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TRANSFORMER CORE

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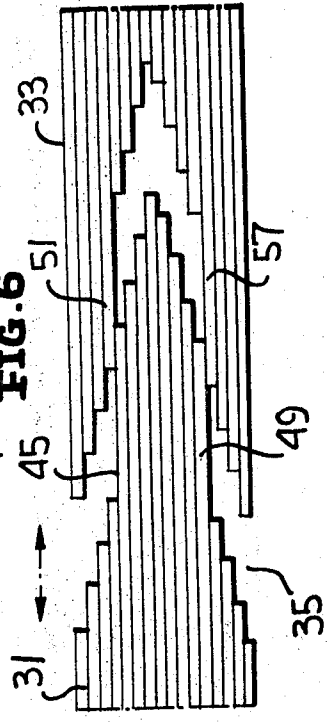
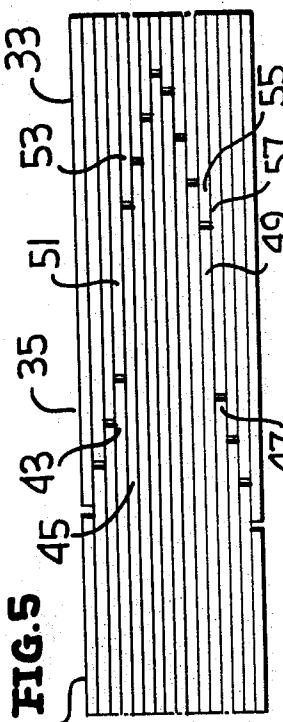
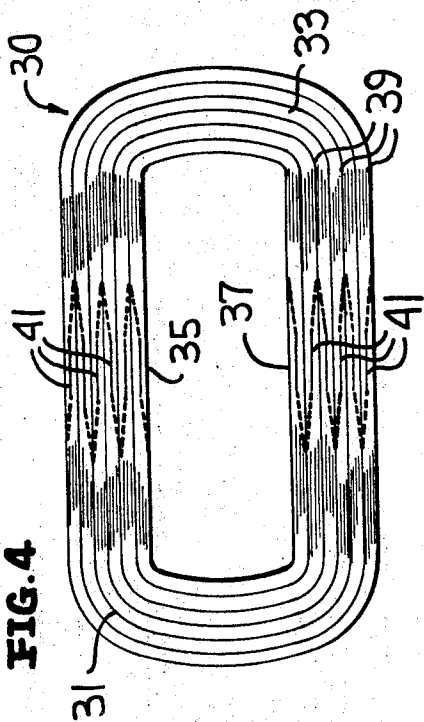


FIG. 1 (PRIOR ART)

FIG. 2 (PRIOR ART)

FIG. 3 (PRIOR ART)

FIG. 4

FIG. 5

FIG. 6

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TRANSFORMER CORE

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16 Claims

ABSTRACT OF THE DISCLOSURE

Assembly of a C-type cut transformer core is facilitated by arranging the laminations in a plurality of groups of laminations and offsetting the ends of adjacent laminations forming each group of the core, the offset being substantially uniform except for predetermined pairs of adjacent laminations in each group which are offset from three to ten times the uniform offset.

BACKGROUND OF THE INVENTION

The present invention relates to transformer cores of the type which comprise a pair of butt-joined laminated sections in which the ends of adjacent laminations are staggered or offset relative to one another. More particularly, the present invention relates to an improved construction of such a core which facilitates assembly of the completed core.

In my U.S. Pat. No. 3,469,221, I disclose a C-type cut transformer core in which two laminated C-shaped core sections are butt-joined, the butt joints being of zigzag configuration. The zigzag configuration is achieved by arranging the laminations in a group of laminations and offsetting the ends of the various laminations in each group relative to each other with the offsets of adjacent groups being in opposite directions. The zigzag joint structure has a twofold effect on the magnetic properties of the core. Specifically, the zigzag structure reduces leakage flux at the joint due to the interleaving of laminations of the core. Further the interleaving of the laminations on a lamination-by-lamination basis prevents undue spreading of the legs of the core and thus reduces gapping between adjacent ends of laminations at the butt-joint and disengagement of various laminations from one another. In addition, since the laminations overlap at the joint, slight disengagement of one lamination from its co-aligned lamination has very little effect on the magnetic characteristics of the core.

In the final assembly of the transformer, the two sections of the core are pulled apart so that a leg of a coil may be placed in the window of the core and the core may then be closed. During the final closing of the core there is no automatic alignment of the zigzag configured ends of the core section and the offset laminations tend to render the final core closing considerably difficult. More specifically, in attempting to assemble the two sections of the core the sharp edges of the laminations in one core section tend to catch or snag on laminations in the opposite core section, making proper alignment of the respective abutting laminations considerably difficult. Some of this difficulty was minimized in accordance with a technique disclosed in my above-referenced U.S. Pat. No. 3,469,221, whereby the ends of the laminations are sprayed with a smooth adhesive of relatively low friction material to facilitate slipping the ends of the core sections into place without any undue manipulation. Primarily, the coating tends to smooth out the small burrs formed at the edges of the various laminations during the core cutting operation. However, it has been found that some manipulation is still necessary in order to properly align the two core sections so as to prevent catching or

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snagging of laminations in one section against laminations in the other section.

It is, therefore, an object of the present invention to provide a core of the type described in which the two sections may be more readily aligned during final core assembly.

It is a further object of the present invention to improve the construction of the transformer core disclosed in my above-referenced U.S. Pat. No. 3,469,221 so as to facilitate alignment of the two core sections during final assembly of the transformer.

SUMMARY OF THE INVENTION

In accordance with the principles of the present invention the offset between predetermined adjacent core laminations of each group is made substantially larger than the uniform offset provided between the remaining adjacent core laminations. The larger offsets provided for the predetermined adjacent laminations provide smooth guiding surfaces which facilitate alignment of the zigzag ends of the abutting core sections. Preferably the larger offset is approximately three to ten times the offset provided for the remainder of the adjacent laminations.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is an illustration of a C-type cut core of the type disclosed in my above-referenced U.S. Pat. No. 3,469,221;

FIG. 2 is an enlarged view of one of the joints of the core of FIG. 1;

FIG. 3 is an enlarged view illustrating the assembly of the joint of FIG. 2;

FIG. 4 is an illustration of the C-type cut core of the present invention;

FIG. 5 is an enlarged view of the one of the joints of the core of FIG. 4; and

FIG. 6 is an enlarged view illustrating the assembly of the joint of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring specifically to FIG. 1 of the accompanying drawings, there is illustrated a C-type cut core of the type described and illustrated in my U.S. Pat. No. 3,469,221. The core is designated generally by the reference number 10. Core 10 comprises two C-shaped sections 11 and 13, each comprising individual laminations 19 of grain oriented magnetic material. The two sections 11 and 13 are butted to provide joints 15 and 17 in respective opposed "legs" of the core 10. The vertically (as viewed in FIG. 1) extending segments of the core are called "yokes" and serve to join the two "legs" at their ends. Joints 15 and 17 are of zigzag configuration so that the laminations 19 of the two sections 11 and 13 are interleaved. The interleaving of the laminations 19 is best illustrated in FIG. 2 and is accomplished by providing an offset in the lengths of adjacent laminations at the jointed ends of the core sections 11 and 13 in the manner described in my above-referenced U.S. Pat. No. 3,469,221. The interleaving provides a non-planar joint and imparts greater mechanical strength than the prior art planar butt-joined C-type cores. In addition, the interleaved or non-planar joint reduces flux leakage due to the fact that leakage flux at each of the small individual gaps finds a low reluctance path in adjacent laminations. The interleaving also tends to minimize outward deflection of the core legs since a certain amount of mechanical strength is added to the

joint by virtue of the compressive forces existing between adjacent laminations.

In assembling the final core of the present invention, difficulty is encountered due to the very small spacing between the laminations, which results in adjacent laminations in the opposite core sections catching or snagging on one another and preventing smooth alignment of laminations in core section 11 with respect to abutting laminations in core section 13. As illustrated in FIG. 2, the laminations in core section 11 are to be aligned in abutting relationship with respective laminations of core section 13. The magnitude of the problem can best be appreciated when it is realized that the individual laminations 19 may be no more than a few thousandths of an inch thick. In FIG. 3, assembly of the core of FIG. 1 to form joint 15, for example, is diagrammatically illustrated. Each lamination, for example lamination 20, in core section 11 has a counterpart lamination 21 in section 13 with which it is to be aligned in abutting relationship in the final assembly of the core. The ends of adjacent laminations in core section 11, as well as the ends of respective adjacent laminations in core section 13, are offset from one another by a substantially uniform amount. Therefore, a number of the laminations in core section 11 protrude further toward core section 13 than does lamination 20, for example. Due to the extremely small width or thickness of the individual laminations and their resulting flexibility, it often happens that one or more laminations such as lamination 21, will catch or snag on one of the laminations which protrudes further toward core section 13 than does lamination 20. In fact, such catching or snagging is possible for a number of the laminations, therefore, requiring a rather unwieldy set of manipulations of core sections 11 and 13 to bring the various laminations into proper abutting relationship.

In order to greatly reduce this problem, I employ a technique disclosed in my above-referenced U.S. Pat. No. 3,469,221, whereby I spray a smooth adhesive coating of relatively low friction material over the ends of the laminations on one or both of sections 11 and 13 in order to facilitate a slipping together of the two sections when they are brought together to form joint 15. I have found, however, that while the coating does in fact reduce the manipulation required to bring sections 11 and 13 together to form joint 15, some manipulation is still required. The transformer business is highly competitive and with labor costs representing as they do a large proportion of the costs of fabricating transformers, even small reductions in time of fabrication can represent a significant increase in the competitive position of a company. It has been this cost factor which to a large extent has prevented the widespread use of staggered joint cores in the C-type transformer core market since the thin laminations used in such cores have made assembly of the cores a time consuming process. A significant time reduction was achieved by the teaching of the aforesaid application. Further reductions in time of assembly of such cores have been achieved by the present invention.

In accordance with the present invention I have found that the manipulation required to assemble such cores may be reduced by extending the offset between adjacent laminations in preselected pairs of adjacent laminations. This feature will be best understood by reference to FIGS. 4, 5 and 6 and the description pertaining thereto in the following paragraphs.

In FIG. 4, there is illustrated a core 30 in accordance with the principles of the present invention. Core 30 comprises two C-shaped sections 31 and 33 having joints 35 and 37 formed in parallel legs thereof. Joints 35 37 are zigzagged joints, as are the joints 15 and 17 of core 10 in FIG. 1. The zigzagged joints are formed by virtue of the fact that adjacent laminations in core sections 31 and 33 are offset at their ends so as to provide an interleaving of the various laminations when the two sections 31 and 33 are placed together in a lamination-to-lamination abut-

ting relationship. This, too, is similar to the construction of core 10 of FIG. 1. However, core 30 differs from core 10 by virtue of the fact in core 10 there is a substantially uniform offset distance between the ends of all of the laminations comprising core sections 11 and 13. In core 30, however, the ends of the laminations in selected pairs of adjacent laminations are offset by a substantially greater distance than the uniform offset distance provided for the remainder of the adjacent laminations. This larger offset distance, designated as 41 in FIG. 4, provides a relatively long guiding surface which readily permits smooth alignment of the two core sections 31 and 33 in final assembly of the core. This may be best seen in FIG. 5, which is an enlarged view of joint 35 of core 33. Core section 31 is seen to abut core section 33 in a lamination-to-lamination manner. It is readily seen that wherein most of the laminations in section 31 have their ends offset by a substantially uniform amount, the ends of adjacent laminations 43 and 45 are offset by a much larger amount. Similarly, adjacent laminations 47 and 49 in core section 31 have their ends offset by a distance substantially in excess of the uniform offset distance provided for the ends of the majority of adjacent laminations. In like manner, section 33 has the ends of its laminations offset by a substantially uniform amount or distance, except for the offset between laminations 51 and 53 and between laminations 55 and 57. It is noted that laminations 51, 53 and 55 and 57 abut laminations 43, 45, 49 and 47 respectively of core section 31. In this manner, proper fitting of core sections 31 and 33 is assured.

Referring now specifically to FIG. 6, assembly of core 30 at the joint 35 is diagrammatically illustrated to best bring out the advantages of the extended offset construction described hereinabove. As noted in FIG. 5, lamination 57 of core section 33 and lamination 49 of core section 31 are interleaved, as are laminations 51 and 45 of core sections 33 and 31, respectively. The interleaving between these laminations extends over a greater length than does the interleaving between other laminations in the core sections 31 and 33 because of the extended offset feature described above. This greater interleaved distance is employed as a guide surface for properly aligning core sections 31 and 33 at the joint 35. In assembling the two sections together, one need merely place the lower surface of lamination 51 adjacent the upper surface of lamination 45 and place the lower surface of lamination 49 adjacent the upper surface of lamination 57 and then push the two sections 31 and 33 together. The long surfaces act as guides for assuring proper alignment on a lamination-to-lamination basis of the overall abutted joint 35.

I have found that the extended offset 41 is preferably three to ten times the uniform offset provided between the ends of the majority of adjacent laminations. The number of extra long offsets employed in most cases is determined by the number of laminations in the core, it being necessary to provide a sufficient number of long guide surfaces to enable smooth merging of the two core sections into a common zigzag joint. Though not necessary in accordance with the principles of the present invention, I have found it somewhat easier to guide the core sections into place where the extended offsets 41 are disposed like distances between the ends of the core leg; that is, the offsets 41 are located such that a vertical cross section through the core as viewed in FIG. 4 can be taken so as to intersect all of the extra long offsets.

The improved core construction of the present invention benefits substantially by employing the adhesive material coat described above as disclosed in my U.S. Pat. No. 3,469,221. The particular material employed to coat the laminations is not critical, it is only necessary that the material, in effect, cover the sharp edges of the laminations with a relatively low friction and relatively tough material that might well be pushed aside as the core is assembled.

Although the invention as thus far described primarily

employs zigzag joints as illustrated in FIG. 4, other staggered joints may be employed. A useful configuration is one in which the joint pattern is a W with the outer legs about half the length of the inner legs. Also it should be noted from FIG. 5 and FIG. 6 that the joints are staggered relative to one another; that is, the joints above and below the joint extending farthest to the right are not aligned perpendicular to the length of the leg. Outside of magnetic benefits achieved by thusly staggering the joints, the overall joint 35 slips together more easily when the individual joints are staggered. As discussed in my above-referenced U.S. Pat. No. 3,469,221 and in my U.S. Pat. No. 3,328,737, the joints should extend over as long a length of the legs as is practical, since the larger the ratio of the joint length to leg length, the better the core performance.

Further, as discussed in my above-referenced U.S. Pat. No. 3,469,221, the core may initially be wound quite tight or it may be wound with sufficient looseness to provide a 90 to 92 percent space factor preferred for the core of the present invention. By employing such a lamination space factor of not greater than 90 to 92 percent, assembly of the final core from the two sections 31 and 33 is greatly facilitated.

The present invention, though originally intended for the manufacture of C-type, cut cores has been found to be equally applicable to E-type cores such as illustrated and described in my aforementioned U.S. Pat. No. 3,469,221. Such a core may be composed of two C-type cut cores, individually manufactured and assembled, and a further C-type cut core made large enough to snugly receive the other two cores arranged side-by-side. All of the cores would have staggered joints with a preselected number of extended offsets according to the present invention.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. A core for an inductive device comprising two core sections, each section including an equal plurality of laminations of grain-oriented material, said sections abutting lamination-to-lamination at two butt joints in respective legs of said core such that both ends of each lamination in one of said sections abut respective ends of a corresponding lamination in the other of said sections, the ends of all adjacent laminations in each core section being offset to provide a sequence of steps between adjacent ones of said laminations, said offset being uniform for all but a predetermined number of pairs of adjacent laminations, the offset between laminations in each of said predetermined number of pairs of laminations being substantially larger than said uniform offset, each substantially larger offset being stepped in the same direction as the offsets immediately preceding and succeeding said each substantially larger offset.

2. The core according to claim 1 wherein the offset ends of said laminations define a zigzag configuration of butt-joints in which a first series of successive offsets are stepped in one direction and are followed by a second series of successive offsets stepped opposite said first direction.

3. The core according to claim 2 wherein said core sections and said laminations are generally C-shaped, said

legs of said core being joined at their ends by respective yokes.

4. The core according to claim 3 wherein the offset between adjacent laminations in said predetermined number of adjacent laminations is between three to ten times said uniform offset.

5. The core according to claim 4 wherein said laminations have a space factor of 90 percent to 92 percent at the junction of the yokes and the legs.

6. The core according to claim 5 wherein said butt joints lie substantially centrally of said legs of said core and extend over approximately one-half the length of the innermost lamination of said legs.

7. The core according to claim 6 wherein the ends of the laminations of at least one core section are coated with a smooth adherent material.

8. The core according to claim 1 wherein the offset between adjacent laminations in said predetermined number of adjacent laminations is between three to ten times said uniform offset.

9. The core according to claim 8 wherein said laminations have a space factor of 90 percent to 92 percent at the junction of the yokes and the legs.

10. The core according to claim 8 wherein said butt joints lie substantially centrally of said legs of said core and extend over approximately one-half the length of the innermost lamination of said legs.

11. The core according to claim 8 wherein the ends of the laminations of at least one core section are coated with a smooth adherent material.

12. The core according to claim 1 wherein said butt joints lie substantially centrally of said legs of said core and extend over approximately one-half the length of the innermost lamination of said legs.

13. The core according to claim 2 wherein at least one of said substantially larger offsets lies in each of said first and second series of successive offsets.

14. The core according to claim 13 wherein none of the lamination ends lying in said first series of successive offsets is aligned with a lamination end lying in said second series of successive offsets in a plane normal to the legs of said core.

15. The core according to claim 1 wherein the laminations in each of said sections are arranged in a plurality of groups, each group including a first series of sequential offsets stepped in one direction and a second series of sequential offsets stepped opposite said one direction, there being one of said substantially larger offsets in each of said first and second series of sequential offsets.

16. The core according to claim 15 wherein none of the lamination ends in any group of laminations are aligned in a plane normal to legs of said core.

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