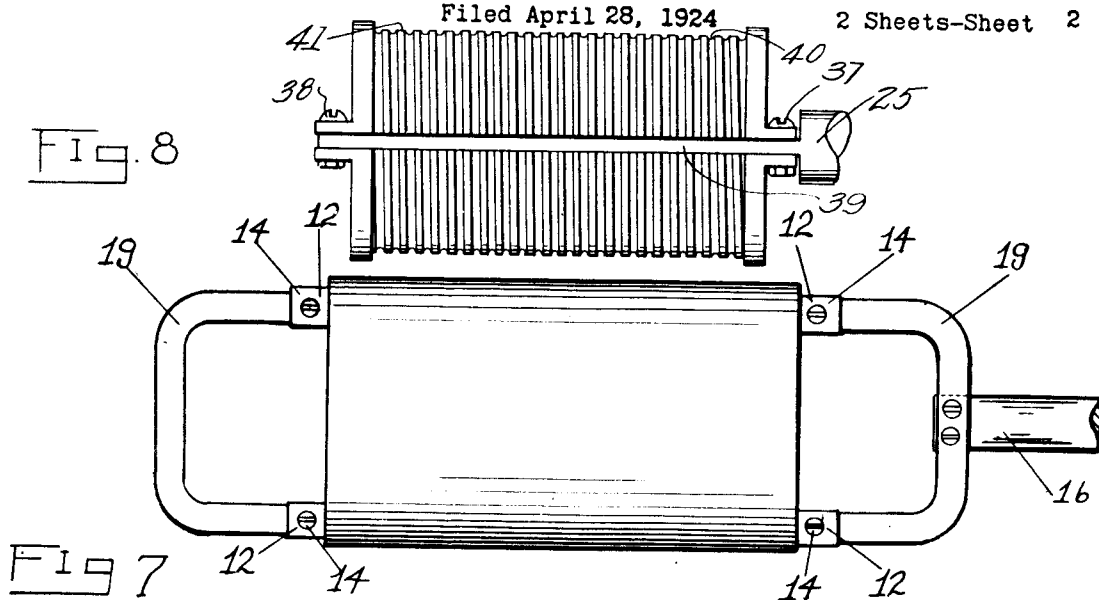


Fig 6

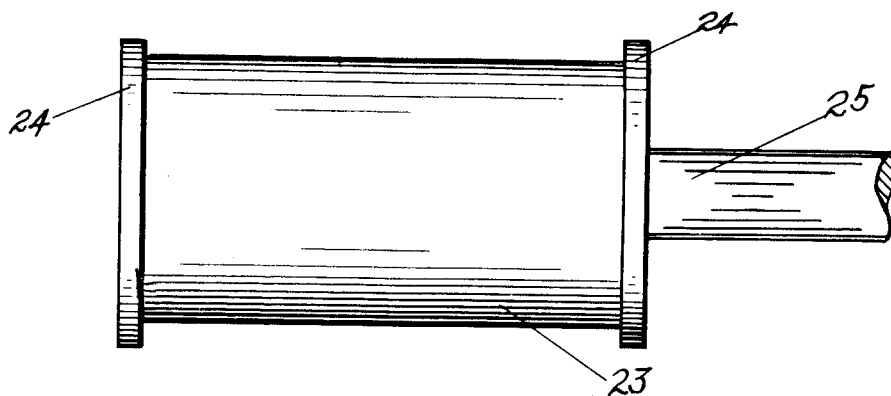
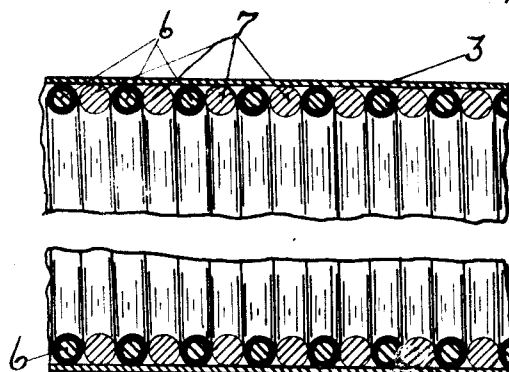


Fig 5



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## UNITED STATES PATENT OFFICE.

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## COIL AND METHOD OF MAKING SAME.

Application filed April 28, 1924. Serial No. 709,630.

This invention relates to electrical coils and method of making the same, and more particularly relates to an electrical coil, together with the means and process for making the same, and which coil is particularly adapted for use in electrical circuits where an extremely high frequency current is employed, such as, for instance, in what are known as radio circuits where the alternating current frequencies employed may be of the order of one million cycles per second.

It is a special object of my invention to provide a means and process for making such coils in a single layer of wire, and which coil will sustain its form as wound without the addition of extraneous wire supporting means such as a bobbin or the like.

It is a special object of my invention to provide such electrical coils that the wire thereon may be in a plurality of convolutions, the successive convolutions being suitably spaced, all of the successive convolutions being securely bound together flexibly by a binding layer of suitable composition, and which, preferably, does not enter the spaces between the successive turns to any considerable extent, but is disposed tangentially in contact with one side only of the turns of wire, making this contact, preferably, on the external side of the coil. In this way the electrostatic capacity and dielectric losses had between the turns is kept to a minimum, and at the same time, the binder firmly secures the different turns together in a unitary form sustaining coil unit.

It is another object of my invention to provide a coil adaptable for radio circuit system purposes which may be wound in a certain form, or shape, such as that of a cylinder, and which will be inherently form-sustaining, but which may be bent from such form as made by the application of sufficient force, and without breaking the successive convolutions of wire, which are held together by the binding material, and which when so bent will preferably retain a desired different form.

Another object of my invention is to provide suitable mechanism for giving the coil its initial form, and which mechanism is removable from the coil at a later stage in the process.

Another object of my invention is to pro-

vide removable spacing means for the successive convolutions of wire in the coil.

Another object of my invention is to provide a suitable insulating binder for the coil of my invention and which binder will possess the necessary properties of a suitable binder, which simplifies the manufacture of the coil, and to make the completed coil durable and changeable as to form after being made and at the same time introduce as little as possible of electrostatic capacity and dielectric losses between the successive convolutions of wire in the coil.

Another object of my invention is to provide an improved process for making the improved coil herein described and which may be employed with suitable obvious variations to coils of other forms than those herein shown.

Another object of my invention is to economically produce coils of the above general description and which may be made in relatively long axial lengths, and which may be very easily cut into shorter unitary form sustaining coils when such shorter coils with a fewer number of turns of wire are desired, and the number of turns in such coils being according to the number desired.

Other objects of my invention and the invention itself will become apparent by reference to the following description and in which description reference will be had to the accompanying drawings in which:

Fig. 1 shows a coil which is an embodiment of my invention;

Fig. 2 shows a shorter coil which may be made from such a longer coil as shown in Fig. 1 by merely cutting the desired length of such shorter coil from the longer coil as along the dotted line of Fig. 1;

Fig. 3 shows a longitudinal medial section of the coil of Fig. 1;

Fig. 4 shows, in longitudinal medial section, the coil on a collapsible winding form or bobbin in an intermediate stage of manufacture, according to one method for making such coils, wherein spacing turns of bare wire or other spacing material are disposed between adjacent turns of the coil winding, the intervening spacing turns being subsequently removed after performing the initial spacing function;

Fig. 5 shows, in longitudinal medial section, a coil such as that shown in Fig. 3,

after the winding binder has been applied, but subsequent to being removed from the collapsible winding form or bobbin and prior to the removal of the spacing wire winding;

Fig. 6 shows a mandrel insertable longitudinally within such a coil as shown in Fig. 5 and upon which mandrel the extra intervening turns of bare spacing wire or other material may be wound to remove such spacing turns in the production of the finished coil;

Fig. 7 shows a collapsible mandrel cylindrical in form, in plan, and upon which mandrel I may wind a coil of wire, together with a spacing winding, for the production of such a finished coil, as is shown in Fig. 5, and ultimately as shown in Figs. 1 to 3 inclusive;

Fig. 8 shows another form of mandrel which I may employ in making the coil of Figs. 1 to 3, inclusive.

Referring now to the drawings in the different figures, by which I have designated like numbers by like reference characters, in Fig. 3 I show in longitudinal medial section a portion of a finished coil, the coil also being shown in perspective in Fig. 1. This coil, as shown, is cylindrical in form, comprising a plurality of turns of wire as at 2, and in the embodiment of my invention illustrated the successive turns are spaced from one end. At 3 I show an insulating binding material joining the successive turns of wire in the coil, the binding material 3 being approximately of cylindrical form on its external side 4 and joining the successive turns of wire by a cementing contact as at 5 on its inner surface. In the coil of my invention, I preferably so dispose the cementing cylinder 4 that the successive turns 2, adhering thereto contact therewith only over a minimum area of the exterior surface of each such turn of wire and cementing function involving, where the winding is composed of insulated wire, that portion of the insulation only which is contained on the outer surface of the turns. The nature of the contact between the binding cylinder and the successive turns of wire which usually are of circular cross section, being in the nature of a tangent or point contact, so far as such a contact can be approached in actual practice.

The cylindrical winding, supporting tube 3, so formed and so carrying the successive turns of wire, each properly spaced as may be desired, is preferably composed of such a material as may be elastic to a degree and yet sufficiently inelastic that if the finished coil is bent with sufficient abruptness that it may retain some part of the distortion occasioned by such bending, so that by careful bending one may cause such a coil winding to depart from the substantially

cylindrical form herein illustrated and to take other forms, such as oval or more irregular forms, such as that of a half circle, in transverse sectional views.

In this description, wherein the form of the coil is described as being primarily cylindrical, I wish it to be understood that my invention is not limited to the making and to a coil of true cylindrical form, but that it may be constructed to be primarily of various forms, such as conical or forms of differing width from the cylindrical and conical forms, but only for the purpose of describing my invention in a preferred embodiment do I refer to the cylindrical form of coil and show such in the drawings accompanying this specification.

I find that for a suitable material with which to make the binding insulating layer 3, I can secure a very good result when this layer is made of a congealed solution of commercial celluloid dissolved in acetone, the celluloid being dissolved in the acetone, the relative proportions of celluloid and acetone being preferably such that the resulting liquid prior to congealing is about the consistency of commercial maple syrup.

In constructing the coil of my invention, the turns of wire are arranged in a suitable manner in the form which the finished coil is to take primarily and which may be so as to substantially form a cylinder, as shown in Fig. 3, and the liquid binding material solution is applied over the outside of the coil, precaution preferably being taken in application so that the film or layer of binding material does not penetrate deeply between the spaces or interstices between the successive turns of wire. Where the film is applied to the coil as by spreading it thereon by a brush, I find that this can be best accomplished when the brush is operated in directions approximately parallel to the axis of the coil, that is, transversely to the direction of the turns comprising the winding. The coil is then cooled and the film or layer of binding material congealed from its liquid form into that of a solid form, the congealing being accelerated suitably by the application of heat, but I find that with the binding material composition heretofore mentioned, there is a practical limit to the amount of such acceleration by heating, in order that the finished product be homogeneous and possess the proper mechanical and electrical qualities, and likewise that it may present a neat and pleasing appearance to the eye. If the process is hurried unduly, "bubbling" or the formation of air or gas bubbles detracts from the appearance and serviceability of the insulating binding film. A coil constructed according to this method will have its exterior surface composed entirely of the film insulating film and the exterior surface will appear relatively smooth,

whereas the interior of the coil being free from any contact with the exterior binding film will comprise merely the successive turns of wire separated by air spaces, each turn of wire standing out sharply from the encircling insulating binding material. My invention comprehends the making of coils wherein the inner surfaces of the successive turns are only in contact with the binding insulating film, this being disposed interiorly of the wire winding, but for all practical purposes I prefer the form herein shown and described.

In order to make up the coil winding having the successive turns suitably spaced, where such spacing is desired between successive turns I may accomplish this in a number of different ways, two of the ways being herein illustrated but others being well known in the art, some of these being for the purpose of my invention merely alternative and equivalent. A manner of accomplishing this, which I prefer for some reasons, comprises the winding of a second wire not intended to be contained in the finished coil at the same time the coil wire is wound, the two wires being wound side by side on a suitable mandrel so that successive turns of wire on the mandrel as wound will, as shown in Fig. 4, comprise alternately a turn of electrical coil wire 6 and a turn of spacing wire 7, the spacing wire 7 being preferably non-insulated, and I find that a bare copper wire serves the purpose better than an insulated wire for a reason which will become apparent later. The true winding comprising turns 6 and the spacing winding comprising turns 7 having been placed on the coil and the ends secured, as by inserting them through openings 22 in the mandrel, the winding binding film of insulating material, as above described, is applied to the exterior of the coil and the coil as wound is left on the mandrel until the binding film is sufficiently congealed that the coil will be self form sustaining, the film turns being capable of holding the turns in the form of the exterior wall of the mandrel. At such time the bolts 14 are removed, the U-shaped mandrel expanding members 18 and 21 are removed and the two sections of the mandrel are collapsed inwardly and thus disengaged from the inner surfaces of the winding convolutions, the mandrel sections being thereupon removed by an axial movement from the interior of the coil. The coil then is placed over a spacing wire removing mandrel 23, this mandrel comprising a bobbin having heads 24 of smaller external diameter than the interior diameter of the coil into which the mandrel is to be inserted, and a handle 25 secured rigidly to one side of the mandrel and by which handle the mandrel may be rotated. The mandrel 23 and the coil are

then relatively rotated preferably by holding the coil still and rotating the mandrel until the spacing turns of wire 7 are all removed from the coil spaces between successive turns of coil wire 6, it being possible to so remove the spacing turns of wire since such wire is bare and contains no fibres to make a good cementing contact with the congealed binder film, this binder film being that shown at 3 in Figs. 3 and 5, and in certain other figures.

Fig. 5 shows the form of the coil before the removal of the spacing turns of bare wire, and Figs. 1 and 3 show the coil as it appears after the spacing turns have been removed. The finished coil, as shown in Figs. 1 and 3, may then be cut up into smaller coils of smaller axial length, such as the coil of Fig. 2, which may be assumed to have been separated from the coil of Fig. 1 by cutting the binding film along the dotted line 26 and severing the turn of coil wire crossing such line. In this way economy may be accomplished in manufacture by making a single tubular coil of considerable length, the coil thereafter being divided into smaller coils having the requisite number of turns of wire for the purpose for which such coils may be intended.

While I have described a particular kind of mandrel as capable of being used in connection with the production of the coil of my invention and in the process by which such a coil is produced, other forms of mandrels may be employed but not departing from my invention. For instance, I may use the mandrel as shown in Fig. 8, wherein the two sections as joined together by bolts 37 and 38 and which bolts hold securely a mandrel section spacing element 39 carrying at one or both of its outer ends, one as shown, a handle 25', the outer surface of the mandrel containing a spiral groove 40, the successive groove convolutions being suitably separated, suitably formed ridges 41. Such a mandrel when used does not require the extra subsequently removed bare wire winding in order to provide the proper spacing between the turns of wire of the finished coil, the ridges 41 providing the spacing and the coil winding binding film maintaining this spacing after application. The ridges 41 also serve to prevent the insulating material from penetrating between the convolutions of the coil, as the bare wire of Fig. 5 does, and thus restricts the adherence of the insulating material to the winding surface of the coil as previously described. In making coils on this mandrel after the coils are wound, the ends are secured to the mandrel in the usual manner to prevent premature unwinding, and the binding film in solution is applied to the exterior of the coil winding. When tried, the bolts 37 and 38 are removed and the

mandrel section spacing element 39 is removed to permit the clappings of the mandrel inwardly, leaving the finished coil in self-sustaining form free from the mandrel.

5 I find that my invention may also be practiced where the turns of wire are tightly wound by a machine having what is known as an automatic screw machine threading attachment, whereby the mandrel is ad-  
10 vanced axially at a proper speed to provide the proper spacing of successive convolutions of coil winding.

It will be understood from the foregoing description that I constructed a coil having  
15 spaced convolutions maintained in the desired position by insulating material which does not extend an undesired distance into the spaces between the convolutions, as a result of which the current losses due to  
20 capacity between convolutions of the coil are maintained at a minimum.

It will also be understood that various insulating materials other than the above mentioned celluloid and in various forms  
25 and consistencies may be used as full equivalents thereof provided, of course, that they possess the property of adhering to and supporting the convolutions of the coil without introducing capacity losses due to marked  
30 penetration between the coils.

Having described my invention in certain specific embodiments and employing generically a novel method of manufacture and a novel method of application and specific  
35 embodiments of such generic invention, I am aware that numerous and extensive departures may be made from the embodiments herein illustrated and described but without departing from the spirit of my invention.

40 I claim:

1. The method of making an inherently form-sustaining coil for electrical currents, comprising first arranging the successive  
45 convolutions of the winding in a single layer and spaced apart, then cementing a binding insulating film to one of the winding surfaces, with the film making only an approximately tangential contact with the different  
50 winding convolutions, then in drying the binding film and rendering the film self-sustaining and winding supporting.

2. The method of making an inherently form-sustaining coil for radio frequency currents comprising first arranging the suc-  
55 cessive convolutions of the winding spaced separately from each other and in a single layer, then in applying a binding film of syrup-like consistency to a winding surface of each convolution of the coil with the  
60 film making only an approximately tangential cementing contact with the different convolutions, then in congealing the binding film to solid form while mechanically hold-  
ing the winding convolutions in their de-

sired relative spaced positions until the  
65 binding film is congealed into solid self-sustaining form.

3. The method of making an inherently form-sustaining coil having spaced turns of wire for radio frequency currents, compris-  
70 ing the winding of a conducting wire and a filler wire, side by side, into helical form, then in applying a binding film of syrup-like consistency to one side of the coil con-  
75 volutions of the said wires, making only an approximately tangential contact with the different winding convolutions, then in drying the binding film in cementitious rela-  
80 tion with the winding convolutions, while mechanically holding the winding in its desired form until the binding film is congealed into solid form, then in removing the  
85 filler wire of the double winding by withdrawing it from that side of the coil to which the binding film is not applied.

4. A coil comprising a helix of conducting wire, the convolutions of which are spaced  
90 apart, a sheet of insulating material touching a winding surface of said coil throughout substantially its entire length, the space  
95 between the convolutions being open and substantially free from insulating material and the convolutions being cemented to the said sheet.

5. A coil comprising a helix of conducting  
100 wire, the convolutions of which are spaced apart, a sheet of insulating material surrounding said coil and touching the outer winding surface of said coil throughout sub-  
105 stantially its entire length, the space between the convolutions being open and the convolutions being cemented to the sheet.

6. A coil comprising a helix of conduct-  
110 ing wire, the convolutions of which are spaced apart, a sheet of collodion touching a winding surface of said coil throughout sub-  
115 stantially its entire length, the space between the convolutions being open and the convolutions being cemented to the sheet.

7. An inductance coil comprising a helix  
120 of conducting wire, a sheet of insulating material touching and adhering to a surface of said helix throughout substantially its entire extent, the wire making contact with  
125 the sheet on only a small segment of its circumference.

8. A coil comprising a space wound helix  
130 of conducting wire, helix supporting insulating material extending lengthwise of the helix for substantially the entire axial length  
135 thereof and touching and adhering to a surface of said helix, the wire making contact with the insulating material on only a small segment of the circumference of the wire.

In testimony whereof I hereunto affix my  
140 signature this 24th day of April, 1924.

JOHN AUSTIN VICTOREEN.