Oct. 13, 1959 A. G. STEINMAYER ET AL 2,908,880

MAGNETIC CORE

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Fig. 1

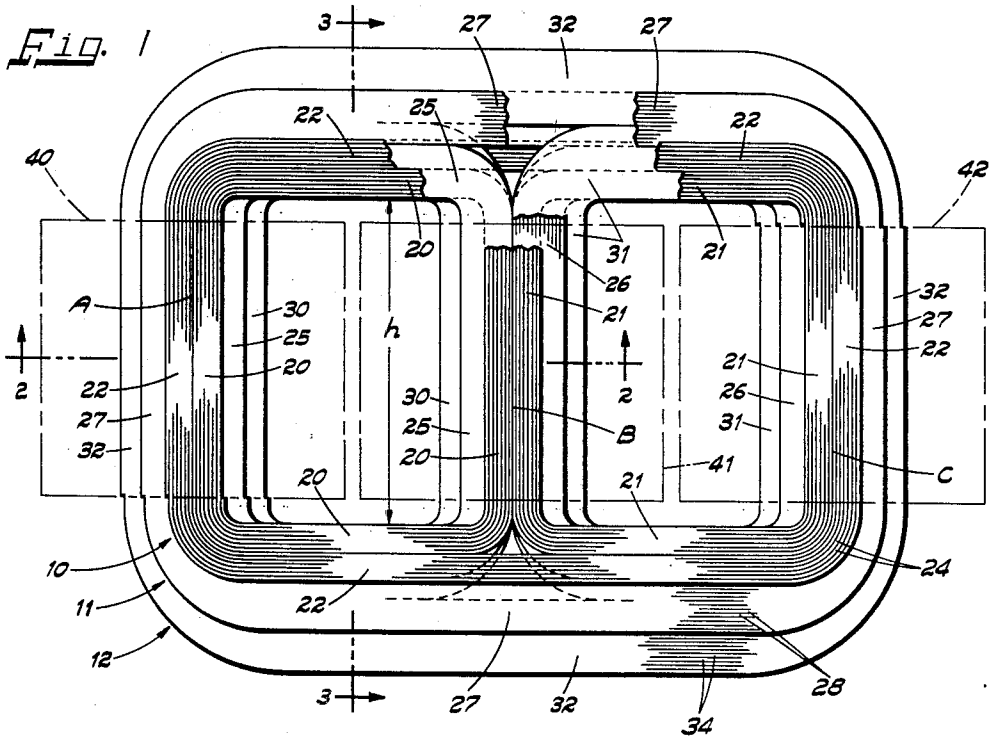


Fig. 3

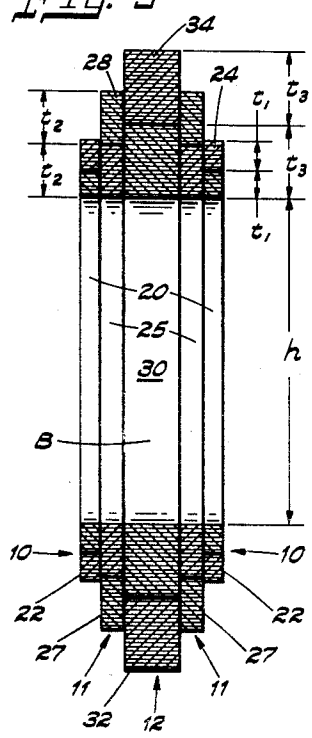
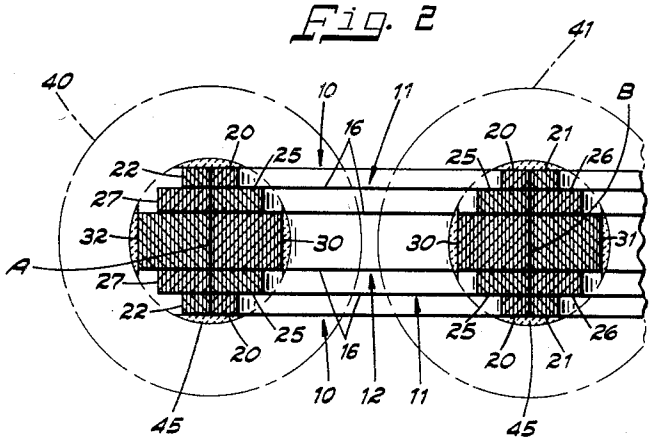


Fig. 2



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Fig. 4

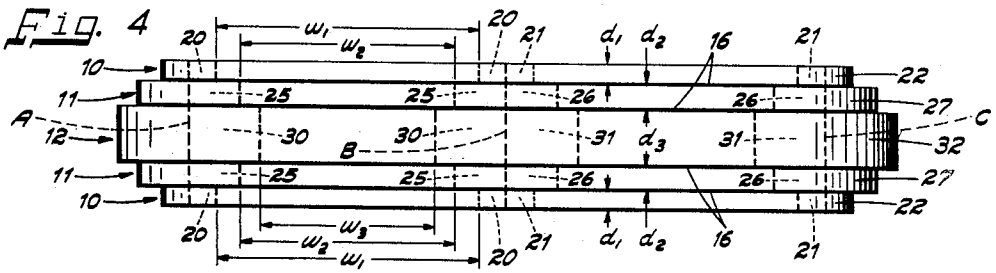


Fig. 5

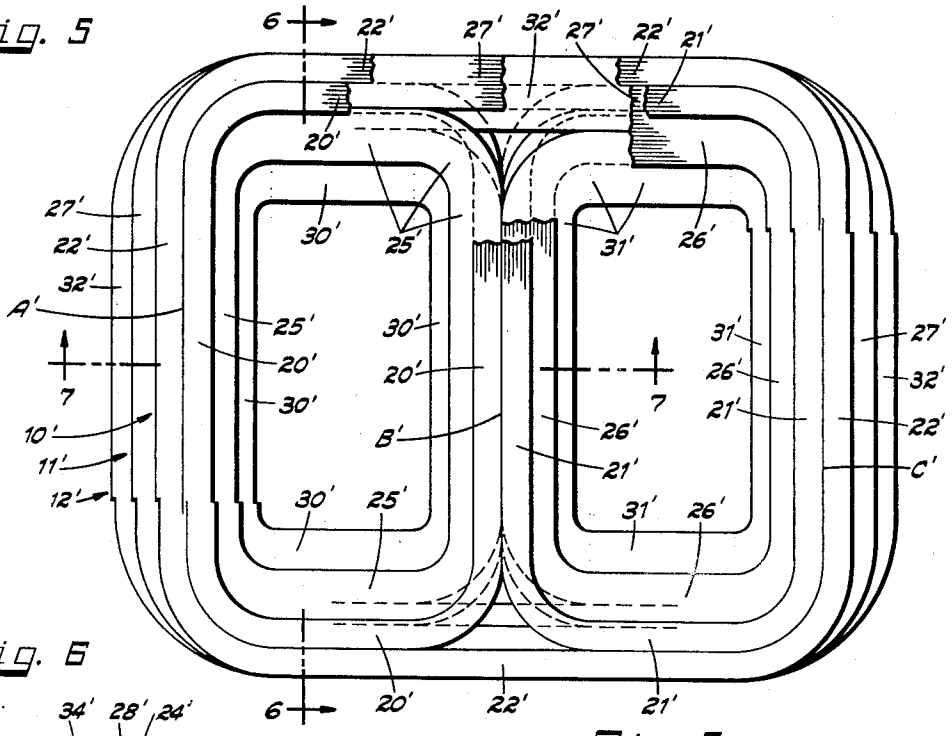


Fig. 6

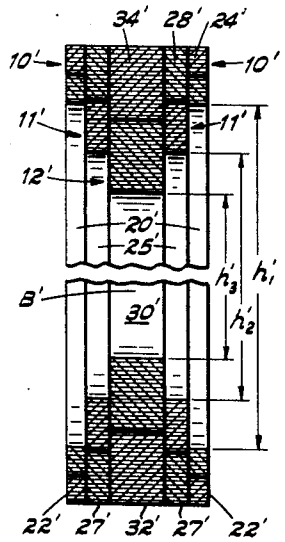
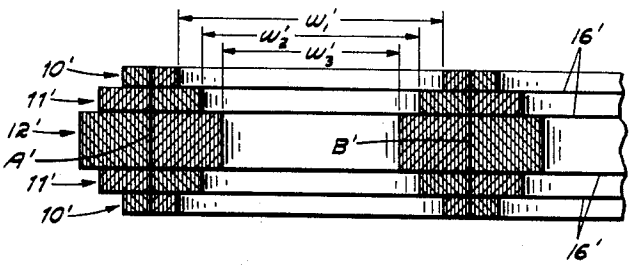


Fig. 7



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Fig. 8

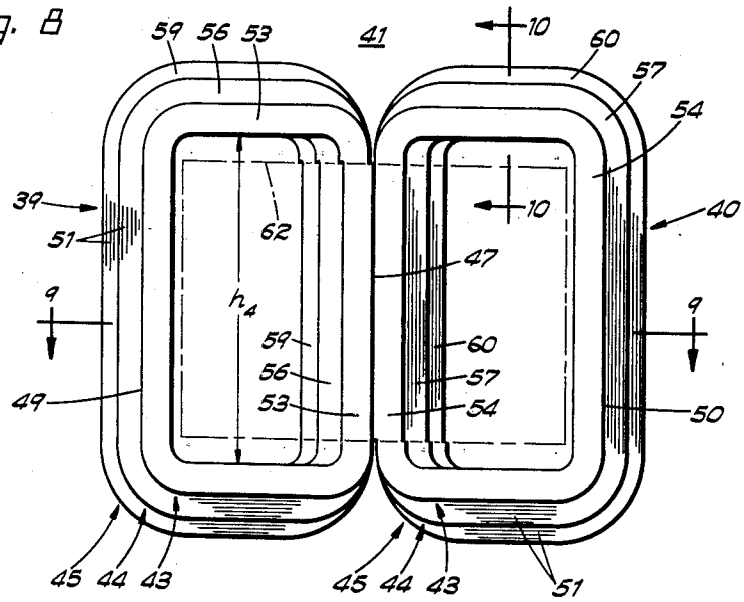


Fig. 9

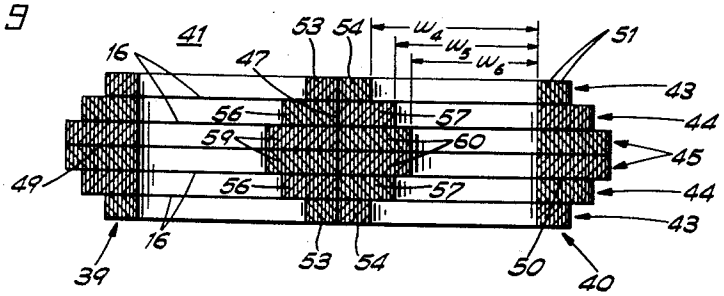
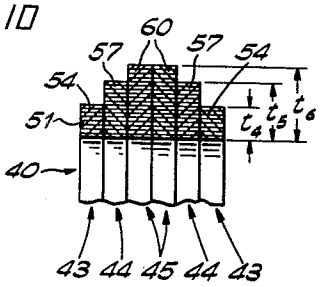


Fig. 10



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Patented Oct. 13, 1959

2,908,880

MAGNETIC CORE

Alwin G. Steinmayer, Milwaukee, Wis., and James G. Everhart, Sherman, Tex., assignors to McGraw-Edison Company, a corporation of Delaware

Application August 8, 1955, Serial No. 526,955

5 Claims. (Cl. 336—213)

This invention relates to magnetic cores for stationary induction apparatus and in particular to multi-legged magnetic cores for electrical transformers.

It is an object of the invention to provide a new and improved multi-legged magnetic core for stationary induction apparatus.

It is a further object of the invention to provide a magnetic core of spirally wound magnetic strip material wherein the mean length of iron turn is appreciably less than in prior art cores of similar configuration.

Another object of the invention is to provide a magnetic core of concentrically nested, flatwise curved, magnetic strip laminations which is appreciably lighter in weight than prior art cores of similar configuration.

A magnetic core constructed in accordance with the invention comprises a plurality of core sections in side by side relation across the width of the core. Each core section includes at least one closed loop of flatwise curved, concentrically nested laminations, and the total cross sectional height of the laminations in the closed loops and the window dimensions of the loops are so selected that the winding legs of the core formed jointly by the core sections are of cruciform cross section and the yokes of the core are of approximately semi-cruciform cross section, whereby the greatest amount of iron in the yokes is immediately adjacent the electrical winding and the mean length of iron turn is minimized.

The preferred embodiment of the present invention is an improvement on the polyphase magnetic core which forms the subject matter of U.S. Patent No. 2,431,128 to Edwin A. Link entitled Three Phase Core and assigned to the present assignee. The Link core comprises two similar, contacting, closed magnetic core loops spirally wound of magnetic strip material and an outer core loop of magnetic strip material spirally wound in embracing relation about the contacting inner core loops. The contiguous sides of the inner core loops constitute the center leg of the core, while the outer side of each inner core loop and the side of the outer core loop adjacent thereto forms an outer leg of the core. Various widths of magnetic strip material are utilized in each of the loops to provide core legs of cruciform cross section. In such a core it is desirable that some of the magnetic flux from the center winding leg, formed jointly by the abutting inner core loops, pass to the outer core loop so that a greater cross sectional area of the iron is available as a return path for the center winding phase flux. However, the reluctance to flux travel in a direction perpendicular to the laminations is relatively high and very little of the center leg flux transfers to the outer core loop.

In accordance with the preferred embodiment of the invention, a cruciform-in-cross-section magnetic core is constructed so that the inner, wound strip loops which pass through the center phase winding and jointly from the center winding leg are in side-by-side relationship with certain of the outer, wound strip loops which pass through the outer phase windings only and, with the inner

loops, form the outer legs of the core. In such a magnetic core the magnetic flux from the inner loops, jointly forming the center phase winding leg, can transfer much more easily to the outer loops, as the flux will move parallel to the laminations.

For a better understanding of the principles and objects of the invention, reference should be had to the following description taken in conjunction with the accompanying drawing wherein:

Fig. 1 is an elevation view of the core and coil assembly of a three phase induction apparatus embodying the invention; Fig. 2 is a sectional view taken on line **2—2** of Fig. 1; Fig. 3 is a sectional view taken on line **3—3** of Fig. 1; Fig. 4 is a plan view of the magnetic core of the apparatus of Fig. 1; Fig. 5 is an elevation view of an alternative embodiment of the invention; Fig. 6 is a sectional view taken on line **6—6** of Fig. 5; Fig. 7 is a sectional view taken on line **7—7** of Fig. 5; Fig. 8 is an elevation view of an alternative embodiment of the invention for a single phase, shell type transformer; Fig. **9** is a sectional view taken on line **9—9** of Fig. 8; and Fig. 10 is a sectional view taken on line **10—10** of Fig. 8.

All of the advantages of the present invention inhere in the preferred embodiment of the polyphase stationary induction apparatus illustrated in Figs. 1 through 4 having a three legged, cruciform-in-cross section, magnetic core comprising a plurality of core sections **10, 11** and **12** in side-by-side relation across the width of the core, five such sections being shown in the drawing. Each core section **10, 11** and **12** can be separately constructed and is similar to the core of the aforementioned Link patent with the exception that only a single width of magnetic ribbon is utilized and consequently, the legs thereof are of rectangular cross section. Thus, the magnetic core of the preferred embodiment is subdivided, or sectioned, along parallel planes intersecting the three legs A, B and C of the core, said planes being vertical with the magnetic core disposed as shown in the drawing. Each core section **10, 11** and **12** comprises two inner contacting loops spirally wound of magnetic strip material and an outer loop spirally wound of magnetic strip material embracing the inner loops. The core sections **10, 11** and **12** are so constructed that they jointly form magnetic core winding legs A, B and C of cruciform cross section, and the yokes of the inner loops of certain core sections are in side-by-side relation to the yokes of the outer loops of core sections adjacent thereto to permit transfer of magnetic flux between the inner and outer loops parallel to the laminations.

In order to minimize eddy current losses in the finished transformer, suitable insulating means **16** such as single ply paper or a resinous varnish film is preferably provided between adjacent core sections **10, 11** and **12.**

The core sections **10** at both outer faces of the magnetic core are identical, and each core section **10** comprises two inner, substantially rectangular, loops **20** and **21** having the longer sides thereof abutting and an outer substantially rectangular loop **22** embracing the inner loops **20** and **21.** Each of the loops **20, 21,** and **22** is formed by winding a closed loop of magnetic ribbon, and the magnetic ribbon is of the same width d_1 (see Fig. 4) in each of the loops **20, 21,** and **22.** Any suitable magnetic strip material may be utilized in constructing the loops, although it is preferable to use cold rolled silicon steel having a direction of easiest magnetization lengthwise thereof. The inner core loops **20** and **21** are duplicates, and each is formed by spirally winding magnetic ribbon **24** of suitable width flatwise on a mandrel to provide a closed convoluted loop of concentrically nested, flatwise curved, lamination layers. Although the winding is preferably on a rectangular mandrel, the winding can be accomplished on a circular mandrel and

thereafter shaped to the desired rectangular configuration. Each of the inner loops **20** and **21** is wound to the same thickness t_1 (see Fig. 3) of magnetic ribbon **24**, and the inner and outer ends of the magnetic ribbon **24** may be brazed, tack welded or otherwise secured in a manner well known in the art.

The outer loop **22** may be spirally wound of magnetic ribbon **24**, having the same width d_1 as the magnetic ribbon of the inner loops **20** and **21**, on a rectangular mandrel (not shown) and after completion positioned so as to encircle the abutting inner loops **20** and **21**, or the outer loop **22** may be wound directly on the contacting inner loops **20** and **21**. Preferably the two inner loops **20** and **21** are not removed from the mandrels on which they are wound, and the mandrels (not shown) are mounted on a common rotatable member to accomplish the winding of the outer loop in a manner similar to that disclosed in the copending application Serial No. 502,374 of Robert P. Thompson and Albert C. Wurdack, Jr., entitled Magnetic Core and Method of Construction Thereof and having the same assignee as the present invention. Preferably the outer loop **22** is wound to approximately the same thickness t_1 of magnetic ribbon **24** as each of the inner loops **20** and **21**. If desired, the magnetic strip **24** from one or both of the inner loops **20** and **21** may be left unsevered after the completion thereof, and the outer loop **22** may be spirally wound from an uncut length of magnetic ribbon **24** continuous with the magnetic ribbon of one or both of the inner loops **20** and **21** in a manner disclosed in patent application Serial No. 422,374 to Anderson and Everhart entitled Polyphase Transformer and also disclosed in the aforementioned Thompson and Wurdack application, both of which have the same assignee as the present invention. After the winding of the outer loop **22** is completed, the end of the magnetic strip material **24** may be tack welded, brazed, or otherwise secured.

The core sections **11** adjacent to and disposed inward from the core sections **10** are similar to the core sections **10** except that they are wound of wider magnetic ribbon and to a greater thickness. Each core section **11** comprises two inner, substantially rectangular loops **25** and **26** having their longer sides abutting and an outer, substantially rectangular loop **27** embracing the inner loops **25** and **26**. Each of the inner loops **25** and **26** is formed by winding a closed loop of magnetic ribbon **28** having a width d_2 which is greater than the width d_1 of the magnetic ribbon **24** forming the loops **20**, **21** and **22** of the core section **10**. The winding of magnetic ribbon **28** is preferably on a rectangular mandrel (not shown) having the same height but being narrower than the mandrel on which the inner loops **20** and **21** are wound. As a consequence, the width w_2 (see Fig. 4) of the winding window of the inner loops **25** and **26** is less than the width w_1 of the loops **20** and **21**, but the height h (see Fig. 1) of the winding window is the same in the inner loops **25** and **26** as in the inner loops **20** and **21** of core section **10**. The magnetic ribbon **28** is wound to a greater thickness t_2 (see Fig. 3) in the inner loops **25** and **26** than the thickness t_1 to which the magnetic strip material **24** is wound in the inner loops **20** and **21** of core sections **10**.

In a manner similar to that described for core section **10**, the outer loop **27** may be spirally wound of magnetic strip material **28**, having the same width d_2 as the magnetic strip material forming the inner loops **25** and **26**, on a rectangular mandrel (not shown) and after completion positioned so as to encircle the abutting inner loops **25** and **26**, or the outer loop **27** may be wound directly on the contacting inner loops **25** and **26**. The outer loop **27** may be wound after the two inner loops **25** and **26** are mounted on a common rotatable member as above described, and the magnetic ribbon **28** from which the outer loop **27** is wound may be a free length of uncut magnetic strip material continuous with the magnetic strip material of one or both the inner loops **25** and **26**. The magnetic ribbon **28** is wound to a thickness t_2 approximately equal to the thickness to which the inner loops **25** and **26** are wound, and the outer end thereof is brazed, tack welded or otherwise secured as described above.

The core section **12** is similar to the core sections **10** and **11** except that it is wound of still wider magnetic ribbon and to still greater thickness. Core section **12** comprises two inner, substantially rectangular loops **30** and **31** having longer sides thereof abutting and an outer, substantially rectangular loop **32** embracing the inner loops **30** and **31**. Each of the inner loops **30** and **31** is formed by spirally winding a closed loop of magnetic ribbon **34** having a width d_3 (see Fig. 4) which is greater than the width d_2 of the magnetic ribbon **28** forming the loops **25**, **26** and **27** of the core section **11**. The winding is preferably on a rectangular mandrel (not shown) having the same height but being narrower than the mandrel on which the loops **25** and **26** are wound. As a consequence, the width w_3 (see Fig. 4) of the winding window of the inner loops **30** and **31** is less than the width w_2 of the inner loops **25** and **26**, but the height h (see Fig. 1) of the winding window is the same as in the inner loops **20**, **21**, **25** and **26** of the sections **10** and **11**. The magnetic ribbon **34** is wound to a greater thickness t_3 (see Fig. 3) in the inner loops **30** and **31** than the thickness t_2 to which the inner loops **25** and **26** are wound.

In a manner similar to that described for core sections **10** and **11**, the outer loop **32** may be spirally wound of magnetic strip material **34**, having the same width d_3 as the magnetic strip material forming the inner loops **30** and **31**, and after completion positioned so as to encircle the abutting inner loops **30** and **31**, or the outer loop **32** may be wound directly on the contacting inner loops **30** and **31**. The outer loop **32** may be wound after the two inner loops **30** and **31** are mounted on a common rotatable member as described above, and the magnetic ribbon **34** from which the outer loop **32** is wound may be a free length of uncut magnetic strip continuous with the magnetic strip material of one or both the inner loops **30** and **31**. In forming the outer loop **32**, the magnetic ribbon **34** is wound to a thickness t_3 approximately equal to the thickness to which the inner loops **30** and **31** are wound, and the end thereof is brazed, tack welded or otherwise secured as described above.

The core sections **10**, **11** and **12** may be separately strain relief annealed to remove all strains due to the working of the magnetic ribbon during winding or during winding and subsequent shaping, depending on which process hereinabove described is followed. Preferably, however, the core sections **10**, **11** and **12** are disposed in side-by-side relation as shown in Figs. 1 through 4, and clamped together, and the entire core is strain relief annealed as a unit. Metal bands encircling the legs or yokes may be utilized to clamp the core sections together as a unit during annealing. In the finished core the core mounting frame (not shown) is preferably constructed to support and clamp the core sections **10**, **11** and **12** in the position shown in the drawing, and nonconducting tapes may be utilized circumjacent the yokes to further bind the core sections **10**, **11** and **12** together.

As shown in the drawing, the thickness t_1, t_2 and t_3 to which the inner and outer loops of the core sections **10**, **11** and **12** are wound provide winding legs A, B and C which are identical and of cruciform cross section and yokes which are of generally semicruciform cross section. The outer loops of the core sections are disposed in side-by-side relation to the inner loops of a core section adjacent thereto to permit the magnetic flux to pass over between inner and outer loops parallel to the laminations. As best seen in Fig. 3 the yoke portion of outer loop **22** of each core section **10** is in side-by-side relation to the yoke portion of the inner loops **25** and **26** of a core section **11**. In a similar manner inner loops **30** and **31** of

core section 12 are in side-by-side relation to outer loop 27 of both core sections 11. Inasmuch as the magnetic flux from the portion of the center phase winding leg formed by the inner loops 25 and 26 of core sections 11 can transfer more easily parallel to the laminations to the outer loops 22 of core sections 10, and the magnetic flux from the portion of the center phase winding leg formed by the inner loops 30 and 31 of core section 12 can transfer more easily parallel to the laminations to the outer loops 27 of core sections 11, a greater proportion of the magnetic flux can return through the entire cross sectional area of the iron of the outer core legs than in the prior art cores wherein the flux could only travel to the outer core loop through the relatively high reluctance paths perpendicular to the laminations and only a negligible percentage of flux from the center leg transferred to the outer core loop.

Although the preferred method of construction has been described as including the separate construction of the core sections 10, 11 and 12, it will be appreciated that if a winding mandrel is provided having a stepped periphery identical to the winding window of the final core, the inner loops 20, 25 and 30 (or the inner loops 21, 26 and 31) can be wound simultaneously.

The separate phase conducting winding assemblies 40, 41 and 42 for connection to the different phases of a polyphase alternating current circuit are wound on the finished annealed core in any suitable manner. For example, the winding machine disclosed in the patent to Steinmayer et al. 2,305,999 can be utilized. After the conducting windings 40, 41 and 42 have been finished, suitable wedges may be driven into place to suitably hold the conducting winding assemblies firmly in position with reference to the core.

It will be apparent that inasmuch as the greatest amount of iron in the yokes of the core is immediately adjacent to the winding window (in contrast to the core of the aforementioned Link patent wherein the yoke is of cruciform cross section and the greatest amount of iron in the yoke is disposed away from the winding window), the mean length of iron turn in the core of Figs. 1 through 4 is appreciably lessened in comparison to the core of the Link patent and consequently, that the weight of the core is reduced proportionally.

In an alternative embodiment of invention illustrated in Figs. 5 through 7, all of the core sections are identical in height and the cross section of the yokes of the magnetic core is inverted from that of the embodiment of Figs. 1 through 4. The parts of the alternative embodiment are given the same reference numerals as the parts of the preferred embodiment to which they are similar with the addition of the prime (') designation. The core sections 10' are constructed in a manner similar to that of the core sections 10 of the embodiment of Figs. 1 through 4, although for a given height of core the inner loops 20' and 21' are wound on a mandrel having a greater height than the mandrel used for winding the inner loops 20 and 21. The inner loops 25' and 26' of core sections 11 are preferably wound on a mandrel which is shorter and narrower than the mandrel on which the inner loops 20' and 21' are wound, and consequently, the width w_2' of the window in the inner loops 25' and 26' is less than the width w_1' of the window in the inner loops 20' and 21' and further, the height h_2' of the window in the inner loops 25' and 26' is less than the height h_1' in the inner loops 20' and 21'.

The inner loops 30' and 31' of core section 12 are preferably wound on a mandrel which is shorter and narrower than the mandrel on which the inner loops 25' and 26' are wound, and consequently, the width w_3' of the window in the inner loops 30' and 31' is less than the width w_2' of the window in the inner loops 25' and 26' and further the height h_3' of the window in the inner loops 30' and 31' is less than the height h_2' in the inner loops 25' and 26'.

The winding legs A', B' and C' are all substantially identical and of cruciform cross section. The top surfaces of the core sections 10', 11' and 12' are in a common plane, and similarly the bottom surfaces of these core sections lie in a common plane. The yokes of inner loops 20' and 21' of each core section 10' are disposed in side-by-side relation to the yokes of the outer loop 27' of a core section 11', and the yokes of the inner loops 25' and 26' of the core sections 11' are disposed in side-by-side relation to the yokes of the outer loop 32 of the core section 12 to permit the magnetic flux to transfer between inner and outer loops of the core sections parallel to the layers of magnetic strip material.

Although the illustrated embodiments have been shown and described as including two inner loops in each core portion, the invention is not so limited and comprehends any number of contacting inner loops in each core section. For example, in a four-legged magnetic core constructed in accordance with the invention, each core section comprises three inner loops in back-to-back relation in a common plane.

Although the core sections 10, 11 and 12 of the embodiments of Figs. 1 through 4 and Figs. 5 through 7 are illustrated as being constructed of magnetic ribbons 24, 28 and 34 of different widths, the invention is not so limited, and magnetic cores having winding legs of cruciform cross section can be constructed in accordance with the invention wherein the same width magnetic ribbon is utilized in all the core sections. For example, it will be apparent that the equivalent of section 12 can be constructed by winding a plurality of narrower ribbons each having the width of ribbon 24 (or of ribbon 28) to thickness t_3 in both the inner and outer loops to form a plurality of core sections each having a width of the ribbon 24 and disposing such sections in side by side relation to provide a total width equal to the width d_3 of ribbon 34. In the magnetic core structure illustrated in Figs. 8 to 10, all of the core sections are formed of magnetic ribbon of the same width. The invention is particularly advantageous in polyphase magnetic cores of the types illustrated in the embodiments of Figs. 1 through 4 and Figs. 5 through 7, but single phase magnetic cores may also be constructed in accordance with the invention which are lighter in weight and have a considerably smaller mean length of iron turn than prior art cores of similar configuration. It may be considered that two similar, closed, rectangular cores 39 and 40 comprise the single phase, shell type, three legged magnetic core structure 41 illustrated in Figs. 8 to 10. However, inasmuch as the two cores 39 and 40 are mechanically held as a unit in the finished apparatus and coact with a single electrical winding, the magnetic core structure 41 will be described as including a plurality of core sections 43, 44 and 45 disposed in side by side relation across the width of the core, with each core section including two closed loops in back to back relation, one loop being in each core half 39 and 40. Thus, each core section 43, 44, and 45 is somewhat analogous to the core sections 10, 11 and 12 of the embodiments described hereinbefore in that it includes two closed, rectangular, wound strip loops in back to back relation, but no outer loop surrounds the back to back loops of core sections 43, 44 and 45. Thus, flux transfer parallel to the laminations between inner to outer loops is not effected in the single phase magnetic core structure 41 of Figs. 8 to 10 as in the three phase cores of Figs. 1 to 4 and Figs. 5 to 7, but the features of decreased length of iron turn and consequent reduction in weight are inherent in the magnetic core structure 41 of Figs. 8 to 10.

As illustrated the single phase magnetic core structure 41 has a central leg 47 of cruciform cross section formed by the back to back sides of the core halves 39 and 40 and outer legs 49 and 50 of approximately semi-cruciform cross section. All of the closed loops of all of the sections 43, 44 and 45 are wound of the same width mag-

netic ribbon **51**, but the winding is performed on different mandrels (not shown) all of the same height h_4 but having different widths w_4, w_5, and w_6. Each of the loops **53** and **54** of a core section **43** are wound from magnetic ribbon **51** on a mandrel (not shown) of height h_4 and width w_4 to a thickness t_4 (see Fig. 10) and the loops **53** and **54** are disposed in back to back relation to form a core section **43**. Two core sections **43** are provided in the core structure **41**, one at each outside edge thereof. Each of the loops **56** and **57** of a core section **44** are wound from magnetic ribbon **51** on a mandrel (not shown) having a height h_4 and a width w_5, which is smaller than width w_4, to a thickness t_5 (see Fig. 10), which is greater than thickness t_4, and the loops **56** and **57** are disposed in back to back relation to form a core section **44**. Two core sections **44** are provided in the core structure **41**, one being disposed inward from each core section **43**. Each of the loops **59** and **60** of a core section **45** are wound from magnetic ribbon **51** on a mandrel having a height h_4 and a width w_6, which is smaller than width w_5, to a thickness t_6 which is greater than the thickness t_5, and the loops **59** and **60** are disposed in back to back relation to form a core section **45**. Two core sections **45** are provided and are arranged in side to side relation inward from the core sections **44** and at the innermost portion of the core. As in the preferred embodiment suitable insulating means **16** such as single ply paper or a resinous varnish film may be provided between adjacent core sections **43**, **44** and **45** to minimize eddy current losses in the finished transformer.

The back to back sides of the loops **53** and **54**, the back to back sides of the loops **56** and **57**, and the back to back sides of the loops **59** and **60** jointly form the center leg **47** of the single phase shell type magnetic core structure **41**, and insulating tape (not shown) may be wound around the abutting sides of all the loops **53**, **54**, **56**, **57**, **59**, and **60** to hold the core sections as an integral unit. An electrical winding **62** shown in dash-dot lines may be wound in embracing relation about the center leg **47**. One outer leg **50** of the single phase, shell type magnetic core structure **41** is formed jointly by the adjacent legs of the loops **54**, **57** and **60**; similarly the other outer leg **49** of core structure **41** is formed jointly by the adjacent legs of the loops **53**, **56** and **59**.

It will be apparent that the yokes of the magnetic core structure **41** are of semi-cruciform cross section and consequently a greater amount of iron in the yokes is immediately adjacent to the electrical winding **62** than in a conventional wound core wherein the yokes are of cruciform cross section and that thus the magnetic core structure of Figs. 8 to 10 has a shorter mean length of iron turn and smaller weight than a conventional cruciform-in-cross section wound core.

While we have shown and described particular embodiments of our invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and therefore, it is intended in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. A multi-legged magnetic core for stationary induction apparatus comprising, in combination, a plurality of core sections disposed in side-by-side relation, each core section at least including two similar, generally rectangular, closed inner loops of spirally and flatwise wound magnetic strip material arranged back to back in the same plane and a generally rectangular, closed, outer loop of spirally and flatwise wound magnetic strip material in embracing relation about said inner loops and said outer loop being in the plane of said inner loops, the magnetic strip material in each core section being in planes perpendicular to the plane of said inner and outer loops and being of the same width in both the inner and outer loops of said core section, the abutting sides of the inner loops of all the core sections jointly forming the central leg of the core, in each core section the outer side of each inner loop and the side of the outer loop adjacent thereto constituting a portion of an outer leg of the core, the thickness of the magnetic strip material to which the inner and outer loops of the core sections disposed at the outer portion of the core in a direction perpendicular to said planes of the inner and outer loops is wound being less than the thickness of magnetic strip material to which the inner and outer loops of the core sections disposed inward therefrom is wound, the winding legs formed jointly by the core sections being of approximate cruciform cross section and the yokes joining said winding legs and formed jointly by said coil sections being of approximate semicruciform cross section and the yoke portions of the inner loops of certain of the core sections are in side-by-side relation to the yoke portions of the outer loop of a core section adjacent thereto.

2. Three phase electromagnetic induction apparatus comprising, in combination, three conductive winding structures each adapted to be connected to one of the phases of a three phase electrical system, said winding structures being side-by-side in a row and each having a window for the reception of magnetic core material, and a magnetic core having three winding legs, one of said legs passing through the window of each of said winding structures, said core comprising a plurality of core sections disposed in side-by-side relation in a direction perpendicular to the median plane of said core defined by the axes of said core legs, each core section including a first generally rectangular, closed, inner loop of radially nested, flatwise curved, lamination layers passing through the window of one of the end winding structures and the window of the middle winding structure, a second generally rectangular, closed, inner loop of radially nested, flatwise curved, lamination layers passing through the window of the middle winding structure and the window of the other end winding structures, said first and second inner loops being back to back in a common plane parallel to said median plane, and a generally rectangular closed outer loop of radially nested, flatwise curved, lamination layers passing through the windows of the two end winding structures and embracing the two inner loops, the laminations being of the same width in the inner and outer loops of each core section, the height of magnetic strip material to which the inner and outer loops of the core sections disposed at the outer portions of the core in a direction perpendicular to said median plane is wound being less than the height of magnetic strip material to which the inner and outer loops of the core sections disposed inward therefrom is wound and the winding legs formed jointly by said core sections being of approximate cruciform cross section and the yokes formed jointly by said core sections and connecting said winding legs being of approximate semicruciform cross section and the yokes of the inner loops of cetrain core sections being in side-by-side relation to the yokes of the outer loop of a core section adjacent thereto.

3. Three phase electromagnetic induction apparatus comprising, in combination, three conductive windings each adapted to be connected to one of the phases of a three phase electrical system, said windings being side-by-side in a row and each having a window for the reception of magnetic core material, and a magnetic core having three winding legs, one of said legs passing through the window of each of said windings, said core comprising a plurality of core sections disposed in side-by-side relation, each core section including a first, generally rectangular, closed inner loop of radially nested, flatwise curved, magnetic strip laminations passing through the window of one of the end windings and the window of the middle winding, a second, generally rectangular, closed, inner loop of radially nested, flatwise curved,

magnetic strip laminations passing through the window of the middle winding and the window of the other end winding, said first and second inner loops being back to back in a common plane, and a generally rectangular, closed outer loop of radially nested, flatwise curved, magnetic strip laminations passing through the windows of the two end windings and embracing the two inner loops, the magnetic strip laminations being of the same width in the inner and outer loops of each core section, the closed loops of the different core sections having different cross sectional heights of magnetic strip laminations, the arrangement being such that the legs formed jointly by the core sections are of cruciform cross section and the height of the window in all of said first inner loops in a direction parallel to the core legs is the same and the height of the window of all of said second inner loops in a direction parallel to the core legs is the same and the yokes of the inner loops of certain core sections are in side-by-side relation to the outer loop of a core section adjacent thereto.

4. A three legged magnetic core for stationary induction apparatus comprising, in combination, a plurality of core sections disposed in side-by-side relation across the width of the core, each core section having portions in each of the legs of the core and each core section comprising two similar, generally rectangular, closed, inner loops of concentrically nested, flatwise curved, magnetic strip laminations, said inner loops being arranged back to back in the same plane, and a generally rectangular, closed, outer loop of concentrically nested, flatwise curved, magnetic strip laminations in embracing relation about said inner loops, the magnetic strip laminations being of the same width in both the inner and outer loops of each core section, the abutting sides of the inner loops of all of the core sections jointly forming the central leg of the core, in each core section the outer side of each inner loop and the side of the outer loop adjacent thereto forming a portion of an outer leg of the core, the height of the window in the inner loops of all the core sections being the same in a direction parallel to the core legs, the total cross sectional height of the magnetic strip laminations of the loops of the innermost core section being greater than that of the loops of the core sections disposed outward therefrom, the arrangement being such that the winding legs of said core formed jointly by the core sections are of cruciform cross section and the yokes of said core connecting said winding legs and formed jointly by the core sections are of approximate semicruciform cross section and the yokes of the inner loops of certain of the core sections are in side-by-side relation to the yokes of the outer loop of a core section adjacent thereto.

5. A three legged magnetic core for stationary induction apparatus comprising, in combination, a plurality of core sections disposed in side-by-side relation across the width of the core, each core section having portions in each of the legs of the core and each core section comprising two similar, generally rectangular, closed, inner loops of concentrically nested, flatwise curved, magnetic strip laminations, said inner loops being arranged back to back in the same plane, and a generally rectangular, closed, outer loop of concentrically nested, flatwise curved, magnetic strip laminations in embracing relation about said inner loops, the magnetic strip laminations being of the same width in both the inner and outer loops of each core section, the abutting sides of the inner loops of all of the core sections jointly forming the central leg of the core, in each core section the outer side of each inner loop and the side of the outer loop adjacent thereto forming a portion of an outer leg of the core and adjacent said portions jointly forming a winding leg of said core, the height of all the core sections being the same in a direction parallel to the core legs, the total cross sectional height of the magnetic strip laminations of the loops of the innermost core section being greater than that of the loops of the core sections disposed outward therefrom, the arrangement being such that the winding legs of said core formed jointly by the core sections are of cruciform cross section and the yokes of said core formed jointly by the core sections are of approximate semicruciform cross section and the yokes of the inner loops of certain of the core sections are in side-by-side relation with the yokes of the outer loop of a core section adjacent thereto.

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