J. J. FRANK & W. O. DWYER.

ELECTRICAL WINDING.

APPLICATION FILED MAR. 27, 1917.

1,253,166.

Patented Jan. 8, 1918.

Fig. 1.

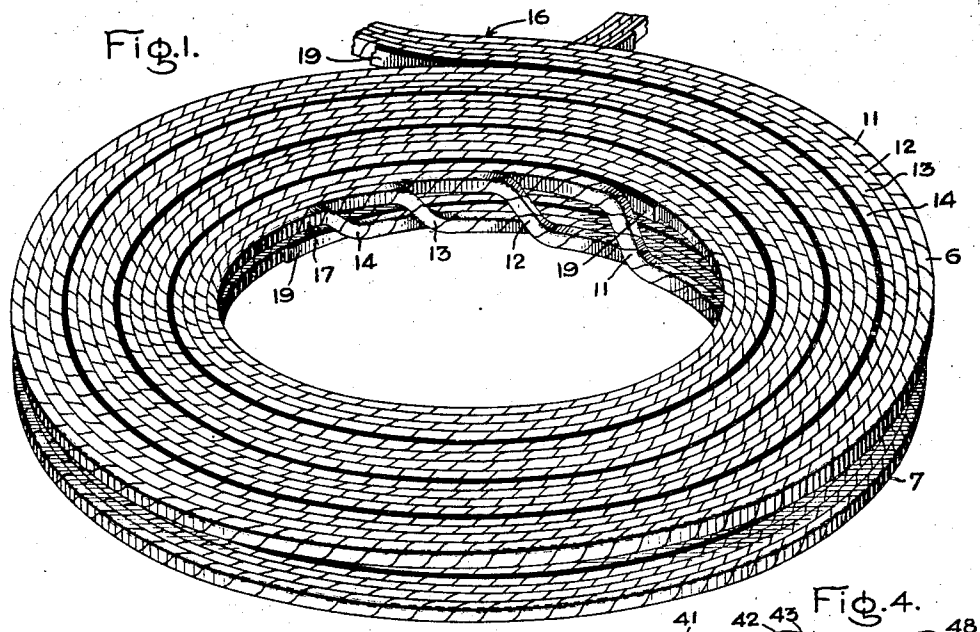


Fig. 2.

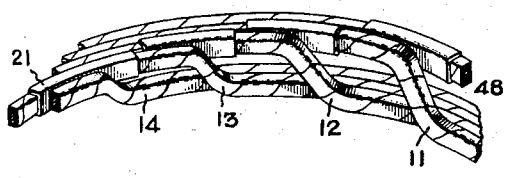


Fig. 4.

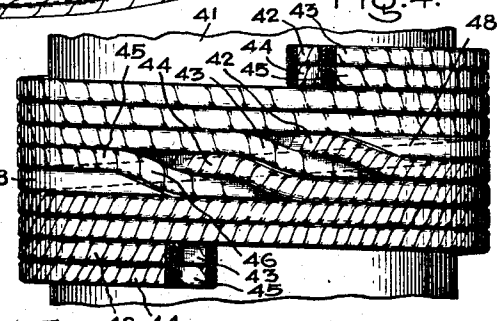
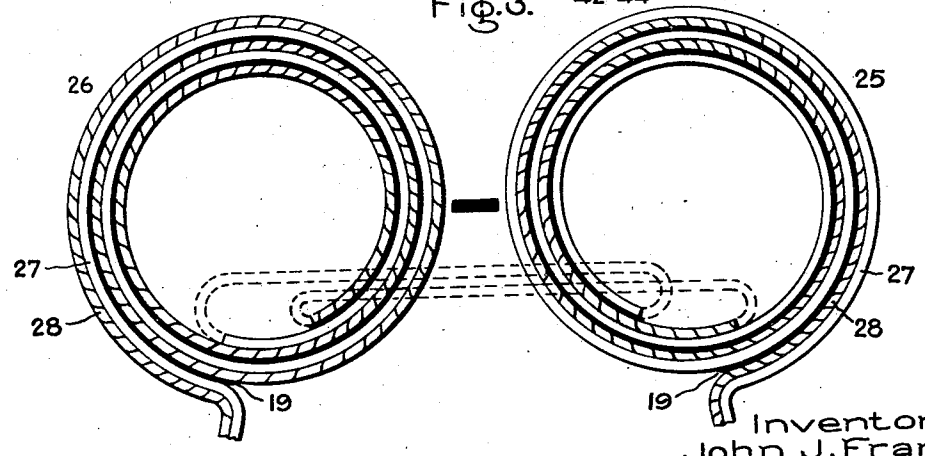


Fig. 3.



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UNITED STATES PATENT OFFICE.

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ELECTRICAL WINDING.

1,253,166. Specification of Letters Patent. Patented Jan. 8, 1918.

Application filed March 27, 1917. Serial No. 157,860.

To all whom it may concern:

Be it known that we, JOHN J. FRANK, a citizen of the United States, and WILLIAM O. DWYER, a subject of the King of Great Britain, residents of Pittsfield, in the county of Berkshire, State of Massachusetts, have invented certain new and useful Improvements in Electrical Windings, of which the following is a specification.

Our invention relates to electrical windings comprising interwound multiple conductors or conductors connected in parallel; it relates particularly to disk coil windings, the coils being circular or of any other shape, wherein each coil is made up of multiple conductors. An object of our invention is to provide an improved construction of the multiple conductor type wherein the conductors are transposed relatively to each other with the sacrifice of minimum winding space and with minimum distortion of the winding. Multiple conductors are quite commonly transposed in order that they may divide the total current something like equally among themselves.

Heretofore multiple conductors have been transposed in various ways one or more times throughout a winding, thereby reversing the positions of the conductors relatively to themselves, probably most commonly by simultaneously twisting all of the conductors as a unit through 180° at the points of transposition. By our invention we accomplish substantially the same result. However, when the conductors are twisted according to this common prior practice there appears one or more undesirable features, such as: a considerable waste of winding space, a misshapen structure resulting in decreased mechanical strength and unbalanced resistance of the conductors to the electrical stresses of attraction and repulsion, etc. By our invention these undesirable features are eliminated.

According to our invention, the multiple conductors enter each layer, coil or winding at substantially the same point, and where it is desirable to transpose the conductors the respective conductors are crossed over from one turn into the adjacent turn individually, the cross-over of each conductor preferably beginning substantially adjacent the end of the cross-over of the immediately preceding cross-over and ending substantially immediately adjacent the beginning of the next succeeding cross-over so far as there are preceding and succeeding cross-overs; the conductors changing positions at the cross-overs. With such an arrangement of cross-overs the conductors are readily, almost naturally, transposed or reversed relatively to each other. The turns between which the transpositions are made, may or may not be in different coils or layers of the winding. Additional insulation may be added adjacent the cross-overs if desired to forestall or negative the destruction of insulation likely to occur during the construction of the cross-overs.

In accompanying drawings and the following detailed description we have illustrated and described some preferred embodiments of our invention. Figure 1 is a perspective view of two disk coils embodying our invention. Fig. 2 is a perspective view of the portions of two disk coils immediately embodying our invention in a slightly modified form. Fig. 3 is a diagrammatic view of two disk coils of unequal numbers of turns of the respective conductors to which our invention has been applied. Fig. 4 is a perspective view of a portion of a single cylindrical coil in which four multiple conductors are transposed in accordance with our invention.

In Fig. 1 is illustrated two disk coils 6 and 7 about substantially the same winding axis and in substantially parallel planes. Each coil comprises four conductors 11, 12, 13 and 14. The conductors enter the coil 6 at substantially the same point 16 in the outer circumference of the coil 6, progressing together in a fixed relation to each other from the point 16 to substantially adjacent the point 17 in the last turn at the inner circumference of the coil, the conductors being disposed radially one outside the next. The conductors 11, 12, 13 and 14 are multiple conductors, that is, are adapted to be connected in parallel and divide the total current among themselves. The adjacent turns of the multiple conductors about the winding axis are separated from each other by the layer insulation 19.

Adjacent point 17 on the inner circumference of the coil 6 the conductors begin their cross-overs into the inner turn of the coil 7. The innermost or exposed conductor 14 first and alone crosses into the adjacent or inner turn of the other coil 7. The manner in which this cross-over is made is quite apparent from the drawing; the conductor 14, in leaving the coil 6, is first bent toward the plane of the coil 7, and as it reaches the plane of this coil is bent into the plane of this coil 7, and then continued in its progress about the winding axis, preferably gradually receding from the winding axis to give place for the conductor 13 within it or between it and the winding axis. After the beginning of the cross-over of the conductor 14, the conductor 13, still in the coil 6 and now the exposed conductor, preferably continues to approach the winding axis. The cross-over of the conductor 13 is angularly displaced from the point of the cross-over of the conductor 14 and begins substantially immediately adjacent the completion of the cross-over of the conductor 14 as appears from Fig. 1. The conductor 13, like conductor 14, is first directed from the plane of the coil 6 toward the plane of the coil 7, and finally bent again into the plane of the coil 7. The conductor 13, however, in the coil 7 covers the conductor 14 which first crossed into the coil 7, or is located radially within the conductor 14. In the coil 7 the conductor 13, like the conductor 14, preferably recedes from the winding axis to give place for the conductor 12. The conductor 12 crosses into the coil 7 in the same manner, like the preceding conductors beginning its cross-over substantially immediately adjacent the cross-over of the conductor 13. Likewise, substantially immediately adjacent the cross-over of the conductor 12, the conductor 11 is crossed over in a like manner. It will appear that the complete cross-over from the coil 6 to the coil 7, and the transposition of the conductors relative to themselves or the reversal of the position of the conductors, have been accomplished with little distortion of the entire winding and with an exceedingly small, or no, waste of winding space. In the coil 7 layer insulation 19 is employed in the same manner as in coil 6. The conductors may leave the coil 7 at a single point in the same manner as they enter the coil 6. Obviously a complete electrical winding may comprise as many disk coils like those shown in Fig. 1 as may be necessary, and as many cross-overs of the sort we have illustrated and described may be employed as may be desired or necessary; also other types of cross-overs may be employed between other coils of a winding comprising the coils 6 and 7. It will be understood that we have illustrated only two disk coils because only this number of disk coils are necessary to completely describe the cross-overs and transposition of our invention.

In making the cross-overs of the individual turns it may be found that the insulation of the conductors adjacent the cross-overs of other conductors is abraded or worn by the workman in bending the conductors into the forms desired. This may be taken care of by increasing the insulation locally on the conductors adjacent cross-overs of other conductors. In Fig. 2 we have illustrated a preferred form of this. For example, adjacent the cross-over of conductor 14, the conductor 13 is provided with a channel piece 21 of any suitable insulating material which is slipped over the conductor 13 to take the wear adjacent the cross-over of conductor 14.

Fig. 3 illustrates our invention applied to the case where a part of all the multiple conductors makes more turns in any one coil than the remainder of the conductors. The figure is drawn on a plan different from that of the preceding figures and may illustrate the scheme for crossing over the conductors individually somewhat more clearly. The two coils 25 and 26 are like the coils 6 and 7 of Fig. 1, except that the coils 25 and 26 comprise but two conductors, 27 and 28, instead of four, and except that the respective conductors make different numbers of turns in any one coil. Layer insulation 19 is provided between adjacent turns as before. The conductors 27 and 28 of coils 25 and 26 are differently marked in the drawing, in order that their relations may appear more clearly. The conductor 27 makes three turns in the coil 25 and two turns in the coil 26, and the conductor 28 makes two turns in the coil 25 and three turns in the coil 26. Coils 25 and 26 have been cut apart adjacent the cross-covers and slipped apart perpendicularly to their winding axis; in other words, the coils have been separated from each other but continued in their original planes. The dotted lines indicate the original connections between the two coils. At the inner circumference of the coils, the exposed or inner conductor (although in this case it is also the exposed conductor on the outer circumference of the same coil) leaves that coil first and becomes the second conductor from the inner circumference of the adjacent coil. Likewise the second conductor from the inner circumference of the first coil leaves that coil after the exposed conductor and becomes the inner or exposed conductor of the adjacent coil.

In Fig. 4 our invention is shown applied to a single cylindrical coil. This coil is wound on the form or carrier 41 and comprises four conductors adapted to be connected in multiple. Each turn of the coil

comprises two pairs of conductors disposed side by side. One of these pairs comprises the conductors 42 and 43 disposed radially one above the other, the other pair comprising the conductors 44 and 45 likewise disposed one above the other. The conductors 42 and 44 have been shaded somewhat more heavily than the conductors 43 and 45 in order that the transposition and the effect of the transposition may be more readily apparent. From the beginning of the winding at the upper end of the coil the four conductors continue in their original relations to each other to substantially the middle of the length of the coil. Adjacent the point 46 the conductor 45 is abruptly bent axially into the position of the next succeeding turn as illustrated, its companion conductor 44 and the conductors 42 and 43 continuing for a short distance farther in their respective original positions in the length of the coil. During its cross-over the conductor 45 is displaced radially from outside the conductor 44 to the surface of the form or carrier 41. Substantially immediately after the completion of the cross-over of the conductor 45, the conductor 44 is crossed over, likewise abruptly, to outside the conductor 45. The conductors 44 and 45, as a result, have been transposed with respect to each other and have been abruptly advanced the width of one conductor in the direction of the axis of the coil; this appears clearly from the drawing. Closely after the cross-over of the conductor 44, the conductor 43 of the other pair is abruptly advanced the distance of the width of one conductor along the axis of the coil and brought down from outside the conductor 42 to the surface of the form 41. Likewise substantially immediately thereafter the conductor 42 is advanced the distance of the width of one conductor and in this distance is brought outside the companion conductor 43. The conductors 42 and 43 have therefore likewise been transposed relatively to each other. In accomplishing this cross-over and transposition of conductors a space has been left in the winding, which in the direction of the axis of the coil is of a width substantially equal to the width of one conductor. This space is preferably filled by a ring 48 of any suitable material, for example, pressboard, if desirable similar fillers may be inserted in any other small spaces there may be left, as between the cross-overs of the two pairs of conductors. The dashed lines in the center of the figure illustrate something of the course of the filler 48 at the side of the coil opposite that illustrated in Fig. 4. It will be observed that the winding is of no greater thickness in the space occupied by the cross-overs than elsewhere in the coil.

While we have described the principle of our invention and the best mode we have contemplated for embodying this principle, other modifications will occur to those skilled in this art, and we aim in the appended claims to cover all modifications which do not involve a departure from the spirit and scope of our invention.

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

1. Two connected disk coils about the same axis, each comprising a plurality of multiple conductors disposed radially one outside the next, the conductors entering one coil at substantially the same point on one circumference thereof and progressing together from that point to the last turn at the opposite circumference of that coil, the exposed conductor of said last turn crossing individually into the adjacent turn of the other coil, the adjacent conductor crossing individually into said other coil substantially immediately adjacent the completion of the crossover of the said exposed turn and, in said other coil, covering the first conductor to cross-over, the conductors continuing in such changed relative positions through said other coil.

2. Two connected coils, each comprising a plurality of multiple conductors, the conductors entering one coil at substantially the same point thereof and progressing together from that point to the last turn of that coil, one of the conductors of said last turn crossing individually into the other coil, an adjacent conductor crossing individually into said other coil substantially immediately adjacent the completion of the first mentioned cross-over, said two conductors changing their relative positions between said cross-overs and continuing in such changed relative positions through said other coil.

3. An electrical winding comprising a plurality of multiple conductors, the conductors entering said winding at substantially the same point thereof and progressing together from that point to a point of transposition, one of said conductors crossing individually adjacent thereto into an adjacent turn, an adjacent conductor crossing individually into said other turn substantially immediately adjacent the cross-over of said first mentioned conductor, said conductors changing their relative positions between such cross-overs and continuing in such changed relative positions from said point of transposition.

4. An electrical winding comprising a plurality of multiple conductors, the conductors entering said winding at substantially the same point thereof and progressing together from that point to a point of transposition, one of said conductors crossing individually adjacent thereto into an ad-

jacent turn, an adjacent conductor crossing individually into said other turn substantially immediately adjacent the cross-over of said first mentioned conductor, said conductors changing their relative positions between such cross-overs and continuing in such changed relative positions from said point of transposition, portions of the conductors at the sides of the cross-overs being extra heavily insulated.

In witness whereof, we have hereunto set our hands this 23rd day of March, 1917.

JOHN J. FRANK.
WILLIAM O. DWYER.