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3,066,388

METHODS FOR MAKING MAGNETIC CORES

Filed July 29, 1957

3 Sheets-Sheet 1

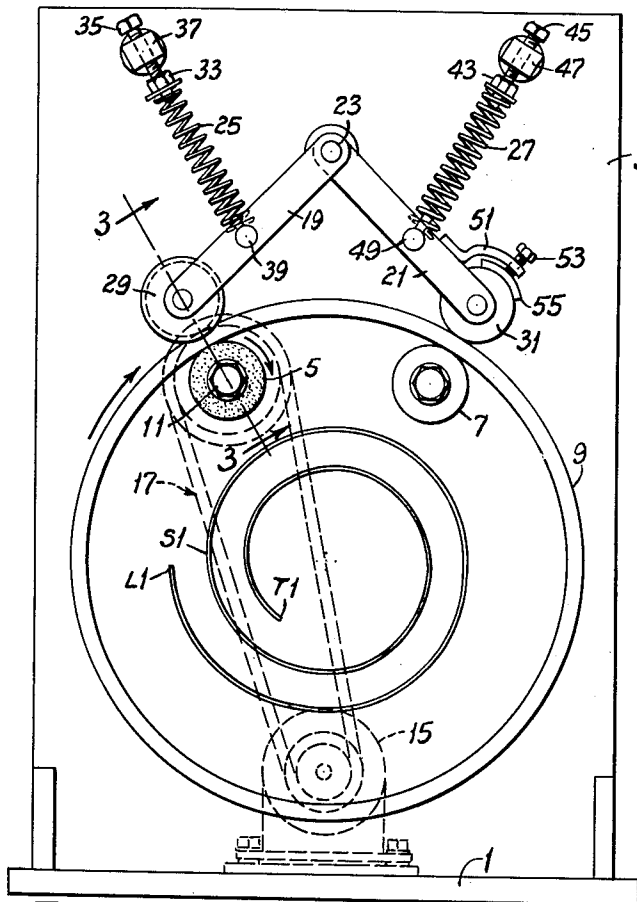


FIG. 1.

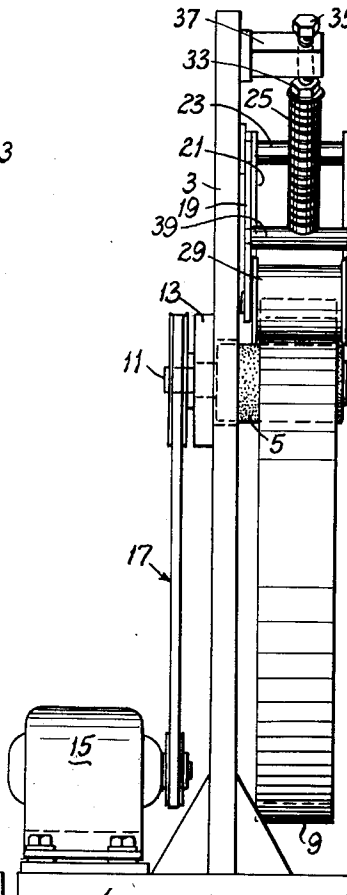


FIG. 2.

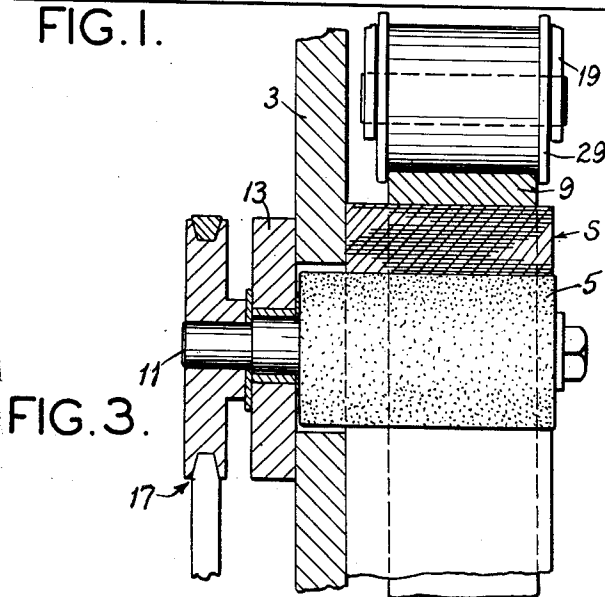


FIG. 3.

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3 Sheets-Sheet 2

FIG. 4.

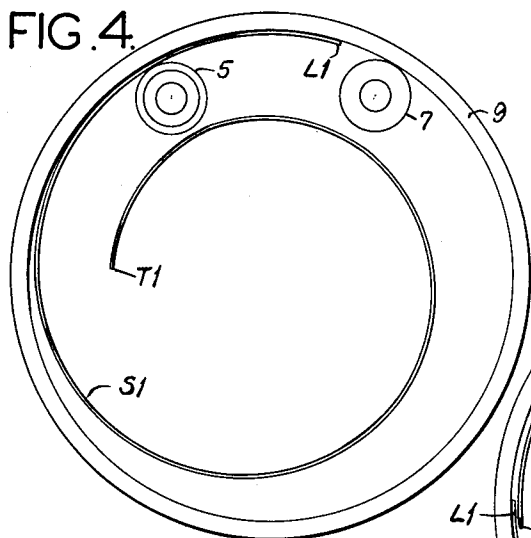


FIG. 5.

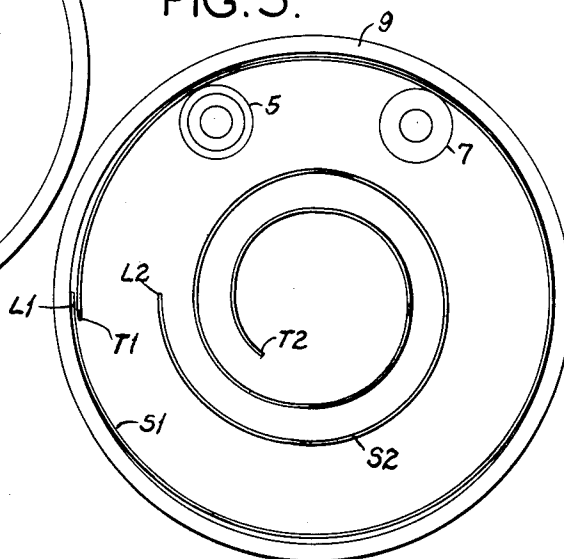


FIG. 6.

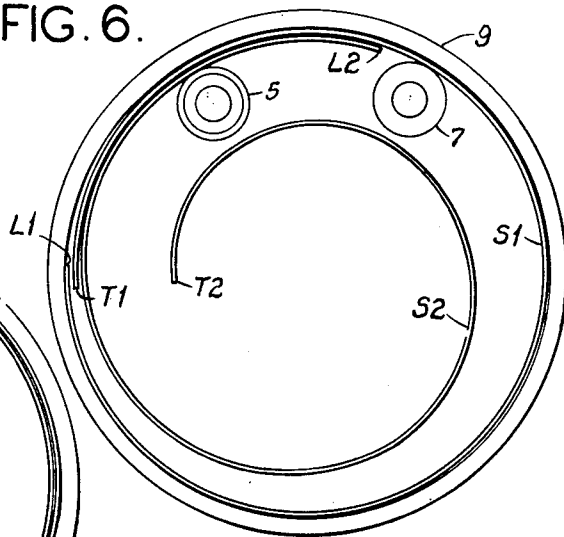
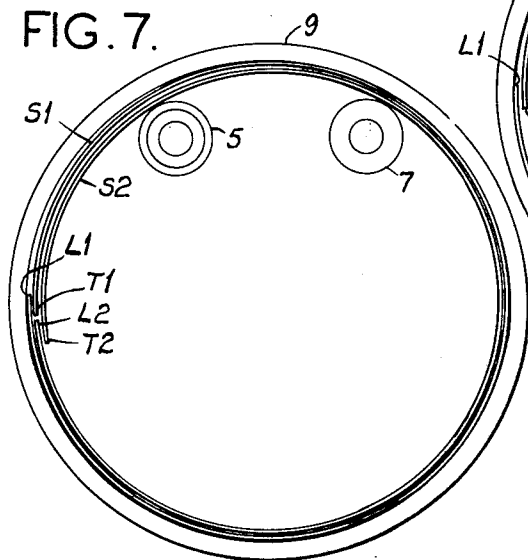


FIG. 7.



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3,066,388

METHODS FOR MAKING MAGNETIC CORES

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3 Sheets-Sheet 3

FIG. 8.

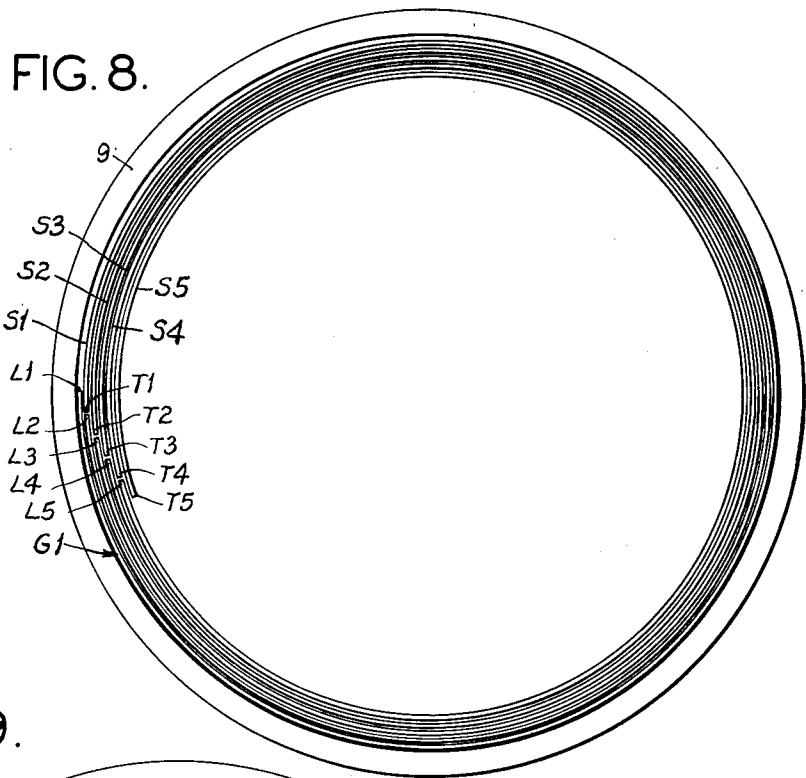
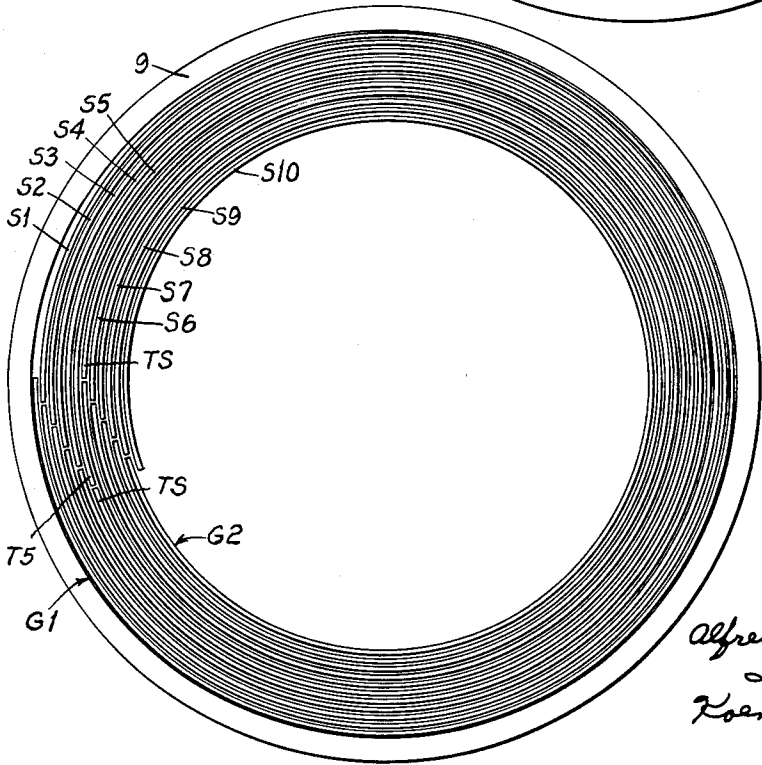


FIG. 9.



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1

3,066,388

METHODS FOR MAKING MAGNETIC CORES

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16 Claims. (Cl. 29—155.57)

This invention relates to methods of and apparatus for making magnetic cores, and more particularly to methods of and apparatus for making wound cores for electrical induction apparatus from grain-oriented magnetic strip material.

Among the several objects of the invention may be noted the provision of a method of and apparatus for economically making a wound core of the class described which comprises a succession of separate strip segments wound one after another with the leading end of each segment making a flux-transmitting joint with the trailing end of the preceding segment, characterized in that the segments are coiled from the outside in; the provision of a method and apparatus of this class adapted for making wound cores of the class described in which the leading end of each strip segment makes a butt joint with the trailing end of the preceding segment; and the provision of a method and apparatus adapted for making a wound core of this class comprising groups of strip segments, each group being applicable as a whole to a preformed transformer winding. Other objects and features will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the constructions and methods hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawings, in which one of various possible embodiments of the invention is illustrated,

FIG. 1 is a front elevation of an apparatus of this invention, and illustrates a first step in the method of this invention;

FIG. 2 is a side elevation (the left side) of FIG. 1;

FIG. 3 is an enlarged section taken on line 3—3 of FIG. 1;

FIGS. 4-7 are views illustrating further steps in the method;

FIG. 8 is an enlarged view showing a completed group of strip segments; and,

FIG. 9 is a view corresponding to FIG. 8 showing a second group of strip segments.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring to FIGS. 1-3 of the drawings, an apparatus of this invention is shown to comprise a base 1 on which is a vertical plate 3. This plate carries horizontal rollers 5 and 7 projecting from one face of the plate at right angles to the plate and supporting a ring 9. Roller 5 is a drive roller. As shown, it is a rubber roller having a shaft 11 journaled in a bearing 13 mounted on the plate 3 and adapted to be positively driven by a motor 15 via a belt and pulley drive 17. Roller 7 is an idler roller, located at about the same elevation as roller 5.

The ring 9 surrounds and hangs on rollers 5 and 7. It is positively biased downward against the rollers by means of frames 19 and 21 both pivoted on a stud 23 extending out from plate 3, these frames being biased to swing downward by compression springs 25 and 27. Frame 19 carries a flanged guide roll 29 engaging the ring 9 and holding it spaced from the plate 3. Frame 21 carries a braking roll 31 engaging the ring 9. Spring 25 reacts from a nut 33 on a bolt 35 threaded in a stud 37 on plate 3, and acts against a crossbar 39 on frame 19. Spring 27 reacts from a nut 43 on a bolt 45 threaded

2

in a stud 47 on plate 3, and acts against a crossbar 49 on frame 21. The frame 21 has a bracket 51 in which is threaded a screw 53 carrying a brake shoe 55 which frictionally engages the roll 31 for braking it.

The apparatus illustrated in FIGS. 1-3 is used for coiling from the outside in a succession of separate segments of magnetic strip material one after another, with each successive strip segment having its leading end portion engaging the trailing end portion of the preceding strip segment. As shown in FIG. 1, a first strip segment S1 is loosely coiled up into a spiral and inserted within the ring 9. It is then allowed to spring out from its FIG. 1 condition so that its outer end portion engages the inner periphery of the ring 9. The drive roller 5 drives the ring 9 clockwise as viewed in FIGS. 1 and 4. Accordingly, the leading end L1 of strip segment S1 is carried around by the ring 9, passes between the ring and roller 5 (see FIG. 4), then between the ring and roller 7, and finally segment S1 is completely spread out against the inner periphery of the ring as illustrated in FIG. 5. As shown, the length of strip segment S1 is somewhat greater than the inner circumference of the ring 9 so that the two ends of S1 overlap, with the leading end L1 of the segment on the outside and the trailing end T1 of the segment on the inside.

Then a second strip segment S2 is loosely coiled up into a spiral and inserted within the ring 9 (and within the first strip segment S1). This segment S2 is allowed to spring out, and its leading end L2 passes between segment S1 and roller 5 (see FIG. 6), then between S1 and roller 7. Since the ring 9 is retarded by braking roll 31, strip segment S2 is advanced by drive roller 5 faster than segment S1 is rotated by ring 9 and the leading end L2 of segment S2 catches up with and butts against the trailing end T1 of segment S1 (see FIG. 7). As shown, the length of segment S2 is somewhat greater than one turn around the inside of S1, so that the two ends of segment S2 overlap as shown in FIG. 7 with the leading end L2 of segment S2 on the outside and the trailing end T2 of segment S2 on the inside.

The above described operations are repeated, as many strip segments as desired being introduced into the ring 9 and released for being coiled up from the outside in. FIG. 8 shows five segments S1 to S5 as having been coiled from the outside in. Each segment has a length somewhat greater than one turn, and the leading end of each segment makes a butt joint with the trailing end of the preceding segment. Thus, the leading end L3 of segment S3 butts the trailing end T2 of segment S2, the leading end L4 of segment S4 butts the trailing end T3 of segment S3, and the leading end L5 of segment S5 butts the trailing end T4 of segment S4. In FIG. 8, each of the strip segments S1 to S5 extends about 365° of arc and successive segments are progressively shorter in length, decreasing in length by a factor equal to $2\pi t$, where t is the thickness of the strip material. The butt joints are angularly offset. The strip segments may be precut from a continuous strip in any suitable way. For example, a continuous strip of magnetic material may be fed through a shearing apparatus designed to cut progressively shorter lengths. It will be understood that the strip segments may be less than one turn in length, and similar results accomplished, i.e., butt-jointing the leading end of each segment to the trailing end of the preceding segment.

The above-described operations produce a round core within the ring 9. The core is removed from within the ring and one or more steel bands may be applied around it to keep the segments from springing out. The same result may be accomplished by spot welding together the lapping ends of segment S1. If the round form of core is satisfactory, the next step is to anneal the core. If a

3

core shape other than the round shape is desired, the round core may be formed to the desired shape (for example, rectangular shape) and then annealed. In assembling a core with a preformed conductive transformer winding, the strip segments are taken out one at a time from the inside of the core. Each segment is sprung open to allow it to be passed through the window of the conductive winding and after it has been passed through the winding it is allowed to spring back to its annealed form. As the segments are assembled one on another with the winding, care is taken to see that the butt joints are properly fitted. When the assembly is complete, steel bands are applied around the core to hold the butt joints firmly.

FIG. 9 shows within the ring 9 a round core comprising two groups G1 and G2 of strip segments, each group having angularly offset butt joints, with a transition strip segment TS between the groups. As shown, group G1 comprises strip segments S1 to S5 and group G2 comprises strip segments S6 to S10. Strip segments S1 to S5 are identical to and are coiled in the same manner as segments S1 to S5 previously described. The transition strip segment has a length substantially different from the preceding segment S5, preferably being of lesser length than segment S5 in an amount equal to the amount of overlap of the two ends of a segment multiplied by the number of segments in group G1.

The transition strip segment is coiled on the inside of group G1 in the same manner as any other segment, and its leading end engages and makes a butt joint with the trailing end T5 of segment S5. The segments S6 to S10 of group G2 are successively coiled from the outside in on the inside of the transition strip segment, the leading end of segment S6 making a butt joint with the trailing end of the transition strip segment.

The round grouped core shown in FIG. 9 may be used in its round form, or it may be formed to some other shape (rectangular shape, for example) and then annealed. In assembling the grouped core (whether round or of some other shape), group G2 may be taken out from the inside of the core and assembled as a whole with the transformer winding, and then group G1 may be assembled as a whole with the winding around group G2.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions and methods without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. The method of making a magnetic core which comprises at least in part a spiral coil consisting of individual segments of magnetic strip material nested one within another and wherein the outermost segment has its ends spaced one from the other around the coil and successive segments have their ends butted together, comprising the steps of introducing a first segment which constitutes the outermost segment into an annular core form and causing it to engage the inner periphery of the form, said first segment being of different length than the inner periphery of the form so that its ends are spaced one from the other around the coil, introducing a second segment into the form within the first segment and causing it to nest within the first segment with one of its ends butted against one end of the first segment by rotating it relative to the first segment around a transverse axis of said core form until its leading end abuts the trailing end of said first segment, introducing a third segment into the form within the second segment and causing it to nest within the second segment with one of its ends butted against the other end of the second segment by rotating

4

it relative to the second segment around a transverse axis of said core form until its leading end abuts the trailing end of said second segment, and repeating the stated operations until the desired number of segments are provided, and removing all of the nested segments from within the annular core form while preventing the segments from springing outwardly.

2. The method of claim 1 wherein the first segment is longer than the inner periphery of the form so that its ends overlap, and the said one end of the second segment is butted against the inner end of the first segment.

3. The method of claim 2 wherein the second, third and successive segments are of such length that the successive butt joints between the segments are angularly offset one from another around the coil.

4. The method of claim 3 wherein the second, third and successive segments are of such length that each of these segments has overlapping ends.

5. The method of claim 1 wherein the core form is rotated, wherein the segments are introduced into the form by coiling them up into a spiral small enough for introduction within the form, and wherein a leading end of each of the second, third and successive segments is caused to abut the trailing end of the preceding segment by driving each of said segments faster than the form until its leading end catches up with and butts against the trailing end of the preceding segment.

6. The method of claim 5 wherein the first segment is longer than the inner periphery of the form so that its ends overlap, and the said one end of the second segment is butted against the inner end of the first segment.

7. The method of claim 6 wherein the second, third and successive segments are of such length that the successive butt joints between the segments are angularly offset one from another around the coil.

8. The method of claim 7 wherein the second, third and successive segments are of such length that each of these segments has overlapping ends.

9. The method of making a magnetic core which comprises outer and inner spiral coils each consisting of individual segments of magnetic strip material nested one within another and wherein the outermost segment of each coil has its ends spaced one from the other around the coil and successive segments of each coil have their ends butted together, with a transition segment of magnetic strip material between the coils, comprising the steps of forming the outer coil by introducing a first segment which constitutes the outermost segment of the outer coil into an annular core form and causing it to engage the inner periphery of the form, said first segment being of different length than the inner periphery of the form so that its ends are spaced one from another around the coil, introducing a second segment into the form within the first segment and causing it to nest within the first segment with one of its ends butted against one end of the first segment by rotating it relative to the first segment around a transverse axis of said core form until its leading end abuts the trailing end of said first segment, introducing a third segment into the form within the second segment and causing it to nest within the second segment with one of its ends butted against the other end of the second segment, by rotating it relative to the second segment around a transverse axis of said core form until its leading end abuts the trailing end of said second segment, repeating the stated operations until the desired number of segments are provided in the outer coil, then introducing a transition strip segment having a length substantially different from the length of the last segment of the outer coil into the form and causing it to nest within said last segment, forming the inner coil within said transition strip segment in the same manner as the outer coil, and removing all of the nested segments from within the annular core form while preventing the segments from springing outwardly.

10. The method of claim 9 wherein the first segment

5

of each coil is of such length that its ends overlap, and the said one end of the second segment of each coil is butted against the inner end of the first segment thereof.

11. The method of claim 10 wherein the second, third and successive segments of each coil are of such length that the successive butt joints between the segments are angularly offset one from another around the coil.

12. The method of claim 11 wherein the second, third and successive segments of each coil are of such length that each of these segments has overlapping ends.

13. The method of claim 9 wherein the core form is rotated, wherein the segments are introduced into the form by coiling them up into a spiral small enough for introduction within the form, and wherein a leading end of each of the second, third and successive segments of each coil is caused to abut the trailing end of the preceding segment by driving each of said segments faster than the form until its leading end catches up with and butts against the trailing end of the preceding segment.

14. The method of claim 13 wherein the first segment of each coil is of such length that its ends overlap, and the said one end of the second segment of each coil is butted against the inner end of the first segment thereof.

6

15. The method of claim 14 wherein the second, third and successive segments of each coil are of such length that the successive butt joints between the segments are angularly offset one from another around the coil.

16. The method of claim 15 wherein the second, third and successive segments are of such length that each of these segments has overlapping ends.

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