March 24, 1959 W. F. GAKLE ET AL 2,878,855

MANDREL FOR FORMING LAMINATED TRANSFORMER CORE

Filed May 12, 1954 4 Sheets-Sheet 1

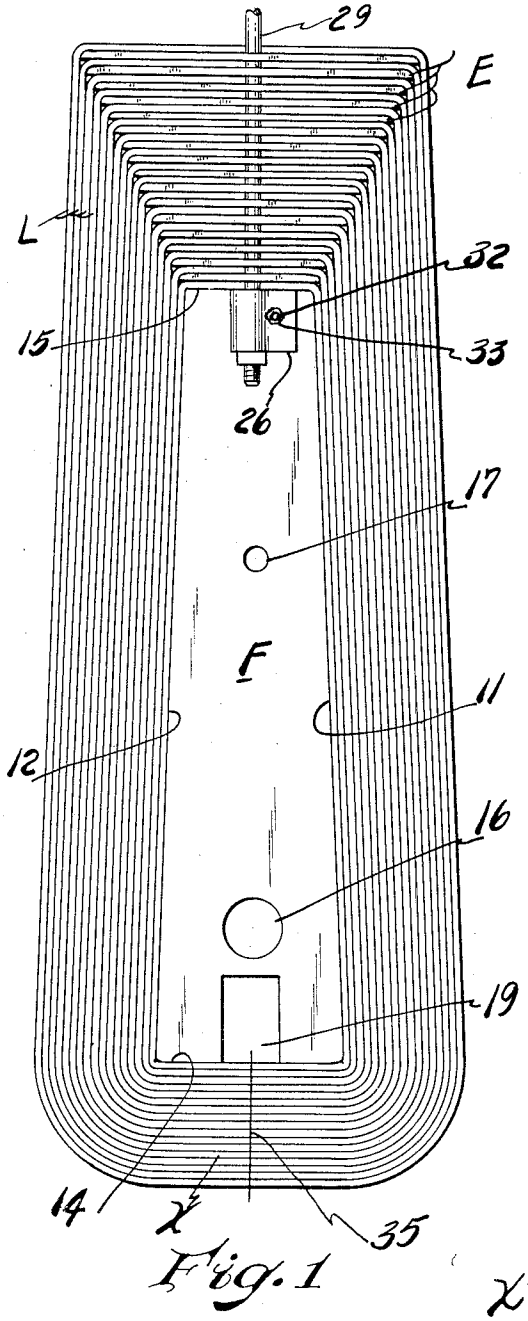
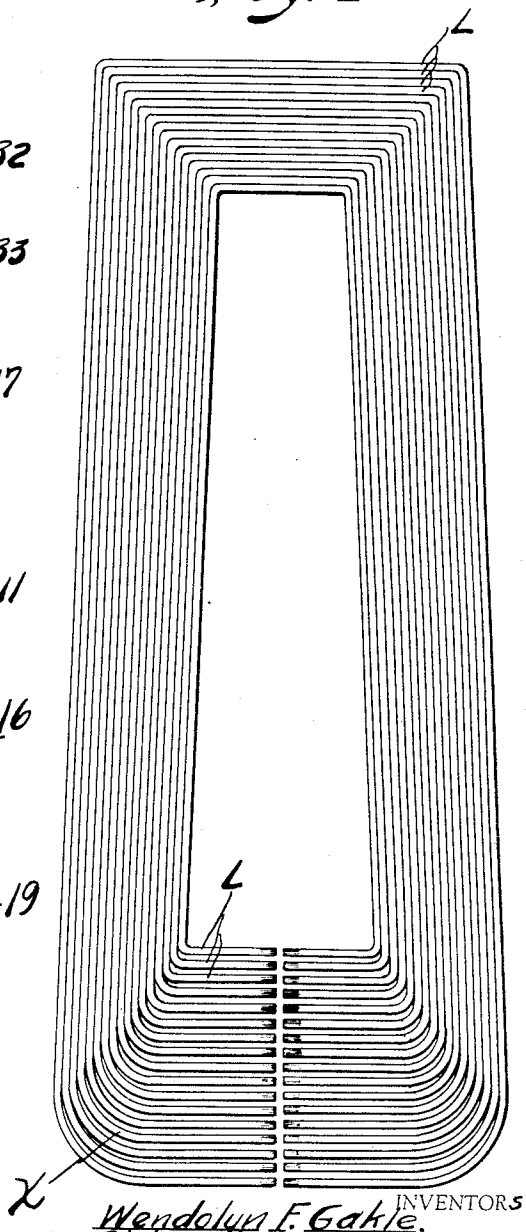


Fig. 1

Fig. 2



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4 Sheets-Sheet 2

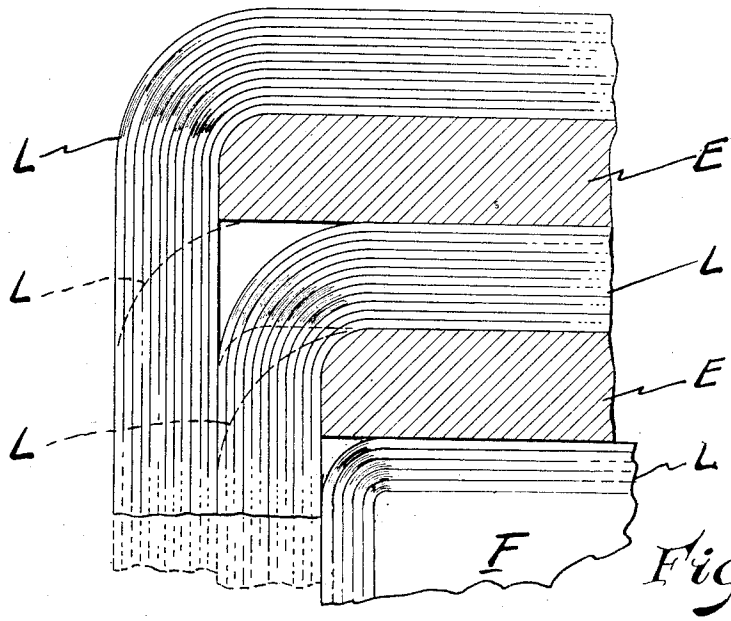


Fig. 3

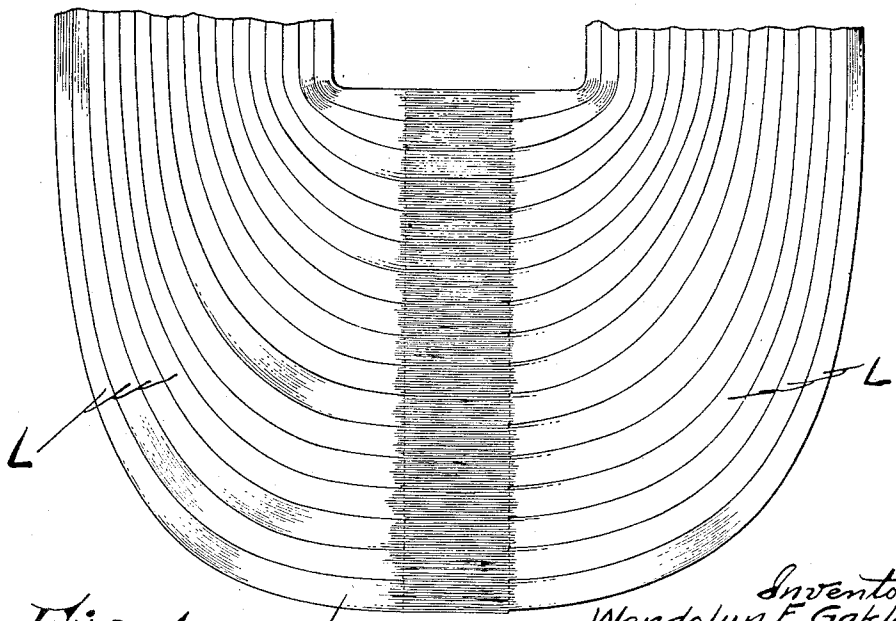


Fig. 4

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Filed May 12, 1954 4 Sheets-Sheet 3

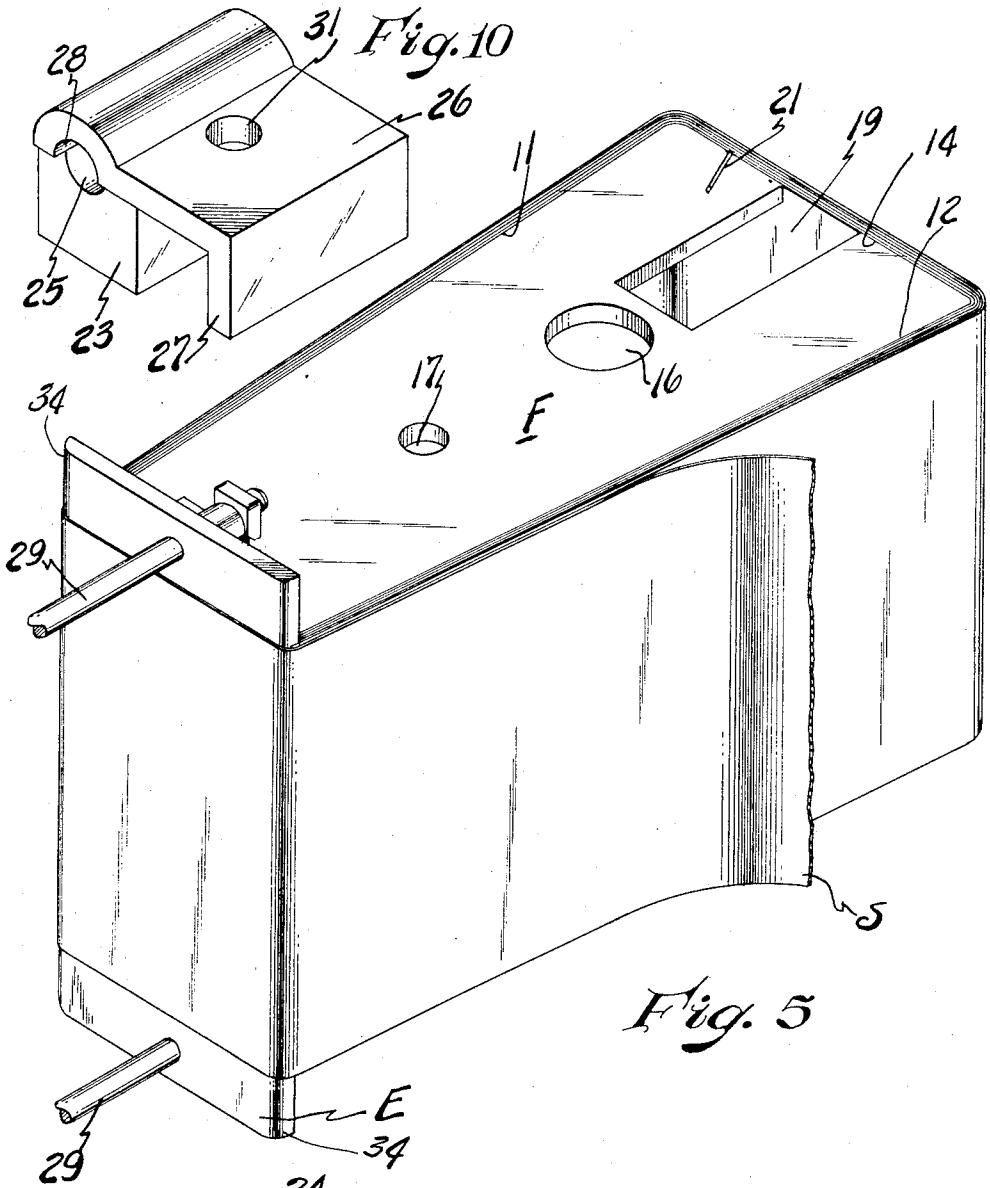


Fig. 10

Fig. 5

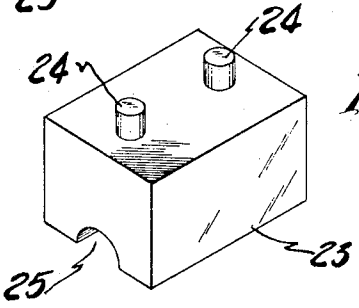


Fig. 11

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4 Sheets-Sheet 4

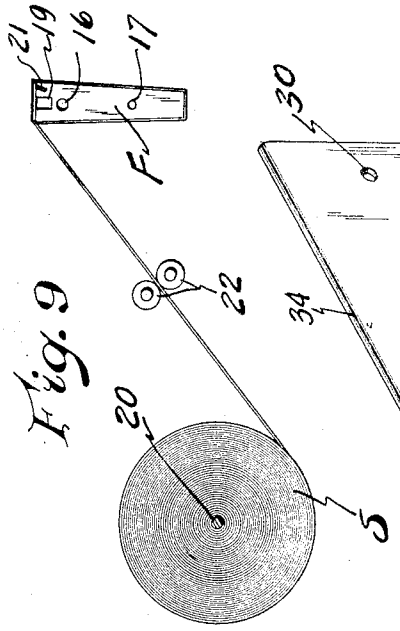


Fig. 9

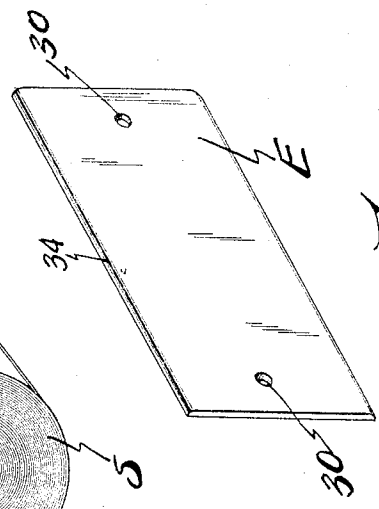


Fig. 7

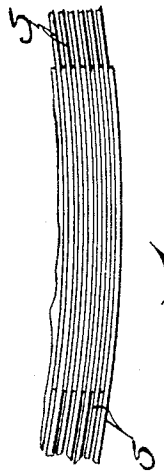


Fig. 8

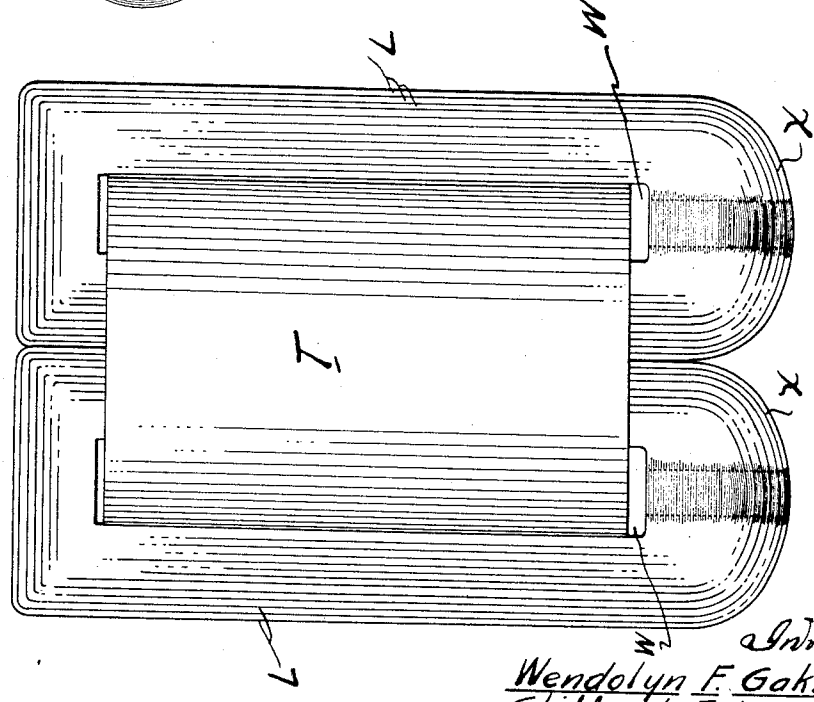


Fig. 6

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2,878,855

MANDREL FOR FORMING LAMINATED TRANSFORMER CORE

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Application May 12, 1954, Serial No. 429,208

4 Claims. (Cl. 153—64)

This invention relates to magnetic cores such as used in transformers and similar electrical equipment and to a method of producing the same.

One of the prime objects of the instant invention is to provide a transformer core made by winding a continuous length of magnetic strip into a core and linking said core with pre-formed electrical windings. The use of cold rolled strip in the manufacture of transformer cores has proven highly desirable because of its greater uniformity, lower production costs and excellent magnetic properties in the direction of rolling; that is, lengthwise the direction of the strip; however, the winding of the strip usually impairs the magnetic properties of the metal and necessitates that the cores be annealed after they have been formed in order to obtain the full advantage of the magnetic properties of the cold rolled strip.

Another object is to design a core which can be cut to provide an openable leg to permit assembly of the core in the window of the usual transformer coils, and in which the cut ends of the individual laminations can be overlapped to permit the magnetic flux to pass the air gap without undue concentration.

A further object is to provide a winding form or mandrel of predetermined shape onto which the core is wound with spacers of certain thickness and width wound into one side of the core at certain intervals to provide proper length of lamination for lapping after the core has been annealed and the core is filled into the coil window.

Another object is to provide a new and improved method of making a magnetic core.

Still another object is to provide a method of forming and winding a magnetic core and provide removable spacers wound in the core on the leg opposite to the leg that is to be cut and lapped, so as to provide necessary space in the opposite leg to permit the severed ends of the individual laminations to be overlapped to form a closed core.

A further object still is to design a wound magnetic core in which spacers are wound in one of the core legs as the core is being wound and provide means for centering and securing these spacers on the centerline of the core during the winding operation.

Another object is to provide space in the winding form so that the core leg can be readily cut for lapping after the core has been annealed.

With the above and other objects in view, the present invention consists in the combination and arrangement of parts, hereinafter more fully described, illustrated in the accompanying drawings, and more particularly pointed out in the appended claims, it being understood that changes may be made in the form, size, proportion, and minor details of construction, without departing from the spirit, or sacrificing any of the advantages of the invention.

In the drawings:

Fig. 1 is an elevation of a completed core winding showing the spacers in position therein.

Fig. 2 is a view similar to Fig. 1 showing the spacers removed and the opposite leg of the core cut.

Fig. 3 is an enlarged, fragmentary, elevational view, the solid lines showing the strip wound on the spacers, the removal of the spacers providing means to position the strips as shown by the broken lines.

Fig. 4 is an enlarged, fragmentary, elevational view showing sections of the strips and the overlap.

Fig. 5 is a perspective view showing the winding form or mandrel with a section of the strip wound thereon.

Fig. 6 is an elevational view of a transformer with the cores in position.

Fig. 7 is a perspective view of one of the spacer plates.

Fig. 8 is an enlarged, fragmentary view illustrating the manner in which the ends of the successive turns overlap.

Fig. 9 is a fragmentary, side elevational view showing the core being wound from a coil of magnetic strip.

Fig. 10 is a perspective view showing the winding form or mandrel pin holders.

Fig. 11 is an inverted plan view of the inner section of the pin holder.

Referring now more particularly to the accompanying drawings in which we have shown the preferred embodiment of our invention, the letter F indicates a winding form which can be made up of any desired material, the two sides **11** and **12** being of the same length, while the end **14** is somewhat longer than the opposite end **15**, and this form can be ribbed, if desired, to provide reinforcement. Openings **16** and **17** are provided in the side plates of the form F to facilitate attachment to the winding spindle of a lathe or turning device (not shown), and slots **19** are provided in the end walls **14** of the side plates and for a purpose to be presently described.

The winding form F is mounted on the face plate of a conventional winding lathe (not shown) and the core is wound from a continuous strip of ferrous strip stock S of suitable composition and dimension. The coil strip of stock S is mounted on a pin **20** spaced from the winding device, and one end of said strip is anchored to the winding form F by inserting the end section into a slit **21** provided in the end wall **14**, and it will be obvious that the strip readily unwinds from the coil onto said form as the lathe is driven. Tension rollers **22** are provided at a point intermediate the coil and winding form to maintain the strip taut.

In a wound core of the nature herein described, it is necessary that one leg of the core be openable to provide for assembly with the coil of a transformer T; consequently, it is necessary that the formed strip core be cut, and the cut ends overlapped after assembly in the coil window W so that proper magnetic characteristics are maintained.

To provide the proper length of laminations to permit the required lapping, the winding form or mandrel F is made wider at the one end where the lapping occurs, by the required length of lap, and it will further be obvious that the stack or thickness of the lapped core leg will be twice that of the other three sides or legs, and to provide for this "build-up" on the lapped side, a plurality of spacers E of predetermined thickness, width and length are wound in the core at certain points on the leg or side opposite to the leg or side which is to be cut and lapped.

To properly position and secure the spacers E, we provide means on the side walls of the mandrel for engagement with said plates, said means comprising a block member **23** formed with spaced-apart, projecting lugs **24** on the lower face thereof, said lugs seating in suitable openings (not shown) provided in the side plates, the upper face of said block being grooved as at **25**. A mating cap member **26** fits on the block **23**, one edge being formed with a depending leg **27** which bears on

the face of the side wall of the form, the edge of the cap opposite to said leg being grooved as at **28** and lying in alignment with the groove **25** to form a cylindrical opening and clamp which is of a size to accommodate the locating pins **29**, said pins projecting upwardly through openings **30** provided in the spacer plates E which are interposed between a plurality or predetermined number of strips or turns, which for identifying purposes can be termed "stacks." An opening **31** is provided in the cap member **26** directly adjacent the leg **27**, and a rod **32**, threaded at both ends, spans the form and projects through the openings **31** on the opposite sides of the form, nuts **33** being threaded on the ends of the rod to secure the clamps and hold the block assembly and provide anchorage for the pins **29**.

When a winding form, with the clamps in position, is mounted on a driven winding machine, the operator begins the winding-on operation (see Fig. 5 of the drawings). He first inserts the end of the strip S in the slit **21** and winds on a predetermined number of turns, about nine or ten, which is termed a "stack," indicated by the letter L in Figs. 1 to 5 of the drawings; he then winds in the first spacer plate which is somewhat thicker than the first stack, said plate being provided with spaced-apart openings **30** which accommodate the locating pins **29**. The two edges of the spacer plate E are rounded as at **34**, and we wish to point out that the first stack is usually thinner than the first spacer plate and thereafter each stack and its companion spacer plate may vary in thickness from the remaining stacks and spacer plates, depending on the size etc. of the core desired. Inasmuch as the strip S is deformed as it is bent around the corners of the winding form, it has a tendency to unwind if not restrained, and a wire, band or other means (not shown) is secured around the core to prevent unwinding.

The core is now ready for annealing to remove the effects of the deformation to which the turns of the core are subjected in the winding operation above described. The pins and securing means are first removed and the core is then annealed in the conventional manner by placing in an oven (not shown), and heating to a temperature of approximately 1450 degrees F. As a result of the annealing, the laminations take a permanent set and remain in place without binding or wrapping of any nature.

After the annealing operation, the coil, still mounted on the form, is secured in a suitable clamping means (not shown) and the laminations are cut on the line **35** to render them discontinuous and provide an openable leg X, the cut being made in alignment with the slots **19** in the side walls of the form which provide necessary clearance for the saw blade.

When the cut **35** has been made, the individual stacks are loosened; the spacers E in the opposite end or leg slide out from between the stacks of turns, permitting these spacer separated stacks to move together and nest in intimate facial contact with each other (see broken line position in Fig. 3), thus providing necessary space in the leg opposite to the leg in which the spacers are wound to permit the lapping of the laminations in a neat and uniform manner, all as clearly shown in Fig. 4 of the drawings. During the winding operation, each spacer plate must be wound in, with the center of the plate on the centerline of the form, and it will also be observed that each succeeding spacer plate is cut to a length greater than the preceding spacer plate, to compensate for the increased width as additional stacks are wound on, and it will be further observed that these spacer plates are useable over and over again.

The next step is to assemble the core in the window W of the pre-formed transformer windings T as illustrated in Fig. 6 of the drawings. When the openable core has been sprung to provide the necessary opening to permit one leg to be passed through the window opening W in the coil, the cut ends of the core spring back together so that the ends of the successive laminations are placed in overlapping relation as clearly shown in Fig. 8 of the drawings, and it will, of course, be obvious that this springing or bending action is distributed over the three closed legs of the core so that there is a minimum of deformation and there is very little detrimental effect on the magnetic characteristics of the core, and it will be further observed that the core legs **14** and **15** will now be of substantially the same length. The laps are preferably disposed at the top of the core so that coiled strip transformers can be constructed without increasing the overall width of the transformer.

While we have herein shown and described particular embodiments of the invention, it will be obvious that to those skilled in the art that changes and modifications can be made without departing from the invention and therefore it is aimed, 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 is:

1. Apparatus for forming a laminated, magnetic, transformer core comprising a mandrel around which a strip of core forming material may be wound, said mandrel having a pair of end walls, side faces joining said end walls, one of said end walls being shorter in length than the other; a pair of pins; means removably mounting said pins on opposite faces of said side faces of said mandrel adjacent to said shorter end wall so that said pins extend beyond said shorter end wall of said mandrel, and are spaced apart a distance sufficient to receive successive laminations therebetween; and a plurality of spacer plates of progressively increasing length, all of which are adapted to be progressively inserted between successive groups of laminations at said shorter end wall of said mandrel, each of said spacer plates having a width greater than the width of said strip of material and having openings therein spaced in accordance with the spacing of said pins so as to receive the latter, the increase in length of each succeeding spacer plate of said plurality of spacer plates being substantially equal to twice the thickness of the lamination group between itself and the immediately preceding spacer plate.

2. The apparatus set forth in claim 1 wherein the longer end of said mandrel has a slot extending inwardly from said longer end wall and transversely thereof.

3. The apparatus set forth in claim 1 wherein the ends of each spacer plate of said plurality of spacer plates is rounded.

4. The apparatus set forth in claim 1 wherein said pins and the openings in each of said spacer plates are so related to the length of said shorter end of said mandrel that a point midway between the ends of each of said spacer plates is located at substantially the middle of said shorter end of said mandrel when said pins are received in the openings of said plates.

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