United States Patent [19]

Meyer

[11] **3,781,739**

[45] **Dec. 25, 1973**

[54] **INTERLEAVED WINDING FOR ELECTRICAL INDUCTIVE APPARATUS**

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[73] Assignee: **Westinghouse Electric Corporation,** Pittsburgh, Pa.

[22] Filed: **Mar. 28, 1973**

[21] Appl. No.: **345,813**

[52] **U.S. Cl.** **336/70,** 29/605, 336/187

[51] **Int. Cl.** **H01f 15/14**

[58] **Field of Search** 336/69, 70, 186, 336/187; 29/605

[56] **References Cited**

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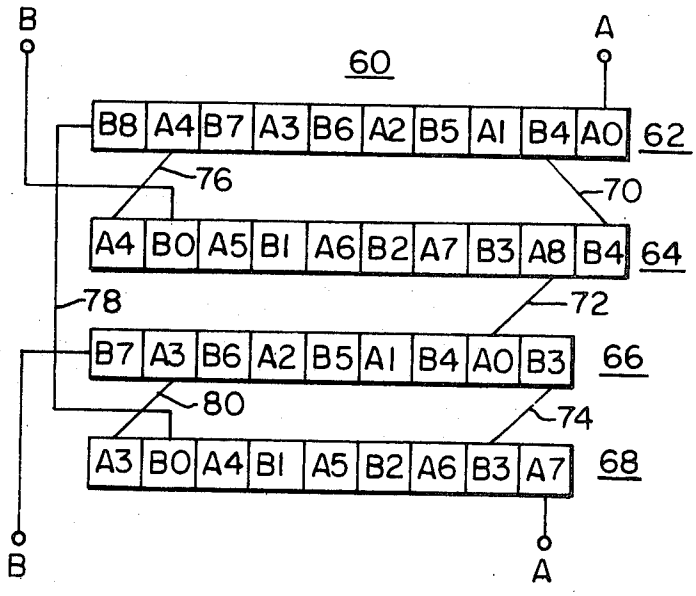
Primary Examiner—Thomas J. Kozma

Attorney—C. L. McHale et al.

[57] **ABSTRACT**

A transformer winding with coil disc sections having an odd number of conductor-turns per section. During construction, one section is wound with a pair of conductors to provide one less conductor-turn that is desired in that section. Another section is similarly wound with the same pair of conductors to provide one less conductor-turn than is desired. One of the conductors is then crossed-over to the previously wound section so that one conductor may be wound around each section for one additional turn. A splice joint in the previously wound section connects the conductor wound thereon to the proper conductor-turn.

4 Claims, 12 Drawing Figures



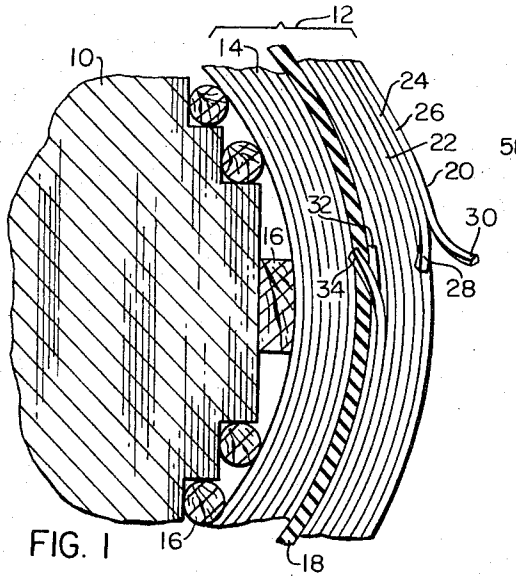
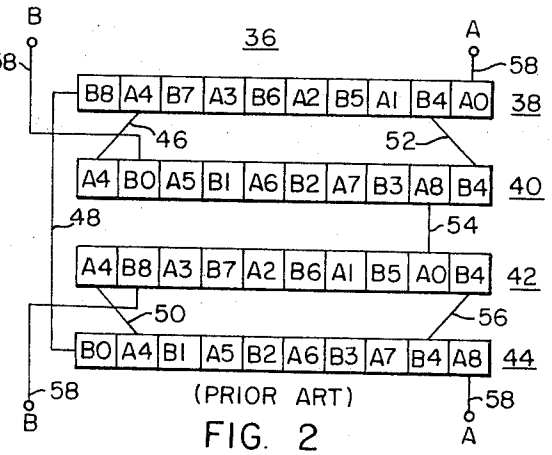


FIG. 1



(PRIOR ART)

FIG. 2

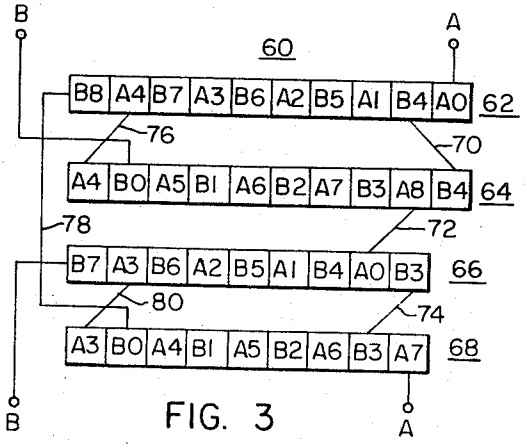


FIG. 3

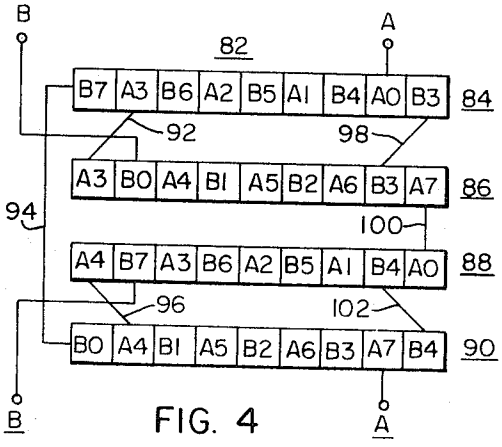


FIG. 4

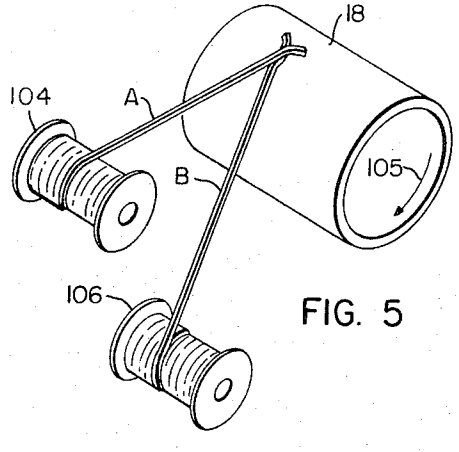


FIG. 5

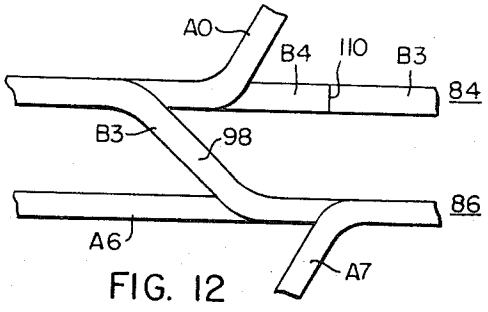


FIG. 12

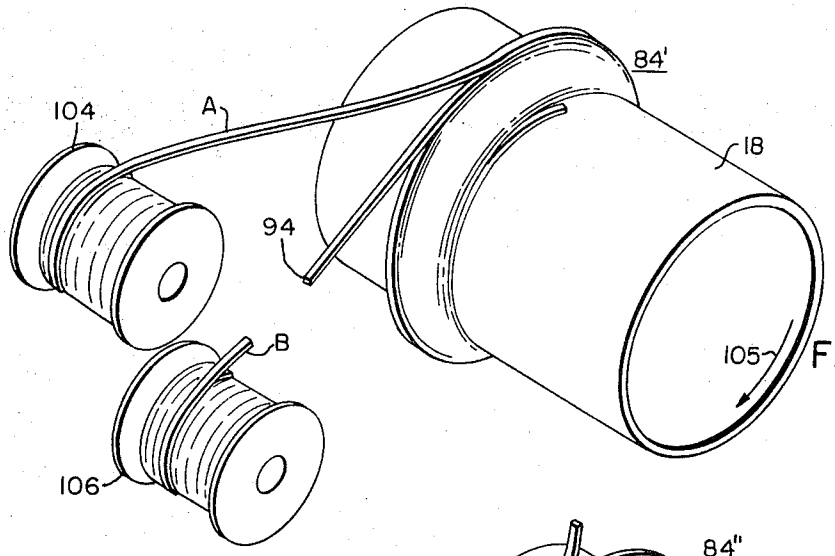


FIG. 6

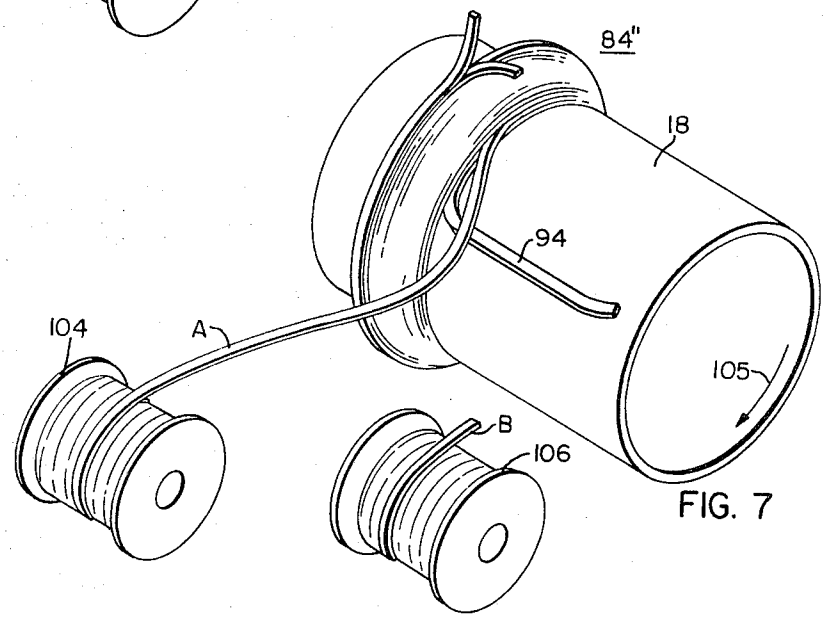


FIG. 7

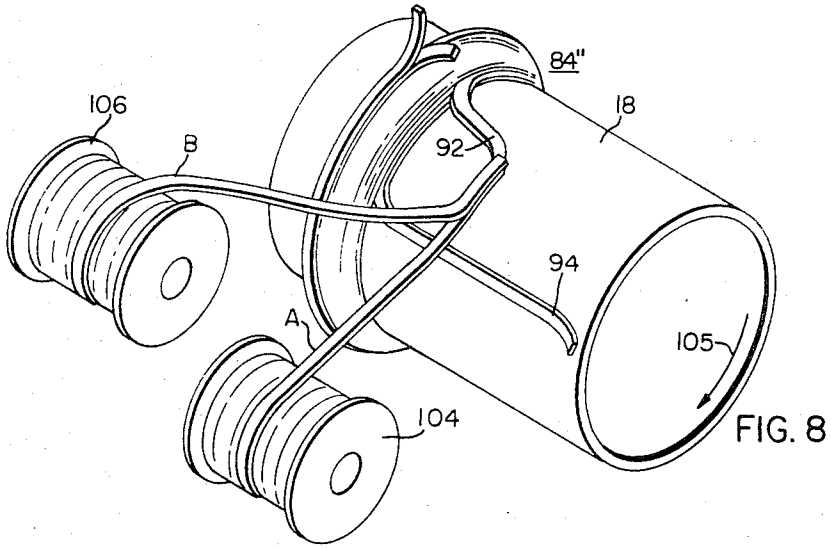


FIG. 8

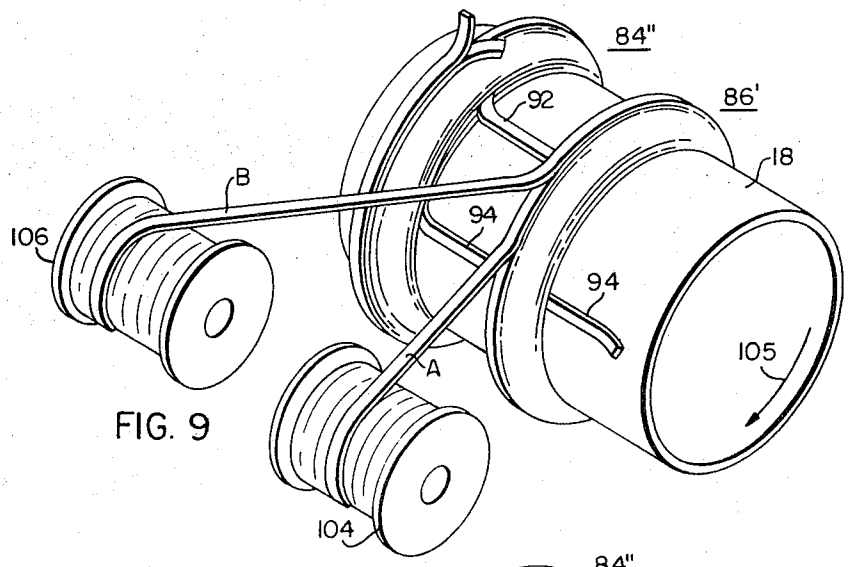


FIG. 9

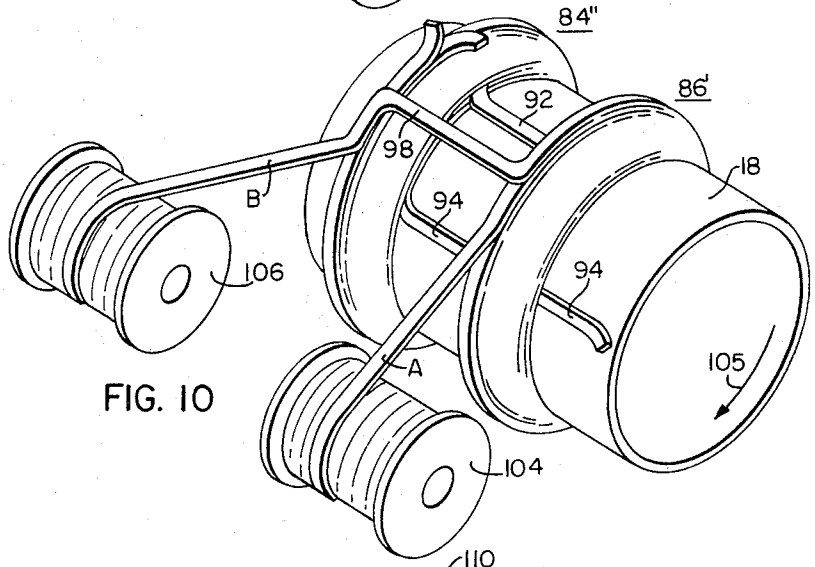


FIG. 10

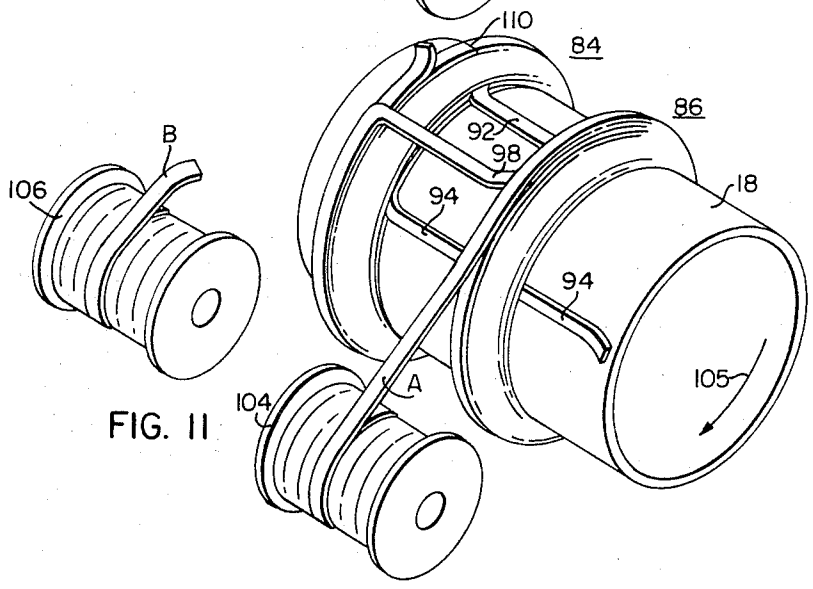


FIG. 11

INTERLEAVED WINDING FOR ELECTRICAL INDUCTIVE APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates, in general, to electrical inductive apparatus and, more specifically, to interleaved windings for power transformers.

2. Description of the Prior Art

Interleaving the conductors of windings for power transformers is very useful for improving the surge voltage characeristics of the winding. One type of interleaved winding is the two-conductor mutually twin interleaved winding. In this type of winding, two conductors provide conduction paths which are interleaved through two coil disc sections. The interleaving pattern is repeated in each pair of disc sections.

The conductors of the twin interleaved winding are wound together since they parallel each other throughout the winding. Since the conductors are wound together, and since each revolution of the winding tube during the winding process increases the number of conductor-turns in the disc section by two, such windings are limited to coil disc sections having an even number of conductor-turns.

It is desirable, for several reasons, to be able to wind interleaved coil disc sections having an odd number of conductor-turns therein. The number of conductor-turns between tap positions is usually determined by the transformer design. If an even number of conductor-turns is necessary for proper tapping between the disc sections, one section must have more turns than the other section according to the prior art. For example, if the total number of conductor-turns for two sections must be 30, one section must have 16 conductor-turns and the other section must have 14 conductor-turns.

Variations in the radial build of disc sections presents winding problems, reduces the mechanical strength of the winding structure, affects the impedance of the transformer, and provides other detrimental effects. Therefore, it is desirable, and it is an object of this invention, to provide a conveniently-wound twin interleaved winding which has an odd number of conductor-turns per coil disc section.

SUMMARY OF THE INVENTION

There is disclosed herein a new and useful interleaved transformer winding with coil disc sections having an odd number of conductor-turns and a method of constructing same. The winding includes two conductors which are spirally wound through each coil disc section of the winding. The two conductors are first wound simultaneously to form one disc section having an even number of conductor turns. The two conductors are also wound simultaneously to form another disc section having an even number of conductor-turns. One of the conductors is crossed-over to the previously wound section and both sections are wound with one more turn of the conductor thereon. The conductor around the previously wound section is cut and joined to one of the conductor-turns of that section. With the use of this invention, coil disc sections may be provided which have an odd number of conductor-turns per section. The disc sections are provided without complicated winding procedures or an excessive number of conductor splices.

BRIEF DESCRIPTION OF THE DRAWING

Further advantages and uses of this invention will become more apparent when considered in view of the following detailed description and drawing, in which:

FIG. 1 is a partial view of a transformer core having a coil disc section disposed therearound;

FIG. 2 is a schematic diagram of an interleaved winding constructed according to the prior art with each section having an even number of conductor-turns;

FIG. 3 is a schematic diagram of an interleaved winding constructed according to one embodiment of this invention;

FIG. 4 is a schematic diagram of an interleaved winding constructed according to another embodiment of this invention;

FIGS. 5 through 11 are views illustrating steps performed in winding a pair of coil disc sections according to this invention; and

FIG. 12 is a partial view of the outer turns of a pair of coil disc sections constructed according to this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following description, similar reference characters refer to similar elements or members in all the figures of the drawing.

Referring now to the drawing, and to FIG. 1 in particular, there is shown a section of a transformer core **10** with a winding structure **12** disposed thereon. The winding structure **12** includes the low-voltage winding **14** which is supported from the core **10** by the spacers **16,** a winding tube **18,** and a high-voltage winding **20** which is wound around the winding tube **18.**

FIG. 1 illustrates one coil disc section **22** of the winding **20.** The disc section **22** is formed by strap conductors **24** and **26** which are disposed radially adjacent to each other throughout the disc section **22.** The finish ends **28** and **30** of the conductors **24** and **26** are located on the outside of the disc section **22.** The start ends **32** and **34** of the conductors **24** and **26** are located on the inside of the disc section **22.** This invention relates to the arrangement of the conductors in disc sections such as section **22,** and to the method of winding such sections.

FIG. 2 illustrates schematically an interleaved winding structure **36** having at least four coil disc sections **38, 40, 42** and **44.** Start-start connections **46, 48** and **50** and finish-finish connections **52, 54** and **56** interconnect the various coil disc sections. Line leads **58** may be appropriately connected to other disc sections or to the line terminals of the winding **36.**

The winding **36** is formed from conductors A and B which are wound together as a conductor pair. Each conductor-turn in FIG. 2 is denoted by a letter and number. The letter represents the conductor which forms the conductor-turn, and the number represents the number of electrical turns, and hence the relative voltage, between the conductor-turns of both conductors.

By conventional representation, FIG. 2 illustrates the start and finish ends of the conductors. Thus, in each coil disc section, there is illustrated two more conductor-turns than the number of actual electrical turns of each conductor in the section. In each coil disc section of FIG. 2, there are electrically four turns each com-

prising two conductors. This type of representation will also be used in describing and claiming the embodiments of this invention.

According to the prior art, disc sections interleaved in the manner illustrated in FIG. 2 have contained an even number of conductor-turns. FIG. 2 illustrates ten conductor-turns per section. Since the conductors A and B are always wound together according to the prior art, variations in the radial build of a section could only be accomplished in intervals of two conductors. Without excessive splices or joints in the conductors A and B, an odd number of conductor-turns could not be wound into the coil disc sections according to the prior art.

FIG. 3 represents schematically an interleaved winding 60 having disc sections with both an even and an odd number of conductor-turns. Coil disc sections 62 and 64 contain an even number of conductor-turns and coil disc sections 66 and 68 contain an odd number of conductor-turns. The finish-finish connections 70, 72 and 74 are made by a continuous conductor and without any splices or joints between the disc sections. The finish-finish connections 70, 72 and 74, together with the start-start connections 76, 78 and 80, provide the same type of interleaving of the conductors as exists in the winding 36 shown in FIG. 2.

FIG. 4 represents schematically an interleaved winding 82 in which the coil disc sections 84, 86, 88 and 90 each contain an odd number of conductor-turns. Development, or progression, of the conduction paths provided by conductors A and B can be determined by following the letter-number designators for each conductor-turn. The start-start connections 92, 94 and 96 the finish-finish connections 98, 100 and 102 provide the same type of interleaving as shown in FIG. 2, but with an odd number of conductor-turns per coil disc section.

Other winding arrangements using the teachings of this invention are possible and are within the contemplation of this invention. In addition, the conduction paths furnished by the conductors A and B are normally connected together at the ends of the winding to effectively place the paths in parallel.

FIGS. 5 through 11 illustrate steps performed in the construction of a pair of coil disc sections having an odd numer of conductor-turns therein. For convenience in indicating the position of the conductors in the disc sections, the sections wound in the illustrations of FIGS. 5 through 11 generally represent the coil disc sections 84 and 86 shown in FIG. 4.

As shown in FIG. 5, the conductors A and B are pulled from the spools 104 and 106, respectively. Conductor B is positioned on the winding tube 18 beneath conductor A. Suitable clamping means, which are not illustrated, may be used to secure the conductors to the winding tube 18. When winding other than the first coil disc section onto the winding tube 18, clamping means may not be required since at least one of the conductors will be attached to the previously wound section. Normally, a portion of at least one conductor from a previously wound disc section is positioned under the conductors A and B for later connection to a coil disc section which is to be formed by the conductors. However, this conductor connection is not illustrated for clarity of the figures.

The winding tube 18 is rotated in the direction indicated by the arrow 105 a sufficient number of times to provide one less radially disposed conductor-turn than is desired in the finished section 84. The winding tube 18 would be rotated three times for the coil disc section 84. FIG. 6 illustrates the partially wound disc section 84'. Conductor B is cut and the connection 94 is properly shaped for splicing to another conductor-turn developed later in the construction process.

The "pre-wound" coil disc section 84' is then broken down and "hand-wound" into section 84'' as shown in FIG. 7. This procedure inverts the coil, or places the last wound conductor-turns near the inside of the section 84''.

Conductor A is then moved to the position where the next coil disc section is to be wound as shown in FIG. 8. This also forms the start-start connection 92. Conductor B is positioned on top of conductor A and is normally connected to the conductor connection which was not illustrated in the interest of clarity. The winding tube 18 is then rotated to wind the conductors into coil disc section 86' as shown in FIG. 9. As with the winding of section 84', the winding tube 18 would be rotated a sufficient number of times to provide one conductor turn less than the number of conductor-turns desired in the finished section 86. In this specific embodiment of the invention, the winding tube 18 would be rotated three times in the direction indicated by the arrow 105.

The conductor B is then crossed-over onto section 84'' as shown in FIG. 10. This procedure establishes the finish-finish connection 98. The winding tube 18 is then rotated one more turn in the direction 105 to wind the conductor B one conductor-turn around the coil disc section 84'' and the conductor A one conductor-turn around the coil disc section 86'. The result is illustrated in FIG. 11. Conductor B is cut and the end thereof is spliced or joined to the next conductor-turn of conductor B at position 110. This completes the conduction path through the coil disc sections 84 and 86 of conductor B. The spacing of the sections 84 and 86 is exaggerated in FIG. 11 to show the interconnections. Normally, section 86 is wound closer to section 84 and is separated therefrom by pressboard radial spacers.

FIG. 12 is a partial view of the outer conductor-turns of the coil disc sections 84 and 86. The conductor-turns are labeled with the corresponding characters shown in FIG. 4. The conductor-turns B3 and B4 are joined together at position 110 by a suitable welding or brazing operation. The conductor-turns B3 and B4 may be overlapped for a short distance to facilitate the joining operation.

Transformer windings constructed according to this invention, preferred embodiments of which are disclosed herein, conveniently contain an odd number of conductor-turns in their coil disc sections. Since numerous changes may be made in the above-described apparatus and method, and since different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all of the matter contained in the foregoing description or shown in the accompanying drawing, shall be interpreted as illustrative rather than limiting.

I claim as my invention:

1. A winding for electrical inductive apparatus, comprising:

first and second electrical conductors;

at least first and second coil disc sections each disposed at different axial positions in the winding,

each of said coil disc sections having a plurality of radially disposed turns of said conductors forming conductor-turns with each of said coil disc sections having an odd number of total conductor-turns,

start and finish conductor-turns in said first coil disc section formed by the same conductor in that section;

start and finish conductor-turns in said second coil disc section formed by the same conductor in that section;

start-start and finish-finish connections which interconnect said coil disc sections; and

a conductor-turn connection joint which connects together the finish conductor-turn of one of said coil disc sections with the next conductor-turn of the same conductor in the same coil disc section.

2. The winding of claim **1** wherein the first and second electrical conductors are interleaved to form first and second conduction paths, respectively;

said first conduction path progressing in a first radial direction through the first coil disc section, then in a second radial direction through the second coil disc section;

said second conduction path progressing in the second radial direction through the second coil disc section, then in the first radial direction through the first coil disc section;

said first radial direction being opposite to said second radial direction.

3. A method of providing an odd number of conductor-turns in first and second interleaved coil disc sections of a transformer winding, comprising the steps of:

winding each first and second coil disc section with an even number of conductor-turns from first and second conductors disposed radially adjacent to each other;

moving the second conductor from the second to the first coil disc section; and

winding substantially one additional turn of the second conductor around the first coil disc section and the first conductor around the second coil disc section.

4. A method of constructing an interleaved winding, comprising the steps of:

positioning a first conductor on a winding tube;

positioning a second conductor on top of the first conductor;

rotating the winding tube an even number of times to form a first coil disc section;

separating the second conductor from the first coil disc section;

breaking down and hand-winding the first coil disc section;

placing the second conductor over the first conductor and rotating the winding tube an even number of times to form a second coil disc section;

moving the second conductor to the outside of the first coil disc section;

rotating the winding tube substantially one additional turn to wind one conductor on each coil disc section;

separating the second conductor from the last conductor-turn of the first coil disc section; and

joining together the last conductor-turn of the first coil disc section and the next conductor-turn of the second conductor in the first coil disc section.

* * * * *