C. R. UNDERHILL.

METHOD OF MAKING ELECTRICAL COILS.

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1,036,937.

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Fig. 1.

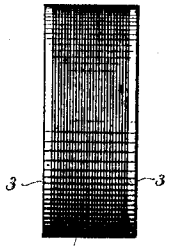


Fig. 2.

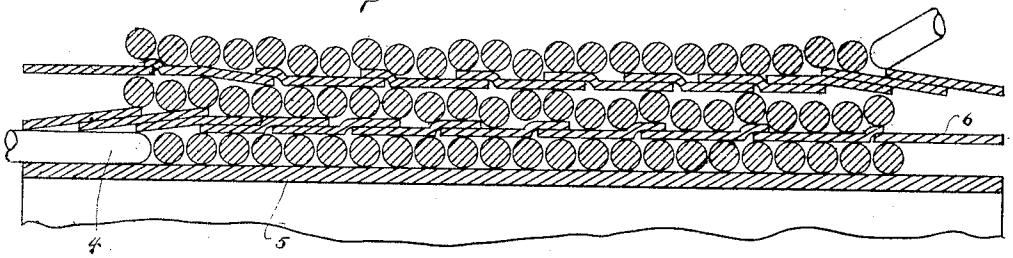


Fig. 4.

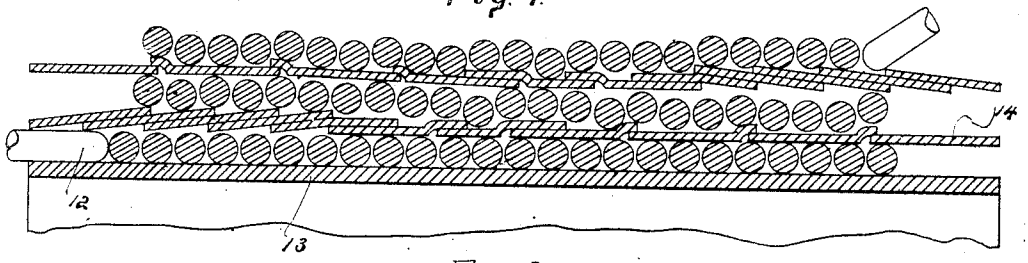
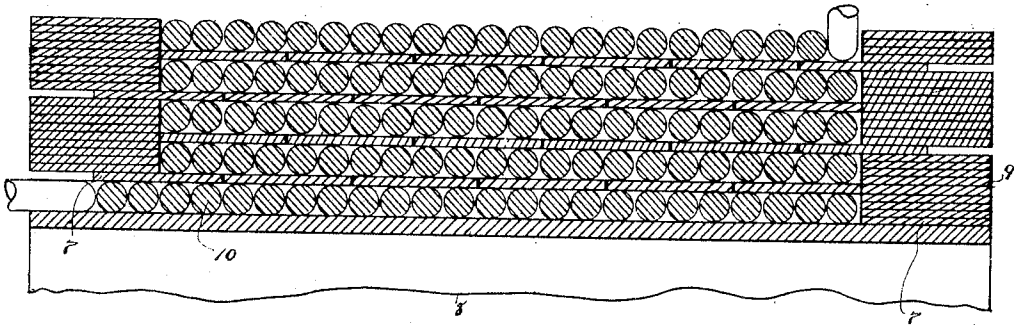


Fig. 3.



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UNITED STATES PATENT OFFICE.

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METHOD OF MAKING ELECTRICAL COILS.

1,036,937. Specification of Letters Patent. **Patented Aug. 27, 1912.**

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To all whom it may concern:

Be it known that I, CHARLES R. UNDERHILL, a citizen of the United States, residing at New Haven, in the county of New Haven and State of Connecticut, have invented a new and useful Improvement in Methods of Making Electrical Coils; and I do hereby declare the following, when taken in connection with the accompanying drawings and the letters of reference marked thereon, to be a full, clear, and exact description of the same, and which said drawings constitute part of this specification, and represent, in—

Figure 1 a view in elevation of an electrical coil constructed in accordance with my improved method. Fig. 2 a schematic view of a coil constructed in accordance with my improved method, this coil having the layer-insulation wound spirally with a progressive overlap but without the end-closures. Fig. 3 a corresponding view of another form of coil produced by a modification of my improved method, the thin narrow tapes being in this case wound edge to edge rather than overlapped, and the coil being furnished at its ends with solid laminated end-closures progressively built up with the building up of the layers. Fig. 4 a corresponding view of still another coil produced by another modification of my improved method by which the layer-insulation is differentiated in bulk by changes in the winding pitch of the tapes during the winding process so that the thickness of each layer is increased on opposite sides of the center of the coil.

My invention relates to an improved method of making electrical coils of that class which consist of alternate layers of wire and paper or other insulating material. These coils have heretofore been made singly and in multiple. In making them singly, wire and a sheet of paper somewhat wider than the length of the layers of wire are generally wound into a bobbin provided at its respective ends with flanges or heads which serve as guides for the paper. In making the coils in multiple, a number of windings of wire are spaced upon a spindle or mandrel and paper is inserted between the layers of wire in the form of a sheet sufficiently wide to be common to all of the windings. Then after the paper and wire have been wound to the required thickness, the coils are separated from each other by severing the paper between the windings of wire. In feeding the paper for the production of these coils, either singly or in multiple, the sheets invariably exhibit a tendency to feed out of line, either to the right or left. This tendency is so marked that practically the sheets never feed straight. In making single coils this tendency must constantly be checked and corrected by guiding the paper by hand which makes the production of the coils singly, difficult and expensive. On the other hand, in practising the multiple method, sufficient margin is left at the outer ends of the outer windings to provide for enough trimming of the paper to cut away its untrue edges which are thrown away as waste.

The object of my present invention is to take advantage of the natural tendency of paper when fed either by hand or automatically, to travel spirally, and by taking advantage of this tendency, to produce coils of superior compactness and mechanical and electrical durability, as well as to produce coils in which the layer-insulation may be differentiated in bulk so as to be localized with respect to the localization of electrical stress and to provide them with solid laminated end-closures built up from the same tapes employed in the production of the layer-insulation.

With these ends in view, my invention consists in a method of producing an electrical coil consisting in building it up from alternate layers of wire and spirally wound thin, narrow tapes of insulating material.

My invention further consists in a method of making an electrical coil consisting in winding, one upon the other, alternate layers of wire, and thin, narrow tapes of insulating material which are spirally wound and terminate at their ends in self-wound solid, laminated end-closures.

My invention further consists in a method of making an electrical coil consisting in winding, one upon the other, alternate layers of wire and thin, narrow spirally wound tapes of insulating material which tapes are progressively overlapped so as to differentiate the layers in bulk in accordance with the electrical stress between the layers of wire.

My invention further consists in a method of producing an electrical coil consisting in

alternately winding, one upon the other, layers of wire and thin, narrow tapes of spirally wound insulating material, the tapes being progressively overlapped and terminating at their ends in concentrically wound solid end-closures.

In Fig. 1 of the drawings I have shown a finished coil in which the outer layer of wire 2 is seen between solid laminated end-closures 3 built up by the concentric winding upon themselves of thin, narrow tapes used in the production of the layer-insulation (not shown) of the coil, this layer insulation being produced by spirally winding thin, narrow tapes of paper or other insulating material of any suitable character between the layers of wire.

In carrying out my invention, the thin, narrow tapes of paper or other insulating material, may be fed and wound in a great variety of ways, dependent upon whether or not the coils are to be produced by hand, or automatically, or semi-automatically, and whether or not they are to be furnished with end-closures, and so on, my invention covering any method of producing electrical coils in which layer-insulation is supplied by the insertion between the layers of wire, of spirally wound tapes, whether wound edge to edge or regularly overlapped or progressively overlapped, or in any other way differentiated in bulk.

For the illustration of my invention, I have shown three ways of practising my improved method.

As shown in Fig. 2 of the drawings, the first layer of wire 4 is wound upon an ordinary paper core 5. Beginning at the right, I then feed to the coil a thin, narrow paper tape 6 which is spirally wound upon the layer of wire and progressively overlapped from right to left so that the bulk of insulating material is localized at the left end of the coil where the electrical stress between the first and second layers of wire is the greatest. After the winding of the tape has been started from right to left to form the first layer of insulating material, the winding of the second layer of wire from right to left is begun; but the paper tapes being much wider than the diameter of the wire will "make" faster, so to speak, so that the first layer of paper will be wound before the second layer of wire is complete. The wire and tape are wound at different pitches. In this connection I may state that on account of the economy of time secured the winding of the wire will be begun immediately after the feeding of the paper. After the completion of the first layer of paper, the tape is severed and fastened upon itself in any suitable manner, as, for instance, by a modicum of some adhesive. No more paper is now fed into the coil until after the completion of the second layer of wire, after which the tape is again fed into the coil at the left hand end thereof and spirally wound with a progressive overlap from left to right, whereby the bulk of insulating material is increased at the right hand end of the coil where the stress will be the greatest between the ends of the second and third layers of wire. The winding of the third layer of wire from left to right follows the winding of the second layer of paper in the same direction in accordance with the practice above described. When the second layer of paper has been completed the tape is again severed and fastened and no more tape is fed until after the completion of the third layer of wire, after which the tape is again fed and wound from right to left, and followed by the winding from right to left of the fourth layer of wire. In this way the coil is built up until the required size has been reached. When the coil is completed the end turns of the respective layers of paper will project beyond the end turns of the respective layers of wire. These projecting turns of paper may be left as they are or treated with solidifying compositions, or left untreated and crushed against the ends of the layers of wire. I should state in this connection that Fig. 2 of the drawings must be viewed as schematic in character, with the tape greatly exaggerated in thickness with regard to its width since it is not practical to represent the paper on the scale of its actual thinness.

The coil illustrated by Fig. 3 of the drawings has its layer-insulation produced by spirally winding thin, narrow tapes edge to edge without any overlap, and therefore without any differentiation in bulk. Also, the coil is provided at its respective ends with solid laminated end-closures built up by winding the same tapes turn upon turn or concentrically to the required height. It must be said, however, that the use of such end-closures is in no way limited to coils in which the tapes are wound edge to edge, nor, on the other hand, are tapes wound edge to edge in any way limited to use with solid laminated end-closures; the two features are independent of each other though well adapted to be used together.

In producing the specific coil shown by Fig. 3, I begin by winding the tape 7 turn upon turn upon the paper core 8 until the right hand end-closure 9 is built up to the height of the top of the second layer of wire. The tape is then severed and fastened. Beginning at the left, at the same time, though not necessarily concurrently, I wind the wire 10 to form the first layer of wire. When the wire reaches the inner face of the above described rudimentary right hand end-closure 9 and just before the second layer of wire is started from right to left, the tape is again inserted and spirally

wound edge to edge from right to left, proceeding in advance of the second layer of wire which is simultaneously wound in the same direction. The left hand end closure 11 is then begun by winding the tape turn upon turn to the height of the top of the third layer of wire, when the tape is again severed and fastened. Meanwhile the second layer of wire is wound on from right to left until it meets the rudimentary left hand end-closure 11, after which the third layer of wire is started from left to right. Just as the third layer of wire is started, the tape is fed again and spirally wound edge to edge in advance of the third layer of wire from left to right. Then when the tape completes the second layer of insulation and reaches the rudimentary right hand end-closure it is wound turn upon turn, and the right hand end-closure built up to the height of the top of the fourth layer of wire when the tape is again severed and fastened. These operations are continued in this order until the coil has been built up to the required diameter or until the predetermined number of turns or layers of wire and tape have entered into it. If preferred the alternate layers of wire and paper may be built up together and the end-closures wound on afterward, or the end-closures may be applied to the core before the wire and layer insulation is applied, but preferably the end-closures will be built up as the work of winding the layers of wire and paper progresses.

In the coil illustrated by Fig. 4 of the drawings, the paper-insulation is differentiated in bulk in accordance with the electrical stress between the layers of wire, not, as in Fig. 2, by a progressive overlapping of the edges of the tapes, but by doubling up the tapes, so to speak, so as to increase the bulk of insulation between the layers of wire where the electrical stress is localized. This principle may be worked out in different ways. As illustrated in Fig. 4, the wire 12 is wound on the paper core 13, beginning from left to right to form the first layer of wire. At the beginning of the winding of the second layer of wire which is wound from right to left, a tape 14 is inserted and wound spirally from right to left, with a uniform overlap until approximately the middle of the coil is reached, after which its winding pitch is changed so that from about the middle of the coil to the left hand end thereof, a double thickness of tape is wound on as shown in Fig. 4. When the left hand end of the coil is reached, the tape is severed and fastened upon itself. The second layer of wire progresses from right to left until it reaches the end of its traverse, when the third layer of wire is started from left to right. Now just as the third layer of wire is started winding from left to right, the tape is again fed into the coil and spirally wound with a uniform overlap until it reaches approximately the middle of the coil after which its winding pitch is changed so that it will be wound of double thickness until it reaches the right hand end of the coil, when the tape will be severed and fastened as before. Meanwhile the third layer of wire follows along from left to right until it reaches its limit of traverse, and is reversed to begin the fourth layer of wire, the layers of wire and tape following each other in the described alternation until the desired amount of wire and tape have been wound. As shown in Fig. 4, the overlapping of the tape at about the middle of the coil will be made slightly irregular, in shifting from one winding pitch to another.

It will be observed that by alternating the doubling of the tapes on opposite sides of the center of the coil as in Fig. 4, the localization of the electrical stress between the respective layers of wire is not only taken care of, but the coil is balanced as to bulk of paper on opposite sides of its center. Of course, this same principle might be utilized in winding any number of thicknesses; thus the tape might be wound for a given distance in two thicknesses, then in three thicknesses, and so on, as far as practical, but in any event the thicknesses would be balanced on the opposite sides of the center of the coil so as to preserve the symmetry thereof.

It is apparent that the tapes on account of their narrowness and thinness have a greater binding effect both as to the wires and as to each other than can possibly be secured when sheets of paper extending throughout the entire length of the coil are employed. It is also apparent that the end-closures of Fig. 3 may be applied to the coils of Figs. 2 and 4.

I claim:—

A method of producing an electrical coil, consisting in alternately winding, one upon the other, layers of wire and thin narrow tapes of insulating material, the tapes being spirally wound and progressively overlapped, and in winding the tapes concentrically at the ends of the said layers to form solid end-closures.

In testimony whereof, I have signed this specification in the presence of two subscribing witnesses.

CHARLES R. UNDERHILL.

Witnesses:
GEORGE D. SEYMOUR.
CLARA L. WEED.