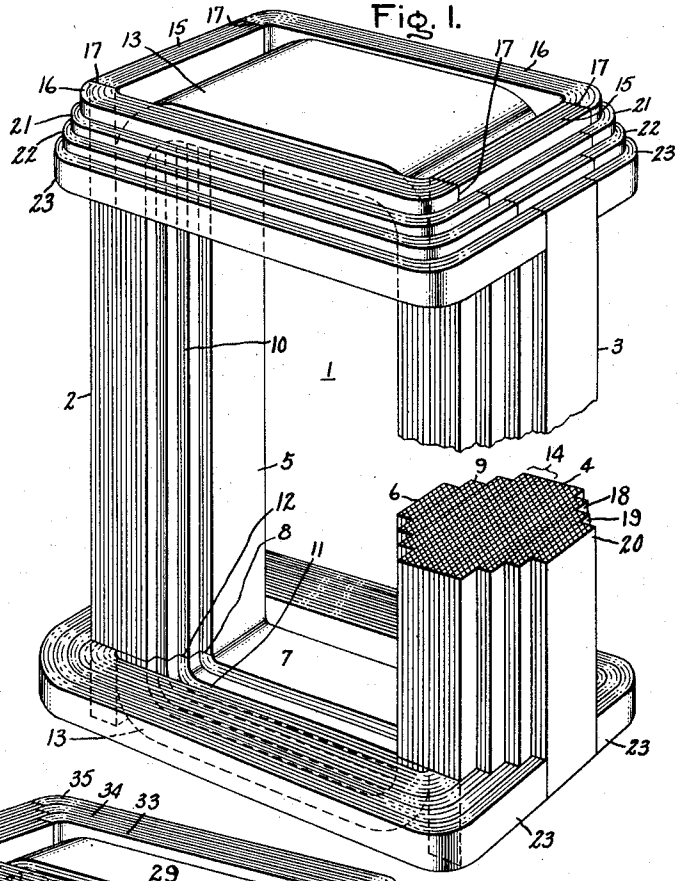
April 24, 1951 LE ROY S. SCHELL, JR 2,550,500

LOW YOKE TRANSFORMER CORE

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Fig. 1.



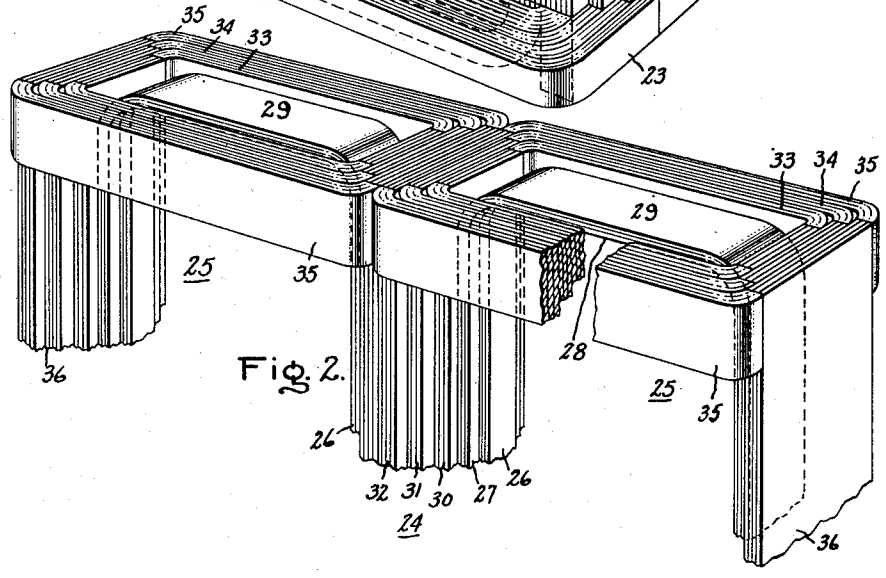


Fig. 2.

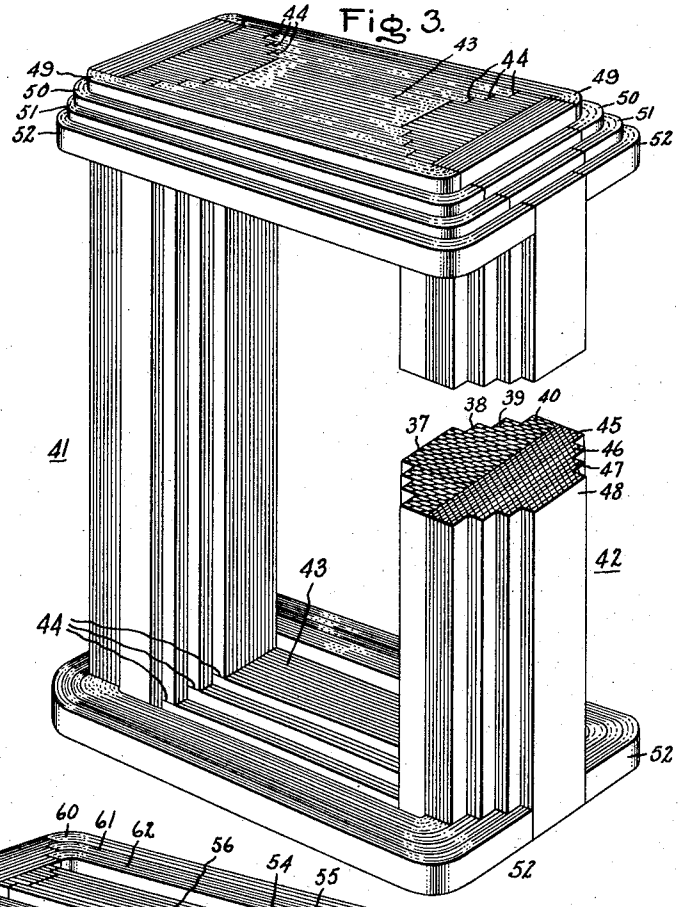
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LOW YOKE TRANSFORMER CORE

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Fig. 3.



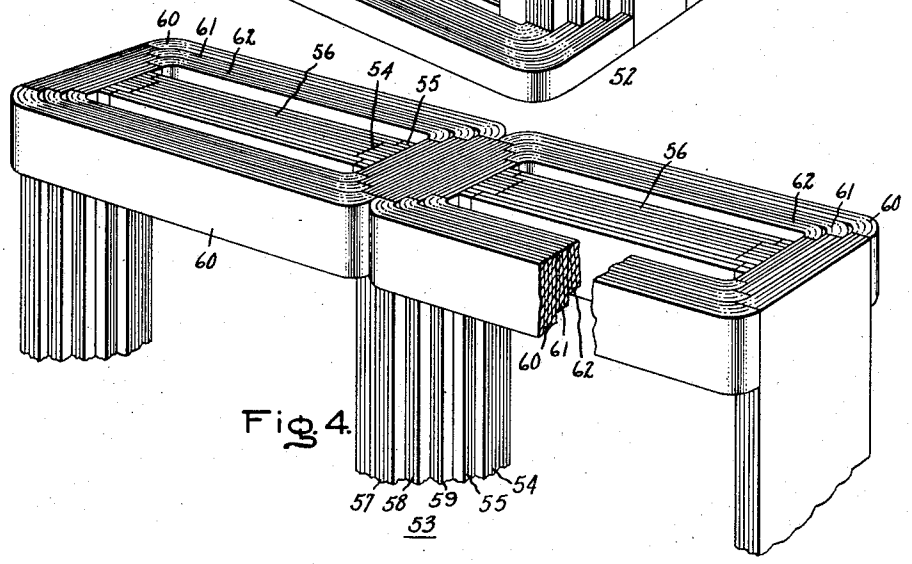


Fig. 4.

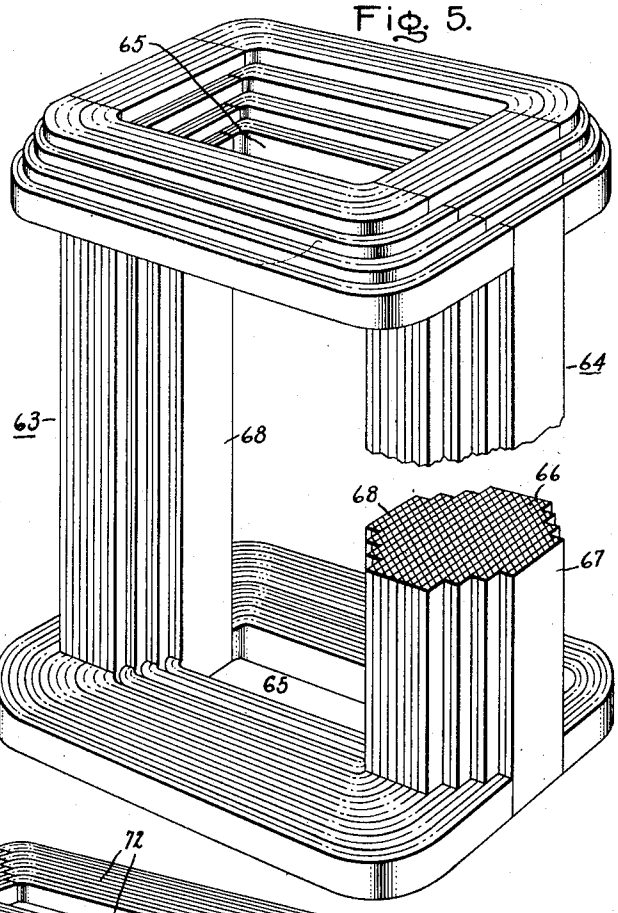
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LOW YOKE TRANSFORMER CORE

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Fig. 5.



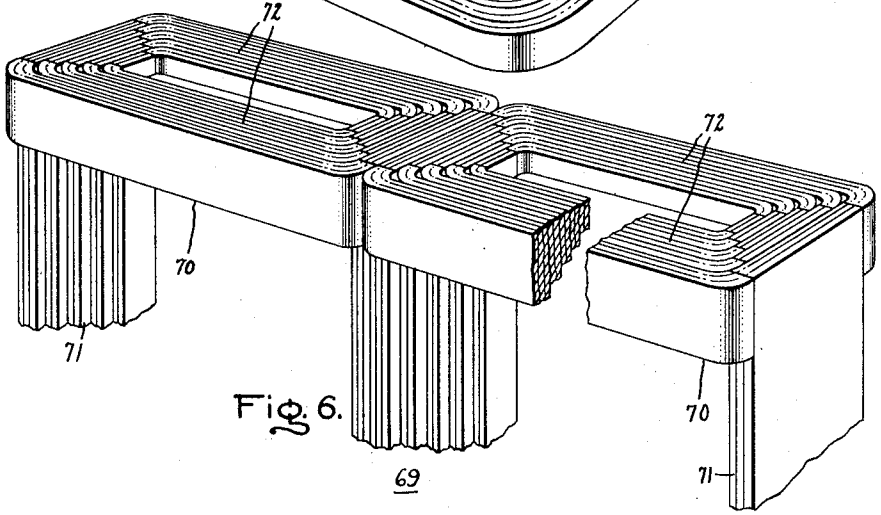


Fig. 6.

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Patented Apr. 24, 1951

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LOW YOKE TRANSFORMER CORE

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Application September 24, 1948, Serial No. 50,973

1 Claim. (Cl. 175—356)

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This invention relates to magnetic cores for electrical induction apparatus and more particularly to improvements in large single phase cores for such apparatus.

A core for electrical induction apparatus, particularly a power transformer which operates at commercial frequency, usually consists of at least one straight winding leg on which is mounted one or more windings, and a yoke portion which interconnects the ends of the winding leg or legs. The yoke portion necessarily adds to the dimensions of the apparatus in the direction of the winding leg. Usually the winding leg is vertical, and thus the yoke portion adds to the height of the apparatus. Therefore, when the term "yoke height" is used herein, it refers to the dimension of the yoke in the direction of the center line of the leg or legs, even though such direction is not vertical or is even horizontal.

In certain transformer applications, such as in electric locomotives, there is very little space available so that as the power of transformers increase there is a considerable problem of constructing them so that they can be fitted into the space available for them.

This invention is characterized by a core construction which materially reduces its yoke height, i. e. the height of the core in excess of the height of the coil or coils on its winding legs. Heretofore, the yoke height of single winding leg cores has usually been reduced by dividing the yoke into two or more oppositely extending parts or flux return paths. Thus, if there are two equal size oppositely extending paths or yoke parts and the flux density is kept the same in the winding leg and in the yoke parts, the yoke height is cut in half. If there are three yoke parts, the yoke height is reduced to one third of what it would be if there were only one yoke part or flux return path. However, dividing the yoke into more than two parts so increases the transverse or horizontal dimensions of the apparatus and the size of its enclosing tank that ordinarily this more than offsets the advantages obtained by the further reduction in yoke height. Furthermore, large single phase cores are usually of the two winding leg variety and for the same transformer KVA and winding length, i. e. winding leg "height," the yoke height of a single leg two part divided yoke core is no less than the yoke height of a two legged core, because the former must operate its winding leg with twice the flux of the latter, as the latter has twice the effective leg length of the former. Therefore, each of the two yoke parts of the divided yoke

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core carries the same flux as the yoke parts of the two legged core, and hence for the same flux density the yoke heights will be the same.

In accordance with this invention, the yoke height of a two legged core is reduced by widening the yokes, and this principle is also applicable to single leg divided yoke cores. This widening is characterized by the use of flatwise curved generally U-shaped laminated yoke members which cooperate with straight leg laminations in such a way that each lamination layer of the core constitutes a closed loop magnetic circuit. The widening of the yokes does not increase the outside dimensions of the core and core assembly, because the yoke width does not exceed the coil width.

An object of the invention is to provide a new and improved magnetic core.

Another object of the invention is to reduce the yoke height of a magnetic core for electrical induction apparatus.

A further object of the invention is to provide a low yoke core in which the yokes are widened to form flat coil supporting surfaces.

The invention will be better understood from the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claim.

In the drawings Fig. 1 is a perspective view, partly in broken away cross section, of a preferred form of the invention as applied to a two legged core; Fig. 2 is a modification of Fig. 1 showing the same principle of core construction applied to a single leg two part divided yoke core; Fig. 3 is a view correspinding to Fig. 1 of a modification of the invention in which the leg laminations run in opposite directions in different parts of the legs; Fig. 4 bears the same relation to Fig. 3 that Fig. 2 does to Fig. 1; Fig. 5 is a view similar to Figs. 1 and 3 of a further modification of the invention; and Fig. 6 bears the same relation to Fig. 5 as Figs. 2 and 4 do to Figs. 1 and 3, respectively.

Referring now to the drawings, and more particularly to Fig. 1, there is shown therein a magnetic core 1 having two legs 2 and 3. These legs are similar and consist of a plurality of groups of straight flat laminations of different widths which are stacked together so as to provide a cruciform cross section, as is indicated at 4. Interconnecting the corresponding ends of the inner half of each leg are radially nested flatwise curved generally U-shaped laminations. Thus, for example, the two innermost and, therefore, narrowest steps of leg laminations 5 and 6

have their corresponding ends joined by yoke caps 7 of the same width, only the lower one of which is visible in Fig. 1. The joint between the yoke cap 7 and the narrowest inner step 5 of the leg 2 is indicated at 8, and this joint may be of any suitable type such as a butt joint or an interleaved joint. Likewise, the next leg steps 9 and 10 are interconnected by yoke caps 11 of the same width, the joint between these parts being indicated at 12. Of course, it will be understood that only one joint is shown, and that there are usually four such joints in each closed loop of the same width. The outermost yoke caps 13 serve to interconnect the corresponding ends of only the inner halves 14 of the straight leg laminations. It will be observed that all of the yoke caps 7, 11—13 do add to the height of the core, that is to say, they do add to their dimensions in the direction of the length of the winding legs, and, furthermore, it will be observed that the U-shape or curved center lines of these yoke caps are in the same plane which contains the center lines of the two legs 2 and 3.

The yoke portions of the core which serve to interconnect the corresponding ends of the outer halves or outermost steps of the winding legs 2 and 3 are arranged quite differently. These yoke portions are in a sense divided into oppositely extending parts, each of which is half the width of the leg step whose ends it cooperates with. Thus, for example, the outer half 15 of the widest leg laminations are interconnected by two oppositely arranged yoke portions 16 which consist of nested flatwise curved laminations which are generally U-shaped. The joints between the yoke portions 16 and the leg laminations 15 are indicated at 17. Similarly, the progressively narrower outside leg steps 18, 19 and 20 have their corresponding ends interconnected respectively by effectively divided yoke portions 21, 22, 23.

The joints between the leg steps 15, 18, 19 and 20 and the yoke portions 16, 21, 22 and 23 may be of any suitable type.

The yoke members 16, 21, 22 and 23 may be nested together in any suitable manner, but it is preferred that their inner edges, that is to say, the bottom edges of the top members and top edges of the bottom members be flush respectively with each other and with the inner flat surfaces of the yoke caps 7. In this manner a relatively wide and flat coil supporting surface is provided for the coils or windings (not shown) which will ordinarily surround the legs 2 and 3. Another advantage of this orientation of the yoke parts 16, 21, 22 and 23 is that it reduces the amount of magnetic material necessary to be used in the outer leg steps, and it will be seen that the leg steps 18, 19 and 20 are progressively shorter. It will also be seen that the curved center lines of the generally U-shaped yoke portions 16, 21, 22 and 23 are in planes which are perpendicular to the plane containing the center lines of the legs 2 and 3.

By the construction shown in Fig. 1, the yoke height is cut in half compared to what it would be if the outer halves of the legs were joined by yoke caps similar to the yoke caps 7 and 13, and superposed thereon. In other words, by effectively cutting such outer yoke caps longitudinally in half and turning them down sideways through ninety degrees to the position shown by curved yoke members 16, 21, 22 and 23, a material reduction in yoke height is achieved while at the same time the transverse dimensions of the entire apparatus are not increased, because the added width of the widest yoke members 23 will ordinarily not exceed the width of the coils or windings (not shown), which in practice will surround the winding legs 2 and 3.

Fig. 2 illustrates an application of the principles of core construction shown in Fig. 1 to a single winding leg core of the so-called divided yoke type. Thus, in Fig. 2 there is a center cruciform cross section leg 24 and two oppositely extending yoke portions 25. In this figure the outer leg steps 26 and 27 are connected respectively to yoke caps 28 and 29, while the inner and widest leg steps 30, 31 and 32 are connected respectively to effectively divided yoke members 33, 34 and 35. The yoke legs 36 each correspond to half the winding leg 24 and like the winding leg 24 consist of straight lamination pieces.

In the modification shown in Fig. 3, the inner half of the core, instead of consisting of radially nested laminations having U-shaped yoke caps, consists of a conventional flat stacked construction in which the yoke laminations are parallel to the leg laminations. Thus, as shown in the cross section of the right-hand winding leg in Fig. 3, the inner leg steps 37, 38, 39 and 40 consist of flat stacked laminations which lie in planes which are parallel to the plane containing the center lines of the legs, which legs are indicated generally at 41 and 42. The ends of steps 37, 38, 39 and 40 are joined by straight yoke laminations 43 which are parallel to the laminations in the steps 37, 38, 39 and 40. The joints between these laminations, which are indicated at 44, are preferably lapped joints of either the square or mitered variety, but they may also be butt joints if desired. The outer half of the core shown in Fig. 3 is generally the same as the outer half of the core shown in Fig. 1, and thus it consists of leg steps 45, 46, 47 and 48 in each leg, which leg steps have their corresponding ends interconnected by effectively divided curved yoke members 49, 50, 51 and 52.

As in Fig. 1, it is preferable for the yoke members 49, 50, 51 and 52 to have their inner edges aligned with the inner edges of the yoke laminations 43 so as to provide a relatively wide flat coil supporting surface 7.

Fig. 4 shows how the construction illustrated in Fig. 3 can be applied to a single leg divided core. In that case, the single leg 53 has its outer steps 54 and 55 composed of laminations which lie in planes parallel to the general direction of the divided yokes and which cooperate with parallel yoke laminations 56, whereas, the innermost and wider leg steps 57, 58 and 59 are engaged by flatwise curved yoke portions 60, 61 and 62, respectively. The construction of the yoke legs out of straight flat lamination pieces is clearly shown in the drawing, each of these yoke legs being in effect half of the winding leg 53.

In the modification shown in Fig. 5, the winding legs 63 and 64 are essentially the same as the winding legs 2 and 3 in Fig. 1. However, the yokes both consist entirely of flatwise curved U-shaped portions oriented like the portions 16, 21, 22 and 23 in Fig. 1. This means that there is an empty space 65 in the center of each yoke. The various generally U-shaped steps of the yoke portions are also preferably so arranged that their inner edges are aligned so as to provide flat coil supporting surfaces and so as to use a minimum amount of steel in the legs. Thus, as will be seen in Fig. 5, only the widest inner leg step 66 is of full length, and the leg steps on both sides thereof get progressively shorter, so that the

outermost leg step **67** and innermost leg steps **68** are the shortest. The joints between the leg and yoke portions in Fig. 5 may be the same as the joints between these parts in the other figures.

Fig. 6 shows how the type of construction illustrated in Fig. 5 can be applied to a core having a single winding leg **69** and oppositely extending divided yoke portions **70** of similar construction. As in Figs. 2 and 4, the yoke legs **71** each correspond to one-half the central winding leg, and the interconnections between the corresponding ends of these legs and the generally U-shaped flat-wise curved yoke steps **72** is clearly indicated.

Figs. 2, 4 and 6 illustrate how the curved yoke members may have their edges aligned at the outside instead of in the inside, as in Figs. 1, 2 and 5, and it is clear from a comparison from these figures how the constructions shown in Figs. 2, 4 and 6 require the use of a greater amount of steel in the legs, because with such an alignment of the edges of the curved yoke members all of the leg laminations have to be as long as the longest one of them.

While there have been shown and described particular embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein without departing from the invention, and, therefore, it is aimed in the appended claim to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

A single phase core for electrical induction apparatus comprising, two similar laminated straight parallel cruciform-cross-section winding legs whose laminations are all parallel with each other and perpendicular to a common plane through the center lines of both legs, and generally U-shaped yoke members of radially nested

flatwise curved strips of magnetic material which interconnect the corresponding ends of said winding legs, the yoke laminations which interconnect the corresponding leg laminations of the inner half of the core being as wide as said leg laminations and having the plane of their center lines coinciding with the plane of the center lines of said leg laminations, the yoke laminations which interconnect the corresponding leg laminations of the outer half of the core being divided into two groups each of half the width of said last-mentioned leg laminations, the center lines of said two groups of yoke laminations being in planes perpendicular to the plane of the center lines of said leg laminations, the inner edges of all of the last-mentioned outer yoke laminations being in the plane of the center part of the adjacent innermost U-shaped lamination of the first-mentioned yoke laminations so as to provide a relatively wide, flat support for conductive windings on said winding legs, the last-mentioned yoke laminations being of progressively varying width in accordance with the cruciform cross section of said legs.

LE ROY S. SCHELL, JR.

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