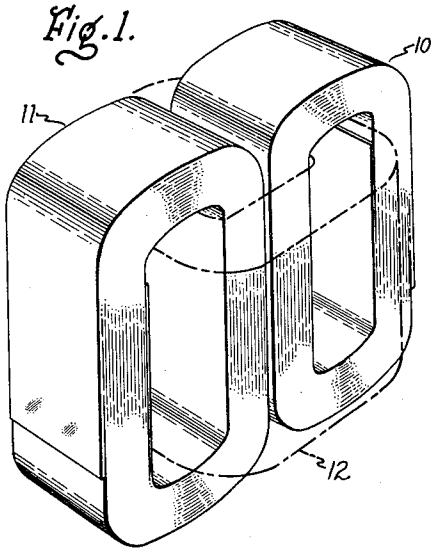
March 13, 1962 E. D. TREANOR 3,025,483

MAGNETIC CORE

Original Filed Nov. 16, 1953 2 Sheets-Sheet 1

Fig. 1.



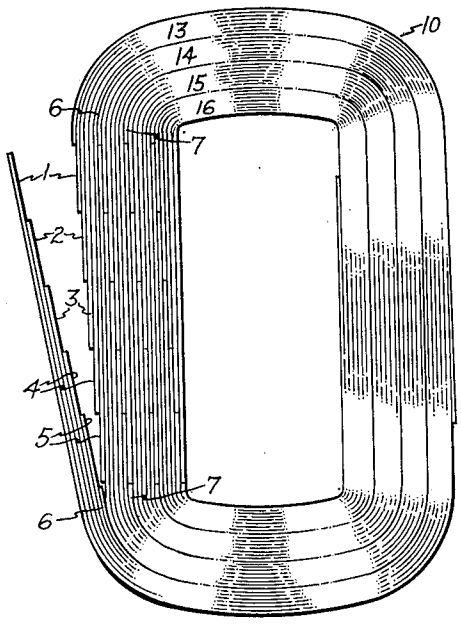


Fig. 2.

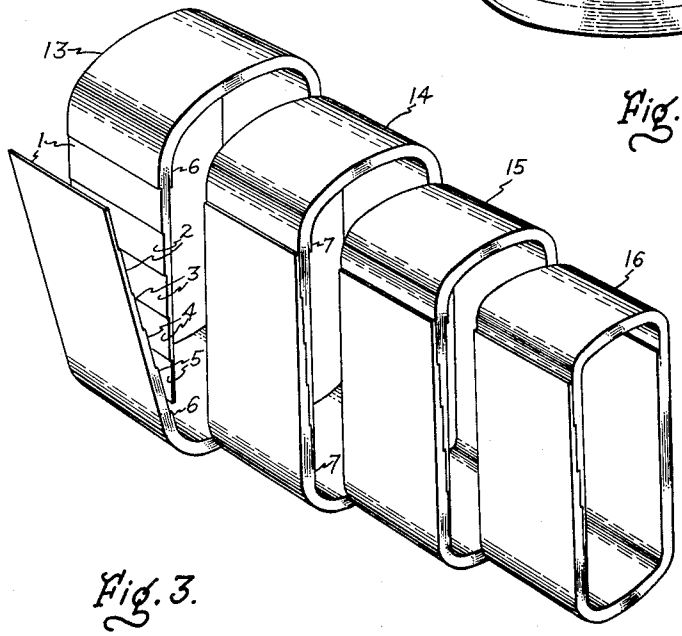


Fig. 3.

Inventor,
Edward D. Treanor,
by Gilbert P. Tarleton
His Attorney.

March 13, 1962 E. D. TREANOR 3,025,483

MAGNETIC CORE

Original Filed Nov. 16, 1953 2 Sheets-Sheet 2

Fig. 4.

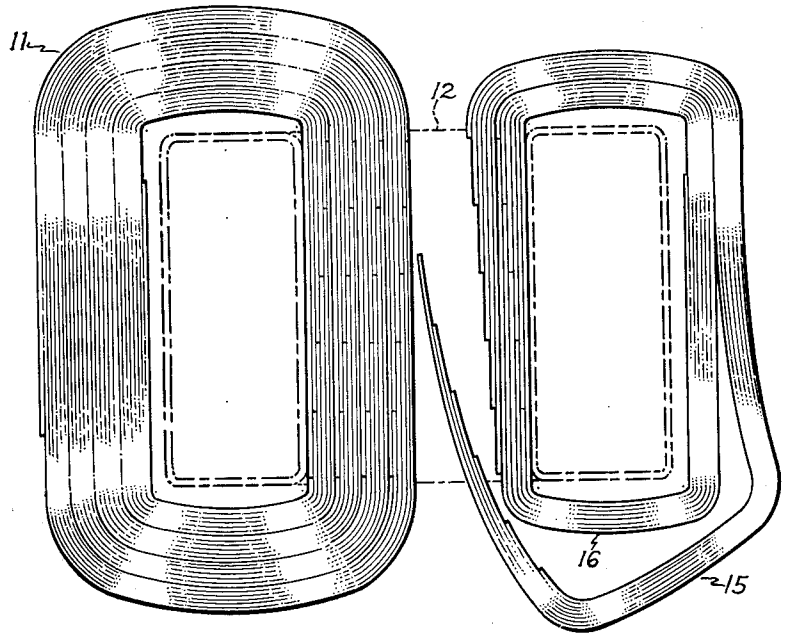


Fig. 6.

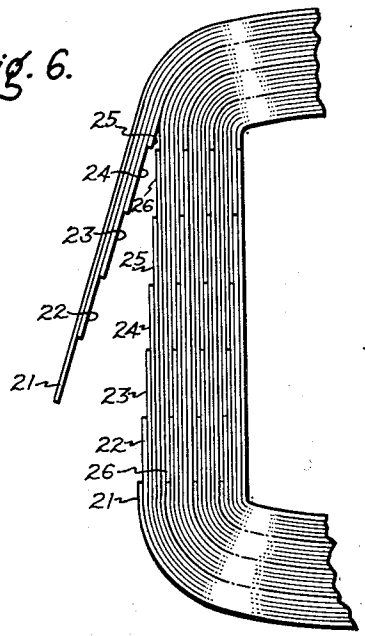


Fig. 5.

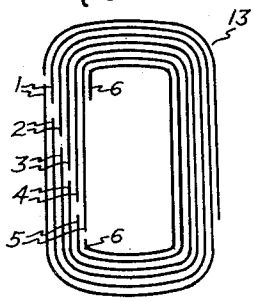
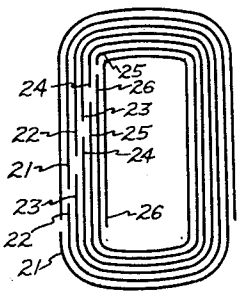


Fig. 7.



Inventor,
Edward D. Treanor,
by Gilbert P. Tarleton
His Attorney.

United States Patent Office 3,025,483 Patented Mar. 13, 1962

3,025,483
MAGNETIC CORE

Edward D. Treanor, Athens, Ga., assignor to General Electric Company, a corporation of New York

Original application Nov. 16, 1953, Ser. No. 392,205, now Patent No. 2,960,756, dated Nov. 22, 1960. Divided and this application Jan. 30, 1958, Ser. No. 712,135
12 Claims. (Cl. 336—213)

This invention relates to a magnetic core, and more particularly, to an improved wound magnetic core.

This application is a division of my copending parent application Serial No. 392,205, filed November 16, 1953, now Patent No. 2,960,756. The method described herein is claimed in said parent application.

It is well known practice in the stationary electrical induction apparatus art to continuously wind a strip of magnetic core material into a close circular-like core section having a plurality of turns. After the winding operation, a forming operation follows in order to obtain a neatly and tightly assembled annular or rectangular-like core section. However, the forming operation can be omitted by directly winding the strip of material into an annular or rectangular-like form. In such a core section, the strip of magnetic core material can be a flat metallic strip having its grains oriented in the lengthwise direction of the strip to obtain minimum core losses. During said winding and forming operations, strains are set up in said strip due to repeated flexing of said strip. Accordingly, after the winding and forming operations said core section is annealed to remove said strains. Following the annealing operation a butt joint cut is made transverse to a portion of the core section through all the core section turns so that the core section can be hinged or sprung open for assembly about a preformed coil assembly having a window opening therein.

The magnetic core section resulting from the above described procedure has several disadvantages. With all the cuts of each turn aligned in substantially one common plane, the disturbance of magnetic flux around the cut in one turn affects the disturbance of flux around the cuts in the adjacent turns thereby increasing the core losses and greatly increasing the exciting current. Also, with a single butt joint cut made in the core section difficulty is encountered in accurately closing said butt joint cut after hinged opening of the core section. Furthermore, inasmuch as the core section has a great number of turns or laminations, forces of rather large magnitude must be applied to hinge the core section open and said butt joint cut must be opened up for a considerable distance to enable the core section to be slipped into the coil assembly. Thus, besides the hinged opening operation being rather difficult, the core section may be flexed to such a degree as to set up permanent deformations therein, still further increasing the core losses.

Accordingly, it is an object of this invention to provide a magnetic core section that can be readily hinged opened and accurately closed whereby said core section will have a minimum of core losses and exciting current.

My invention comprises a closed spirally wound strip core section having a plurality of turns therein, a plurality of series of cuts in said turns whereby said turns have a length equal to approximately one complete turn of said core section, each series of cuts commencing adjacent one end of one side of said core section and ending adjacent another end of said one side.

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

In the drawings, FIG. 1 is a view in perspective, of one form of electrical induction apparatus in which the invention may be used. FIG. 2 is a front view of the right-hand core section of FIG. 1, illustrating how said core section is unwound and cut into a plurality of packets. FIG. 3 is an exploded perspective view of the packets formed from the core section shown in FIG. 2. FIG. 4 is a front view of the form of invention disclosed in FIG. 1 illustrating how the packets of FIG. 3 are assembled to form the right-hand core section of FIG. 1. FIG. 5 is a diagrammatic showing of the cutting operation employed in FIG. 2 to better illustrate said cutting operation. FIG. 6 is a front view, partly broken away, of a core section embodying another form of my invention. FIG. 7 is a diagrammatic showing of the cutting operation employed in the FIG. 6 form of invention. Like reference numerals throughout the various figures are used to designate identical parts.

Referring now to the drawings, and more particularly to FIG. 1, shown therein is a stationary electrical induction apparatus or transformer comprising two annular or rectangular-like core sections **10** and **11** linked with a preformed annular or rectangular-like electrical winding coil assembly **12**. Each of the core sections **10** and **11** and the winding assembly **12** have a window opening therein whereby the core sections **10** and **11** can be looped through the window opening of the winding assembly **12** in a manner well known in the art. The core sections **10** and **11** are identically constructed and the manner of forming and assembling the core sections **10** and **11** is illustrated in FIGS. 2, 3, 4 and 5.

The core section **10**, for instance, is formed by continuously spirally winding a flat strip of magnetic material about a mandrel or the like into a plurality of concentric turn laminations. As will be obvious to those skilled in the art, during said winding operation suitable spacing material, not shown, is inserted between adjacent turns of the strip to facilitate reassembly of the core section **10** after the strip has been unwound and cut. If the strip is not directly wound into an annular or rectangular-like form, but into a circular-like core section, the wound core section undergoes a forming operation whereby the turn laminations of the core section will be neatly and tightly arranged with respect to each other to present a closed annular or rectangular-like core section. During said winding and forming operations mechanical strains are set up in the strip of magnetic material due to repeated flexing of said strip of material. Therefore, after said winding and forming operations the core section is placed in an oven or the like for a heat treating or annealing operation whereby said mechanical strains are relieved. The winding, forming, and annealing operations just described are well known in the art.

After the annealing or heat treating operation, the continuously wound strip of magnetic material is unwound from the annealed core section and cut into a plurality of turns having a length of approximately one complete turn of said core section. A plurality of individual packets are assembled from said cut turns and said packets are then assembled about the preformed winding assembly **12** in the inverse order from which they were formed as will be more clear hereinafter.

The unwinding and cutting operation is disclosed in FIGS. 2 and 5. As seen in FIG. 2, a cut is made in the outermost turn of the continuous strip of magnetic material adjacent the upper left-hand side portion of the core section **10**. The outermost turn or lamination **1** is then unwound and another cut is made in the continuous strip of magnetic material at a point along the left-hand side of core section **10** offset or staggered with respect to the first cut towards the lower end of the left-hand side portion of core section **10**. After the outer turn or lamination **1** is removed the second turn or lamination **2** of the con-

tinuous strip of magnetic material is unwound and then cut at a point along the left-hand side portion of core section 10 offset or staggered with respect to the second cut towards the lower end of the left-hand side portion of core section 10. The unwinding and cutting operation just described is repeated until a plurality of turn laminations having a length of approximately one complete turn of the core section 10 are obtained. Each subsequent cut in the strip of material is made at a point progressively closer to the lower end of the left-hand side portion of core section 10 whereby the last cut of a first series of cuts is made at a point disposed at the lower end of the left-hand side portion of core section 10. Said last cut of the series of cuts defines the terminating end of turn lamination 5 and the commencing end of turn lamination 6. The cut turn laminations 1, 2, 3, 4 and 5 are assembled as they are being cut and unwound into a packet 13 shown in FIG. 3.

The turn laminations comprising packet 13 and the manner of making the first series of cuts in the continuous strip of magnetic material to obtain packet 13 possibly is more clearly illustrated in FIG. 5. As illustrated in FIG. 5, the just described unwinding and cutting operation enables all the cut turns or laminations to be easily reassembled with respect to each other in the same position they occupied before they were unwound and cut. That is, the commencing end of each cut turn lies in the same plane as the terminating end of an immediately preceding cut turn. For instance, the terminating end of turn or lamination 1 is positioned radially inward of the commencing end of turn or lamination 1 and is staggered with respect thereto towards the lower end of the left-hand side of the core section whereby it lies in the same plane as the commencing end of turn 2. The terminating ends of the other turns or laminations are similarly arranged with respect to their commencing ends whereby each cut turn or lamination has a length slightly greater than one complete turn of the core section.

Referring again to FIG. 2, after the outermost series of turns 1 to 5 are formed and assembled into packet 13 shown in FIG. 3, the remainder of the continuous strip of magnetic material is unwound for approximately three-quarters of a complete turn of the closed core section and is again cut at the upper end of the left-hand side portion of core section 10 to commence another series of cuts which will progressively be spaced closer to the lower end of the left-hand side portion of core section 10. After another five turns of the continuous strip of material are unwound and cut another packet 14 shown in FIG. 3 is formed out of the second series of cut turns or laminations. The three-quarters of a turn lamination 6 is assembled with packet 13. However, turn 6 can also be assembled with packet 14 if so desired. The last cut of the second series of cuts will be made at the lower end of the left-hand side portion of core section 10. The first cut of the third series of cuts will be made at the upper end of the left-hand side portion of core section 10. Accordingly, the last cut of the second series of cuts and the first cut of the third series of cuts will define another three-quarters turn 7. Three-quarters turn 7 is assembled with the second packet 14 but can be assembled with packet 15 formed subsequent thereto. The unwinding or cutting operation as above described is repeated until a plurality of packets 13, 14, 15 and 16 are obtained.

Thus, it will now be seen that the unwinding and cutting operation comprises unwinding the continuous strip of material from the annealed core section one turn at a time and cuting said strip into lengths slightly greater than one complete turn of the core section except for the transitional pieces between the packets which have a length of approximately three-quarters of a turn. A plurality of series of cuts are made in said core section and each first cut of each of said plurality of series is made at a same end of a same side of the annular or rectangular-like core section. Each subsequent cut of the series of cuts is positioned radially inward of the immediately preceding cut and is staggered with respect thereto towards the other end of said same side of the core section whereby the last cut of each series of cuts will be disposed at a point adjacent said other end of said same side. In other words, the joints in the packets or core section are long as compared to the thickness of the side in which they are located.

The number of packets, the number of turns in each packet, and the spacing between the cuts will have been previously determined with several factors in mind. The cuts should be far enough apart to avoid the disturbance of flux around one cut from affecting the disturbance of flux around the cut in the next adjacent turn. Also, the resulting packets should be of such thickness and flexibility as to be capable of being sprung around the preformed winding coil assembly 12 without permanent deformation of the turns comprising the completed core section 10. Many strip wound magnetic cores are made out of flat magnetic strip material having a 12 mils thickness. For such a thickness it is suitable that the cuts be spaced from each other by $\frac{3}{16}$ to $\frac{5}{16}$ of an inch to avoid the disturbance of flux around one cut from affecting the disturbance of flux around the cut in the next adjacent turn.

After the continuously wound annealed core section is cut into the packets 13, 14, 15 and 16, said packets are assembled about the preformed winding coil assembly 12 as shown in FIG. 4. The smallest or innermost packet 16 is opened up and sprung around the coil assembly 12 with the joints or cuts of the packet 16 positioned within the window opening of the coil assembly 12 as shown in FIG. 4. With properly proportioned packets, the packets may be hinged or sprung open and looped about the windings 12 without exceeding the elastic limit of the strip material and thus affecting the magnetic properties of the magnetic strip material. The next larger packet 15 is similarly hinged opened and sprung about the windings 12 in superposed concentric relationship with the smallest packet 16. This procedure is repeated until all of the packets are sprung about the coil assembly 12 and disposed with respect to each other in a concentric relationship to form a closed magnetic core section. The turns of the completely assembled core section and the packets thereof may be secured together by applying a cement along the cut faces of the turns or between the packets or the core turns may be secured together by clamps alone. The cuts of the completed core section preferably are disposed within the window opening of the electrical windings 12 inasmuch as with such an arrangement the packets comprising the completed core section need be hinged open only a minimum amount for springing about the electrical windings 12.

In the core section 10 shown in FIG. 2 the strip of material comprising the core section was initially wound clockwise in a spiral from its radially inner end outwardly towards its radially outer end. It should be noted that if the continuous strip of material was initially wound counterclockwise into a closed core section the first cut of each series of cuts would have been made at the lower end of the left-hand side portion of core section 10 in order to secure cut turns of slightly more than one complete turn length with the cuts progressing towards the upper end of the left-hand side of core section 10 whereby the last cut of each series of cuts would have been disposed at the upper end of the left-hand side portion of core section 10. This will be readily apparent by viewing the core section 10 of FIG. 4 when FIG. 4 is inverted.

Referring now to FIGS. 6 and 7, shown therein is another form of my invention wherein the cut turns of the core section extend for a length slightly less than one complete turn of the core section. In this form of my invention each series of cuts is commenced at the lower end of the left-hand side portion of the core section and the series of cuts progresses towards the upper end of the left-hand side portion of the core section until the last cut of each series is positioned at the upper end of

the left-hand side portion of the core section. Thus, viewing FIGS. 6 and 7 together, it will be seen that a first cut is made in the outer turn or lamination of a continuously clockwise wound strip material core section adjacent the lower left-hand corner thereof. The first lamination **21** is unwound and then a second cut is made in the strip of material at a point radially inward of the first cut staggered or offset with respect thereto towards the upper left-hand corner of the core section. The first and second cuts define the first turn or lamination **21**. The second turn or lamination **22** is unwound and a third cut is made radially inward of the second cut staggered and offset with respect thereto towards the upper end of the left-hand side portion of the core section. The strip of material defined by the second and third cuts constitutes the second turn or lamination **22** of the first packet of turns or laminations. This cutting and winding operation is continued until five turns or laminations **21** to **25** are obtained. Said turns or laminations **21** to **25** are stacked in a packet. The last cut of the first series of cuts is disposed adjacent the upper left-hand corner of the core section and defines the terminating end of lamination **25** and the commencing end of lamination **26**. The transitional lamination **26** is unwound for approximately one and one-quarter turns of the core section and is then cut adjacent the lower left-hand end of the core section similar to the first cut of the first series of cuts. Turn or lamination **26** can be stacked with the first packet of turns or laminations or with the second packet of turns or laminations. The unwinding and cutting operation just described is repeated periodically until a plurality of packets are obtained. Then, as in the first form of invention the packets are assembled in the inverse order from which they were formed about a preformed electrical winding coil assembly.

In the FIGS. 6 and 7 form of invention, the series of cuts were always commenced at the lower left-hand corner of the core section in order to obtain cut turn laminations having a length of slightly less than one complete turn of the core section inasmuch as the strip of material was initially wound clockwise into a closed core section. However, it should be noted that if the strip of magnetic material continuously wound into a closed core section had been spirally wound counterclockwise and radially outward to obtain cut turn laminations having a length slightly less than one complete turn of the core section the series of cuts would have been commenced adjacent the upper left-hand corner of the core section.

While there have been shown and described particular embodiments of the invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention, and that it is intended by the appended claims 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:

1. In a closed core section which is linked with a hollow electrical winding coil assembly having a window opening, said core section comprising a flat continuous strip of magnetic material which is spirally wound into a plurality of concentric superposed turns, several series of cuts in said strip dividing said strip into cut turns having a length equal to approximately one complete turn of said core section, each of said series of cuts distributed along only one side of said core section and commencing adjacent an identical end of said side and terminating adjacent an opposite end of said side while progressing inward of said core section, and said side being positioned in said window opening.

2. In a closed core section which is linked with a hollow electrical winding coil assembly having a window opening, said core section comprising a flat continuous strip of magnetic material which is spirally wound into a plurality of concentric superposed turns, a plurality of series of cuts in said strip dividing said strip into cut turns having a length equal to slightly more than one complete turn of said core section, each of said series of cuts distributed along only one side of said core section and extending from the same end of said side towards the other end of said side while progressing inward of said core section, and said side being positioned in said window opening.

3. In a closed core section which is linked with a hollow electrical winding coil assembly having a window opening, said core section comprising a flat continuous strip of magnetic material which is spirally wound into a plurality of concentric superposed turns, a plurality of series of cuts in said strip dividing said strip into cut turns having a length equal to slightly less than one complete turn of said core section, each of said series of cuts distributed along only one side of said core section and extending from the same end of said side towards the other end of said side while progressing inward of said core section, and said side being positioned in said window opening.

4. In a closed magnetic core which has a window opening and a plurality of radially superposed and spirally arranged approximately single turn length laminations which extend continuously for a bout a single turn of said core, a side of said core having a joint therein whose length is long with respect to the thickness of said side, said joint comprising a plurality of series of butt joints in said laminations which are staggered along said joint length and progress radially outward, all of said series of butt joints commencing at the same end of said joint.

5. A magnetic core for stationary induction apparatus comprising, in combination, a plurality of concentric groups of lamination lengths of magnetic material forming a closed four-sided magnetic core having a pair of opposed legs and a pair of opposed relatively shorter yokes, one of said legs being a winding leg, each of said groups comprising a plurality of radially successive lamination lengths, each lamination length constituting a closed magnetic circuit and having its ends overlapped a relatively short distance in one side of said core, substantially all of said lamination lengths having those improved strain-free properties characteristic of magnetic material relief-annealed subsequent to mechanical working, radially successive lap joints in each of said groups being circumferentially displaced along said one side and having one end of each adjoining pair of lap joints disposed in a common layer with the end of one lamination length in said layer discontinuous from the end of the other lamination length in said layer to provide an interfitting flight of lap joints in said one side, whereby the lamination lengths of each group may be separated at their overlapped ends and collectively inserted through the window of an electrical winding and said lamination lengths inherently assume said overlapping relation.

6. A closed magnetic core for stationary induction apparatus comprising, in combination, a plurality of radially nested, flatwise curved laminations of magnetic material having a preferred grain orientation lengthwise thereof, substantially all of said laminations having those improved strain-free properties characteristic of magnetic material relief-annealed subsequent to mechanical working and having a permanent set of rectangular configuration with four sides joined at approximately right angle corners to form a hollow core having oppositely disposed sides and relatively shorter, oppositely disposed ends, one of the sides of said core being a winding leg, each one of said laminations being of longer length than the additive length of said sides and ends of said magnetic core measured circumferentially at said one of said laminations, said laminations being in solid contact along substantially their entire length with the corner bends compactly nested together and each lamination having the ends thereof overlapped a relatively short distance in one of the sides of said core, the lap joints of radially successive laminations being progressively displaced peripherally along a substantial portion of the circumfer-

ential length of said one side of said core and the outermost end of each lamination being in the same layer as, but discontinuous from the innermost end of the lamination radially outward therefrom to provide an interfitting flight of lap joints along said one side, whereby said laminations may be collectively inserted through the window of an electrical winding and said laminations inherently resume said overlapping relation.

7. In combination, a closed magnetic core having four sides surrounding a window and comprising a plurality of concentric groups of laminations of magnetic material, each group including a plurality of radially successive laminations, each lamination comprising a whole turn in said core and substantially all of said laminations having those improved strain-free properties characteristic of magnetic material relief-annealed subsequent to mechanical working and having a permanent set of rectangular configuration with four sides joined at approximately right angle corners to form a hollow, closed core having oppositely disposed legs and oppositely disposed, relatively shorter yokes, one of said legs being a winding leg, said laminations of each group being in solid contact along substantially their entire length with the corner bends compactly nested together and each lamination of said group having its ends overlapped a relatively short distance in one side of said core, radially successive lap joints in each group being progressively displaced in a circumferential direction along a substantial portion of the length of said one side and the radially outermost end of each lamination being in the same layer as, but discontinuous from, the radially innermost end of the lamination radially outward therefrom to provide an interfitting flight of lap joints in said group along said one side, whereby the laminations of each group may be separated at their overlapped ends and collectively inserted through the window of an electrical winding to link said one leg with said winding and said laminations inherently assume said overlapping relation, the interfitting lap joints in radially successive groups being similarly arranged and displaced along at least one side of said core.

8. A magnetic core for stationary induction apparatus comprising, in combination, a plurality of radially nested, lengthwise bent lamination lengths of magnetic material each having a preferred grain orientation lengthwise thereof, said lamination lengths having those improved strain-free properties characteristic of magnetic material relief-annealed subsequent to mechanical working and having a permanent set of four-sided configuration to form a closed, hollow magnetic core having a pair of opposed legs and a pair of opposed, relatively shorter yokes surrounding a window, one of said legs being a winding leg, each of said lamination lengths constituting a whole turn in said core and having its ends overlapped a relatively short distance in one side of said core, radially successive lap joints being progressively displaced in a circumferential direction along said one side and having one end of each adjoining pair of lap joints disposed in a common layer in said one side with the end of one lamination length in said layer discontinuous from the end of the other lamination length in said layer, whereby said lamination lengths may be separated at their overlapped ends and collectively inserted through the window of an electrical winding and said lamination lengths inherently assume said overlapping relation.

9. Stationary induction apparatus comprising, in combination, an electrical winding having a window therethrough and sides of substantially rectangular cross section surrounding said window, a closed quadrilateral magnetic core including a plurality of concentric groups of lamination lengths, said core passing through said window and closely embracing one of said sides of said winding and having a pair of opposed legs, one of which is disposed within said window, and a pair of opposed, relatively shorter yokes, said lamination lengths having those improved strain-free properties characteristic of magnetic material relief-annealed subsequent to mechanical working and having a permanent set of quadrilateral configuration, each said group including a plurality of radially successive lamination lengths in solid contact along substantially their entire length and each of which comprises a whole turn of said core and has its ends overlapped a relatively short distance in one side of said core, radially successive lap joints in each said group being progressively displaced in a circumferential direction along said one side and the outermost end of each lamination length being in the same layer as but discontinuous from the radially innermost end of the lamination length radially outward therefrom to provide a flight of interfitting lap joints in said group along said one side.

10. A magnetic core for stationary induction apparatus comprising in combination a plurality of concentric groups of laminations of magnetic material wound to form a closed four-sided magnetic core, each of said groups comprising a plurality of radially successive laminations being cut to have a length slightly more than one turn of said core, each lamination thereby constituting a closed magnetic circuit having its ends overlapped a relatively short distance in one side of said core, radially successive joints in each of said groups being longitudinally displaced along said one side, one end of each lamination being disposed in a common layer with one end of the next succeeding lamination, whereby the laminations of each group may be separated at their joints and collectively inserted through the window of an electrical winding.

11. A magnetic core for stationary induction apparatus as set forth in claim 10 in which the radially successive joints in each group begin at one end of said one side and are displaced substantially along the entire length of said one side.

12. A magnetic core for stationary induction apparatus as set forth in claim 11 in which the radially successive joints in each group all begin at the same end of said one side.

References Cited in the file of this patent

UNITED STATES PATENTS

2,431,128	Link	Nov. 18, 1947
2,534,312	Somerville	Dec. 19, 1950

FOREIGN PATENTS

106,986	Great Britain	June 14, 1917