United States Patent

Johnston et al.

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[45] **Mar. 28, 1972**

[54] TELESCOPED ELECTRICAL WINDINGS AND METHOD OF MAKING SAME

[72] Inventors: **Ralph W. Johnston**, Sharon; **Donald S. Stephens**, Sharpsville; **Robert W. Miller**, Grove City; **Clarence W. Hunt**, Transfer; **Frank J. Klecic**, Sharon, all of Pa.

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

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[52] **U.S. Cl.**.....**336/170**, 29/605, 336/185, 336/208, 336/220, 336/192

[51] **Int. Cl.**.....**H01f 27/30**

[58] **Field of Search**.....336/170, 185, 208, 220, 182; 29/605

[56] **References Cited**

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Primary Examiner—E. A. Goldberg

Attorney—A. T. Stratton, C. L. Freedman and D. R. Lackey

[57] **ABSTRACT**

An electrical winding structure having first and second concentrically disposed, radially adjacent bobbins, each having at least one electrical coil wound thereon. The outer bobbin provides layer insulation between the coils disposed on the bobbins. A method of constructing the winding is disclosed which includes the steps of winding coils on first and second bobbins, telescoping the first bobbin into an opening in the second bobbin, against a stop, and securing a retainer cap to an end of the second bobbin, to retain the first bobbin in assembled relation with the second bobbin, between the retainer cap and stop.

13 Claims, 6 Drawing Figures

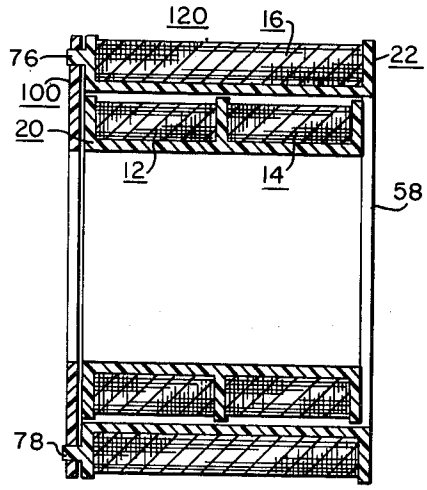


FIG. 2

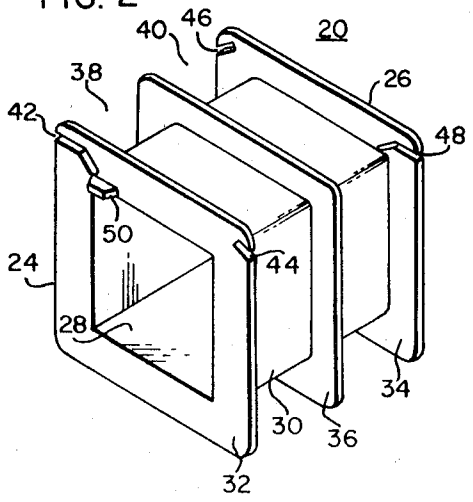
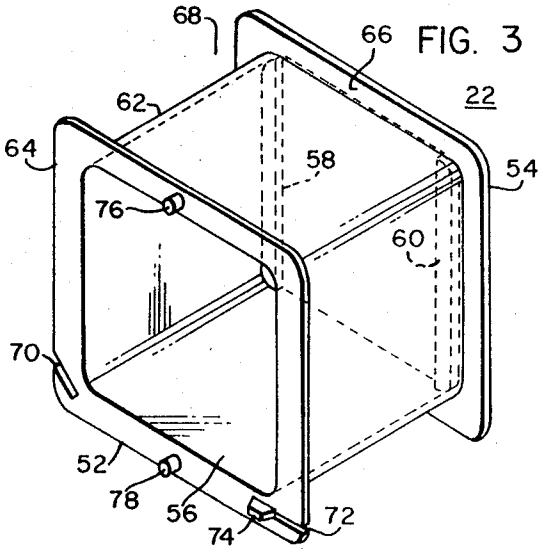


FIG. 3



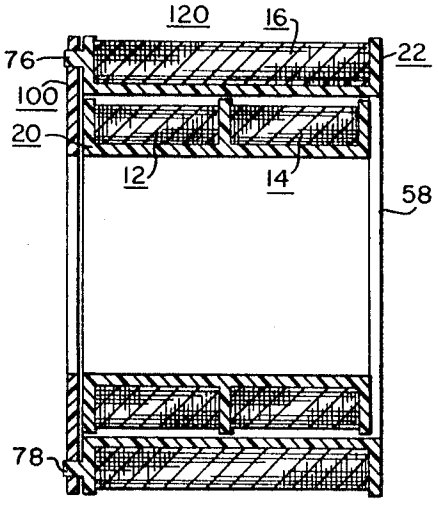


FIG. 6

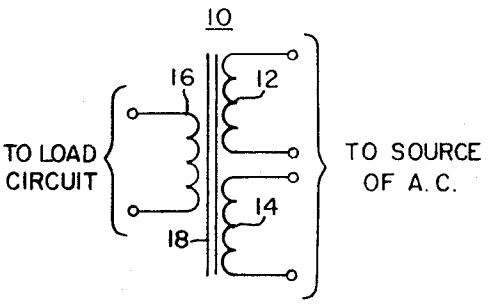


FIG. 1

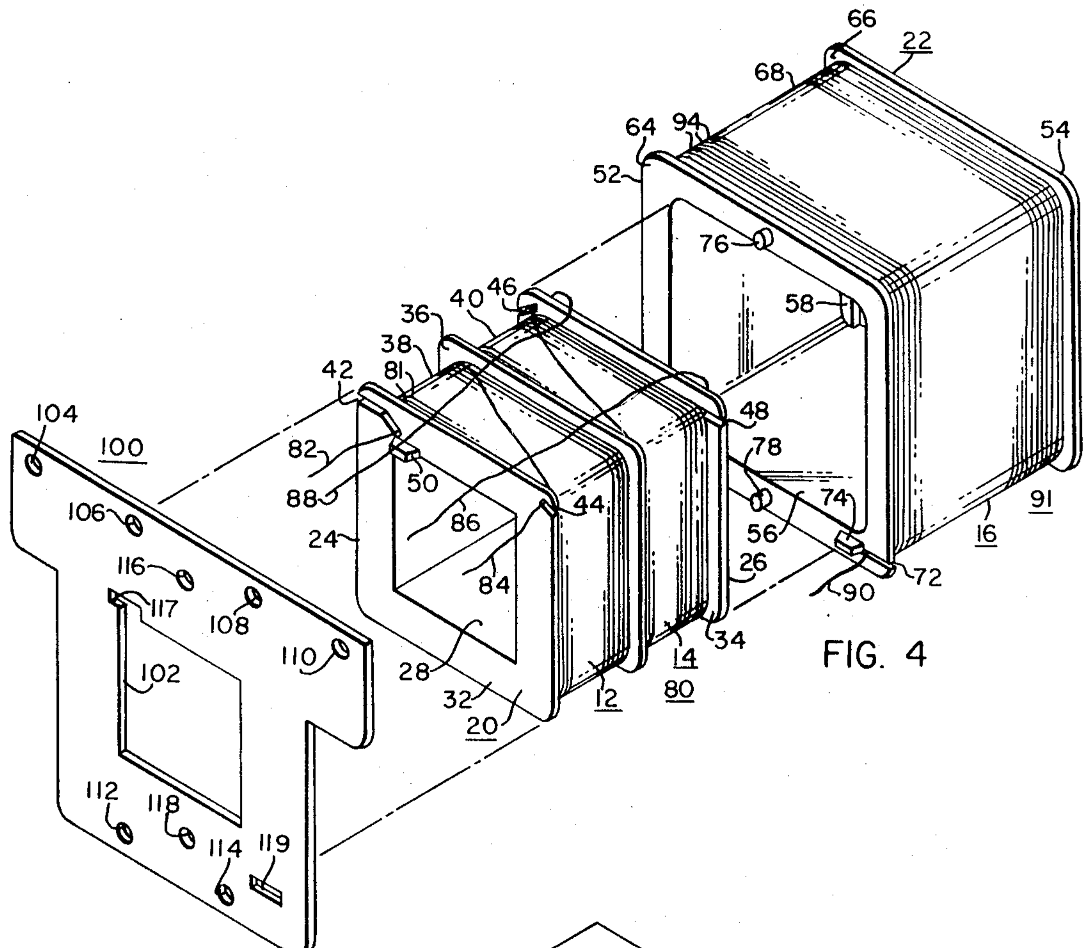

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FIG. 4

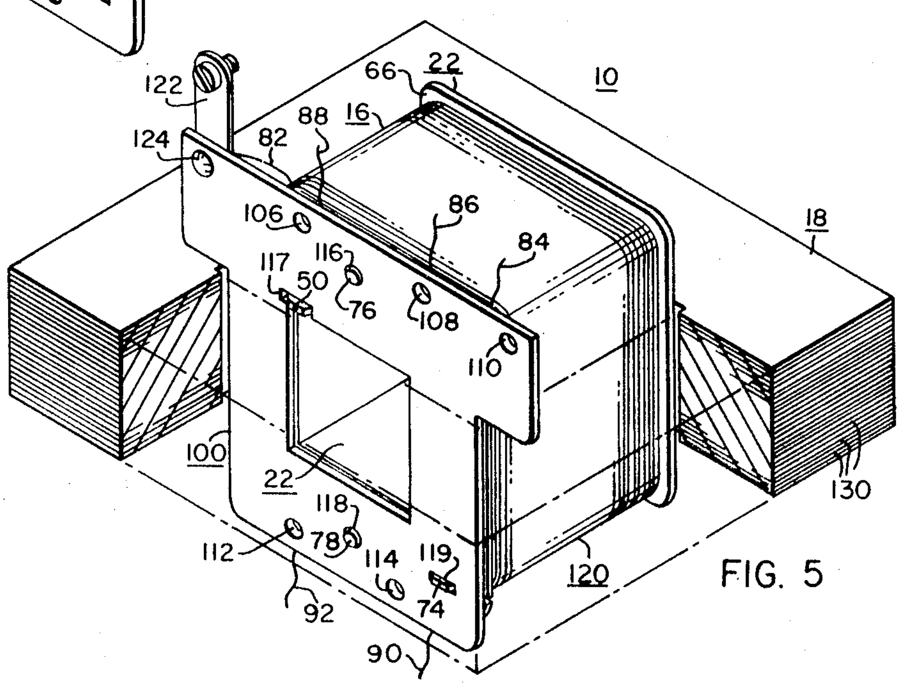
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FIG. 5

ELECTRICAL WINDINGS AND METHOD OF MAKING SAME TELESCOPED

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates in general to electrical transformers, and more specifically to new and improved arrangements and methods for providing electrical windings therefor.

2. Description of the Prior Art

Certain types of electrical winding assemblies, such as winding assemblies for electrical transformers commonly used for control purposes, are progressively wound. The plurality of coils which make up the primary or high voltage winding, and the secondary or low voltage winding, are concentrically and radially disposed, by winding a coil on an insulating bobbin, and taping the outer surface of the coil with an insulating tape to provide layer insulation, winding a second coil over the first coil, and taping the outer surface of the second coil, and repeating the steps of winding coils and hand taping the outer surfaces of the coils, until the desired number of electrical coils are provided for the primary and secondary windings of the transformer. The insulating tape is turned up at the edges of the coils, to provide additional insulation between the radially adjacent coils. While this method is satisfactory from a functional viewpoint, the manual taping step adds substantially to the manufacturing cost of the transformer, the hand taping and progressive winding techniques do not lend themselves to the multiple deck, multiple station, automatic type winding machines that position the start and finish leads, and the hand taping produces a transformer in which the effectiveness of the insulation system is dependent upon the skill of the operator.

Thus, it would be desirable to provide a new and improved winding structure, and method of constructing same, which eliminates hand taping and enables automatic winding.

SUMMARY OF THE INVENTION

Briefly, the present invention is a new and improved electrical winding assembly for transformers, in which the primary and secondary windings are concentrically adjacent, on separate first and second winding forms or bobbins, respectively. The second winding form provides layer insulation between the primary and secondary windings, and individual coils of the primary and secondary windings are axially spaced by intermediate flanges provided on the bobbins, thus providing layer and section insulation without taping.

A new and improved method of constructing the new winding assembly includes the steps of winding the primary and secondary windings on first and second insulating bobbins, respectively, and telescoping the first bobbin into an opening in the first end of the second bobbin, against a stop at the second end of the second bobbin. An insulating retainer cap is then secured to the first end of the second bobbin, which maintains the first and second bobbins in assembled relation, between the retainer cap and stop.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be better understood, and further advantages thereof more readily apparent when considered in view of the following detailed description of exemplary embodiments, taken with the accompanying drawings, in which:

FIG. 1 is a schematic diagram of a transformer of the type which may be constructed according to the teachings of the invention;

FIGS. 2 and 3 are perspective views of first and second insulating bobbins, respectively, constructed according to the teachings of the invention;

FIG. 4 is an exploded perspective view of an electrical winding utilizing the first and second bobbins shown in FIGS. 2 and 3, illustrating the assembly of the winding according to the teachings of the invention;

FIG. 5 is a perspective view of the winding assembly shown in FIG. 4 with the components in assembled relation, and including a magnetic core; and

FIG. 6 is a cross-sectional view of the winding assembly shown in FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, FIG. 1 is a schematic diagram of a transformer **10** of the type which may advantageously utilize the teachings of the invention. Transformer **10** is a control transformer with a dual primary voltage rating, such as a rating of 230/460 to 115 volts, with the dual rated primary winding requiring first and second coils **12** and **14**, respectively, which may be connected in series or in parallel depending upon the magnitude of the supply voltage, and a single secondary coil **16**. Electrical coils **12**, **14** and **16** are disposed in inductive relation with a magnetic core **18**, which may be of the stacked or wound type, as desired. While the invention may be applied to transformers in which the primary and secondary windings each have one or more coils, the invention will be described relative to windings having the electrical arrangement shown in FIG. **1**, as the construction of other electrical arrangements will become apparent from the description thereof. In the prior art, the three coils **12**, **14** and **16** are usually wound one upon the other, hand taping the outer surface of each coil before the next coil is wound, to provide layer insulation. The present invention eliminates hand taping, reducing the manufacturing cost of the winding, while improving the insulating structure thereof.

The new and improved winding structure may be better understood by considering the new and improved method of constructing electrical windings, according to the teachings of the invention, in which first and second bobbins or coil forms **20** and **22** are provided, shown in perspective in FIGS. **2** and **3**, respectively. The first bobbin **20** is formed of a good electrical insulator, and is preferably molded of a resinous insulating system, such as a glass filled polyamide, but other insulating materials may be used. Bobbin **20** has first and second axial ends **24** and **26**, respectively, and an opening **28** which extends between its ends. Opening **28** is sized to snugly receive a leg of the magnetic core **18**, which is associated with the transformer **10**, and is therefore substantially square or rectangular in cross-sectional configuration. Bobbin **20**, in this example, is used for the high voltage or primary winding, which includes first and second coils **12** and **14**. Instead of radially spacing the primary coils **12** and **14**, they are axially spaced, separated by a barrier or intermediate flange, thus enabling the coils to be wound on a multiple deck, multiple station, winding machine.

Specifically, bobbin **20** includes a relatively thin walled winding tube **30**, which defines the opening **28**, and which includes outwardly extending flanges **32** and **34** at the first and second ends **24** and **26**, respectively, of the bobbin **20**, and an outwardly extending flange **36** disposed intermediate the ends of the bobbin. The flanges **32**, **34** and **36** have like dimensions and configurations, and are spaced in parallel relation, perpendicular to the longitudinal axis of the bobbin **20**, providing first and second axially spaced conductor channels **38** and **40**, respectively, for receiving the plurality of conductor turns of the high voltage or primary coils **12** and **14**, respectively.

The flanges **32** and **34** each have two slots formed therein through which the ends of the adjacent coils are directed. Flange **32** has slots **42** and **44** formed in adjacent corners of the flange, with slot **42** being disposed in the upper left-hand corner of flange **32**, when viewing FIG. **2** from the front, and slot **44** in the upper right-hand corner. Slot **42** extends inwardly, substantially to the outer surface of the winding tube **30**, as it is used for the end of coil **12** which is placed against the winding tube to start the coil, i.e., the start end of the coil. Slot **44** extends to a point which substantially coincides with the outer surface of the finished coil, as it is used to direct the lead at the finish end of the coil **12**.

Flange **34** has slots **46** and **48** formed in the upper left- and right-hand corners respectively, when viewing the bobbin **20** from the first end **24** in FIG. **2**, with slot **46** being for the finish end and slot **48** for the start end, of coil **14**. By placing the slots **42** and **48** for the start ends of the coils **12** and **14**,

respectively, at diagonally opposite upper corners of the flanges 32 and 34, and slots 44 and 46 for the finish ends of the coils 12 and 14, respectively, at diagonally opposite upper corners, bobbin 20 may be used without aligning it in a predetermined manner, as the bobbin has the same construction when viewed from either axial end.

A member 50 is fixed to flange 32 at the first end 24 of the bobbin 20, adjacent slot 42, to provide an insulating barrier between the "start" lead which will extend through slot 42 and the magnetic core which will extend through opening 28. A similar insulating barrier member (not shown) is disposed on flange 34 adjacent to slot 48, to provide solid insulation between the "start" lead which will extend through slot 48 and the magnetic core.

Bobbin 22, shown in FIG. 3, is formed of a good electrical insulating material, such as the same material of which bobbin 20 is formed. Bobbin 22 has first and second axial ends 52 and 54, respectively, and an opening 56 which extends between its ends. Opening 56 is sized to slidably but snugly receive the dimensions and configurations of the flanges 32, 34 and 36 of the first bobbin 20, and thus it is substantially square or rectangular, as required, with slightly rounded corners to receive the rounded corners of the flanges on the first bobbin 20. Bobbin 20 should easily slide into the opening 56 from the first end of the bobbin 22, but the clearance between the outer edges of the flanges on bobbin 20 and the walls of opening 56 should be close enough to prevent excessive relative movement between the two bobbins once they are assembled.

Bobbin 22 includes means at its second end 54 for stopping and locating the second end 26 of the first bobbin 20 when it is telescoped into the second bobbin 22, such as inwardly extending members 58 and 60 which are disposed at end 54 of bobbin 22, extending perpendicularly inward into opening 56 for predetermined dimensions, from opposite sides of the opening 56. Stop members 58 and 60 also function as insulating barriers between the coils to be wound on the bobbin 20 and the magnetic core. Bobbin 22 is axially dimensioned such that when bobbin 20 is telescoped into position in its opening 56, the outer surfaces of the first flanges 32 and 64 on bobbins 20 and 22, respectively, are substantially coplanar. Bobbin 22 thus requires axial orientation when winding, as the opening 56 is larger at the first end of the bobbin than it is at the second end of the bobbin.

Bobbin 22, in this example, is used for the low voltage or secondary winding, which includes only one coil 16, and thus only one coil channel is required. Bobbin 22 includes a relatively thin walled winding tube 62, which defines the opening 56, and which includes first and second outwardly extending flanges 64 and 66 at the first and second ends 52 and 54, respectively, of the bobbin. Flanges 64 and 66 have like dimensions and cross-sectional configurations, and are spaced in parallel relation, perpendicular to the longitudinal axis of the bobbin, providing a single channel 68 between the flanges for receiving a plurality of conductor turns of the secondary or low voltage coil 16.

The first flange 64 has first and second slots 70 and 72 formed therein for receiving the finish and start ends, respectively, of coil 16, with the slots being formed in adjacent corners. Slot 70 is in the lower left-hand corner, when viewing bobbin 22 from the first end thereof, and circumferentially oriented to receive the first bobbin 20, and it extends to the outer surface of the coil 16 to be wound on the bobbin, to receive the finish end of the coil 16. Slot 72 is in the lower right-hand corner, and extends substantially to the outer surface of the winding tube 62, to receive the start end of coil 16. The first flange 64 has an insulating barrier member 74 fixed thereto, adjacent to slot 72, which provides solid insulation between the "start" lead of the coil wound on bobbin 22, and the adjacent coil wound on bobbin 20. Flange 64 also has first and second projections, such as cylindrical projections 76 and 78, which extend outwardly from the first end of the bobbin 22, and which cooperate with openings disposed in the retainer cap, as will be hereinafter explained.

After providing bobbins 20 and 22, the next step of the method is to wind the coils thereon. Bobbin 20 may be placed on a mandrel and positioned on a winding machine, along with any desired number of similar bobbins, for winding the primary coils. The start turns of the high voltage or primary coils 12 and 14 are positioned in channels 38 and 40 of the first bobbin 20, with their start ends directed through slots 42 and 48, respectively. The two coils 12 and 14 may then be wound on bobbin 20, providing a high voltage winding assembly 80, as illustrated in FIG. 4, which is an exploded perspective view illustrating how the various parts of the complete winding assembly are assembled. As illustrated in FIG. 4, each of the coils have a plurality of conductor turns, such as turns 81 of coil 12, which are formed of copper or aluminum wire insulated with a coating of a suitable wire enamel, such as a polyester resin system. Each of the electrical coils have start and finish ends, with coil 12 having a start end 82 which is directed through slot 42 from channel 38, and extends perpendicularly outward from the first end 24 bobbin 20, and a finish end 84 which is directed through slot 44 from channel 38, and also extends perpendicularly outward from the first end 24 of the bobbin 20. Coil 14 has start and finish ends 86 and 88, respectively, which extend through slots 48 and 50, respectively, from channel 40, and then their direction is changed 180°, looping about flange 66 and extending across both channels 38 and 40 to also extend outwardly from the first end 24 of the bobbin 20. Thus, the ends of coils 12 and 14 extend outwardly from the same end of bobbin 20.

As shown in FIG. 4, the start end of the secondary or low voltage coil 16 is positioned in channel 68 of the second bobbin 22, with a start end 90 directed through slot 72. Coil 16 may then be wound on bobbin 22, providing a secondary or low voltage winding assembly 91 having a plurality of conductor turns 94 formed of copper or aluminum wire, coated with a suitable insulating wire or enamel, such as a polyester resin system. The finish end 92 of coil 16, shown in FIG. 5, is directed through slot 70, and extends outwardly from the first end 52 of bobbin 22.

The winding assembly for transformer 10, shown schematically in FIG. 1, is completed by providing an insulating retainer cap 100, shown in the exploded perspective view of the winding assembly in FIG. 4. Retainer cap 100 provides the functions of retaining the primary winding assembly 80 within the secondary winding assembly 91, once they are assembled in concentric, radially adjacent relation, and as additional solid insulation between the adjacent ends of the coils and the magnetic core.

Retainer cap 100 may also provide the function of a terminal board, if terminals are required for the transformer, or the function of locating and directing the leads from the coils, if terminals are not required.

More specifically, retainer cap 100 is a relatively thin platelike member, having first and second major opposed sides or surfaces, and may be formed of the same insulating material of which bobbins 20 and 22 are formed. Retainer cap 100 includes a major opening 102 which extends between its major surfaces, with the dimensions and configuration of opening 102 substantially matching those of the opening 28 in bobbin 20, as the opening in the retainer cap 100 must receive the winding leg of the associated magnetic core 18. Retainer cap 100 is selected for the specific application, having terminals affixed thereto if they are required. For purposes of example, retainer cap 100 is illustrated as being of the terminal type, having a plurality of small, spaced openings 104, 106, 108 and 110 along its upper edge for receiving terminals (not shown), which terminals are adapted to receive the ends of the high voltage coils 12 and 14. Spaced openings 112 and 114 are also provided along the lower edge of the retainer cap 100, for receiving terminals (not shown) which are adapted to receive the ends of the low voltage coil 16.

Openings 116 and 118 are provided on opposite sides of the major opening 112, spaced to receive projections 76 and 78 on bobbin 22 and dimensioned such that retainer cap 100 will

snap into a retained position when the openings **116** and **118** are aligned with projections **76** and **78**, respectively, and the retainer cap pressed to cause the projections to enter the openings.

Openings **117** and **119** are also provided through cap **100**, located to receive insulating barriers **50** and **74**, respectively. Opening **117** may be a part of the major opening **102**, as illustrated.

If the retainer cap **100** is not to function as a terminal board, instead of utilizing openings for riveting terminals to the retainer cap, the retainer cap may have spaced depressions which extend inwardly on opposite edges, in which the leads from the coils may be positioned.

In the assembly of transformer **10**, the primary or high voltage assembly **80** is telescoped into opening **56** in bobbin **22**, from the first end thereof, as illustrated in FIG. **4**, with the coil leads all extending outwardly from the first end of the bobbin **20**. The retainer cap **100** is then snapped into a retained position on the first end of bobbin **22**, with the barrier members **74** and **50** on bobbins **22** and **20** extending into openings **119** and **117**, respectively, in the retainer cap **100**, and with projections **76** and **78** extending through openings **116** and **118**, respectively, in retainer cap **100**. This last step forms a complete winding assembly **120** for transformer **10**, with the complete winding assembly **120** being illustrated in perspective in FIG. **5**, and in a sectional elevational view in FIG. **6**. If retainer cap **100** is of the terminal type, it will include a plurality of terminals fixed in the small openings, such as terminal **122** which is shown fixed in opening **104** with a suitable fastener **124**, such as a rivet. The terminals, such as terminal **122**, include means for connecting the end of a coil lead thereto, and means for connecting external leads thereto.

It will be noted that once retainer cap **100** is secured in position to the first end of bobbin **22**, that the winding assembly **80** is restrained against axial movement relative to the winding assembly **91**, by the stops **58** and **60** at the second end of bobbin **22**, and by the retainer cap **100**. Thus, the complete winding assembly **120** may be easily handled, which facilitates later manufacturing operations, such as placing the winding assembly in an automatic stacking machine for stacking the laminations of the associated magnetic core.

Transformer **10** is completed as shown in FIG. **5**, by assembling a magnetic core **18** about the winding assembly **120**. Magnetic core **18** may be of the stacked type, shown in FIG. **5**, having a plurality of layers **130** each including a plurality of magnetic, metallic laminations, such as an E and I lamination in each layer, with the resulting magnetic core structure encircling the complete winding assembly **120**, as well as having a connecting leg portion which extends through the aligned openings **102** and **28** in the retainer cap **100** and bobbin **20**, respectively. Or, the magnetic core **18** may be of the wound type, as desired.

In summary, there has been disclosed a new and improved winding assembly **120**, best shown in the perspective and cross-sectional elevational views of FIGS. **5** and **6**, respectively, which has no hand taping of electrical insulation, thus facilitating automatic multistation winding of the electrical coils. The primary and secondary windings are radially spaced on separate bobbins, with the outer bobbin providing solid layer insulation between the two winding assemblies. Individual coils of the primary and secondary windings, when more than one coil is required, are spaced axially apart on their associated bobbins, and insulated with a flange or barrier which may be an integral part of the bobbin. The innermost bobbin is retained in assembled relation with the outer bobbin by a stop at one end of the outer bobbin, and by a retainer cap affixed to the other end of the outer bobbin.

The new and improved method of manufacturing electrical windings includes the steps of providing first and second separate bobbins, winding coils on the separate bobbins, telescoping the first bobbin into an opening in the second bobbin, against the stop, and attaching a retainer cap to the second bobbin to retain the two bobbins in assembled relation.

We claim as our invention: bobbin

1. A method of constructing an electrical winding assembly, comprising the steps of:
- providing a first insulating bobbin having first and second ends, and an opening which extends between its ends,
- providing a second insulating bobbin having first and second ends, and an opening which extends between its ends, with the opening being sized to receive the first bobbin through the first end and retain it by a stop disposed at its second end,
- winding at least one coil on said first bobbin,
- winding at least one coil on said second bobbin,
- telescoping the first bobbin into the second bobbin,
- and attaching a retainer cap to the first end of the second bobbin, to restrain the first bobbin against axial movement, between the stop on the second bobbin and the retainer cap, said retainer cap having an opening therein in registry with the opening in said first bobbin.

2. The method of claim **1** wherein the retainer cap has terminals thereon, and including the step of attaching the ends of the coils wound on the first and second bobbins to terminals on the retainer cap.

3. The method of claim **1** wherein the first bobbin has flanges at its first and second ends and intermediate its ends, providing a plurality of axially spaced channels, with the at least one coil being wound in one of the channels, and including the steps of winding a coil in each of the remaining channels.

4. The method of claim **1** wherein the first and second bobbins have an outwardly extending flange at each end thereof, with at least certain of the flanges having slots disposed therein, and including the steps of directing the ends of the coils wound on the bobbins through slots in adjacent flanges of its associated bobbin.

5. The method of claim **1** wherein the first end of the second bobbin has spaced projections disposed thereon and the retainer cap has similarly spaced openings therein, with the step of securing the retainer cap to the first end of the second bobbin including the step of inserting the projections on the second bobbin into the openings in the retainer cap.

6. The method of claim **1** including the step of disposing metallic laminations about the assembled bobbins, and through the openings in the retainer cap and first bobbin.

7. An electrical winding assembly, comprising: first and second bobbins each having first and second ends, and an opening extending between its ends,
- electrical coils disposed on said first and second bobbins,
- said first and second bobbins being concentrically disposed, with the first bobbin being snugly positioned within the opening in said second bobbin,
- stop means disposed at the second end of said second bobbin,
- and a retainer cap fixed to the first end of said second bobbin,
- said first bobbin being held in assembled relation with said second bobbin by said stop means and said retainer cap.

8. The electrical winding assembly of claim **7** including terminal means affixed to said retainer cap, with the ends of the electrical coils being connected to said terminal means.

9. The electrical winding assembly of claim **7** including flange members disposed at each end of the first and second bobbins, and openings in the flange members for receiving the start and finish ends of the electrical coils wound on the first and second bobbins.

10. The electrical winding assembly of claim **9** including insulating barrier members disposed on the flange members, between the slots for receiving the start ends of the electrical coils and the opening extending between the ends of each bobbin.

11. The electrical winding assembly of claim **10** including openings disposed in the retainer cap into which the insulating barrier members on the flanges adjacent to the retainer cap extend.

12. The electrical winding of claim **7** including spaced projections disposed on the first end of the second bobbin, and

similarly spaced openings in the retainer cap, with the projections on the second bobbin and extending into the openings in the retainer cap.

13. The electrical winding of claim 7 including parallel flange members disposed at the end of the first bobbin and intermediate its ends, providing a plurality of axially spaced channels, and including an electrical coil disposed in each channel.

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