

Sept. 17, 1946.

A. U. WELCH, JR

2,407,626

MAGNETIC CORE

Filed Dec. 30, 1942

3 Sheets-Sheet 1

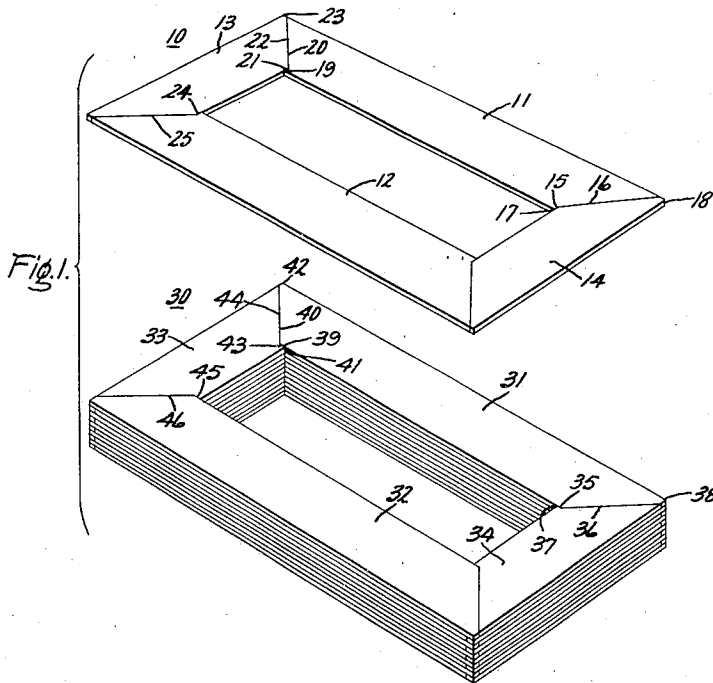
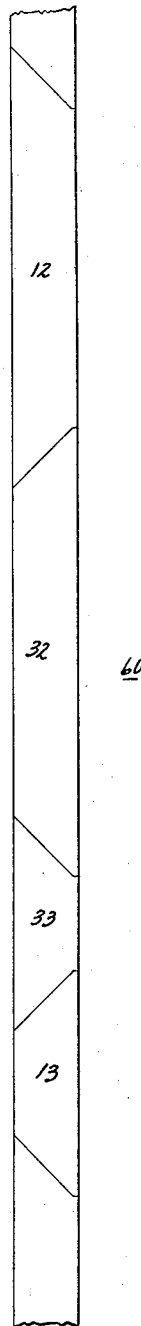
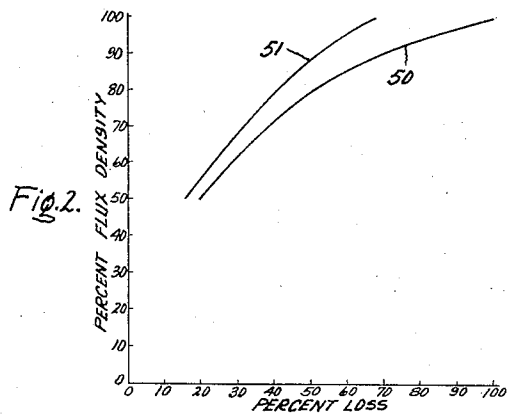
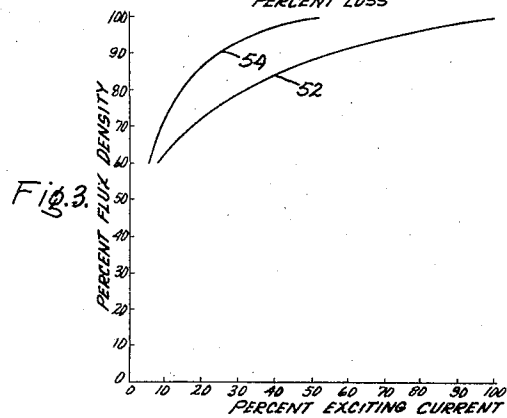


Fig. 4.



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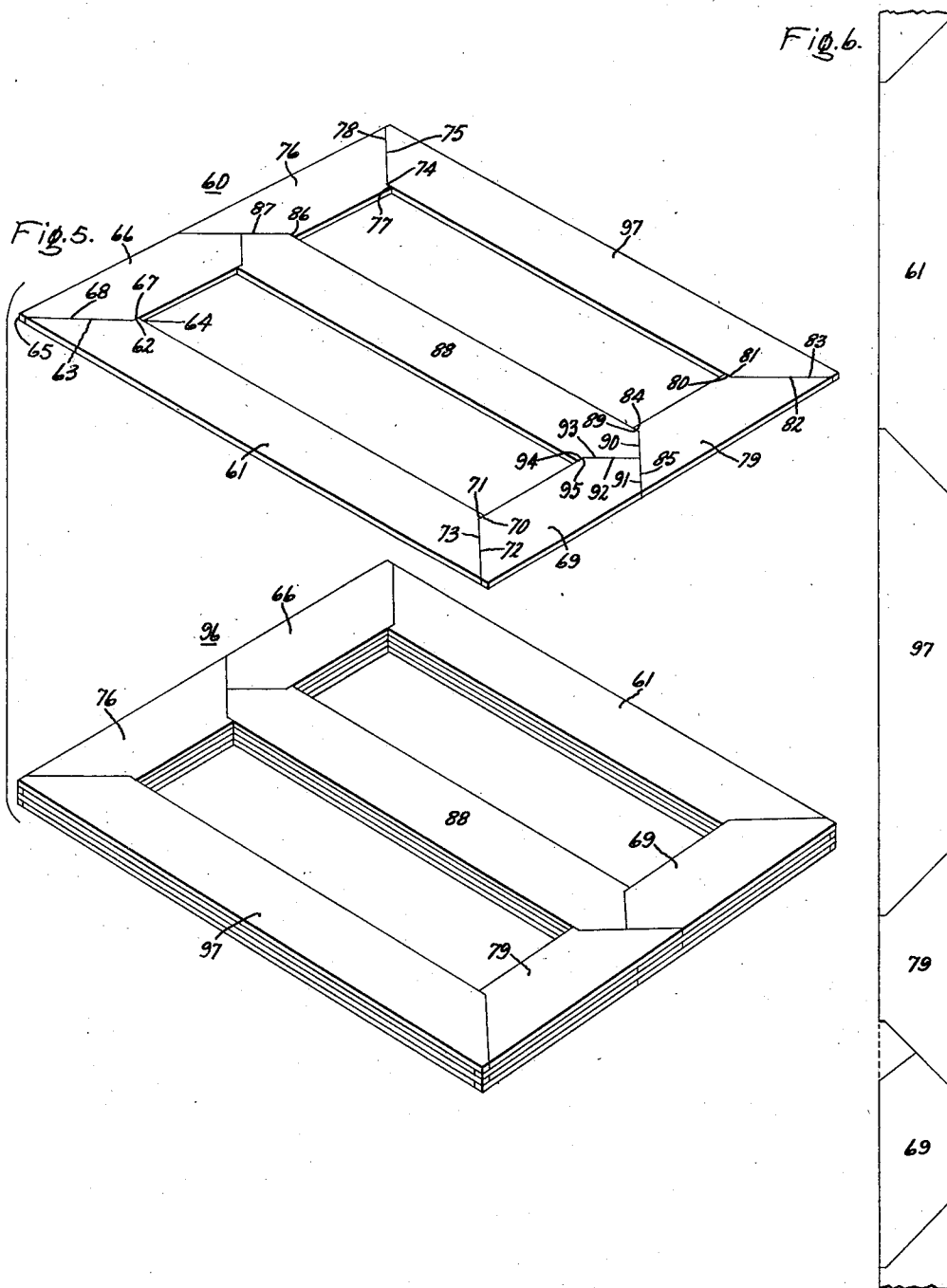
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MAGNETIC CORE

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3 Sheets-Sheet 2



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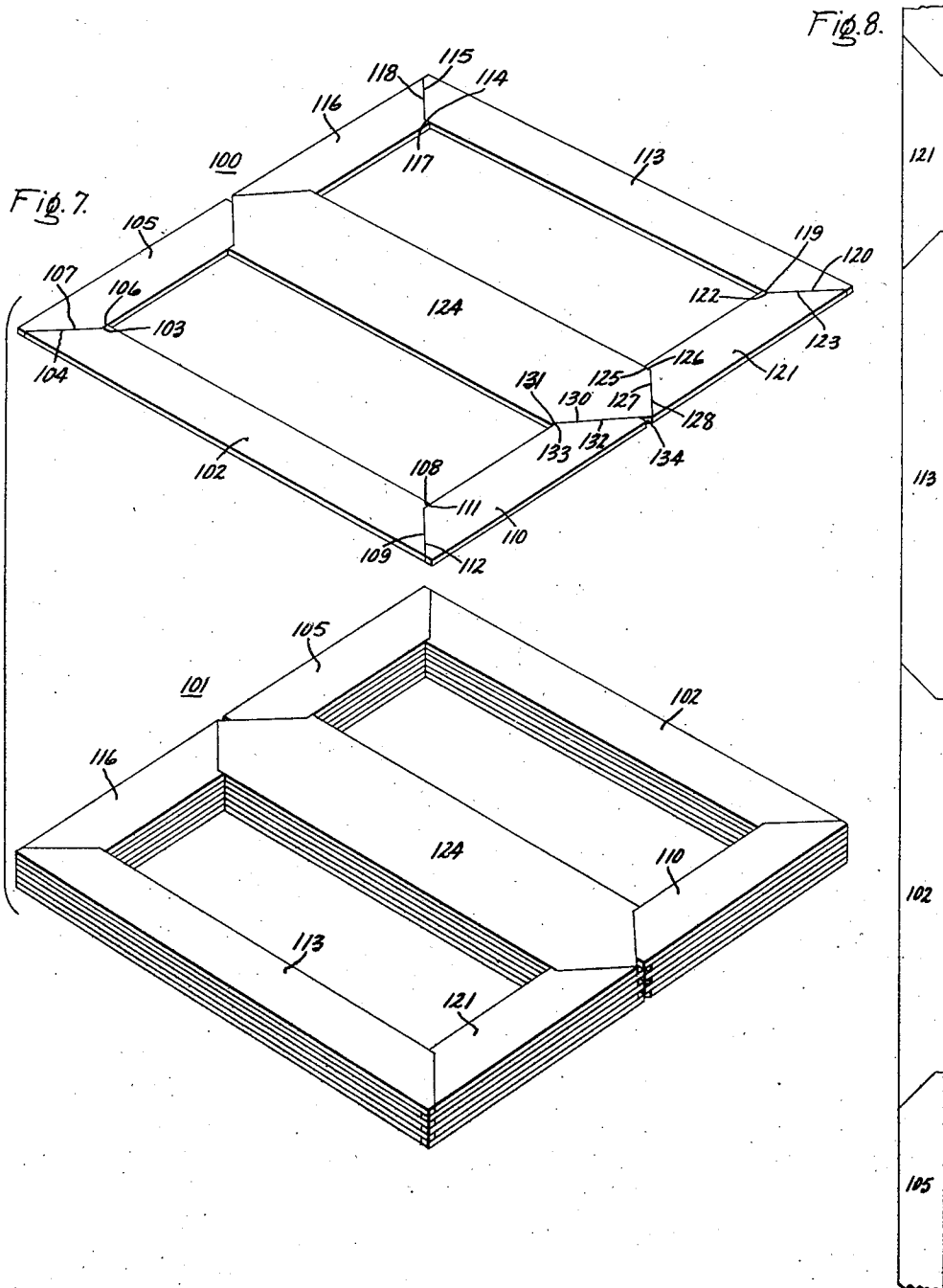
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MAGNETIC CORE

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,407,626

MAGNETIC CORE

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Application December 30, 1942, Serial No. 470,580

16 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 of 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 a rectangular core with adjacent laminations being 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 success-

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ful in the production of relatively small 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 kv.-a. 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 the rectangular core are coincident with the diagonal running from the inside corner to the outside corner, all of the joints will be in substantial registry so that the possibility of gaps being formed at the joints for increasing 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 and for preventing separation at the joints is described and claimed in patent application S. N. 376,304, Granfield, filed January 28, 1941, and assigned to the same assignee as this present invention. In that application there is described a stacked laminated core formed of laminations which have staggered mitered butt joints with extensions and corresponding indentations in the edges of the adjacent laminations, so as to prevent an appreciable gap from being formed at the butt joint. 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 may extend in opposite directions for the adjacent joints of contiguous layers an overlapping will be provided at the joints so as to substantially preclude separation of the laminations of the assembled core.

There is also described in an application S. N. 470,578 to Brand, filed concurrently herewith, and assigned to the same assignee as this present invention, a corner construction which pro-

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vides a minimum of magnetic reluctance at the corners and which also provides overlap so as to minimize separation of the stacks of the assembled core. In the construction of this depending application mitered butt joints are provided at the corners of each layer of laminations, the joints between laminations of one layer being displaced or offset from the adjacent joint of a contiguous layer. The offsetting is obtained by cutting one edge of each of the laminations on a diagonal so that the joints will be coincident with the diagonal running from the inside to the outside corner of the assembled laminations and cutting each of the other ends of the laminations with a mitered butt joint which is offset or displaced from a diagonal running from the inside corner to the outside corner of the assembled laminations. These latter joints are obtained by notching the corner or providing a first portion which is parallel with a longitudinal axis of the assembled core and a second portion of a corner which is parallel with the diagonal. The laminations are then stacked to provide layers and the layers are oppositely arranged so that the joints between laminations of one layer will be offset from joints between laminations of a contiguous layer. Thus, a joint between laminations of one layer which is coincident with the diagonal will be adjacent to but staggered from a joint of the adjacent or contiguous layer which is offset from the diagonal.

An object of my invention is therefore to provide an improved corner construction between laminations to form a core of the type described in the above-mentioned Brand application.

Another object of my invention is to provide a new and improved magnetic core stack of punched laminations which has a minimum of electrical power loss throughout the magnetic circuit.

A further object of my invention is to provide a new and improved core construction which is simple in construction, economical to manufacture, and efficient in operation.

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 a laminated core comprising a plurality of layers of laminations formed according to 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 the core of Fig. 1 may be cut from a single strip with no loss; Fig. 5 is an exploded perspective view of a three-legged core which is provided with an embodiment of my invention; Fig. 6 illustrates a method by which some of the laminations employed in the core of Fig. 5 may be cut from a single strip of magnetic material with a minimum of waste; Fig. 7 is an exploded perspective view illustrating a modification of the three phase core of Fig. 5, and Fig. 8 illustrates a method by which some of the laminations employed in the construction of Fig. 7 may be cut from a strip of magnetic material with a minimum of waste.

In Fig. 1 of the drawings I have illustrated a magnetic core construction including a plurality of assembled laminations to form layers of laminations. The assembled core includes a layer

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10 having leg sheets 11 and 12 and yoke sheets 13 and 14. As has already been stated when laminations are punched with edges which are coincident with a diagonal running from an inside corner to an outside corner of the assembled lamination the joints will be in registry and thus there is a possibility of the adjacent laminations of each layer pulling apart to form gaps at the joints which will greatly increase the magnetic reluctance of this circuit. It is therefore desirable to stagger the joints and still provide a mitered butt joint which type of joint produces a minimum of magnetic reluctance at the joint or corner as it provides a minimum of distance in which the flux need pass crosswise of the most favorable magnetic direction.

One way of accomplishing this, as described and claimed in the above-mentioned Brand application, is to provide butt joints which are coincident with the diagonal and butt joints in which the major portion thereof is offset but still parallel to the diagonal running from the inside corner to the outside corner of the assembled lamination. With such a construction an overlapping will be provided when stacks of laminations are oppositely arranged and a relatively short distance will be provided at the corners at the overlapping in which the flux must pass crosswise of the grain. I have found another arrangement of providing overlap and producing a minimum of magnetic path at the corners in which the flux must pass crosswise of the grain at the corners may be produced by so forming the laminations that each of the mitered butt joints at the corners will be offset from an adjacent diagonal running from the inside corner to the outside corner of the assembled lamination. With this construction each of the offsets may be closer to the diagonal and still provide a sufficient overlap than with the construction where all the overlap is provided by displacing the gap on one side only of the diagonal. Thus, in Fig. 1 I have illustrated a core construction including a layer 10 having laminations 11, 12, 13 and 14, each of the laminations being provided with a broken line joint the major portion thereof being parallel with the diagonal running from the inside corner to the outside corner of the assembled laminations. Thus, one edge of the lamination 11 has an edge surface 15 which is parallel with a lateral axis of the assembled core or perpendicular to the axis of the lamination, and a second edge portion 16 which is parallel with the adjacent diagonal running from the inside corner 17 to an outside corner 18 of the assembled laminations. In like manner the opposite end of the lamination 11 has an edge portion 19 parallel with the lateral axis of the assembled lamination and a second portion 20 which is offset but parallel to the adjacent diagonal running from the inside corner to the outside corner of the assembled lamination. The adjacent end of the lamination 13 is so constructed as to snugly fit the broken line joints, the lamination 13 having an end portion 21 which is parallel with the lateral axis of the assembled laminations or parallel to the axis of the lamination 13, and a second portion 22 which is parallel with a diagonal running from the inside corner to the outside corner. Thus, the portions of the joint which are parallel with the diagonal are offset from the diagonal by an amount proportional to the distance of the offset portions 19 and 15 or notch 21. In order to provide a corner for the assembled laminations which is offset from the portion 20 of the lami-

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nation 11 it will be seen that the edge portion of the lamination 13 has a short portion 23 which extends parallel with the longitudinal axis of the core before the corner is formed. It will be seen that the opposite end of the lamination 13 is similarly formed and therefore has a surface portion 24 to provide a joint which is parallel with the lateral axis of the assembled laminations, and a second portion 25 which is parallel and offset from the adjacent diagonal running from the inside corner to the outside corner of the assembled laminations. It will also be seen that the lamination 12 is a duplicate or equivalent to the lamination 11, while the lamination 14 is a duplicate of the lamination 13.

In order to provide a staggering of the joints between the layer 10 and an adjacent layer 30 the laminations which form the layer 30 are formed of laminations 31, 32, 33, and 34. Since, in the construction as illustrated in Fig. 1, the lamination 31 of layer 30 is placed at right angles to the lamination 13 of layer 10, the mitered butt joint between the laminations 31 and 33 is placed on the side of a diagonal opposite to the joint formed by the edges 20 and 22, by forming the ends of the lamination 31 similar to the ends of the lamination 13. Thus, the lamination 31 has an edge portion 35 which is parallel with the longitudinal axis of the assembled lamination or parallel with the axis of the lamination 31, and a second portion 36 which is parallel with the adjacent diagonal running from an inside corner 37 to an outside corner 38 of the assembled laminations. In like manner the opposite end of the lamination 31 is formed with an edge portion 39 which is parallel with the longitudinal axis of the assembled laminations and a second portion 40 which is parallel but offset from the diagonal running from an inside corner 41 to an outside corner 42 of the assembled laminations. With this construction it will be noted that the edge portions 20 and 22 will be on one side of the adjacent diagonal while the edge portion 40 will be on the opposite side of a diagonal. This is obtained since the offset portions 19 and 21 at adjacent corners of the contiguous laminations are parallel with the lateral axis of the assembled core, while the edge portion 39 is parallel with the longitudinal axis of the core. It will be seen that the lamination 33 has an edge portion 43 which is parallel with the longitudinal axis of the assembled laminations and a second portion 44 which is parallel with the diagonal. Furthermore, the opposite end of the lamination 33 has a portion 45 which is parallel with the longitudinal axis of the assembled laminations and a second portion 46 which is parallel with the diagonal. It will be apparent that the lamination 32 is an equivalent to the lamination 31 while the lamination 34 is an equivalent to the lamination 33.

It will be seen in view of the above that when a layer 10 is assembled contiguously with a layer 30, the joints at corners of the contiguous laminations will be symmetrically disposed on opposite sides of the adjacent diagonal running from the inside corner to the outside corner. Thus an overlapping is provided with a minimum of flux path being provided which is at an angle or crosswise to the line of lowest magnetic resistance.

I have illustrated in Fig. 2 a comparison between the magnetic characteristics of my improved corner construction and the conventional construction having rectangular corners which

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are overlapped. Thus, in Fig. 2 I have plotted on the abscissa axis per cent loss and on the ordinate axis per cent flux density. Curve 50 represents the loss in the corners of the conventional core made with rectangular sheets stacked with overlapping corners while curve 51 represents the characteristics of my improved corner construction. In Fig. 3 I have illustrated the exciting current in which per cent exciting current is plotted as abscissa and per cent flux density on the ordinate axis. Curve 52 represents the characteristics of an entire conventional core having rectangular overlapping corners while curve 54 represents the characteristics of the entire core formed with my improved joint construction.

My improved corner construction not only produces a core which is very efficient magnetically but it also produces a core which may be efficiently manufactured by punching out the various laminations from a single sheet of magnetic material having the proper flux orientation. Thus, in Fig. 4 I have illustrated a strip of magnetic material 60 from which all the laminations may be formed by punchings simultaneously with two different dies and I have marked the punchings to show that the laminations fit together so that they may be punched from the ribbon 60 with no waste.

In view of the above it will be seen that I have provided an assembled core formed of various assembled layers which have a minimum of magnetic reluctance at the corners. Furthermore, the various laminations may be formed from strip material having a single width and may be punched with only two different dies or with one die if the steel is reversed for making alternate cuts. Furthermore, the ends of all similar punchings are similar and the laminations may be cut without waste.

It is to be understood that my invention has application for a core having any suitable number of punchings in each layer, and in Fig. 5 I have illustrated a core having three legs which has particular application to a three phase electrical apparatus. The illustrated construction includes a layer 60 including three leg sheets and four yoke sheets which are so punched that the adjacent butt joints between laminations of contiguous layers may be displaced on opposite sides of a diagonal running from an inside corner to an outside corner of the assembled laminations or some joints are displaced on the leg side and some on the yoke side of the adjacent diagonal between inner and outer ends of the corner. Thus the layer 60 includes a leg sheet 61, one end having an edge surface or notch 62 which is parallel with a lateral axis of the assembled laminations and a second edge portion 63 which is parallel but offset from an adjacent diagonal running from an inside corner 64 to an outside corner 65 of the assembled laminations. A cooperating yoke sheet 66 has a straight or extending portion 67 which cooperates with the portion 62 of the leg sheet and a second portion 68 which cooperates with the edge portion 63 of the leg sheet 61. Similarly, a yoke sheet 69 is provided which is an equivalent to the yoke sheet 66 and includes a portion 70 which cooperates with a notched portion 71 of the leg sheet 61, both of which are parallel with the lateral axis of the assembled laminations. The remainder of the substantially mitered butt joint is provided by a surface 72 of the lamination 69 and a surface 73 of the leg sheet 61, both of which are parallel and offset from a diagonal run-

ning between the corners of the assembled laminations. The offsetting of the joints at the ends of the other outer leg sheet 97 is provided by providing the extensions in the leg sheet 97 instead of in the yoke sheet, as is done on the opposite side. Thus, the leg sheet 97 is provided with an extension 74 or a portion parallel with the longitudinal axis of the assembled lamination, and a second portion 75 which is parallel and offset from the adjacent diagonal. Cooperating with these corner surfaces there is provided a yoke sheet 76 having a portion 77 which is parallel with the longitudinal axis of the assembled laminations and a second portion 79 which mates with the edge portion 75 of the leg sheet 97. Similarly a yoke sheet 79 is provided which has a similar configuration as the yoke sheet 76 and includes an edge portion 80 which mates with an edge portion 81 of the leg sheet 97. The yoke sheet 79 is also provided with an edge portion 82 which cooperates with an edge portion 83 of the leg sheet, these latter portions being parallel and offset from the adjacent diagonal. The opposite end of the yoke sheet 79 is provided with an edge mating surface portion 84 which is also parallel with the longitudinal axis and a second portion 85 which runs diagonally at a suitable angle such as 45 degrees from the edge portion 84. In like manner a similar end of the yoke sheet 76 is provided with an edge portion 86 which is parallel with the longitudinal axis of the assembled lamination and a second portion 87 which runs diagonally at a suitable angle or 45 degrees from the edge portion 85. Cooperating with the edges of the yoke sheets there is provided edges of a center leg sheet 88 and edges of the yoke sheets 66 and 69. Thus the leg sheet 88 is provided with an edge portion 89 which mates with the portion 84 of the yoke sheet 79 and a second portion 90 which mates with a part of the diagonally extending edge 85. The remainder of the edge 85 cooperates with an edge 91 of the yoke sheet 69. Another angular edge portion 92 of the yoke sheet 69 cooperates with a similar angularly extending edge portion 93 of the leg sheet 88. The angularly extending edge 93 is offset by providing another edge portion 94 of the leg 88 which is parallel with the lateral axis of the assembled lamination. A similar edge portion 95 is provided on the yoke sheet 69 which mates with the edge portion 94. A similar joint is provided at the other end of the leg sheet 88 between the yoke sheets 66 and 76. It will therefore be seen that when stacking a layer of laminations 96 which is composed of laminations similar to that forming a layer 60 but laterally reversed, the adjacent joints between contiguous laminations will be on opposite sides of the adjacent diagonal running between corresponding inside and outside corners of the assembled laminations.

In the construction illustrated in Fig. 5 it will be seen that the joints at either end of the leg sheet 61 are on the leg sheet side of the diagonal while the joints on either end of the leg sheet 97 are on the yoke side of the diagonal of the assembled laminations. However, it is to be understood that the joints of the laminations may all be staggered on one side or they may be staggered on either of the sides of the diagonals between the corners of the assembled laminations as is convenient.

In Fig. 6 I have illustrated how all the laminations with the exception of the center leg sheet 88 may be punched from a single ribbon of steel with a minimum of waste. It will be seen that

the only waste is a small triangular piece which must be removed from the ends of the yoke sheets 66 and 69 so that they will have the suitable V shape to cooperate with the ends of the center leg and adjacent yoke sheets. The center leg 88 may be formed by cutting a triangularly shaped piece from sheets having the shape of the leg sheets 61 and 97.

In Fig. 7 I have illustrated a modification of a three legged core design which may be either employed as a three phase core or since the center leg is about double the width of the two outer legs it may be advantageously used as a three legged single phase core. The construction includes a layer of laminations 100 having three leg sheets and four yoke sheets, the staggering of joints being provided by an adjacent layer 101 composed of laminations similar to those that make up layer 100 except being laterally reversed. The layer 100 includes a leg sheet 102 having an edge or notch 103 which is parallel with a lateral axis of the assembled laminations and a second portion 104 which is parallel to but offset from a diagonal running between the adjacent corners of the assembled lamination. The adjacent yoke sheet 105 has an edge or extending portion 106 which cooperates with the notch 103 and a second portion 107 which cooperates with the diagonal portion 104 of the leg sheet 102. The opposite end of the leg sheet 102 is similarly formed with an edge portion or notch 108 which is parallel with the lateral axis of the assembled laminations and a second portion 109 which runs diagonally from the portion 108 and parallel and offset from the diagonal running between the corners of the assembled laminations. In like manner a yoke sheet 110 is provided with a portion 111 which mates the portion 108 and a diagonal portion 112 which cooperates with the portion 109. The other outer leg sheet 113 is provided with an extending portion 114 which is parallel with the longitudinal axis of the assembled laminations and a second portion 115 which runs diagonally and offset from the diagonal running between the corners. Similarly a yoke sheet 116 is provided with an edge portion or notch 117 which cooperates with the edge portion 114 and a second portion 118 which cooperates with the portion 115. The opposite end of the leg sheet 113 is also provided with a joining surface including portions 119 and 120 and an adjacent yoke sheet 121 has a notched portion 122 which cooperates with the edge 119 and a portion 123 which cooperates with the edge portion 120. A center leg 124 is provided having an extending portion 125 which cooperates with a similarly shaped notch portion 126 of the yoke sheet 121 which runs parallel with the longitudinal axis of the assembled laminations and a diagonally extending portion 127 which cooperates with the portion 128 of the yoke sheet 121. The same end of the center leg 124 is provided with a diagonal cut portion 130 and a notch portion 131 which is parallel with the lateral axis of the assembled laminations. Cooperating with these two surfaces is a diagonally running portion 132 of the adjacent yoke sheet 110 and a portion 133 which runs parallel with the lateral axis of the assembled laminations. So that the yoke sheet 110 may be cut from a ribbon sheet without a minimum waste a corner may be cut off as is shown at 134. The upper end of the leg sheet 124 and the cooperating ends of the yoke sheets 105 and 116 are similarly formed.

Since all the laminations except the center leg sheet 124 are of similar width they may all be punched from a similar ribbon of steel and in Fig. 8 I have illustrated how all the laminations except the center leg 124 may be cut from a single ribbon of steel with no waste and I have illustrated by similar numerals how the various ends of the laminations fit together with no waste.

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, said layers including at least four assembled laminations with diagonal butt joints at adjacent ends, said layers having at least two dissimilar symmetrical laminations with each of said laminations having edge surfaces in six planes, edge surfaces in four of said planes forming the edges for said butt joints of said laminations.

2. 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 core structure comprising three leg members and yoke members connecting the ends of said leg members forming a substantially rectangular core having two substantially rectangular windows, said mitered butt joints at the corners between said outer leg and yoke members of said core structure being offset from an adjacent diagonal running from the inside corners to the outside corners of the assembled laminations, said adjacent joints between adjacent laminations of contiguous layers being offset on opposite sides of said adjacent diagonal so as to provide overlapping between adjacent laminations of contiguous layers at said joints.

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 core structure comprising three leg members and yoke members connecting the ends of said leg members forming a substantially rectangular core having two substantially rectangular windows, said mitered butt joints at the corners between said outer leg and yoke members of said core structure being offset from an adjacent diagonal running from the inside corners to the outside corners of the assembled laminations, some of said joints being offset on the leg side of said adjacent diagonal and some of said joints being offset on the yoke side of said diagonal.

4. A laminated magnetic core having at least four punchings of magnetic strip material per layer, the two ends of each punching consisting

of a major portion at an angle of forty-five degrees with the lengthwise dimension of the punching and a minor portion perpendicular to the lengthwise dimension of the punching, the two perpendicular minor portions at the opposite ends of each punching being adjacent the same side of the punching.

5. A laminated magnetic core having at least four punchings of magnetic strip material per layer, the two ends of each punching consisting of a major bias cut portion and a minor portion cut perpendicular to the lengthwise dimension of the punching, the two perpendicular minor portions at the opposite ends of each punching being adjacent the same side of the punching.

6. A punching for a mitered joint magnetic core, said punching having straight sides parallel with its lengthwise dimension and broken line ends, each broken line end comprising a minor portion perpendicular to the lengthwise dimension of the punching and a major portion making an angle of forty-five degrees with the lengthwise dimension of the punching, said perpendicular minor portions extending for equal distances from the same side of said punching, said forty-five degree major portions being perpendicular to each other.

7. A punching for a mitered joint magnetic core, said punching having straight sides parallel with its lengthwise dimension and broken line ends, each broken line end including a minor portion perpendicular to the lengthwise dimension of the punching, said perpendicular minor portions extending for equal distances from the same side of said punching.

8. A stacked lamination core having generally mitered butt joints in each layer which joints are staggered in adjacent layers, each layer comprising a plurality of punchings having straight sides parallel with their lengthwise dimension and having broken line ends, each broken line end comprising a minor portion perpendicular to the lengthwise dimension of the punching, said perpendicular minor portions extending for equal distances from the same side of said punching.

9. A stacked rectangular magnetic core composed of two different kinds of leg punchings and two different kinds of yoke punchings, said punchings all being of equal width with ends which are generally bias cut, odd-numbered lamination layers of said core each comprising two leg punchings of the same kind and two yoke punchings of the said kind, even-numbered lamination layers each comprising two of the other kind of leg punchings and two of the other kind of yoke punchings.

10. A stacked rectangular magnetic core composed of two different kinds of leg punchings and two different kinds of yoke punchings, said punchings all being of equal width with ends which are generally bias cut, odd-numbered lamination layers of said core each comprising two leg punchings of the same kind and two yoke punchings of the same kind, even-numbered lamination layers each comprising two of the other kind of leg punchings and two of the other kind of yoke punchings, one kind of leg punching being identical except for length with one kind of yoke punching and the other kind of leg punching being identical except for length with the other kind of yoke punching.

11. A stacked rectangular magnetic core composed of two different kinds of leg punchings and two different kinds of yoke punchings, said punchings all being of equal width with ends

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which are generally bias cut, odd-numbered lamination layers of said core each comprising two leg punchings of the same kind and two yoke punchings of the same kind, even-numbered lamination layers each comprising two of the other kind of leg punchings and two of the other kind of yoke punchings, one kind of leg punching being identical except for length with one kind of yoke punching and the other kind of leg punching being identical except for length with the other kind of yoke punching, the leg and yoke punchings in each layer being different in shape as well as in length.

12. A laminated overlapping mitered joint magnetic core having at least four magnetic punchings per lamination layer, each of the magnetic punchings being symmetrical about an imaginary bisector perpendicular to the length of the punching.

13. A three-legged magnetic core consisting of stacked lamination layers, each layer comprising seven I type punchings of which three are leg punchings and four are yoke punchings, all of said punchings having generally bias cut ends which are interfitted to form generally mitered butt joints in each layer, all of said yoke punchings and at least the two outside leg punchings being of equal width.

14. A three-legged magnetic core consisting of stacked lamination layers, each layer comprising seven I type punchings of which three are leg punchings and four are yoke punchings, all of said punchings having generally bias cut ends

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which are interfitted to form generally mitered butt joints in each layer, all of said yoke punchings and at least the two outside leg punchings being of equal width, the center leg punching being substantially twice as wide as the other punchings.

15. A single phase shell type laminated core having a central winding leg and oppositely extending yoke portions which are substantially narrower than the winding leg, said core being made of straight magnetic pieces in each lamination layer, each piece having a most favorable magnetic direction coinciding with its length, the ends of said pieces being generally bias cut to form mitered butt joints therebetween, said mitered joints being offset from each other in successive layers so as to form overlapping mitered core joints.

16. A single phase shell type laminated core having a central leg portion of twice the area of its two oppositely extending yoke portions, said core being made of an equal number of straight magnetic pieces in each lamination layer, each piece having a most favorable magnetic direction coinciding with its length, the ends of said pieces being generally bias cut to form mitered butt joints therebetween, said mitered joints being offset from each other in successive layers so as to form overlapping mitered core joints in which the core flux will be substantially parallel with the most favorable magnetic direction of the pieces.

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