April 25, 1950 P. A. D'ORIO 2,505,104

METHOD OF MAKING ELECTRICAL COILS

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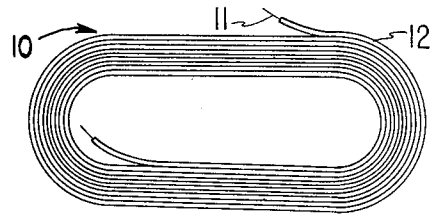


FIG. 1

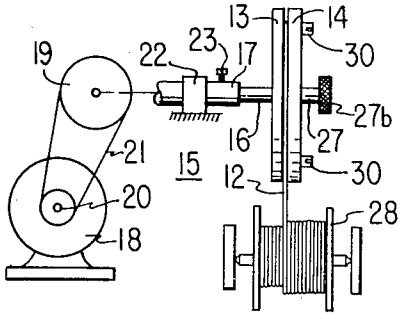


FIG. 2

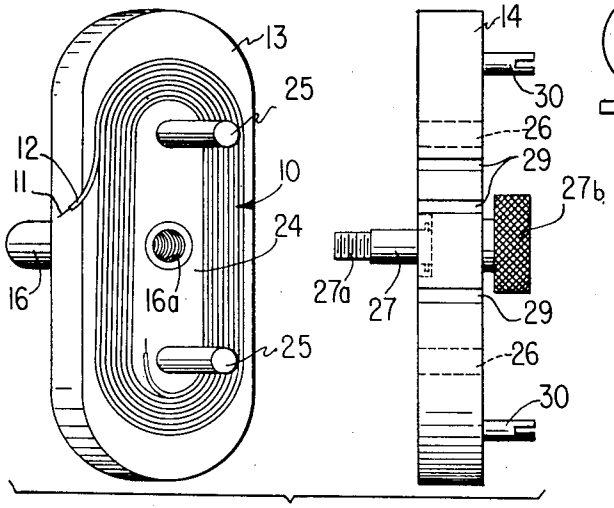
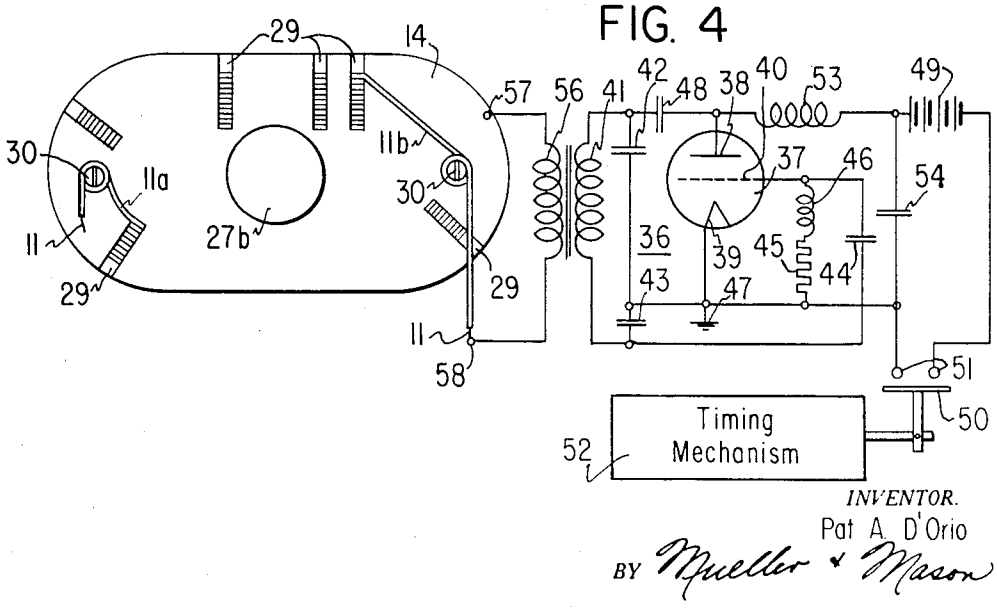


FIG. 3

FIG. 4



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METHOD OF MAKING ELECTRICAL COILS

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2 Claims. (Cl. 154—80)

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The present invention relates to a method of making electrical coils and more particularly to a process of manufacturing built-in type loop antennas.

Loop antennas of the built-in type have been extensively employed in recent years in the radio industry. Such antennas or coils are adapted for assembly as an integral part of a radio receiving set and since they are usually placed within the radio cabinet, the size or bulk of the coil directly affects the size of the cabinet and hence, the over-all cost of the set. An electrical coil or winding which is suitable for use as a built-in type of radio antenna usually comprises a flat, either elliptical, circular or rectangular, winding which is often referred to as a pancake winding in which a suitable electrical conductor is spirally wound one turn on the outside of the next turn with the adjacent turns of the conductor insulated from one another either by air or a suitable insulating material.

In a prior copending application, Serial No. 650,063, filed February 25, 1946, now abandoned, and assigned to the same assignee as the present application there is disclosed and claimed a method of manufacturing a coil in which an insulated conductor or an uninsulated conductor with intervening layers of insulation is arranged in the form of a coil so that the insulating material which is preferably a thermoplastic or a thermosetting material is in engagement between adjacent turns. A self-supporting coil is made in accordance with my prior invention by heating the insulation by passing current through the winding whereby the insulation of adjacent turns is caused to fuse together and cohere. The method of my above-mentioned prior patent has been used commercially and many coils have been manufactured by that method. It has been found that due to the fact that the conductor which is usually formed of copper cools off more slowly than the surrounding insulation which fuses, there is a subsequent contraction of the copper conductor as it cools with the result that shearing stresses are set up in the insulation which has set causing occasional separation of adjacent windings. Although the number of rejects by the prior method is relatively small, it would be desirable to provide a method of manufacturing a coil in which the above-mentioned difficulty is completely eliminated.

Accordingly, it is an object of the present invention to provide a new and improved method for manufacturing electrical coils or windings.

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It is another object of the present invention to provide a method of making coils of the above-mentioned type in which the number of rejects is reduced substantially to zero.

Still another object of the present invention is to provide a new and improved method for manufacturing electrical coils or windings of the self-supporting type wherein heating causes the fusing together of the adjacent layers of insulation surrounding the conductor forming the winding and wherein the conductor is substantially not heated during the fusing operation.

Further objects and advantages of the present invention will become apparent as the following description proceeds and the features of novelty which characterize this invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the present invention, reference may be had to the accompanying drawing in which:

Fig. 1 is a top plan view of a pancake electrical winding made in accordance with the present invention;

Fig. 2 is a somewhat schematic view of apparatus employed in carrying out one step of the process of the present invention;

Fig. 3 is an enlarged perspective exploded view of a portion of the apparatus of the present invention as employed in Fig. 2; and

Fig. 4 is a partially schematic view illustrating one embodiment of the heating step of the present invention.

The process for making an electrical coil in accordance with the present invention is illustrated specifically in connection with the manufacture of a pancake type coil wherein a conductor insulated with a thermosetting or thermoplastic insulating material is spirally wound on an insulating supporting member positioned between two plates which may either be constructed of conducting material or if constructed of insulating material are provided with metallic liners as will become apparent from the following description. The winding is made self-supporting by causing the insulation thereof to act as the dielectric of a capacitor supplied with a high frequency alternating current so that the fusing heat for the thermosetting or thermoplastic insulating material comes from the dielectric heat loss in the insulation.

Referring now to Fig. 1 of the drawing, there is illustrated an electrical winding 10 manufactured in accordance with the present inven-

tion. This winding comprises a length of electrical conductor 11, spirally wound in elliptical form and having a thickness in a direction normal to the drawing of Fig. 1 of one turn. The electrical conductor 11 in the coil 10 is illustrated as having a coating of insulating material 12 thereon. It should be understood that although the invention is specifically disclosed in connection with manufacturing an antenna winding of elliptical shape it could equally well be used to produce a winding of circular or some other shape. It should also be understood that this invention could be applied to the manufacture of any coil in which the adjacent turns are so arranged as to have their insulated surfaces in physical engagement.

Preferably the winding 10 is formed from insulated wire 11 which is built up or wound between a pair of plates 13 and 14 forming the mandrel of a winding machine 15 schematically indicated in Fig. 2 of the drawing. These plates 13 and 14 are shown in greater detail in Fig. 3 of the drawing and preferably comprise a pair of smooth finished flat members formed of conducting material. The plate 13 is provided on one side with a stub shaft 16 which may be inserted into the hollow end of the rotary shaft 17 of the winding machine 15 driven by a suitable winding motor 18 through suitable pulleys 19 and 20 and a belt 21. The shaft 17 is illustrated as being rotatably mounted in one or more bearings such as indicated at 22. In order that the stub shaft 16 on plate 13 may be removably connected with the winding machine shaft 17 a suitable set screw 23 may be employed in shaft 17 at its hollow end whereby rotation of the shaft 17 causes rotation of the shaft 16 and consequently also rotation of the mandrel comprising the plates 13 and 14.

As is best shown in Fig. 3 plate 13 is provided with a raised portion 24 on the side adjacent plate 14 which serves as the core or spool upon which the wire 11 is wound to form electrical coil 10. Although the portion 24 is referred to as a raised portion integral with the plate 13, it may also comprise a separate removable member if desired. It will furthermore be understood that the portion or core 24 may have any desired shape depending upon the form of the coil 10. However, since an elliptical coil is illustrated in Fig. 1 of the drawing, the portion or core 24 is illustrated as of elliptical shape to conform with the central opening in the winding 10 of Fig. 1. The plate 13 is also provided with a pair of aligning pins 25 extending from the raised portion 24 in a direction parallel with the axis of the stub shaft 16. The aligning pins 25 are adapted to be inserted in suitable openings 26 in cooperating plate 14 which latter plate is also provided with suitable fastening means indicated at 27, having a threaded end 27*a* adapted to threadedly engage with the end 16*a* of the stub shaft 16 which preferably extends almost through the plate 13 as is clearly indicated in Fig. 3 of the drawing. Fastening means 27 is also provided at its other end with a manipulating means such as a knurled knob 27*b* so that the two plates 13 and 14 can readily be fastened together in the manner indicated in Fig. 2 of the drawing or taken apart as shown in Fig. 3. The width of the winding space defined between plates 13 and 14 is controlled by the raised portion or core 24 of plate 13. This space is adjusted so as to be just large enough to accommodate a single width of the insulated wire 11 in the event that an insulated wire is employed. With this arrangement it is clear that the wire will be held in place since the space between plates 13 and 14 insures proper positioning thereof. It should be understood that if the diameter of the wire to be employed in constructing the electrical winding 10 is to be greater than the amount core 24 is raised from the surface of plate 13, a suitable shim not shown of the same configuration as raised portion 24 may be inserted between the plates, the shim being provided with suitable openings cooperating with the aligning pins 25 to support the same on the plate 13. By employing an assortment of shims of various sizes electrical windings employing any size wire may be constructed with the same winding apparatus.

As illustrated in Fig. 2 of the drawing, the wire 12 is spirally wound on the core or raised portion 24 between plates 13 and 14 from a suitable supply reel 28 rotatably mounted in any suitable manner as is schematically indicated.

In order to anchor the ends of the winding 10 and so that they may be available to carry out a subsequent step in the process of manufacture to be described hereinafter, plate 14 is provided around the outer edge thereof with a series of notches 29 best shown in Figs. 3 and 4 of the drawing, and a pair of split pegs 30 which extend from the side of plate 14 opposite the side thereof adjacent plate 13. When it is desired to start a new coil 10 the end 11*a* of the wire 11 from the reel 28 is placed between plates 13 and 14 and allowed to extend out of one of the notches 29 as is shown in Fig. 4 of the drawings. This end 11*a* of wire 11 is anchored to the one of the split pegs 30 most closely adjacent to the particular notch 29 through which the wire 11 extends. It will be obvious that the depth of the notches 29 should be such as to extend to the outer periphery of the raised portion 24 whereby the end of the inside turn of the coil 10 may be brought out at the bottom of a particular one of these notches 29. The reason why a plurality of notches such as 29 are provided is to permit one to manufacture coils having different predetermined values of inductance with the same apparatus. To accomplish this the winding may require a fractional turn and accordingly for coils having different inductances it is desirable to have a series of notches 29 judiciously spaced around the periphery of plate 14. In production, it has been found that the coils made by this process have uniform inductance thus requiring a minimum adjustment when placed in the radio sets for which they were designed. Also, it is sometimes desirable to provide a winding having more than two terminals as, for example, a transformer. This is another reason why it is desirable to provide a plurality of notches 29 through which the ends of the wires leading to the plurality of terminals may be brought out.

Upon winding the desired number of turns between plates 13 and 14 the insulated conductor 11 is cut off and the other end 11*b* brought out through another one of the notches 29 and fastened to the other split peg 30 as is shown in Fig. 4. In order to simplify the disclosure the invention is illustrated in connection with manufacturing an electrical winding 10 having but two terminals although it is obvious that additional terminals might be brought out through the notches 29 provided for this purpose.

It should be understood that the winding apparatus described thus far and the particular construction of the mandrel comprising the

plates 13 and 14 forms no part of the present invention and any suitable apparatus for winding the conductor 11 to produce a spirally wound pancake winding 10 of any configuration may be employed as well as apparatus for winding a helix, so long as the adjacent turns have their insulation in physical engagement.

If it were desired to remove the completed winding from between plates 13 and 14 immediately following the winding operation it is obvious that the coil would not retain its desired shape and the adjacent turns would separate from one another. In prior art arrangements various rather complicated processes were employed for causing the insulation of the adjacent turns to cohere to each other whereby a coil which is completely self-supporting without any additional supporting structure is obtained. In accordance with the present invention, this is accomplished in a simple and inexpensive manner by employing an insulated wire 11, the insulation 12 of which preferably comprises a thermoplastic insulating material but might conceivably also comprise a thermosetting insulating material. A very suitable thermoplastic insulating material for this purpose is polyethylene which is extensively used for insulating electrical conductors.

In accordance with the present invention, the insulation 12 on the winding 10 is heated without substantially heating the electrical conductor 11 by causing the insulation 12 to become the dielectric of a capacitor connected to a source of high frequency alternating current. Any suitable source of high frequency alternating current may be employed and as illustrated in Fig. 4 of the drawing, there is provided an oscillation generator generally indicated at 36. Oscillation generator 36 may comprise any standard form of generator for producing high frequency oscillations. In Fig. 4 this generator has been illustrated as comprising the well known Colpitts oscillator including an electric discharge valve 37 having an anode 38, a cathode 39 and a control electrode or grid 40. The oscillating action of the electric discharge valve 37 is controlled by a tuned or resonant circuit generally referred to as a tank circuit comprising the serially arranged inductance 41 connected in parallel with serially arranged capacitors 42 and 43. The cathode 39 of the electric discharge valve 37 is connected to a point on the tank circuit between capacitors 42 and 43 which act as a voltage divider. The lower terminal of the tank circuit is connected to control electrode or grid 40 through a grid blocking capacitor 44. A grid leak circuit is provided between control electrode 40 and cathode 39 which comprises a resistor 45 and an inductance 46. Preferably cathode 39 is grounded as is indicated at 47. The upper terminal of the tank circuit is connected to anode 38 through a plate blocking condenser 48 in order to insulate the anode 38 from control electrode 40 as far as the direct current potential applied to the anode-cathode circuit of electric discharge valve 37 to be described hereinafter is concerned, while still maintaining anode 38 and the upper terminal of the tank circuit at the same high frequency potential. A source of direct current potential is applied across the anode-cathode circuit of the electric discharge valve 37 which will be referred to as the input circuit of the oscillation generator 36. This source of direct current is indicated by a battery 49 shown in Fig. 4 of the drawing.

In order to perform certain control functions such as energizing the oscillation generator 36 for a predetermined time, there is provided an electric switch or circuit breaker 50 in the input circuit of the oscillation generator 36. When this switch 50 is closed it is adapted to bridge contacts 51 so that high frequency oscillations may be obtained at the output circuit of the oscillation generator 36 to be described hereinafter. Electric switch or circuit breaker 50 is adapted to be controlled by a timing mechanism generally indicated at 52 which upon closing of switch or circuit breaker 50 will cause reopening thereof after a predetermined time which time is adjustable at the will of the operator.

In the event that the source of direct current fed to the input circuit of the oscillation generator 36 is obtained by rectifying an alternating current, it may be desirable to provide a filter comprising a choke coil 53 and a by-pass condenser 54 as is indicated in Fig. 4 of the drawing. Such a filter will impede the passage of high frequency power into the rectifier supplying the direct current energy to the input of the oscillation generator 36.

The high frequency output of the oscillation generator 36 is obtained by inductively coupling a winding 56 to the inductance 41 whereby high frequency oscillations appear across the terminals 57 and 58 of winding 56 when these terminals are connected to a suitable load. As indicated in Fig. 4, the terminal 57 is connected to one of the plates such as 13 or 14 forming the mandrel of the winding machine while the other terminal 58 is connected to one end of the conductor 11. If the plates 13 and 14 are formed of conducting material, they are electrically interconnected by virtue of the member 27, the members 25 and portion 24 if the raised portion 24 is also formed of conducting material. In such a case both plates 13 and 14 of the mandrel are electrically connected to the terminal 57. With this arrangement, it will be obvious that two parallel condensers are formed with the conductor 11 forming a common plate for the two condensers while the conducting plate 14 and the conducting plate 13 each form a plate of a different one of the condensers. The high frequency current which is preferably of the order of one megacycle or more causes heating of the dielectric comprising the insulation 12 with the result that the adjacent engaging layers of thermosetting or thermoplastic insulating material are caused to fuse and cohere without appreciably heating the conductor 11. The length of time that the high frequency current is supplied for the dielectric heating process is controlled by circuit breaker 50. Since there is substantially no heating of the conductor 11, there is no possibility of shearing stresses being developed in the insulating material upon cooling of the conductor after the insulating material has set.

If it is desired to employ a mandrel in which insulating plates 13 and 14 are provided, the high frequency heating method may be employed by providing a liner of conducting material on either side of the winding 10 between plates 13 and 14 which can be connected to terminal 57 in the same manner as the plates 13 and 14 if formed of conducting material are connected to this terminal as shown in Fig. 4 of the drawing. If desired, the plates 13 and 14 which may be formed of conducting material could be insulated from each other and one plate connected to terminal 57 while the other plate would be

connected to terminal 58. In this case, the dielectric between plates 13 and 14 would consist of both the conductor 11 and the insulation 12. The dielectric heating of this composite dielectric would cause much greater heating of the insulation 12 by virtue of the fact that it is a high loss insulation as contrasted with the low loss conductor 11. In any event, either method would obviate the thermal lag resulting when the conductor is heated to a high temperature and cools subsequently to the fusing or setting of the insulation.

The antenna 10 constructed by the method of the present invention is well adapted to be mounted on the back of the radio cabinet in any suitable manner. The completed winding 10, when properly manufactured in accordance with the present invention, almost looks like a spirally wound electrical conductor embedded in a flat unitary insulating member due to the thermoplastic welds between adjacent turns of the insulated winding.

It should be understood that the same results can be obtained by using an uninsulated wire and interwinding it with a thermoplastic tape or strip fed from a separate reel or spool. In view of the detailed description included above it is believed that the process of the present invention will be obvious to those skilled in the art.

It should be understood that the present invention is not limited to the particular process disclosed and described in detail above and that changes and modifications may occur to those skilled in the art without departing from the spirit and scope of the present invention. It is, therefore, aimed in the appended claims to cover all such changes and modifications.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The process of making a self-supporting coil from a conductor having insulation thereon made of thermoplastic or thermosetting material which comprises, arranging the conductor in the form of a flat spiral winding with the insulation of each turn of the winding in physical engagement with the insulation of at least one adjacent turn, placing a conducting plate against one side of the flat winding so that the plate and the conductor form the electrodes of a capacitor with the insulation forming the dielectric therebetween, and applying a high frequency alternating current between the conductor and the conducting plate so that the insulation on the conductor is heated and softened and adjacent turns cohere, the conductor being heated substantially entirely by conduction from said insulation and being heated to a lesser extent than said insulation.

2. The method of constructing a self-supporting coil from wire having insulation thereon made of thermoplastic or thermosetting material which comprises, arranging a length of the wire between a pair of conducting plates in the form of a spirally wound coil with the insulation of adjacent turns in mutual engagement, whereby condenser means is formed with the wire serving as one electrode, the conducting plates serving as the other electrode and the insulation serving as the dielectric, and applying a high frequency alternating current between the plates and the wire so that the insulation is heated and is thereby softened and adjacent turns of the coil cohere, with the wire being thereby heated to a lesser extent than the insulation.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,874,723	Dawson	Aug. 30, 1932
2,177,260	Laube	Oct. 24, 1939
2,282,759	Gavitt	May 12, 1942
2,422,525	Brown	June 17, 1947

FOREIGN PATENTS

Number	Country	Date
555,054	Great Britain	Aug. 3, 1943

OTHER REFERENCES

Hoyler, An electronic "sewing machine," reprint from 1943 issue of Electronics (7 pages).