

Oct. 6, 1959

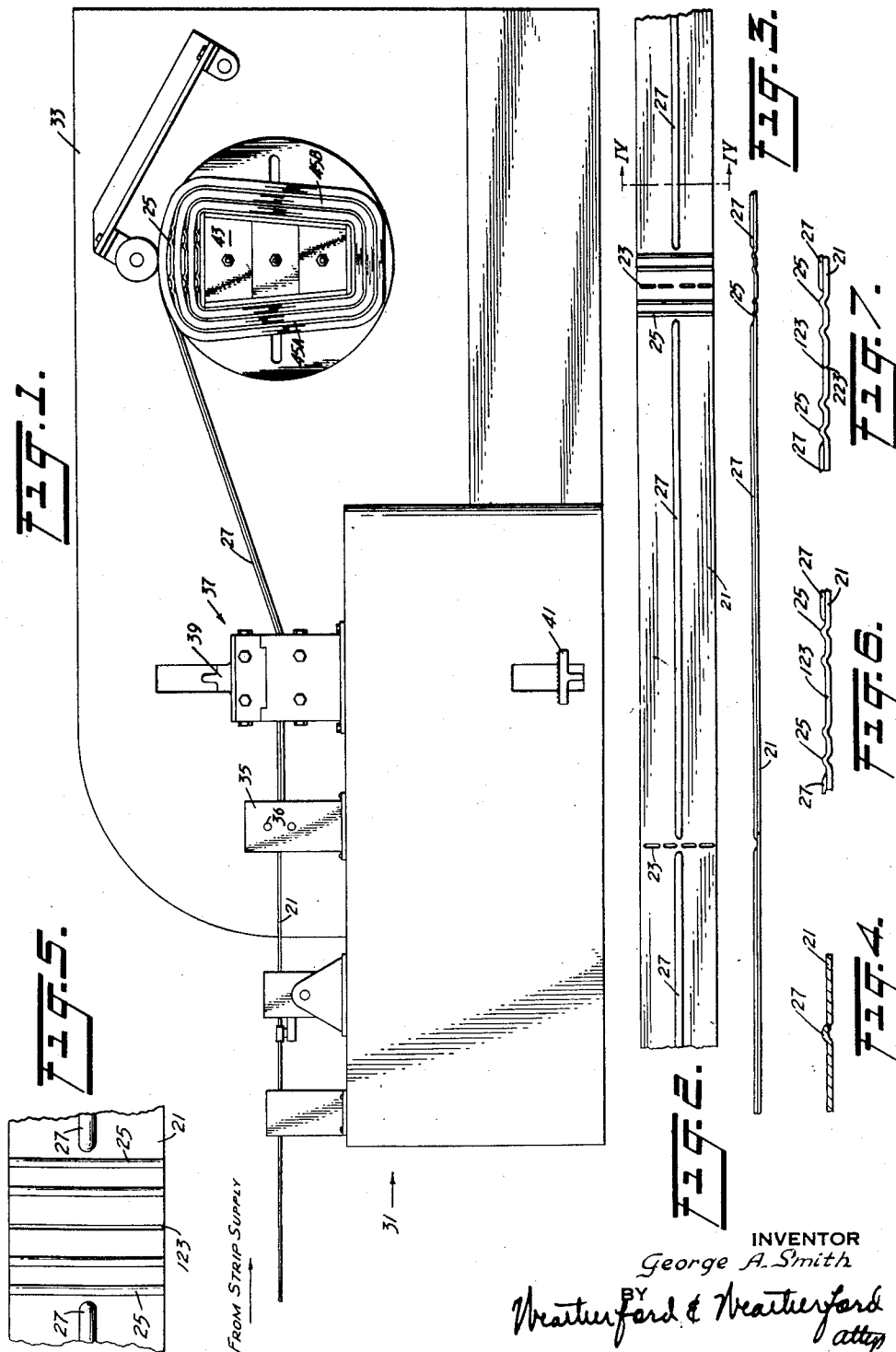
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2,907,967

MAGNETIC CORES FOR TRANSFORMERS

Original Filed Aug. 9, 1954

3 Sheets-Sheet 1



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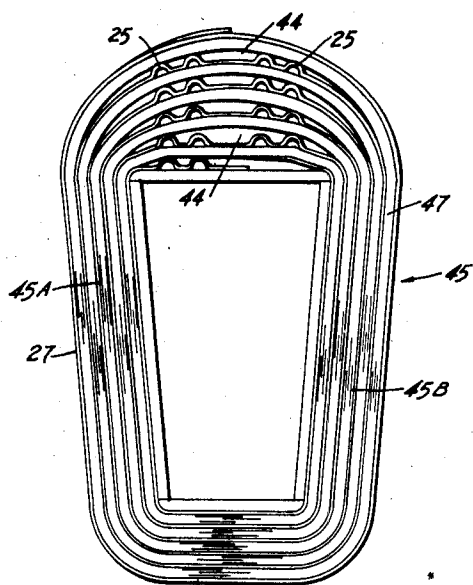


FIG. 8.

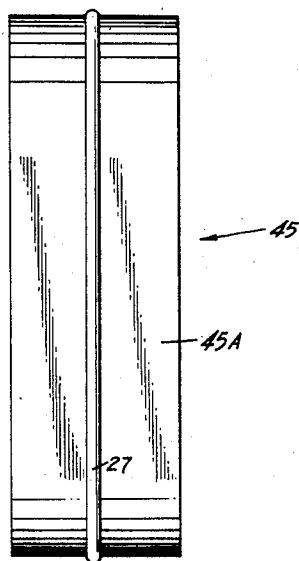


FIG. 9.

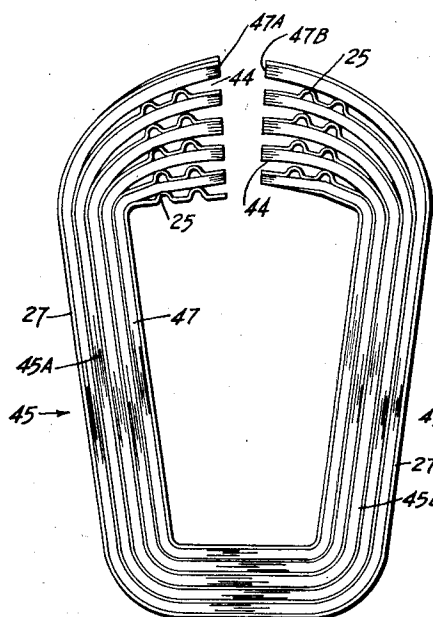


FIG. 10.

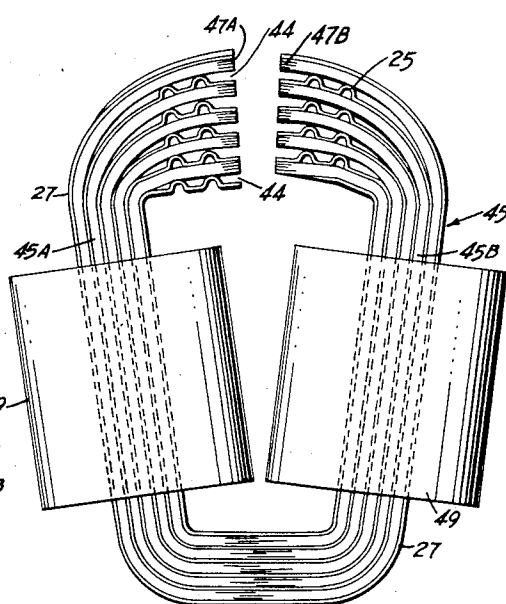


FIG. 11.

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Fig. 12

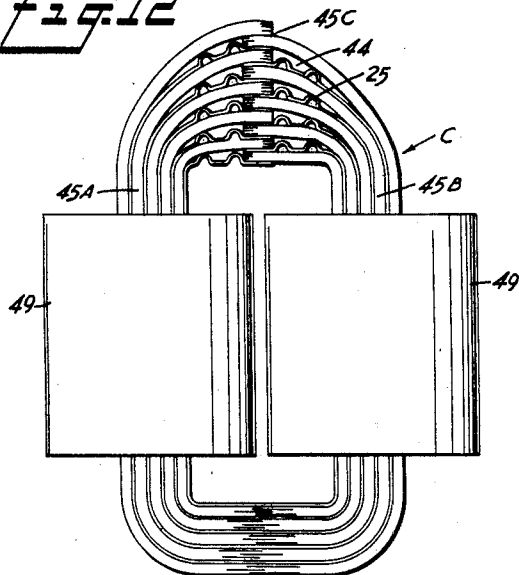


Fig. 14.

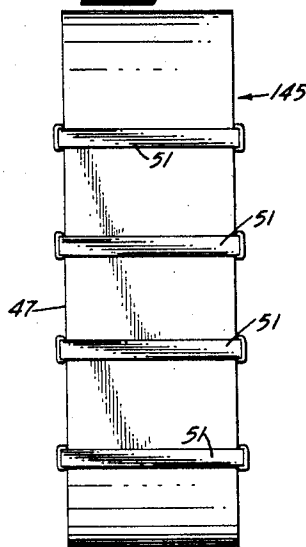


Fig. 13

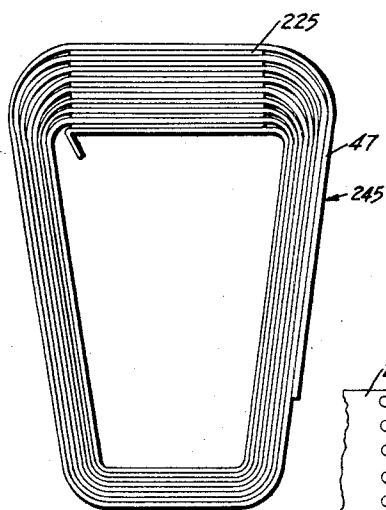
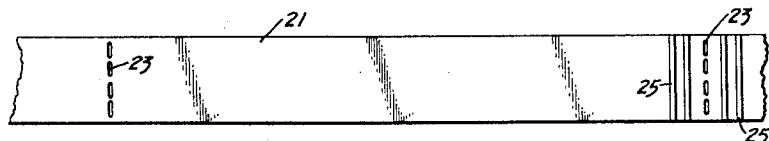


Fig. 15.

Fig. 16.

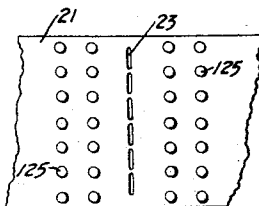
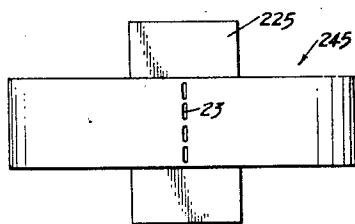


Fig. 17.

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2,907,967

MAGNETIC CORES FOR TRANSFORMERS

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Original application August 9, 1954, Serial No. 448,595.
Divided and this application June 23, 1955, Serial No. 517,423

6 Claims. (Cl. 336—217)

This invention relates to certain new and useful improvements in cores for transformers.

This application is a division of my co-pending application Serial No. 448,595, filed August 9, 1954.

More particularly the invention relates to certain new and useful improvements in cores for transformers formed of magnetic strip material which has been wound into a coil and severed or parted to form distinct and separate laminations.

It has heretofore been contemplated that a core for a transformer could be formed from a plurality of minor laminations placed in superposed relationship and folded into core form. Additionally it has heretofore been contemplated that cores may preliminarily be formed by winding lengths of magnetic strip material and either unwinding the wound magnetic strip material and lacing it through pre-formed windings so as to complete the transformer, or by severing the wound coil of strip along one of the short sides thereof so as to form two separated long legs and either inserting the legs through the windows of pre-formed windings or inserting the windings over the elongated legs. In either of the latter instances it has been considered desirable either to perform the severing prior to annealing of the wound magnetic strip material and interleaving the lamination ends to form lapped lamination joints along the severed short side, or, if severing has been made subsequent to annealing, to form the joints in the respective laminations as butt joints, in which the severed ends of each lamination are brought into abutting relationship and there secured in position. These two latter conditions have been considered necessary in order that the final form of the transformer core would not be altered from the form in which the core has been subjected to annealing, so as to eliminate undesired stresses and disturbance of the grain of the annealed strip and thereby to eliminate undesired conditions in current flow through the transformer core and to avoid improper and undesirable operation.

In such prior structures, particularly of the type in which the wound core has been severed and interleaved prior to annealing, it has been considered desirable during the winding of the core to successively interpose spacers or shims between the layers of the winding as it progresses, in order to provide for adequate spacing for the subsequent insertion of the lamination ends in the interleaving formation of the lap joint heretofore mentioned. Such prior practice has proven to be extremely wasteful of time and operational effort in the formation of cores and has required a considerable nicety of skill on the part of the operator forming up the core in the preliminary steps of the formation of same, particularly in the accurate and careful insertion of the spacers or shims and additionally in the accurate and careful necessity of severing the layers so as to provide for the subsequent interleaving of the same to form lapped joints.

The present invention is specifically directed to the formation of transformer cores from magnetic strip material and contemplates the winding of the strip material into

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a coil, as upon a suitable mandrel, introducing the wound coil of strip material into annealing means, such as an annealing furnace or the like, effecting severing or separation of the respective laminations along one of the short sides of the wound strip material, preferably effecting the severing or separation during the period of annealing, in which case the annealing is continued after the completion of the severing and results in an annealing of the magnetic strip material in severed condition, thus enhancing the magnetic flow qualities of the material when subsequently jointed into transformer core form, and under such preferred conditions removing the severed core from the annealing means, associating pre-formed transformer windings therewith and subsequently interleaving the severed members of the core to form a lapped joint in one of the short sides of the core. It is found that under this procedure and particularly in the preferred embodiment of same, when the severing occurs during the period of annealing that the subsequent hinged action in moving the core from severed condition to interleaved condition is well within the elastic limits of the material and is far superior to prior practice in which severed cores have been interleaved, annealed in interleaved condition, swung open and separated from interleaved condition for the insertion of pre-formed windings and subsequently returned to interleaved condition.

An object of the present invention is to provide magnetic strip material for use in transformer cores which is deformed at spaced intervals to provide integral spacer means.

A further object of the invention is to form such integral spacer means as transversely disposed bosses.

A further object of the invention is to provide magnetic strip material for use in the manufacture of transformer cores with longitudinally disposed rib means for retaining the material in wound or bent condition.

A further object of the invention is to provide a new and novel core for transformers.

A further object of the invention is to provide such a core which includes integral spacer means spacing apart adjacent laminations for the insertion of opposed lamination ends, the spacer means serving to limit the extent of lapping upon lamination insertion.

A further object of the invention is to provide a core for transformers formed of magnetic strip material in which the strip material is ribbed longitudinally, and the longitudinal rib effectively maintains the core in closed condition.

The means by which the foregoing and other objects of the present invention are accomplished and the manner of their accomplishment will be readily understood from the following specification upon reference to the accompanying drawings, in which:

Fig. 1 is a somewhat diagrammatic elevational view illustrating the processing of magnetic strip material prior to winding, and further illustrating the winding thereof.

Fig. 2 is a fragmentary face or plan view of a portion of the magnetic strip material after processing and prior to winding.

Fig. 3 is a side or edge view of the material as seen in Fig. 2.

Fig. 4 is a cross-sectional view on an enlarged scale taken as on the line IV—IV of Fig. 2.

Fig. 5 is a fragmentary face or plan view on a similarly enlarged scale illustrating a modification in the transverse relief zone of the strip.

Fig. 6 is a fragmentary edge or side view of the modification of Fig. 5.

Fig. 7 is a view similar to Fig. 6 illustrating a further modification of the strip material.

Fig. 8 is a front view of a coil of magnetic strip material for a transformer core, after winding and prior to annealing.

Fig. 9 is a side view of the wound coil of Fig. 8.

Fig. 10 is a view similar to Fig. 8, but illustrating the core with the laminations parted.

Fig. 11 is a view similar to Fig. 10 with transformer windings in position on the core legs.

Fig. 12 is a view similar to Fig. 11 illustrating the core completed with the lamination ends formed in a lapped joint.

Fig. 13 is a view similar to Fig. 2 illustrating a further modification in the strip material.

Fig. 14 is a view similar to Fig. 9 illustrating a wound coil employing the strip of Fig. 13.

Fig. 15 is a view similar to Fig. 8 and illustrating a coil wound from further modified strip material.

Fig. 16 is a top view of the coil of Fig. 15 more clearly showing the modification of the strip material; and

Fig. 17 is a view similar to Fig. 5 illustrating a further modification in the strip material.

Referring now to the drawings in which the various parts are indicated by numerals, ferrous strip material, preferably of a selected grade of steel and having properties including magnetic properties rendering the material suitable for use in transformer cores, is additionally processed in accordance with the present invention and after such processing is wound into a continuous coil and the wound coil is subsequently subjected to annealing. As illustrated the strip material, indicated at 21, is drawn from a suitable source of supply, not shown, and in the pre-winding process is primarily provided with longitudinally spaced, transversely disposed, relief zones, in which the strip is partially severed and the cross sectional area of the metal in the strip is thereby ribbed, the zones being longitudinally spaced apart a distance substantially equal to the length of successive turns of the strip material when subsequently wound to form a wound coil. The relief zones may be in the form of perforations 23 (Figs. 2, 13 and 16) which may be stamped out of the strip 21 at the desired spaced intervals or may be formed as substantially V-shaped or angular, transversely extending grooves 123 across the face of the strip material (Figs. 5, 6) or under certain circumstances, an additional similar relief groove 223 may be applied to the opposite face of strip 21 (Fig. 7). Such grooving, either single face or double face, may be formed by a suitable stamping operation.

Additionally it is preferred that strip 21 be provided with integral spacer means which are longitudinally spaced apart along strip 21, the spacing being a distance equal to the length of a plurality of coil turns of the wound coil. Preferably the longitudinal spacing of the integral spacer means is a distance equal to the length of five such coil turns, although under varying circumstances the length of the spacing may be varied, as for example to a distance equal to two whole turns or more. Preferably the integral spacing means is in the form of a group of parallel, transversely extending longitudinally rounded ridge-like bosses 25 which are embossed transversely of the strip material as by a suitable forming die. In the embodiments illustrated it will be observed that the transverse ridge-like bosses 25 are formed in spaced pairs and that preferably the spaced pairs embrace a relief zone, either of perforations 23 (Figs. 2 and 13) or the single face groove 123 (Fig. 6) or the double face grooving 123, 223 (Fig. 7), so that the integral spacer means are positioned on opposite sides of selected relief zones. It will be understood that while ridges 25 are shown as formed in spaced pairs, a single ridge may be formed on the opposite sides of the selected relief zones if desired.

In the alternative the integral spacer means may be formed as rounded, dimple-like bosses 125 (Fig. 17) which may be embossed in strip 21 by a suitable die.

Additionally in many instances it is desirable to provide strip 21 with longitudinally extending, transversely rounded integral binding ribs 27, which may be interrupted from time to time, as shown for example in Fig. 2. Where strip 21 is relatively narrow longitudinal ribs 27 are preferably disposed substantially along the longitudinal center line of the strip. In instances of the employment of strip material of greater width, additional similar longitudinal ribs 27 may be provided and the longitudinal ribs are preferably arranged symmetrically relative to the longitudinal center line.

It thus will be seen that magnetic strip 21 is subjected to a new and novel pre-winding processing in which a new magnetic strip material is produced, which in the preferred embodiment includes transverse relief zones, either in the form of perforations or of sharp grooving or other suitable reduction of the strip metal, which relief zones are longitudinally spaced apart with the spacing between adjacent relief zones being a distance equal to a turn of the coil subsequently to be wound from the strip material. It further will be seen that there may be provided by the pre-winding processing of the present invention a novel magnetic strip for use in a transformer core in which integral spacer means, either in the form of transverse ridges or dimples or other embossment on the strip material, are formed at intervals longitudinally spaced along the strip material, the successive intervals being of a length equal to the length of a plurality of coil turns, and it further will be seen that the pre-winding processing of the present invention may further provide a new and novel magnetic strip material for use in transformer cores which may include longitudinal binding rib means.

It will be understood that the strip material may include a combination of the features mentioned, relief zones, integral spacer means and longitudinal rib means, or that one or more of these features may be employed. Thus in Figs. 2 and 5 the strip material is illustrated as embodying transverse relief zones, integral spacer means and longitudinal binding rib means, while in Fig. 13 the strip is shown as embodying transverse relief zones and integral spacer means, and in Fig. 16 the strip, there shown in wound condition, embodies transverse relief zones.

After the new and novel magnetic strip of the present invention has been produced it is in condition to be wound into a continuous coil to be additionally processed and formed into a core for transformers, and in such condition if desired it may be stored or otherwise held to await use.

Preferably the pre-winding processing and the coil-winding process are parts of a substantially continuous operation which is somewhat diagrammatically illustrated in Fig. 1 of the drawings. As shown, the strip material is withdrawn from a suitable supply, not shown, and is introduced to a pre-winding processing station which is preferably mounted in adjacency to a winding machine 33. At the pre-winding processing station are located instrumentalities for processing the strip material, as described hereinabove, these instrumentalities being preferably selectively operable and if desired the operation may be synchronized with the operation of the winding machine.

Thus the processing station may include a housing 35 for suitable rolls, not shown, but which may be connected to the housing as at 36. The strip material is passed through the housing 35 and the operation of the forming rolls contained therein imparts to the strip material longitudinal ribs 27. An additional processing device is indicated by the housing 37 within which may be contained a suitable stamping die, not shown, for forming perforations 23, or, as already pointed out, the stamping operation may be provided to form transverse grooves 123 or the additional transverse grooves 223. The operation of the stamping die may be automatically controlled, as for example in synchronization with the winding machine, or

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it may be manually controlled as by a lever 39. Additionally contained within housing 37 is a suitable embossing or forming die, not shown, for deforming the strip material to provide the integral spacer means, either in the form of transverse ridge-like bosses 25 or the transverse series of dimple-like bosses 125. Such embossing die may likewise be automatically controlled or it may be manually controlled as by a foot pedal 41. The pre-winding processing of the strip material thus may be completed at the pre-winding station 31 and may be directly passed from the pre-winding processing station to the winding machine. Upon winding machine 33 a mandrel 43 is of substantially Keystone-shape, having two long sides and two short sides, one of which is greater in length, and is driven by the winding machine. The winding operation is substantially continuous and sequentially follows in preferred practice the pre-winding process.

As the winding is, begun the strip material is introduced to the mandrel, secured to the mandrel in any desired manner, and the mandrel is rotated, in the embodiment illustrated, in a clock-wise direction. The integral spacer means, as for example the transverse ridge-like bosses 25, are spaced so that upon winding they are positioned along the upper or greater short side of the mandrel. As the strip material is wound upon the mandrel it bends about the corners of the mandrel and in those circumstances in which the longitudinal binding rib means 27 is imparted to the strip material the bending of the longitudinal rib is effective to maintain the wound material in wound condition.

As can be seen, particularly in Figs. 8, 10 and 11, the deformation of the strip material with the spacer means provides spaces 44 between adjacent turns of the coil which are adapted for receiving, upon subsequent processing, the free ends of opposite laminations. It will be seen that the integral spacer means produces a thickening effect of the strip material, establishing spaces 44 between adjacent turns, without increasing the transverse cross sectional area of the strip per se. As already pointed out, the integral spacer means are respectively formed in the strip material at intervals equal to two or more whole turns of the coil upon the mandrel with the result that the spacer means and spaces 44 are positioned commonly along the greater short side of the mandrel and thus provide the desired spacing along one short side of the core when completed.

It has also been pointed out that the relief zones are spaced apart at intervals having a length of the nature of the length of a single turn upon the mandrel, and when the coil is wound upon the mandrel the relief zones are disposed substantially in a common vertical plane which intersects the greater short side of the coil and which lies between and is embraced by the integral spacer means.

When a sufficient length of strip material, determined by the characteristics desired for the transformer core being produced, has been wound upon the mandrel the winding operation is terminated and the wound coil is removed from the mandrel. A typical wound coil 45, after removal from the mandrel, is illustrated in Fig. 8. It will be understood that while Fig. 8 is a front elevational view of the wound coil 45, only certain of the turns, particularly those in which the integral spacer means have been deformed, are shown in full, the remaining turns of which there are a plurality between each such spacer-carrying turn, being indicated by the broken lines, it being understood that while the spacer-carrying turns divide the coil into sections, each of the sections includes a plurality of laminations 47.

The wound coil 45 may then be removed to a suitable oven or other heating device where the ferrous strip material of the coil wound into the laminations 47 is subjected to the heat of annealing, which is preferably in the nature of 1450° Fahrenheit.

Where the new and novel magnetic strip of the present

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invention including the transverse, partly severed relief zones has been employed in forming coil 45 as described, the coil, after introduction to the annealing heat and prior to completion thereof, will become severed and parted along the transverse relief zones, producing a parted coil 45, as shown in Fig. 10, with the laminations 47 being severed into nested discontinuous laminations having free ends 47A, 47B, and being stacked for subsequent core use. It is found that this parting of the laminations to form discontinuous laminations occurs after a relatively short period of subsection of the coil 45 to annealing heat and consequently annealing of the severed or parted coil, as shown in Fig. 10, is continued in such severed condition. The binder ribs 27 are effective after parting of laminations 47 to substantially limit unfolding movement of the parted laminations with the severed coil being retained thereby substantially in the position shown in Figs. 10 and 11. Upon completion of the period of time desired for annealing, the annealed severed coil, substantially as shown in Fig. 10, is removed from the annealing means and the coil is permitted to cool for a suitable period.

It will be observed that by the employment of the integral spacer means deformed in the body of the strip material from which the coil is formed, the winding operation previously described does not require interruption for the placing of independent spacer means and the winding may be continued substantially without interruption until the desired length of strip material has been wound upon the mandrel. It further will be seen that the employment of the integral spacer means eliminates additionally the necessity of the separate operation heretofore required of removing independent spacer means, either after annealing or after severing of a wound coil. Additionally it is found that since the integral spacer means form a part of the strip material wound into the coil the heretofore difficult problem of preventing relative sagging of wound coil laminations during annealing is substantially eliminated without the necessity of providing combustible spacer or other similar heat destroyed elements.

After the parted coil has cooled for a desired period transformer windings 49 may be respectively associated with the long legs 45A, 45B of the nested laminations of parted coil 45, either by passing the windows of the transformer windings over the lamination ends 47A, 47B, or by threading the laminations ends through the windows of the windings. The association of the transformer windings 49 with the core legs produces the partly completed transformer, as shown in Fig. 11, and thereafter the free lamination ends 47A, 47B are interleaved and overlapped, as shown in Fig. 12, along the lapped joint end 45C of the core, the respective free ends being inserted into the separated spaces 44 formed between adjacent turns or laminations of the core, thus forming the nested laminations into a transformer core C. A plurality of such lamination free ends is preferably inserted in each space 44.

It will be seen from a reference to Fig. 12, that the extent of the insertion or interleaving of the lamination free ends in forming the lapped joint end 45C is accurately limited by the integral spacer means, shown as the ridge-like bosses 25, the free ends of the laminations being moved substantially into abutment with the spacer means and further overtravel beyond the desired extent of interleaving being prevented thereby. In the jointed core condition shown in Fig. 12, under normal circumstances the core C is retained in substantially rectangular condition by the binder rib means 27, although if desired additional binder straps may be employed.

In some instances it is desirable on account of the characteristics of the transformer core which is to be produced to eliminate the longitudinal binder rib. In such circumstances the strip material after preliminary processing may be in the form fragmentarily illustrated

in Fig. 13. It will be understood that while the partly severed transverse relief zones are shown in Fig. 15 as consisting of perforations 23, transverse grooving 123, or 123 and 223 may be applied similarly, and additionally while the transverse integral spacer means are there illustrated as comprising spaced pairs of transverse ridge-like bosses 25, a lesser or greater number of ridge-like bosses 125 may be employed in lieu of the ridge-like bosses.

With the omission of the longitudinal binder rib means 27, it is necessary when the strip material has been wound into a coil 145 of desired length that binders, such as the straps 51, should be applied to retain the strip material in wound condition for annealing and subsequent handling. The wound coil 145 is subjected to annealing, parting of the laminations is effected during annealing by the heat of annealing, the parting occurring along the transverse relief zones, the transverse relief zones being arranged along the greater short side of the wound coil 145, all in manner substantially identical with that heretofore described in connection with wound coil 45, and the parted laminations are subsequently interleaved to form a lapped joint core.

It is also desirable under certain circumstances to merely employ the transverse relief zones in order to effect parting of the laminations during annealing, a typical employment of which is illustrated in Figs. 15 and 16, in which a wound coil 245 is provided with transverse relief zones specifically illustrated as consisting of perforations 23, it being understood that if desired variations in the transverse relief zones may be employed in the strip material if desired. In the absence of the integral spacer means, turns of strip material forming coil 245 are spaced apart in substantially conventional manner, using independent shims or spacers 225. The annealing and parting of the coil laminations of coil 245 into discontinuous laminations under the effect of the heat of annealing is effective in connection with coil 245 in the manner already described, and after association of transformer windings the lamination ends are interleaved to form a lapped joint core.

It will further be understood that in some instances it may be desirable to merely provide the strip material with integral spacer means and to effect severing as by sawing of the wound coil into a parted coil condition similar to that shown in Fig. 10. Under such circumstances the transverse relief zones are omitted from the strip material and the integral spacer means, either in the form of ridges 45 or dimples 125 may be imparted to the strip material.

I claim:

1. In a wound type core for transformers, a plurality of concentrically nested laminations of magnetic strip material, each said lamination comprising a single whole turn divided across one side, a selected minor plurality of said laminations being provided on their respective divided sides with integral embossments extending transversely across and projecting from said material, said embossments being positioned in each embossed lamination on opposite sides of the division in such lamination and spaced from the free ends of such lamination, the remaining said laminations being transversely unembossed, said embossed laminations being disposed at

spaced intervals in said core with a plurality of unembossed laminations interposed between successive embossed laminations, the embossments projecting respectively from the embossed laminations a distance substantially equal to the thickness of said plurality of unembossed laminations and engaging the surface of a next adjacent unembossed lamination and maintaining spacings between the embossed laminations and the next adjacent laminations, the ends of laminations from one side of said division in said laminations positioned in the spacings on the other side of the division in said laminations, and the ends of laminations from the other side of said division in said laminations positioned in the spacings on the one side of said division in said laminations, said positioned ends respectively substantially abutting said transverse embossments.

2. A structure in accordance with claim 1, in which said integral embossments are ridge-like.

3. A structure in accordance with claim 1, in which said integral embossments respectively comprise series of dimples.

4. In a transformer, a wound type core comprising a plurality of concentrically nested laminations of magnetic strip material, each said lamination comprising a single whole turn divided across one side, a selected minor plurality of said laminations being provided on their respective divided sides with integral embossments extending transversely across and projecting from said material, said embossments being positioned in each embossed lamination on opposite sides of the division in such lamination and spaced from the free ends of such lamination, the remaining said laminations being transversely unembossed, said embossed laminations being disposed at spaced intervals in said core with a plurality of unembossed laminations interposed between successive embossed laminations, the embossments engaging the surface of a next adjacent unembossed lamination and maintaining spacings between the embossed laminations and the next adjacent laminations, the ends of laminations from one side of the division in said laminations positioned in the spacings on the other side of said division in said laminations, and the ends of laminations from the other side of said division in said laminations positioned in the spacings on the one side of said division in said laminations, said positioned ends respectively substantially abutting said transverse embossments.

5. A structure in accordance with claim 4, in which said integral embossments are ridge-like.

6. A structure in accordance with claim 4, in which said integral embossments respectively comprise series of dimples.

References Cited in the file of this patent

UNITED STATES PATENTS

1,927,197	Alderfer	Sept. 19, 1933
2,552,109	Nahman	May 8, 1951
2,584,564	Ellis	Feb. 5, 1952
2,588,173	Somerville	Mar. 4, 1952
2,595,820	Somerville	May 6, 1952
2,657,456	Moody	Nov. 3, 1953
2,700,207	Zimsky	Jan. 25, 1955
2,710,947	Gaston	June 14, 1955