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3,290,633

LAMINATED CORE WITH BIDIRECTIONAL JOINTS

Filed Dec. 12, 1962

2 Sheets-Sheet 1

Fig. 1a

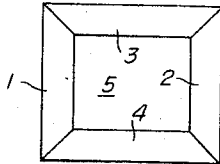


Fig. 1b

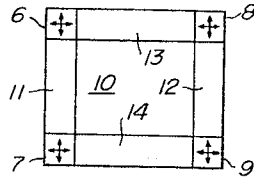


Fig. 1c

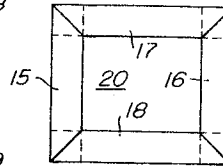


Fig. 2a

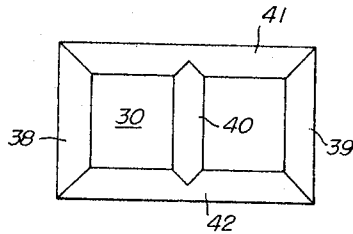


Fig. 2b

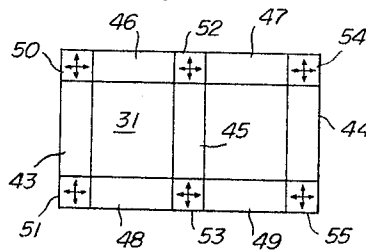


Fig. 2c

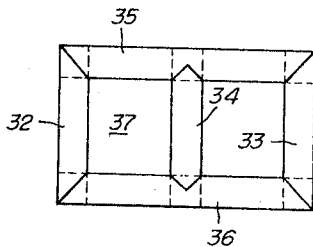


Fig. 3a

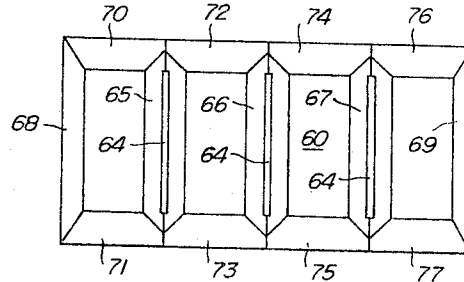
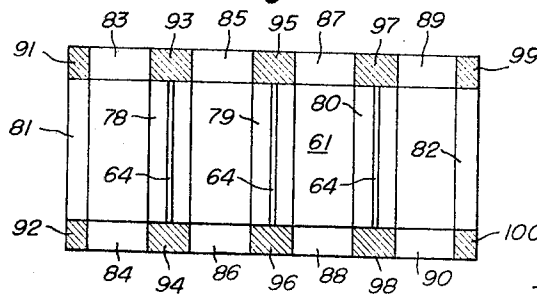


Fig. 3b



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Fig. 3c

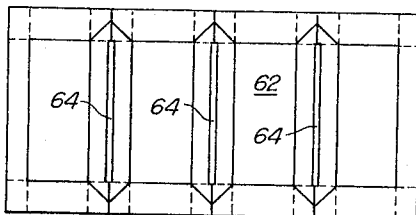


Fig. 4a

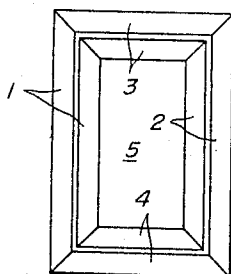


Fig. 4b

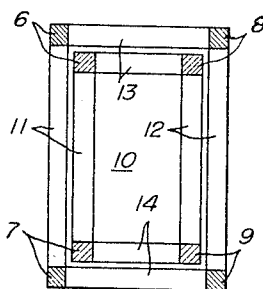


Fig. 4c

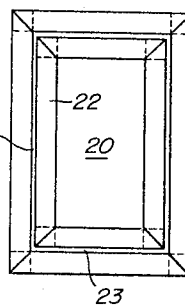


Fig. 5a

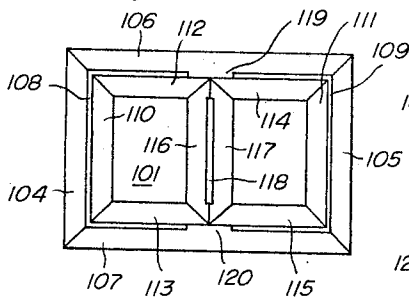


Fig. 5b

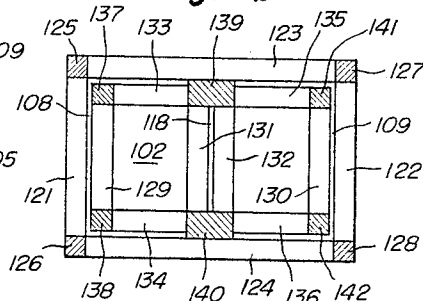
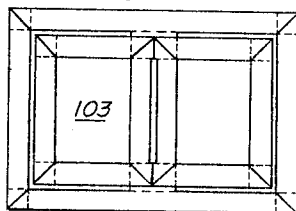


Fig. 5c



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LAMINATED CORE WITH BIDIRECTIONAL JOINTS

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Claims priority, application Japan, Dec. 14, 1961, 36/44,904

3 Claims. (Cl. 336—60)

The present invention relates to improvements in transformer cores and is primarily intended to reduce the iron loss occurring particularly at the joints between the leg and yoke portions of the core structure while facilitating the fabrication thereof.

Conventional transformer cores, comprising a plurality of stacked layers of laminations of directional or oriented silicon steel, generally have had a tendency that a substantial iron loss occurs particularly at joints between the leg and yoke portions of the core structure where the magnetic flux changes its direction to follow the curvature of the flux path, and thus adversely affects the operating efficiency of the transformer.

Various proposals have recently been made to eliminate this deficiency by employing a core structure in which the core leg and yoke portions are diagonally jointed. In such core structure, the adjacent ends of the leg and yoke members of each core unit or layer of the lamination are usually cut diagonally at an angle of 45 degrees and arranged in abutting relation to each other to form a rectangular core unit having diagonal joints between the adjacent leg and yoke members. The diagonal joints of such core units are laminated to form a core structure where the joints are staggered; that is, the diagonal joints of each of the core units are offset relative to the corresponding joints of the two adjacent core units. The fabrication of such core structure requires rather complicated procedures including the diagonal cutting of magnetic strip material and the assembling of the material so cut and thus precludes any substantial reduction in the manufacturing cost of transformer cores of this construction.

The present invention is designed to overcome the above difficulties previously encountered in the manufacture of transformer cores and provides a transformer core of integral structure comprising an alternately laminated assembly of two types of core units, one type including sections of ordinary unidirectional silicon sheet diagonally jointed to each other and the other type including rectangular joint sections of bidirectional silicon sheet and rectangular leg and yoke members of ordinary unidirectional silicon sheet.

Bidirectional silicon sheet usable in forming the joint portions of the core structure according to the present invention includes cubic crystals each having two sides in the plane of the sheet to exhibit the highest permeability in two directions in the plane of the sheet including the direction in which the sheet has been rolled and the direction at right angles to the rolling direction.

The present invention will now be described in detail with reference to the accompanying drawings, which schematically illustrate several embodiments of the invention and in which:

FIG. 1, including three schematic views, illustrates an iron core according to the present invention as applied to a single-phase transformer;

FIG. 2, also including three schematic views, illustrates a three-phase three-legged core structure embodying the invention;

FIG. 3, also including three schematic views, illustrates a three-phase five-legged core structure embodying the

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present invention with oil ducts formed only in the main core legs;

FIG. 4, including three schematic views, illustrates a two-legged core structure constructed substantially similarly to the structure shown in FIG. 1 but having oil ducts formed in the legs and yokes of the core structure; and

FIG. 5 also includes three schematic views and illustrates a three-phase three-legged core structure principally similar in construction to the structure shown in FIG. 4.

Reference will first be made to FIG. 1, which schematically illustrates a single-phase two-legged core structure embodying the present invention. The core structure includes a first core unit indicated generally at 5 in FIG. 1(a) and comprised of members 1, 2, 3 and 4 of ordinary unidirectional silicon sheet diagonally jointed to each other and a second core unit indicated generally at 10 in FIG. 1(b) and comprised of a rectangular arrangement of rectangular leg and yoke members 11, 12, 13 and 14 of ordinary unidirectional silicon sheet and rectangular joint sections 6, 7, 8 and 9 of bidirectional silicon sheet and arranged to join the adjacent leg and yoke members to each other. The crossed arrows in FIGURES 1(b) and 2(b) indicate the bidirectional passage of flux in the joint sections. The core units 5 and 10 are alternately laminated to form a unitary core assembly 20 having legs 15, 16 and yokes 17, 18, as shown in FIG. 1(c). The laminated assembly may be clamped into an integral core structure in the conventional manner by forming through holes in each of the legs and yokes and fitting boltings into the through holes to tighten the assembly by way of a clamping frame, not shown, arranged outside the assembly.

In practice, high capacity transformers often employ a core structure divided into two or more blocks, which are arranged in spaced relation to define oil ducts along the leg and yoke portions of the structure for the purpose of accelerating the cooling of the core and particularly the interior of the laminations thereof. FIG. 4 illustrates an embodiment of the present invention of such block construction. The core assembly 20 shown in FIG. 4(c) includes two core blocks 21 and 22 arranged in spaced relation to each other to define oil ducts 23 therebetween and each corresponding in construction to a core assembly illustrated in FIG. 1. The core assembly 20 may be tightly clamped in the conventional manner by a frame and boltings, not shown, extending through the oil ducts 23.

FIG. 2 illustrates a three-legged core structure for three-phase transformation embodying the present invention. In FIGURE 2(c) the core assembly is comprised of core units 30 and 31, shown in FIGS. 2(a) and 2(b), respectively, laminated alternately to form an integral core assembly 37 having side legs 32 and 33, an intermediate leg 34 and yokes 35 and 36.

The core unit 30 shown in FIG. 2(a) includes leg and yoke members 38, 39, 40, 41 and 42 of ordinary unidirectional silicon sheet and diagonally jointed in abutting relation to each other. On the other hand, the core unit 31 shown in FIG. 2(b) includes side leg members 43 and 44, an intermediate leg member 45, yoke members 46, 47, 48 and 49, and joint sections 50, 51, 52, 53, 54 and 55. The leg and yoke members each take the form of a rectangular strip of ordinary unidirectional silicon sheet while the joint sections each take the form of a rectangular strip of bidirectional silicon sheet.

The core structure shown in FIG. 2 is suitable for use in transformers of relatively limited capacity and may be clamped into an integral assembly by forming through holes in the core to receive boltings, as described in connection with the core structure illustrated in FIG. 1.

FIG. 3 illustrates a five-legged core structure embodying the present invention. The core structure includes

core units 60 and 61 shown in FIGS. 3(a) and 3(b), respectively. The core units 60 and 61 are alternately laminated to form an integral five-legged core assembly 62 as shown in FIG. 3(c).

As shown in FIG. 3(a), the core units 60 each include main leg members 65, 66 and 67 each comprised of spaced parallel strips defining an oil passage 64 therebetween, side leg members 68 and 69, and yoke members 70, 71, 72, 73, 74, 75, 76 and 77 interposed between the adjacent leg members. These core members all take the form of a strip of unidirectional silicon sheet and are joined to each other in the diagonal fashion.

The core units 61 each include, as illustrated in FIG. 3(b), rectangular main leg members 78, 79 and 80 each comprised of spaced parallel strips defining an oil passage 64 therebetween, rectangular side leg members 81 and 82, rectangular yoke members 83, 84, 85, 86, 87, 88, 89 and 90, each of unidirectional silicon sheet, and joint sections 91, 92, 93, 94, 95, 96, 97, 98, 99 and 100 arranged to join the adjacent leg and yoke members to each other in abutting relation and each comprised of a rectangular strip of bidirectional silicon sheet. The bidirectional nature of the joint sections is indicated by shading in FIGURE 3(b).

FIG. 5 illustrates a further embodiment of the present invention which includes core units 101 and 102 shown in FIGS. 5(a) and 5(b), respectively. The core units 101 and 102 are alternately laminated to form an integral three-legged core structure 103 for three-phase transformation, as shown in FIG. 5(c).

As shown in FIG. 5(a), the core units 101 include a set of leg and yoke members 104, 105, 106 and 107 of unidirectional silicon sheet diagonally jointed to each other to form a closed magnetic path, and another set of leg and yoke members 110, 111, 112, 113, 114, 115, 116 and 117 also of unidirectional silicon sheet diagonally jointed to each other to form another closed magnetic path and arranged inside of the first-mentioned set of leg and yoke members in spaced relation thereto to define oil passages 108 and 109 between the two sets of members.

In this core unit 101, the intermediate leg members 116 and 117 are slotted along the adjoining edges to define an oil passage 118 therebetween. In addition, the yoke members 106 and 107 each have an inwardly extended portion 119 or 120 intermediate the opposite ends jointed to the respective adjacent leg members 104 and 105 for the purpose of connecting the inner and outer magnetic paths with each other.

The core unit 102 includes, as illustrated in FIG. 5(b), a set of rectangular leg and yoke members 121, 122, 123 and 124 of unidirectional silicon sheet with rectangular joint sections 125, 126, 127 and 128 of bidirectional silicon sheet arranged between the adjacent unidirectional members in abutting relation thereto to form a closed magnetic path, and another set of rectangular members 129, 130, 131, 132, 133, 134, 135 and 136 of unidirectional silicon sheet arranged inside of the first-mentioned set of unidirectional rectangular leg and yoke members so as to define oil passages 108 and 109 therebetween with rectangular section joints 137, 138, 139, 140, 141 and 142 of bidirectional silicon sheet arranged to join the second-mentioned unidirectional rectangular members to each other in abutting relation thereto to form another closed magnetic path.

In the core unit 102, the leg sections 131 and 132 are slotted along the adjoining edges to define an oil passage 118 as with the case of the core unit 101. Also, the intermediate bidirectional section joints 139 and 140 each have an outwardly extended portion in contacting relation to the adjacent outer yoke member to connect the inner and outer magnetic paths with each other, as seen in FIG. 5(b).

As apparent from the foregoing, in the core structure according to the present invention, the legs and yokes are joined together in abutting relation to each other

through the intermediary of a joint structure comprising an alternate lamination of unidirectional diagonally-jointed silicon strips and bidirectional silicon strips. Thus the transformer core of the present invention is fabricated simply by alternately laminating two different core units without involving any staggered arrangement of sheet joints as employed in conventional core structures. It will readily be appreciated that with such core structure substantial economy of assembling time and labor may be realized in addition to reduction in material cost by use of rectangular sheets.

While the invention has been shown in several forms, it is obvious to those skilled in the art that it is not so limited but is susceptible of various changes and modifications without departing from the spirit and scope of the invention as claimed.

What is claimed is:

1. A magnetic core structure for transformers comprising a plurality of stacked layers of laminations formed from magnetic strip material having a preferred direction of magnetic orientation, said plurality of stacked layers consisting of an alternate arrangement of first and second core units in stacked relationship, said first core units comprising at least two leg members and at least two interconnecting yoke members of unidirectional magnetic strip material diagonally jointed to form a substantially rectangular core and said second core units comprising at least two leg members and at least two yoke members of unidirectional magnetic strip and substantially rectangular joint sections of bidirectional magnetic strip material interconnecting said leg and yoke members to form a substantially rectangular core,

said magnetic core structure having at least one substantially rectangular window therein with the preferred direction of magnetic orientation in each of said unidirectional leg and yoke members being substantially parallel to the side of the member which defines a side of said window,

said bidirectional joint sections having substantially transverse directions of magnetic orientation parallel to the directions of magnetic orientation of said leg and yoke members, respectively,

said first and second core units each having at least one intermediate leg member so that said magnetic core structure has at least two substantially rectangular windows therein, the intermediate leg member in said first core unit having a symmetrical point at either end thereof connected to substantially the center of the respective yoke members of said first core unit and the intermediate leg member in said second core unit being joined to the yoke members of said unit by means of substantially rectangular joint sections of bidirectional magnetic strip material.

2. A magnetic core structure for transformers comprising a plurality of stacked layers of laminations formed from magnetic strip material having a preferred direction of magnetic orientation, said plurality of stacked layers consisting of an alternate arrangement of first and second core units in stacked relationship, said first core units comprising at least two leg members and at least two interconnecting yoke members of unidirectional magnetic strip material diagonally jointed to form a substantially rectangular core and said second core units comprising at least two leg members and at least two yoke members of unidirectional magnetic strip and substantially rectangular joint sections of bidirectional magnetic strip material interconnecting said leg and yoke members to form a substantially rectangular core,

said magnetic core structure having at least one substantially rectangular window therein with the preferred direction of magnetic orientation in each of said unidirectional leg and yoke members being substantially parallel to the side of the member which defines a side of said window,

said bidirectional joint sections having substantially

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transverse directions of magnetic orientation parallel to the directions of magnetic orientation of said leg and yoke members, respectively.

said first and second core units each having at least one intermediate leg member so that said magnetic core structure has at least two substantially rectangular windows therein, the intermediate leg member in said first core unit having a symmetrical point at either end thereof connected to substantially the center of the respective yoke members of said first core unit and the intermediate leg member in said second core unit being joined to the yoke members of said unit by means of substantially rectangular joint sections of bidirectional magnetic strip material, said intermediate leg members of said first and second core units each consisting of a pair of leg members defining a longitudinal slot therebetween serving as an oil duct for said core.

3. A magnetic core structure for transformers comprising a plurality of stacked layers of laminations formed from magnetic strip material having a preferred direction of magnetic orientation, said plurality of stacked layers consisting of an alternate arrangement of first and second core units in stacked relationship, said first core units comprising at least two leg members and at least two interconnecting yoke members of unidirectional magnetic strip material diagonally jointed to form a substantially rectangular core and said second core units comprising at least two leg members and at least two yoke members of unidirectional magnetic strip and substantially rectangular joint sections of bidirectional magnetic strip material interconnecting said leg and yoke members to form a substantially rectangular core,

said magnetic core structure having at least one substantially rectangular window therein with the preferred direction of magnetic orientation in each of said unidirectional leg and yoke members being substantially parallel to the side of the member which defines a side of said window,

said bidirectional joint sections having substantially transverse directions of magnetic orientation parallel to the directions of magnetic orientation of said leg and yoke members, respectively,

said first and second core units each having at least one intermediate leg member so that said magnetic core structure has at least two substantially rectangular windows therein, the intermediate leg member in said first core unit having a symmetrical point at either end thereof connected to substantially the center of the respective yoke members of said first core unit and the intermediate leg member in said

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second core unit being joined to the yoke members of said unit by means of substantially rectangular joint sections of bidirectional magnetic strip material,

said intermediate leg members of said first and second core units each consisting of a pair of leg sections defining a longitudinal slot therebetween serving as an oil duct for said core,

each of said leg and yoke members in said first and second core units consisting of pairs of leg sections and yoke sections, respectively, defining a longitudinal slot therebetween, which longitudinal slot forms a continuous channel around at least two sides of a window formed in the rectangular core by said members in each of said core units, said continuous longitudinal channel in each of said first and second core units being in substantial alignment in the stacked arrangement of said core structure to form an oil duct for said core,

said continuous channels in each of said first and second core units forming inner and outer magnetic paths in each unit, and further including inwardly extending portions in substantial alignment with said intermediate leg member interconnecting said inner and outer magnetic paths, said inwardly extending portions being of unidirectional magnetic strip in said first core unit and bidirectional magnetic strip in said second core unit.

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