

Sept. 17, 1946.

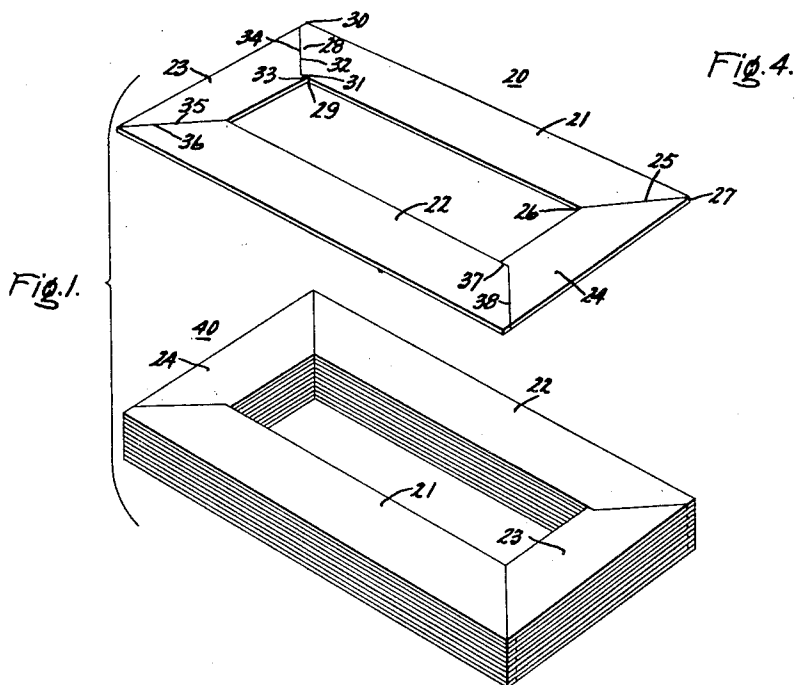
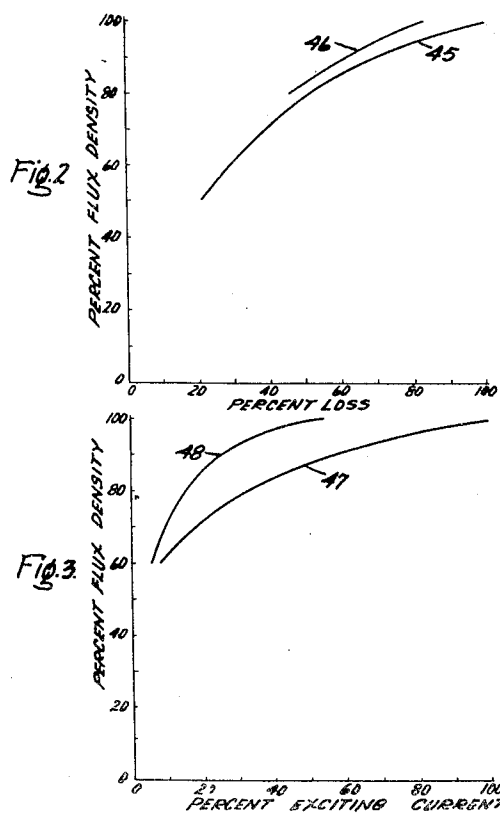
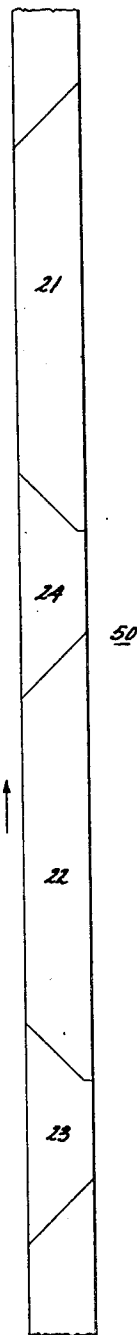
F. F. BRAND

2,407,625

MAGNETIC CORE

Filed Dec. 30, 1942

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 5.

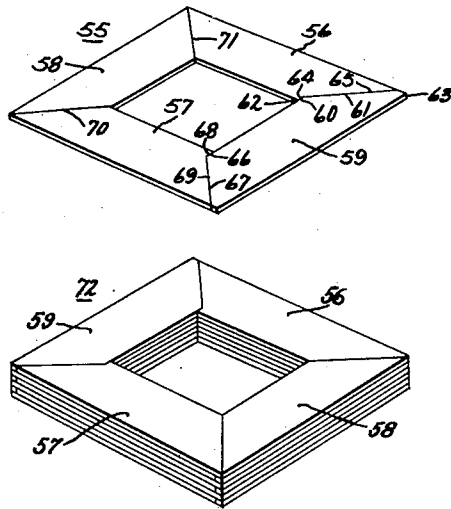


Fig. 6.

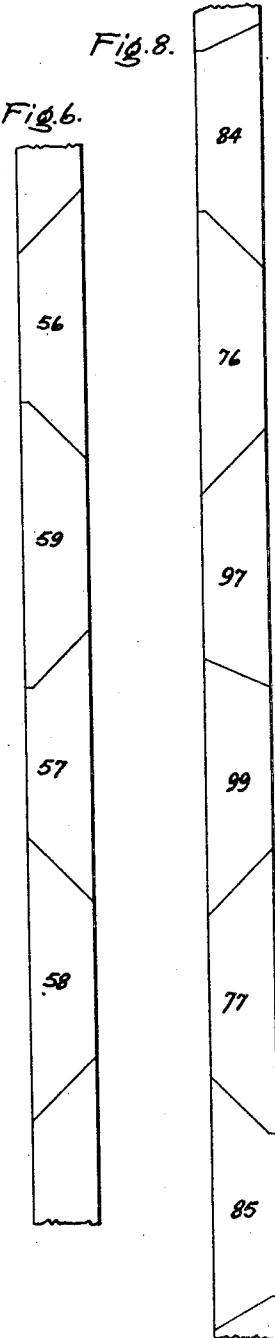
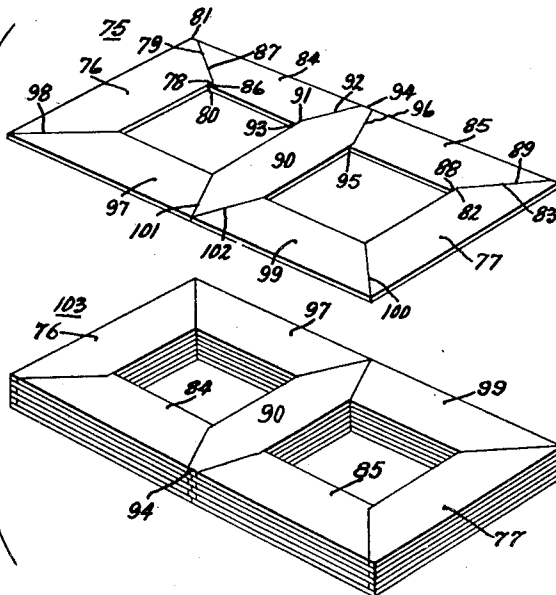


Fig. 7.



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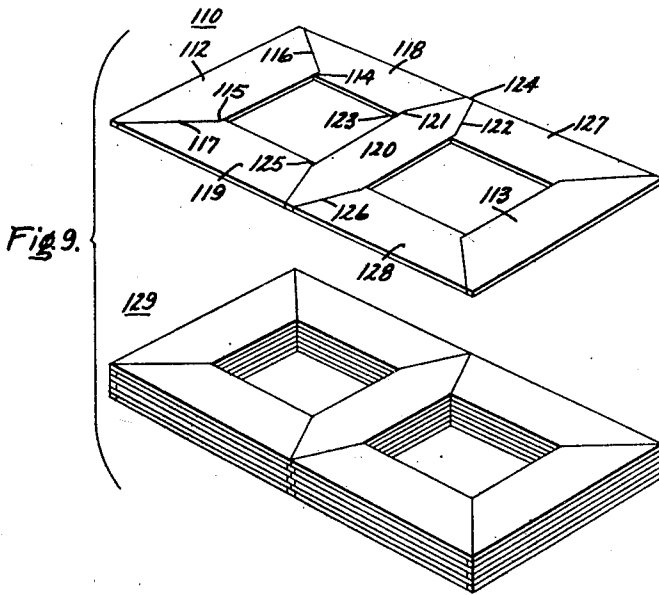
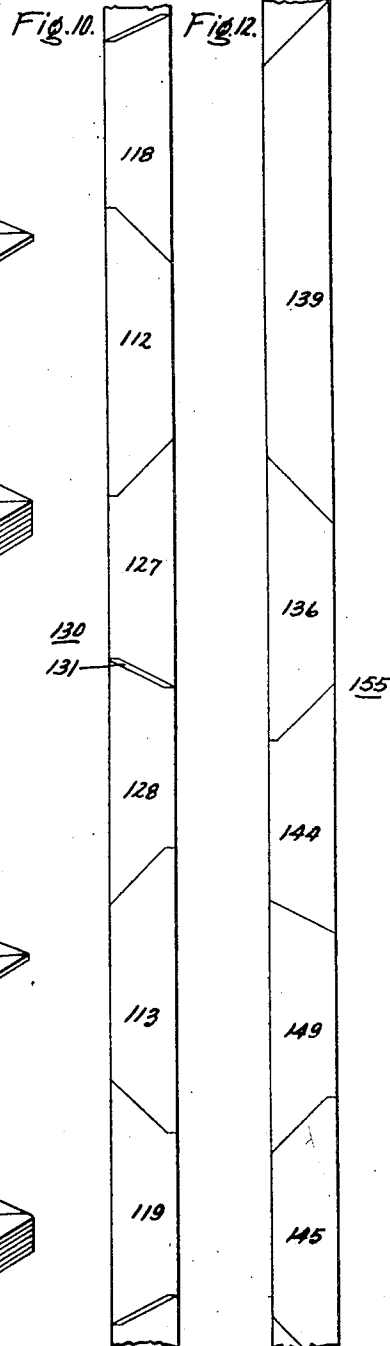
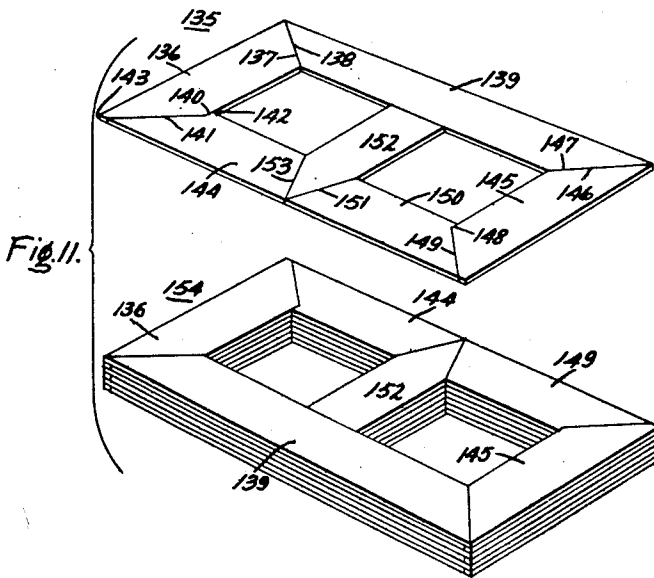
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MAGNETIC CORE

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,407,625

MAGNETIC CORE

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Application December 30, 1942, Serial No. 470,578

12 Claims. (Cl. 175—356)

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My invention relates to laminated magnetic core structures for electrical induction apparatus such as transformers and reactors.

In the usual construction for magnetic cores, the laminations are cut or punched from relatively large stock sheets which are produced by rolling from bars or billets of a suitable magnetic material, such as various steel alloys such as silicon steel or a magnetic nickel iron steel. It is known that the rolling process produces a grain structure in sheets which may extend in the direction in which the sheets have been rolled. It is further known that the path of least magnetic resistance of such material is generally in the direction that the sheets have been rolled, though in certain types of steels the most favorable magnetic direction, in so far as low flux losses are concerned, may be at some angle with respect to the direction of rolling. Thus it will be seen that for optimum results for magnetic cores, it is desirable to cut the laminations from the sheets of magnetic material so that the core flux path is parallel with the path of least magnetic resistance, or parallel with the direction of rolling even at the corners.

One common form of magnetic core consists of a stack of L-shaped punchings, but it will be apparent that such shapes cannot be punched as a single piece from a standard stock in such a manner that the most favorable magnetic direction extends parallel with the flux path in both parts of the punchings. This is due to the fact that the grain extends in the same direction throughout all parts of the stock while the two parts of the L-shaped punchings are at right angles to each other. Another common form of a core consists of rectangular laminations stacked at right angles with respect to each other. While the most favorable magnetic direction in this type of core may be made parallel with the direction of the flux path throughout the central portion of the laminations, the core flux must cut crosswise of the most favorable direction at the ends of the laminations in traversing from one core leg to the next. Due to this crosswise flow of flux at the corners of the core, relatively high losses occur at these points.

One way of overcoming the difficulties referred to above is to provide a core structure by winding a ribbon of suitable magnetic steel so that all the flux will pass parallel to the direction of rolling of the material or in the direction which has the least magnetic reluctance. Such a type of wound core has been found to be very successful in the production of relatively small

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size transformers, which are called distribution transformers in the trade. Due to various mechanical difficulties, however, it has been less economical to wind much larger sizes of ribbon sheet material so as to produce sufficiently large cores for electric apparatus having a high kva. capacity.

Another way of providing cores of laminated material in which the direction of flux path is along the line of least magnetic reluctance in the vicinity of the joints is to assemble the laminations, each corner of which has been cut on the diagonal, so as to provide a mitered joint at each of the corners. It will be seen, however, that when each of the joints at the various corners of a core is coincident with the diagonal running from the inside corner to the outside corner, that all the joints will be in substantial registry so that the possibility of gaps being formed at the joints which increases the magnetic reluctance, is appreciable, even though elaborate means are provided for clamping the magnetic laminations together.

An improved arrangement for providing mitered joints at the various corners of the assembled laminations in a manner so as to minimize separation at the mitered corners is described and claimed in patent application Serial No. 376,304 Granfield, filed January 28, 1941 (now Patent 2,348,003 dated May 2, 1944) and assigned to the same assignee as this present invention. In this application there is described a stacked laminated core formed of laminations which have mitered butt joints and which also have interlocking portions with extensions and corresponding indentations in the edges of the adjacent laminations, so as to minimize separation at the butt joints. The various layers which are stacked to form the core are made up of similarly assembled laminations which are oppositely arranged so as to stagger the joint between laminations between one layer and a contiguous layer. In this manner there will be a minimum of magnetic flux which will pass crosswise of the most favorable magnetic direction and due to the projections and corresponding interfitting indentations which extend in opposite directions for the adjacent joints of contiguous layers overlapping will be provided at the joints so as to substantially preclude separation of the laminations of the assembled core.

It is therefore an object of my invention to provide a laminated core with an improved construction which will have a minimum of resistance to the flow of flux at the corners of the assembled

laminations, and which will have a corner shape so as to facilitate assembly of the laminations.

Another object of my invention is to provide a new and improved core in which the laminations are so cut from metal stock that when fitted together into a unit, the core flux may flow in the most favorable magnetic direction of the lamination substantially completely throughout the magnetic circuit.

A further object of my invention is to provide an assembled magnetic core construction having separate laminations with such corner construction as to facilitate the manufacture thereof as well as provide an efficient assembled core construction.

Further objects and advantages of my invention will become apparent from the following description referring to the accompanying drawings, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

In the drawings Fig. 1 is an exploded perspective view of layers of assembled laminations, the laminations being formed in accordance with an embodiment of my invention; Figs. 2 and 3 illustrate curves which will be employed in the description of my invention; Fig. 4 illustrates a method by which the laminations employed in Fig. 1 may be cut from a single strip of magnetic material with no waste; Fig. 5 is an exploded perspective view of layers of assembled laminations illustrating a modification of my invention; Fig. 6 illustrates a method by which the laminations of Fig. 5 may be cut from a strip of magnetic material with no waste; Fig. 7 is an exploded perspective view of a 3-legged core provided with an embodiment of my invention; Fig. 8 illustrates a method by which some of the laminations employed in Fig. 7 may be cut from a strip of magnetic material with no waste; Figs. 9 and 11 illustrate modifications of the 3-legged core illustrated in Fig. 7, and Figs. 10 and 12 illustrate methods by which some of the laminations may be punched from strips of magnetic material to form the laminations for Figs. 9 and 11, respectively, with a minimum of waste.

Referring to Fig. 1 of the drawings I have illustrated a magnetic core having a plurality of layers 20 of stacked laminations. Any suitable number of layers may be used depending upon the size of the core which is desired. Each of the layers includes a plurality of separate laminations which are closely fitted at their ends forming butt joints. Any suitable number of laminations may be employed to form each of the layers 20 and in the construction illustrated in Fig. 1, four such laminations are employed to form a single layer of what may be used as a single phase core for a suitable electric induction apparatus, such as a transformer. It is to be understood, however, that a core having any suitable number of legs and yokes may be formed according to my invention and I will describe below in reference to Figs. 7 to 12 3-phase cores formed according to my invention. Thus in Fig. 1 I have illustrated layers of stacked laminations, each of the layers including laminations 21 and 22 which may be called leg punchings or sheets and laminations 23 and 24 which may be termed yoke punchings or sheets. It is to be understood, however, that the leg sheets 21 and 22 could be the yoke sheets and the yoke sheets 23 and 24 could be the leg sheets if desired. The various laminations are formed from strip mate-

rial having the most favorable magnetic direction lengthwise of the strip so as to provide a core with a minimum magnetic reluctance. These laminations could be punched with a 45 degree angle at the ends and thus provide substantially no path at the corners through which the flux must pass crosswise of the most favorable direction. However, as has been stated above, if all the joints are at substantial registry, there is considerable difficulty in preventing gaps from being formed at the butt joints, even though elaborate clamping arrangements are provided.

In order therefore to provide an assembled lamination structure which not only has a minimum of reluctance at the corners, but which also is formed so as to provide overlapping between adjacent laminations of contiguous layers so as to maintain the tightness of the joints throughout normal use of the device, I have provided corner constructions which not only have a mitered butt joint but the edges of the laminations which form the joints are so cut and so assembled as to displace the adjacent joints of contiguous layers of laminations from each other and thereby provide overlapping. Thus the lamination 21 is formed with an end 25 which is coincident with a diagonal running from the inside corner 26 to the outside corner 27. The other end of the lamination 21, however, has an edge 28 which is displaced or offset from a diagonal running from an inside corner 29 to the outside corner 30 of the assembled stack. This offsetting may be accomplished and still maintain a mitered joint by providing a broken line joint including a first portion 31 which is parallel with the longitudinal axis of the assembled core construction or the lamination 21 and a second edge portion 32 which is parallel with a diagonal running from the inside corner 29 to the outside corner 30. In order to provide a relatively tight joint between the lamination 21 and the adjacent lamination 23, the corresponding end of the adjacent lamination 23 also has a cooperating first edge portion 33 which is parallel with the longitudinal axis of the assembled laminations or perpendicular to the axis of the lamination 23 and a second portion 34 which is parallel with a diagonal running from the inside corner 29 to the outside corner 30. In this manner the major portion or the portion formed by the edges 32 and 34 provides a mitered joint. The opposite end of the yoke sheet 23 is cut on a diagonal so as to provide an edge 35 similar to the edge 25. In like manner the leg sheet 22 has one end 36 cut on a 45 degree diagonal so as to provide an edge coincident with a diagonal running from the inside corner to the outside corner and the opposite end having an edge 37 which runs parallel with the longitudinal axis of the assembled core and a second edge 38 which is parallel with the diagonal running from the inside corner to the outside corner. It will also be seen that the yoke sheet 24 has one end which has a broken line joint so as to fit the edges 37 and 38, and the opposite end has a straight diagonal line joint. Since the layer of laminations 20 have two opposite mitered butt joints which are coincident with a diagonal running from the inside corner to the outside corner or which provide continuous straight line joints terminating at the corners, and the two other opposite joints which are offset from the diagonal it will be seen, as is shown in Fig. 1, that by forming the adjacent layer of laminations 40 similar to those employed in the layer 20 and then stacking the layers so that the layer 40 is reversed or

oppositely arranged from the layer 20, the joints at each of the corners will be offset from each other so as to provide overlapping of the various laminations of each layer with the adjacent lamination of a contiguous layer in the vicinity of the joint. With this construction it will be seen that the slight overlapping will accomplish the mechanical result of preventing separation of the laminations and thereby minimize the possibility of gaps being formed at the butt edges and also minimize the amount of flux at the corners passing crosswise of the grain. Although the lamination layers in Fig. 1 are shown with each contiguous layer being oppositely arranged it is to be understood that any suitable number of layers, if desired, may be stacked so that the joints are in registry and then stack another suitable number which are oppositely disposed with a first group. In any case there will be two contiguous layers which are oppositely arranged so as to provide an offset at the joints between these layers.

It will be seen that with a plurality of layers of laminations formed in the manner described above only a minimum of flux at the edges will pass crosswise of the grain, and with such a construction considerable improvement in efficiency is obtained over that in which the laminations are formed with overlapping rectangular corners. Thus I have illustrated in Fig. 2 this result in which curve 45 illustrates the per cent loss in the core joints for the conventional joints having rectangular overlappings while curve 46 illustrates the loss in the core joints with joints made according to my invention. In Fig. 2 the per cent core loss at 60 cycles is plotted as abscissa and per cent flux density is plotted on the ordinate axis. In order to show further the improvement in operation of cores formed according to my invention over those formed with rectangular shaped laminations I have illustrated in Fig. 3 characteristics in which per cent exciting current is plotted as abscissa and per cent density is plotted as ordinate. Curve 47 illustrates the characteristics of a conventional core having rectangular ends while curve 48 represents the characteristics of a core formed with my improved joint construction.

Not only is a core formed with my improved laminations efficient in operation but the laminations may be formed of a constant width material with no waste. I have thus illustrated in Fig. 4 a strip of magnetic material 50 having the most favorable direction of flux parallel with its axis as shown by the arrow. The various laminations may then be punched from this strip of magnetic material 50 with only two different dies and with no waste, since each of the corners of each of the laminations has a corner construction similar to one end of another lamination. Thus in Fig. 4 I have illustrated how the laminations 21 through 24 may be punched out of the single strip without waste.

In view of the above it will be seen that I have provided an improved core construction formed of layers of laminations in which not only does the maximum of the flux pass in the direction of most favorable magnetic permeability but overlapping is provided at the ends so as to provide a path of low magnetic reluctance at the joints and so as to preclude separation at the butt joint. Furthermore, the various layers may be formed of similar width or of equal width and be punched from the same strip with substantially no waste. Furthermore, with my construction

the corners are formed so as no voids will be formed at any of the corners.

In Fig. 5 I have illustrated a modification of the single phase core of Fig. 1 with a layer of laminations 55 including leg punchings 56 and 57 and yoke punchings 58 and 59. In the joint between the yoke punchings 59 and the leg punching 56 it will be seen that the joint includes an edge 60 which is parallel with the lateral axis of the assembled core and an edge 61 which is parallel with a diagonal running from an inside corner 62 to an outside corner 63 of the assembled laminations. The adjacent edge of the leg lamination 56 of course has a cooperation portion or notch 64 into which the portion 60 projects and an edge 65 which cooperates with the edge 61 when the laminations are assembled. It will be seen also that the opposite end of the yoke lamination 59 has a portion 66 parallel with the lateral axis of the assembled laminations and another portion 67 which is parallel with the diagonal, while the mating end of the leg portion 57 has a corresponding notch 68 for receiving the portion 66 and an edge 69 for cooperating with the edge 67. The other ends of the leg sheets 57 and 56 it will be seen have edges 70 and 71, respectively, cut on the diagonal while the yoke sheet 58 has similar diagonally cut edges for mating with the cooperating edges of the leg sheets. In order to provide an assembled core in which the adjacent joints of contiguous laminations are staggered a layer 72 is formed of sheets or strips similar to those described above in relation to layer 55 except that the laminations are reversed, as will be seen from an inspection of Fig. 5. It will also be seen that in Fig. 5 the extending portions are provided at opposite ends of a single lamination so that the offsetting joints are provided at the opposite ends of one yoke sheet at one end of the assembled layers rather than having diagonally opposite joints of the assembled lamination offset as is shown in Fig. 1.

In the formation of my improved core according to that shown in Fig. 5 it will be seen that not only may the laminations be formed from a strip of constant width but the laminations may be punched with no waste as is illustrated in Fig. 6, where I have numbered the various laminations 56 through 59 to show how the joints will fit together so as to produce no waste.

It is to be understood that my invention may be applied to a core having any suitable number of assembled laminations per layer and in Fig. 7 I have illustrated my invention as applied to a three-phase core including a plurality of layers each having seven assembled laminations. In the arrangement illustrated in Fig. 7, it will be seen that the various layers are made of similar laminations except that the laminations are stacked in reverse order in adjacent layers so as to provide overlapping at the joints. The layer of laminations 75 includes similar outer leg sheets 76 and 77. The leg sheet 76 has an extending edge 78 or a portion parallel with the lateral axis of the assembled laminations and another portion 79 which is parallel with but offset from a diagonal running from the inside corner 80 to the outside corner 81 of the assembled laminations. Similarly the outer leg 77 has an extending portion 82 which is parallel with the lateral axis of the assembled laminations and another portion 83 parallel with the diagonal running from the inside to the outside corner of the assembled laminations. Cooperating with the leg

sheets 76 and 77 there are provided yoke sheets 84 and 85, the sheet 84 having an end with an indentation or notch 86 adapted to cooperate with the portion 78 and an edge 87 which cooperates with the edge 79 of the leg sheet 76. Similarly, the yoke sheet 85 has an indentation or notch portion 88 and a portion 89 cooperating with the edge 82 and the edge 83, respectively, of the lamination 77. A center leg 90 is provided having a joint portion 91 which runs parallel with the lateral axis of the assembled laminations and a second portion 92 which is offset from the diagonal running from an inside corner 93 to the center 94 of the outer end of the lamination 90. Cooperating edges are provided in the yoke sheet 84, and the opposite side of the lamination 90 has a portion 95 and an edge portion 96 which is offset from a diagonal running from the inside corner to the outside center 94 of the assembled laminations. In like manner the yoke sheet 85 has corresponding edges so that a mitered or diagonal butt joint is provided which is offset from the diagonal. The lamination 76 cooperates with an opposite yoke sheet 97 through a mitered butt joint 98 while the outer leg sheet 77 cooperates with a yoke sheet 99 with a mitered butt joint 100 which runs diagonally from the inside to the outside corners of the assembled laminations. Also, the center leg has an edge which cooperates with a corresponding edge of the yoke sheet 97 to provide a mitered butt joint 101 running from the inside corner to the outside corner of the assembled laminations, while an opposite surface of the leg sheet 90 cooperates with an adjacent edge of the yoke sheet 99 to provide a butt joint 102. As will be seen in Fig. 7, an adjacent layer of laminations 103 is provided similar to the layer 75 except that the laminations are assembled in a laterally reversed order, so as to provide overlapping of the adjacent joints of the contiguous layers 75 and 103.

It will be noted that in this construction the ends of the laminations of each layer on one side of a longitudinal axis are notched so as to offset the joints at the notched ends from diagonals running from inside corners to outside corners adjacent the joints while the joints on the opposite side of the axis are coincident with diagonals running between the corners adjacent the joints.

In the three-phase core construction illustrated in Fig. 7 the various laminations with the exception of the center leg may all be punched from a strip of magnetic material with no waste. Thus I have illustrated in Fig. 8 a strip of magnetic material with the various punchings with the exception of the center leg 90 which makes up the lamination 75.

In Fig. 9, I have illustrated a core for a 3-phase electrical apparatus including a layer of laminations 110 in which the ends of the laminations have notches and cooperating extensions so that the joints between all the laminations of the layer will be offset from diagonals running from the inside corners to the outside corners of the assembled laminations adjacent the joints. Thus the layer 110 includes leg sheets 112 and 113, the leg sheet 112 having extensions 114 and 115 or portions which are parallel with a lateral axis and portions 116 and 117 which are parallel with the diagonals running from the inside corners to the outside corners of the assembled laminations. A yoke sheet 118 is provided with an end which cooperates with the adjacent end of the leg sheet 112, and a yoke sheet 119 is provided with an end

which cooperates with the end of the leg sheet 112 to provide the broken line joints, the major portions of which are parallel but offset from diagonals running between the corners. Similarly, a center leg 120 is provided having an extension 121 or a portion running parallel to a lateral axis and a second portion 122 running parallel but offset from a diagonal running from an inside corner 123 to a center 124 of the end of the leg sheet 120. Similarly, the leg sheet 120 has an end with broken line joints 125 and 126 which cooperate with the adjacent end of the yoke sheet 119. It will be seen from an inspection of Fig. 9 that yoke sheets 127 and 128 are provided which are similar to the yoke sheets 118 and 119, respectively. In fact the four yoke sheets 118, 119, 127, 128 are exactly similar while the leg sheets 112, 113, are exactly similar. A layer 129 is provided in which each of the corners of the various laminations to make up the layers is cut with a joint which is coincident with the diagonals running from inside corners to the outside corners of the assembled laminations adjacent the joints. Thus when a layer composed of laminations having joints in registry with the diagonals are assembled, adjacent a layer of laminations having joints offset from the diagonals a staggering of the joints between contiguous layers may be provided. It is to be understood that instead of staggering joints between contiguous laminations any suitable number of layers may be stacked of similar type and then stack another group of the other type so that there will be through the stack of assembled layers some of the joints between contiguous layers staggered.

In Fig. 10 I have illustrated a method of punching all the leg and yoke sheets except the center leg 120 from a single strip of magnetic material 130 with a minimum of waste. It will therefore be seen that in punching out the six laminations of the two different shapes which go to form the single layer 110 a relatively small amount of waste 131 will result between the ends of the punchings 128 and 127. This small amount of waste 131 however amounts to a very small proportion of the total amount of magnetic material which forms a single layer. The center leg 120 may be punched from another sheet of magnetic material.

In Fig. 11 I have illustrated a core suitable for a three-phase electrical apparatus in which a relatively long yoke punching is provided in each layer which goes the complete length of the assembled three-phase core. While it is true that this construction introduces a path for the flux which is in a crosswise direction at the intersection between the center leg and the long yoke punching it may be desirable for some constructions for mechanical reasons to have the long yoke punchings. Thus the construction in Fig. 11 includes a plurality of layers composed of similar laminations, the layers being laterally reversed so as to obtain the staggering of the joints. The layer 135 includes a leg sheet 136 having one edge 137 which provides a mitered butt joint with an edge 138 of the long yoke sheet 139. The opposite end of the leg sheet 136 has a portion 140 which is parallel with a lateral axis of the assembled laminations and a second portion 141 which is parallel but offset from a diagonal running from an inside corner 142 to an outside corner 143 of the assembled laminations. A yoke sheet 144 is provided having a broken line edge which cooperates with the edges 140 and 141 of the leg sheet 136. A leg sheet 145 is provided

which is similar to the leg sheet 136 and which has an edge 146 which provides a mitered butt joint with an edge 147 of the yoke sheet 139, the joint being coincident with the diagonal running from the inside to the outside corner of the assembled laminations. The opposite end of the leg sheet 145 has a portion 148 which is parallel with the lateral axis and a portion 149 which is parallel but offset from a diagonal running from the inside corner to the outside corner of the assembled laminations. A yoke sheet 150 is provided which has an end which cooperates with the adjacent end of the leg sheet 145 and an edge 151 which cooperates with a corresponding edge of a leg sheet 152. The leg sheet is provided with a similar edge 153 which cooperates with a similar formed edge of the yoke sheet 144. As will be seen from an inspection of Fig. 11 when a layer of laminations 154 is stacked including laminations similar to the laminations which compose the layer 135 but laterally reversed, staggered joints will be provided between adjacent joints of contiguous layers.

In Fig. 12 I have illustrated a method in which the various laminations which go to make up the layers, with the exception of the center leg sheet 152, may be punched from a single ribbon of magnetic material 155 with no waste. The leg sheet 152 may be punched from another sheet of magnetic material with only a relatively small amount of loss.

Although I have shown and described particular embodiments of my invention, I do not desire to be limited to the particular embodiments described, and I intend in the appended claims to cover all modifications which do not depart from the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A magnetic core comprising a plurality of layers of assembled laminations formed lengthwise from strip material having the most favorable magnetic direction lengthwise of the strip, adjacent laminations of each layer having substantially mitered butt joints between ends so that a minimum of flux at the joints will pass crosswise of the most favorable magnetic direction, said mitered butt joints being displaced from diagonals running from inside corners to the outside corners of the assembled laminations at at least two corners of the assembled laminations, the remaining butt joints being substantially coincident with said diagonals, said layers of laminations being oppositely arranged so that a displaced joint of one layer will be staggered from an adjacent joint coincident with said diagonals of a contiguous layer so as to provide overlapping at said joints of adjacent laminations of contiguous layers.

2. A magnetic core comprising a plurality of laminations formed lengthwise from strip material having the most favorable magnetic direction lengthwise of the strip, adjacent laminations of each layer having substantially mitered butt joints between ends so that a minimum of flux passing from one lamination to another will pass crosswise of the most favorable magnetic direction, said mitered butt joints being straight joints substantially coincident with a diagonal running from inside corners to outside corners of the assembled laminations at some corners and being broken line joints at other corners, said layers of laminations being oppositely arranged so that a straight joint of one layer will be staggered from an adjacent broken line joint of a contig-

uous layer so as to provide overlapping at said joints of adjacent laminations of contiguous layers.

3. A magnetic core comprising a plurality of layers of assembled laminations formed lengthwise from strip material having the most favorable magnetic direction lengthwise of the strip, adjacent laminations of each layer having substantially mitered butt joints between ends so that a minimum of flux passing from one lamination to another will pass crosswise of the most favorable magnetic direction, said mitered butt joints being straight line joints substantially parallel with a diagonal running from inside corners to outside corners of the assembled laminations at some corners of the assembled laminations, other of said joints being broken line joints with at least a portion parallel with said diagonals, said layers of laminations being oppositely arranged so that a straight joint of one layer will be staggered from an adjacent broken line joint of a contiguous layer so as to provide overlapping at said joints of adjacent laminations of contiguous layers.

4. A magnetic core comprising a plurality of layers of assembled laminations formed lengthwise from strip material having the most favorable magnetic direction lengthwise of the strip, each of said layers including at least four laminations assembled with diagonal butt joints at adjacent ends, each of said laminations having edge surfaces in five planes, edge surfaces in three of said planes forming the edges for said butt joints.

5. A magnetic core comprising a plurality of layers of assembled laminations formed lengthwise from strip material having the most favorable magnetic direction lengthwise of the strip, each of said layers including at least four similarly shaped assembled laminations with diagonal butt joints at adjacent ends, each of said laminations having edge surfaces in five planes, edge surfaces in three of said planes forming the edges for said butt joints of said laminations.

6. A magnetic core comprising a plurality of layers of assembled laminations formed lengthwise from strip material having the most favorable magnetic direction lengthwise of the strip, adjacent laminations of each layer having substantially metered butt joints between ends so that a maximum of flux passing from one lamination to another will pass substantially longitudinally of each lamination, said mitered butt joints being straight joints substantially coincident with a diagonal running from the inside corner to the outside corner of the assembled laminations at some corners of the assembled laminations and being broken line joints at other corners, said layers of laminations being oppositely arranged so that a straight joint of one layer will be staggered from an adjacent broken line joint of a contiguous layer so as to provide overlapping of said joints of adjacent laminations of contiguous layers.

7. A magnetic core suitable for a three-phase electrical apparatus including a plurality of layers of assembled laminations formed lengthwise from strip material having the most favorable magnetic direction lengthwise of the strip, adjacent laminations of each layer having substantially mitered butt joints between ends so that a minimum of flux passing from one lamination to another will pass crosswise of the most favorable magnetic direction, the ends of the laminations of each assembled layer on one side of an axis

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passing through the center of the assembled laminations being notched so as to offset the joints at the notched ends from diagonals running from the inside corners to the outside corners of the assembled laminations, the joints on the opposite side of said axis being parallel with the diagonal running from an inside corner to an outside corner of the assembled laminations, said layers of laminations being oppositely arranged so that an offset joint will be staggered from an adjacent joint between laminations of a contiguous layer so as to provide overlapping at the joints.

8. A magnetic core suitable for a three-phase electrical apparatus including a plurality of layers of assembled laminations formed lengthwise from strip material having the most favorable magnetic direction lengthwise of the strip, adjacent laminations of each layer having substantially mitered butt joints between ends so that a minimum of flux passing from one lamination to another will pass crosswise of the most favorable magnetic direction, ends of all the laminations of some of said layers being notched so as to offset the joints from the adjacent diagonal running from the inside corner to the outside corner of the assembled laminations, layers of laminations adjacent said last-mentioned layers having mitered butt joints coincident with the adjacent diagonal running from the inside corner to the outside corner so that joints between adjacent laminations of contiguous layers will be staggered so as to provide overlapping at the joints of adjacent laminations of contiguous layers.

9. A magnetic core having at least two straight portions meeting at an angle and forming an inner and an outer corner, and including at least two superimposed layers of laminations, said laminations having substantially more favorable magnetic characteristics along their lengthwise direction, each one of said layers including a butt joint between adjacent laminations of each layer, said joints extending diagonally across said laminations and being generally parallel to each

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other, the joint of one layer being a continuous straight line joint and terminating at said corners and the joint of the other layer being offset to permit a lamination of one layer to overlap the joint of the other layer.

10. A magnetic core for three phase induction apparatus comprising, in combination, a plurality of lamination layers, each layer having three leg pieces and at least two yoke pieces, all of said pieces being of the same width and all having a most favorable magnetic direction parallel with their length, the joints between said pieces in each layer being generally mitered, the superposed joints in successive layers being offset so as to form lapped core joints.

11. A magnetic core for three phase induction apparatus comprising, in combination, a plurality of lamination layers, each layer having three leg pieces and at least three yoke pieces, all of said pieces being of the same width and all having a most favorable magnetic direction parallel with their length, the joints between said pieces in each layer being principally straight lines making an angle with the lengthwise dimension of their respective pieces of half their joint angle, the superposed joints in successive layers being offset so as to form lapped core joints.

12. A magnetic core for three phase induction apparatus comprising, in combination, a plurality of similar lamination layers, each layer having three leg pieces and four yoke pieces, all of said pieces being of the same width and all having a most favorable magnetic direction parallel with their length, the joints between said pieces in each layer being principally straight lines making an angle with the lengthwise dimension of their respective pieces of half their joint angle, the joints in said layers being dissimilar on opposite sides of a corresponding center line through each layer, said layers being alternately reversed about said center lines whereby the superposed joints in successive layers are offset so as to form lapped core joints.

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