Jan. 26, 1971 T. R. SPECHT ET AL 3,559,136

MAGNETIC CORE STRUCTURE

Filed June 20, 1969 2 Sheets-Sheet 1

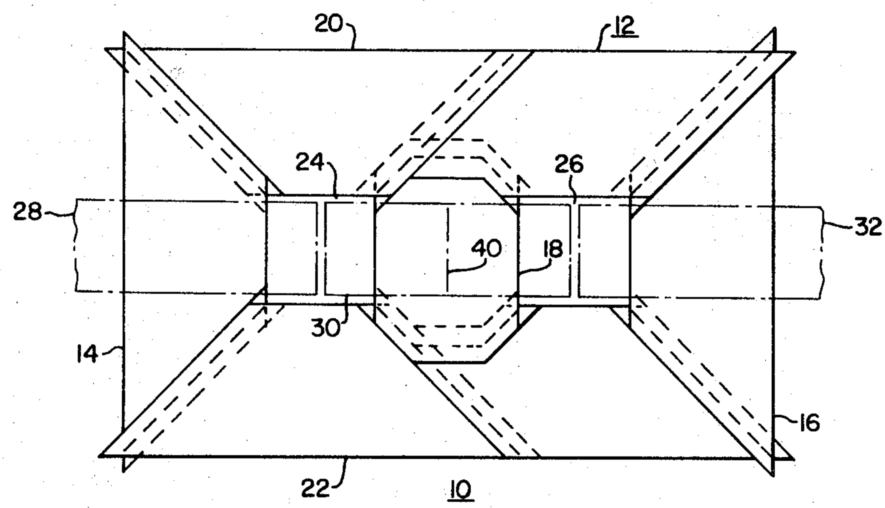

FIG.1.

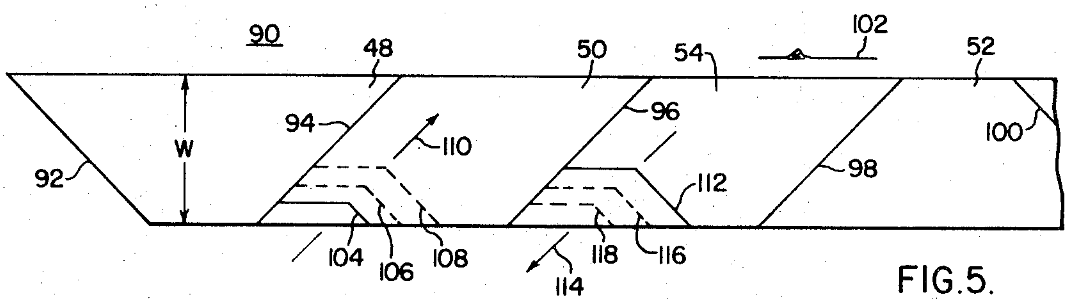

FIG.5.

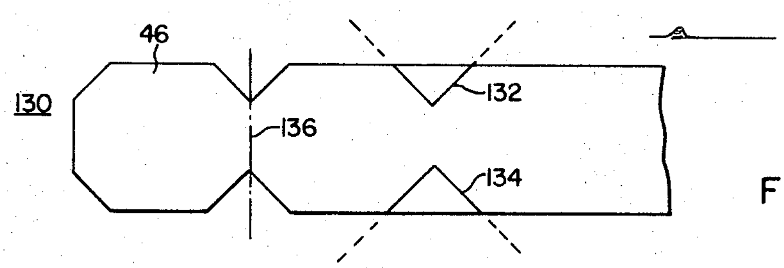

FIG.6.

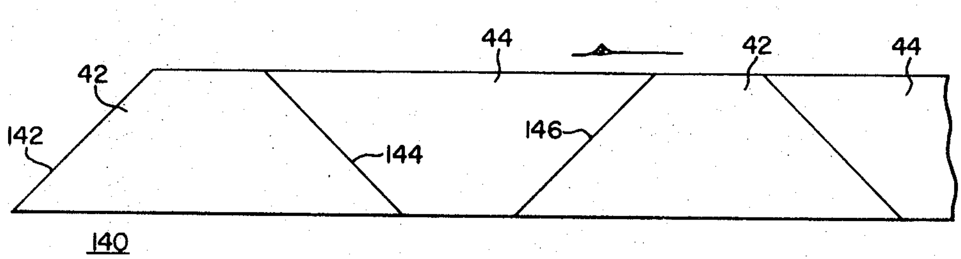

FIG.7.

Jan. 26, 1971 T. R. SPECHT ET AL 3,559,136

MAGNETIC CORE STRUCTURE

Filed June 20, 1969 2 Sheets-Sheet 2

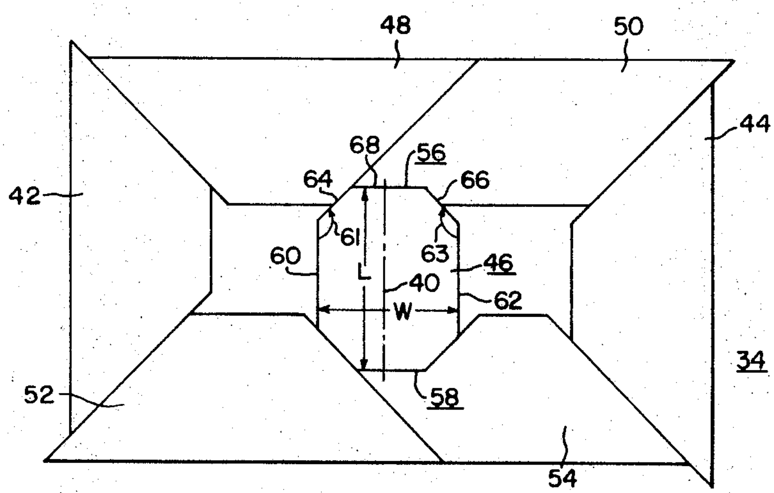

FIG. 2.

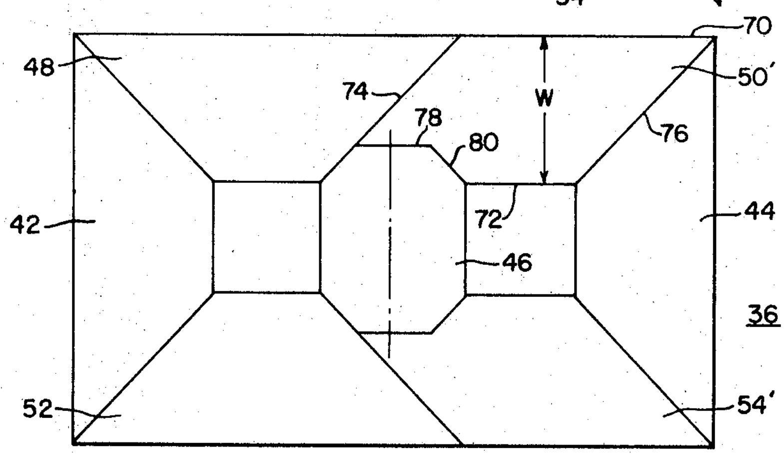

FIG. 3.

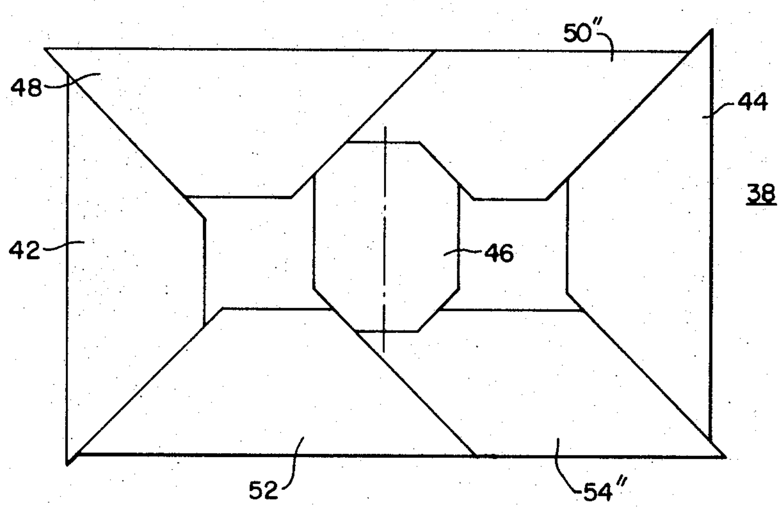

FIG. 4.

WITNESSES

Theodore F. Wrobel

James F. Young

INVENTORS
Theodore R. Specht and
Angelo A. De Laurentis
BY
Donald R. Lackey
ATTORNEY

United States Patent Office

3,559,136

Patented Jan. 26, 1971

3,559,136

MAGNETIC CORE STRUCTURE

Theodore R. Specht, Sharon, and Angelo A. De Laurentis, Sharpsville, Pa., assignors to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed June 20, 1969, Ser. No. 834,998

Int. Cl. H01f 27/24

U.S. Cl. 336—217 13 Claims

ABSTRACT OF THE DISCLOSURE

A magnetic core structure of the stacked type having a plurality of layers of metallic laminations. Each layer includes outer leg laminations, at least one inner leg lamination, and yoke laminations. Each of the ends of each inner leg lamination have the configuration of a truncated isosceles triangle, with the ends of the inner leg laminations being offset from layer to layer in a predetermined stepped-lap pattern.

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates in general to magnetic core structures for electrical inductive apparatus, such as transformers and reactors, and more specifically to magnetic core structures of the stacked type.

Description of the prior art

United States Pat. 3,153,215, which is assigned to the same assignee as the present application, discloses magnetic core structures of the stacked type which have stepped-lap joints between the mitered ends of the leg and yoke portions of the magnetic core. In a stepped-lap joint, the joints between the mitered or diagonally cut ends of the leg and yoke laminations, in each layer of the laminations, are incrementally offset from similarly located joints in adjacent layers, in a predetermined stepped or progressive pattern, with the joints being stepped at least three times in one direction before the direction is changed or the pattern repeated. The stepped-lap joint was found to substantially improve the performance of the magnetic core, compared with magnetic cores which utilize the conventional butt-lap type joint, lowering the core losses, lowering the exciting volt-ampere requirements, and lowering the sound level of the magnetic core.

While the stepped-lap joint configuration disclosed in the hereinbefore mentioned patent is a significant advance in the art, it has the disadvantage of producing about 4% scrap when the magnetic core is of the type which requires an inner leg, such as in certain single-phase shell-form constructions, and in polyphase shell and core-form constructions. The spear or triangular V-shaped point on each end of each inner leg lamination generates the scrap, but it has been tolerated due to the superiority of the mitered stepped-lap joint over the square joint at the inner leg, from the standpoint of core losses, exciting volt-amperes and sound level.

It would be desirable to be able to reduce the amount of scrap in the manufacturing of stepped-lap stacked cores, if the reduction in scrap is not penalized by an increase in core losses, or more costly manufacturing techniques.

SUMMARY OF THE INVENTION

Briefly, the present invention is a new and improved magnetic core of the stacked stepped-lap type, having a plurality of layers of magnetic, metallic laminations. Each layer of laminations includes outer leg laminations, at least one inner leg lamination, and yoke laminations which join the ends of the leg laminations to complete the desired magnetic circuits. The inner leg lamination, in one embodiment of the invention, has the same configuration and dimensions in each of the layers, with the ends of the inner leg lamination having the configuration of a truncated isosceles triangle. The stepped-lap joint between the inner leg and the adjoining yoke laminations is formed in this embodiment by incrementally offsetting the inner leg lamination from layer to layer along the longitudinal axis of the inner leg laminations. The truncated isosceles triangular configuration of the ends of the inner leg lamination substantially reduces the scrap generated, compared with prior art structures which utilize a V-shaped inner leg lamination. By selecting the average penetration of the inner leg lamination into the adjoining yoke laminations to be about 25–30% of the yoke width, the core losses and sound level of the magnetic core constructed according to the teachings of the invention are substantially the same as a similarly rated stepped-lap magnetic core of the prior art utilizing the V-shaped triangular inner leg laminations, which produces about 4% scrap.

BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages and uses of the invention will become more apparent when considered in view of the following detailed description and drawings, in which:

FIG. 1 is an elevational view of a polyphase magnetic core-winding assembly of the core-form type, having a magnetic core constructed according to the teachings of the invention;

FIGS. 2, 3 and 4 are elevational views of different layers of laminations of the magnetic core structure shown in FIG. 1;

FIG. 5 is a plan view of magnetic strip material illustrating the pattern for cutting the yoke laminations for the magnetic core structure shown in FIG. 1;

FIG. 6 is a plan view of magnetic strip material, illustrating the pattern for cutting the inner leg laminations for the magnetic core structure shown in FIG. 1; and

FIG. 7 is a plan view of magnetic strip material illustrating the pattern for cutting the outer leg laminations for the magnetic core structure shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and FIG. 1 in particular, there is shown an elevational view of a magnetic core-winding assembly **10** of the core-form type, having a magnetic core **12** constructed according to the teachings of the invention. The windings, which are shown in phantom, may be for a transformer, or a reactor, as desired.

More specifically, magnetic core **12** includes first and second outer leg portions **14** and **16**, respectively, an inner leg portion **18**, and upper and lower yoke portions **20** and **22**, respectively. Magnetic core **12** is of the stacked type, with each of the leg and yoke portions being constructed of a stack of metallic, magnetic laminations, such as grain oriented silicon steel. Magnetic core **12** thus has a plurality of layers of laminations, with the ends of the various laminations of each layer being butted together to provide closed magnetic loops about openings or windows **24** and **26**, through which the windings pass.

The magnetic core-winding assembly **10** includes phase winding assembly **28**, **30** and **32** disposed about leg portions **14**, **18** and **16**, respectively, with the phase winding assemblies including the high and low voltage windings of a transformer, or reactor windings, depending upon the specific application.

Magnetic core **12** is of the stepped-lap type, with the joints between the leg and yoke portions of the magnetic core being incrementally offset from layer to layer in a predetermined pattern. The joints between the outer leg portions **14** and **16** and the yoke portions **20** and **22** are mitered, preferably at an angle of 45° with respect to the sides of the laminations, with the mitered joints being offset from layer to layer in a predetermined stepped-lap pattern. The pattern may step incrementally in one direction only, and then return to the starting point to repeat the pattern, or it may incrementally step in both directions, as desired. FIG. 1 illustrates three layers of laminations, with the outer two layers illustrating the maximum limits of the stepped pattern, and with the inner of the three layers corresponding to the central layer of a pattern which steps incrementally in only one direction, returning to the starting point to repeat the pattern. As many steps in one direction may be utilized as desired. While the stepped-lap pattern may utilize as few as three steps in one direction, it has been found that better results are obtained, from the standpoint of efficiency and noise, when using more than three steps. For example, seven steps in one direction when using a step increment of 3/16 of an inch, has been found to be about optimum. Smaller magnetic cores may utilize a step increment of 1/8 of an inch, while the larger cores may utilize a step increment as great as one-quarter of an inch. Therefore, the three layers of laminations shown in FIG. 1 may correspond to the first, fourth and seventh layers of a seven step pattern. These three layers are shown in FIGS. 2, 3 and 4 with the reference numerals **34**, **36** and **38**, respectively.

In prior art stepped-lap magnetic core structures, the inner leg laminations butt against the adjoining leg laminations with mitered or diagonal joints, in order to avoid right angle joints with their higher losses. Thus, each of the ends of each inner leg lamination have the configuration of an isoceles triangle. Then, in order to provide a stepped-lap joint between the inner leg and the yoke portion of the core, the V-shaped ends of the inner leg lamination are incrementally shifted transverse to the length dimension of the lamination, in order to provide a stepped-lap joint without narrowing the yoke portion of the core. In other words, the penetration of the inner leg lamination into the yoke is maintained constantly by shifting the V-shaped end of the inner leg lamination in a direction parallel with the longitudinal dimension of the yoke portions of the core. This construction, however, requires a large plurality of different lamination configurations for the inner leg portion of the core, and it produces about 4% scrap.

This invention discloses a new and improved magnetic core structure which substantially reduces the amount of scrap generated, while still obtaining a stepped-lap joint at the inner leg portion of the core which has substantially the same efficiency and sound level as magnetic cores having stepped-lap joints of the prior art configurations. Further, these results have been obtained while utilizing an inner leg constructed of only one lamination size, and the incremental shifting of the inner leg lamination to achieve the stepped-lap pattern does not unduly narrow the yoke portion of the core.

More specifically, as shown in FIG. 1, the inner leg portion **18** has a plurality of like dimensioned laminations, offset from one another along the longitudinal axis **40** of the inner leg laminations, to step the ends of the laminations from layer-to-layer in a predetermined stepped-lap pattern. However, instead of having each end of the inner leg lamination cut into a V-configuration, i.e., the configuration of an isoceles triangle, the configuration of each end of each inner lag lamination is that of a truncated isosceles triangle. In other words, the apex of the normal triangular point is cut-off by a plane which passes through the mitered or angularly proceeding edges in a direction perpendicular to the major sides of the laminations.

The new and improved magnetic core structures **12** may be better understood by examining the layers **34**, **36** and **38** of laminations shown in FIGS. 2, 3 and 4, respectively. As hereinbefore stated, layers **34** and **38** represent the two extreme positions of the stepped pattern, and layer **36** an intermediate position. The first layer **34**, shown in FIG. 2, includes first and second outer leg laminations **42** and **44**, respectively, an inner leg lamination **46**, upper yoke laminations **48** and **50**, and lower yoke laminations **52** and **54**. The yoke portions **20** and **22** are illustrated as being divided, as it is felt that the magnetic core may be more easily assembled using this construction, especially on the larger magnetic core ratings. However, it will be understood that the upper and lower yoke portions may each have a single lamination per layer if desired, since the maximum penetration of the inner leg lamination into the core is substantially less than the overall width of the yoke laminations.

The inner leg lamination has first and second ends **56** and **58**, the edges of which define the longitudinal dimension L, and first and second sides **60** and **62**, respectively, the edges of which define the width dimension W of the lamination. Each end of the lamination **46** has a composite cut which includes first and second mitered edges, and an extreme end which is perpendicular to the sides of the lamination, with the extreme end having a dimension less than the width dimension W. For example, the first end **56** of lamination **46** has first and second mitered edges **64** and **66** which angle inwardly from the sides **60** and **62** at angles **61** and **63**, respectively, ending at the extreme ends **68** of the lamination. The extreme end **68** of the lamination is perpendicular to imaginary extensions on the sides **60** and **62** of the lamination. The second end **58** is of like configuration. Thus, since mitered edges **64** and **66** have a like length dimension and make like angles with the parallel sides of the lamination, the configuration of the ends of the inner leg lamination is that of a truncated isosceles triangle. While the magniture of angles **61** and **63** is preferably 45°, other angles may be chosen if desired.

All of the like positioned laminations of the various layers have exactly the same dimensions in magnetic core **12**, except for the two yoke laminations **50** and **54**. The outer leg laminations **42** and **44** are trapezoidal in configuration, and each have the same dimensions in each layer, and their dimensions remain the same from layer to layer. The inner leg laminations **46** has the same dimensions from layer to layer. The upper and lower yoke laminations **48** and **52** are trapezoidal in configuration, and have the same dimensions as one another, and the same dimensions from layer to layer. The remaining yoke laminations **50** and **54** are substantially parallelogram in configuration, but each is modified with a composite cut to accommodate the truncated ends of the inner leg laminations. In this embodiment, the composite cut is of minimum size in lamination **50** and of maximum size in lamination **54** in the first layer of the pattern, and the sizes of the incremental cuts change until reaching the last layer **38** of the pattern, where the cut is of maximum size in lamination **50** of minimum size in lamination **54**. The composite cuts are of equal size in the intermediate layer **36** shown in FIG. 3.

In describing the composite cut in the yoke lamination, layer **36** shown in FIG. 3 will be referred to. Like positioned laminations in FIGS. 2, 3 and 4 with identical dimensions from layer to layer are given the same reference numerals, while like positioned laminations which change in configuration from layer to layer are given the same reference numeral with the addition of prime marks. Thus, as illustrated in FIG. 3, lamination **50'** has first and second parallel sides **70** and **72**, respectively, which define the width dimension W of the lamination, and first and second parallel edges **74** and **76** which intersect the sides **70** and **72** with predetermined angles, such as a 45° angle. The corner of lamination **50'** defined by sides **72** and **74** is modified to have the same configuration as the extreme end **68** and mitered edge **66** of the first end **56** of the inner leg lamination **46**, by utilizing a composite cut having first and second portions or edges **78** and **80**, respectively. The second edge **80** angles inwardly from side **72**, towards the apex of the corner defined by sides **72** and **74**, until the width dimension W is narrowed by the specific predetermined penetration of the inner leg lamination into the yoke lamination for the specified layer, and then the composite cut is completed by edge **78** which is parallel with sides **70** and **72** and which extends to edge **74** of the lamination. A similar composite cut is made in yoke lamination **54'**. Since layer **36** is the intermediate layer of the pattern, the volume of material removed from lamination **50'** and from lamination **54'** by the composite cuts is identical. In the first layer **34**, the composite cut in yoke lamination **50** removes less material than the composite cut in yoke lamination **54**, while in the last layer **38** the composite cut in yoke lamination **50''** removes more material than the composite cut in yoke lamination **54''**.

As illustrated in FIGS. 1, 2, 3 and 4, only about half of the inner leg laminations of a pattern fully penetrate the yoke. In the remaining laminations of the pattern a portion of the mitered edges on the ends of the inner leg laminations extend outside the outer limits of the yoke portions. This arrangement has been found to be preferable, as it produces less scrap than an arrangement where the inner leg laminations start the stepped-lap pattern with the position shown in FIG. 3 and step inwardly into the yoke portion of the core from this position, with all of the mitered edges being within the limits of the yoke portion of the core.

In the embodiment of the invention shown in FIGS. 1, 2, 3 and 4, the stepped-lap joints at the other corners of the core, and between the yoke and inner leg laminations, is achieved by incrementally moving the laminations which make up the outside core loop, in a counterclockwise direction, which incrementally moves the inner leg "into" the upper yoke portion **20** and "out" of the lower yoke portion **22**. When the extreme end position of the pattern is reached at layer **38**, the pattern may start all over again with layer **34**, or the outer laminations which make up the outer core loop may all be incrementally moved clockwise to move the inner leg incrementally back into yoke portion **22** and out of yoke portion **20**, until reaching the layer **34** configuration.

While the embodiment of the invention shown in FIGS. 1, 2, 3 and 4 is preferred because all of the inner leg laminations have the same dimensions in all of the layers, it would also be suitable to change the length of each inner leg lamination from layer to layer, while maintaining the same configurations on their ends. In this embodiment, the inner leg laminations would not be incrementally moved along their longitudinal axis from layer to layer, but would all have their axes, which intersect the geometrical center of the lamination perpendicular to the major plane of the lamination, in alignment. In this situation, the upper and lower yoke laminations **50** and **54** would both have the same configuration in each layer, but their configurations would change from layer to layer.

The magnetic core **12** shown in FIG. 1 generates less scrap than a similar magnetic core having V-shaped points on the ends of the inner leg laminations. This may be more clearly understood by laying out the laminations required for each layer on strips of magnetic steel. FIG. 5 is a plan view which illustrates how the yoke laminations may be cut from a strip of magnetic material. FIG. 6 is a plan view which illustrates how the inner leg laminations may be cut from a strip of magnetic material, and FIG. 7 is a plan view which illustrates how the outer leg laminations may be cut from a strip of magnetic material. Specifically, FIG. 5 illustrates a strip **90** of magnetic metallic material having a width dimension W. An oscillating shear may cut the strip diagonally along lines **92, 94, 96, 98** and **100**, to form yoke laminations **48, 50, 54** and **52**, while dies are indexed at an angle of 45° to the strip direc-

tion indicated by arrow **102**, to provide the composite cuts in laminations **50** and **54**. For example, a first composite cut **104** would be made in lamination **50**, and then the similar lamination for the next layer would be cut after the die is indexed in the direction of arrow **110**. The composite cut for the intermediate layer of the pattern is shown at **106**, and the composite cut for the layer at the extreme end of the pattern limit is shown at **108**.

In lamination **54**, the first composite cut would be the cut of maximum penetration, which is given the reference numeral **112**, and then the die is indexed in the direction of arrow **114**, also at an angle of 45° with respect to the sides of the lamination, with the composite cut for the intermediate layer of the pattern being shown at **116**, and the composite cut for the layer at the extreme end of the pattern being shown at **118**. Indexing the dies at an angle of 45° to the sides of the strip, or parallel with the cut **94**, is essential in order to keep the dimension of the portion of the composite cut which will butt against the extreme end of the inner leg laminations constant. Indexing the die perpendicular to the sides of the strip would change the dimension of portion **78** of the composite cut, which would be unsuitable since the width of the extreme ends of the inner leg laminations are the same for each of the laminations. It will be noted that offsetting the inner leg laminations incrementally from layer to layer along the longitudinal axis of the inner leg laminations, provides a stepped-lap pattern in which the dimension of the step increment is different between the extreme ends of the laminations than it is between the mitered edges of the laminations, with the step increment between the ends of the laminations exceeding that of the increment between the mitered edges.

If the yoke laminations were to be cut to accommodate a V-shaped point on the end of the inner leg laminations, it will be noted from FIG. 5 that more material would have to be removed from the yoke resulting in more scrap, and also a greater narrowing of the yoke by the inner leg lamination.

FIG. 6 illustrates a strip **130** of metallic magnetic material, illustrating how the inner leg lamination **46** may be cut from the strip. Dies may cut the V-shaped notches **132** and **134** at like locations on opposite sides of the strip **130** to a predetermined depth, determined by the desired dimension of the extreme end of the inner leg lamination. Then, an oscillating shear may make a cut **136** between the apexes of the triangular cuts **132** and **134** to complete the truncated isosceles triangular configuration of the end of the lamination. The only scrap is the small triangular portion removed from each side of the strip by the dies. It will be noted that if the inner legs were to have a V-shaped point, instead of a truncated isosceles triangular end, the scrap generated would be substantially increased.

FIG. 7 is a plan view of a strip **140** of magnetic metallic material, illustrating how the outer leg laminations may be cut. An oscillating shear may be used to make diagonal cuts **142, 144** and **146**, to produce outer leg laminations **42** and **44** without scrap.

While the magnetic core **12** shown in FIG. 1 illustrates the stepped-lap joints at the outer corners of the core advancing around the corners of the core, the stepped-lap pattern at the corners may be formed with other configurations. For example, the stepped-lap pattern may be formed as taught in the hereinbefore mentioned U.S. Pat. 3,153,215, wherein the stepped joints are located on only one side of each of the corners; or, as taught by copending application Ser. No. 774,941, filed Nov. 12, 1968, which is assigned to the same assignee as the present application, the stepped-lap joints may be formed in a manner which eliminates voids at the inner and outer corners of the core.

Tests made to compare the core losses and sound levels of stepped-lap magnetic cores constructed according to the teachings of the invention, using the truncated isosceles triangular inner leg configuration, with stepped-lap cores having the V-shaped point on the inner leg laminations, indicate that with a certain penetration of the inner leg laminations into the yoke portions of the core, that a magnetic core will be obtained that has substantially the same losses and sound level as magnetic cores of the prior art, while experiencing a substantial savings in core material.

The cores of the prior art and the cores constructed according to the teachings of the invention, used in the test, both utilized a seven step pattern, wherein the step increment advances in only one direction and then returns to the starting point to repeat the pattern. Both types of cores weighed 502.5 pounds, and both utilized the same stepped-lap arrangement at the outer corners of the core. The cores were tested at 17 kg. The test, therefore, will indicate if a penalty in losses and/or sound level is incured by utilizing the teachings of the invention, which has the advantage over the prior art in scrap savings. The following table lists the results of the test, with two different average penetrations of the inner leg laminations into the yoke for the cores constructed according to the teachings of the invention, and all of the cores were tested with the joints tight, and then opened 1/16 of an inch in the top 68% of the stack of laminations. The cores with the 1/16 inch gap at the joints more closely simulate magnetic cores which would be obtainable in production.

We claim as our invention:

1. A magnetic core comprising:

a plurality of stacked layers of metallic laminations,

each of said layers including first and second outer laminations, an inner leg lamination having first and second ends, and yoke laminations, said yoke laminations connecting the ends of said leg laminations with predetermined joint configurations,

each end of each inner leg lamination having a similarly dimensioned configuration of a truncated isosceles triangle, including first and second mitered edges which angle inwardly from the sides of the lamination to an extreme end, the surface of which is substantially perpendicular to the sides of the lamination,

the ends of said inner leg lamination being incrementally offset from layer to layer in a predetermined stepped-lap pattern, which progresses at least three steps in one direction before repeating.

2. The magnetic core of claim 1 wherein the dimension of the incremental steps between the extreme ends of the inner leg lamination, from layer to layer, exceeds the dimension of the incremental steps between the mitered edges of the inner leg laminations.

3. The magnetic core of claim 1 wherein the outer leg laminations join the yoke laminations with mitered joints,

[Core test results at 17 kg.]

Core	Scrap, percent	Sound level in oil		Losses in air	
		Joints tight	Joints opened	Joints tight, percent	Joints opened, percent
Inner leg, V Point	4	Reference	Reference	Reference	Reference.
Inner leg truncated, 14.5% average penetration.	1.15	+2 db 40	+1.5 db 40	+3	+4.2.
Inner leg truncated, 29% average penetration.	2.3	+3 db 40	0	−1	0.

As indicated by the results shown in the table, a greater savings in scrap may be realized with less average penetration of the truncated inner leg laminations into the yoke portions of the core, but some disadvantage in core losses and sound level is experienced. However, by increasing the penetration to an average of 25 to 30% or specifically to 29%, the sound level and core losses of the core with the truncated inner leg are substantially the same as for the prior art magnetic core having the V-shaped pointed inner legs, for the joints which are slightly opened, and the savings of scrap of 1.7% can still be realized. This is a substantial savings when considering magnetic cores for large power transformers and reactors.

In summary, there has been disclosed new and improved magnetic core structures for power transformers and reactors of the stacked, stepped-lap type, which experience a substantial savings in scrap material, without an offsetting penalty in core efficiency and sound level. The additional manufacturing effort required to construct the truncated isosceles triangular ends of the inner leg laminations is offset by the fact that all of the inner leg laminations may be identical. In prior art cores, a large plurality of inner leg configurations are required, in order to provide a stepped-lap joint which will not unduly narrow the yoke portion of the core. Since the triangular point on the ends of the inner leg laminations are eliminated by following the teachings of this invention, the inner leg laminations may step incrementally in the direction of the longitudinal axis of the inner leg laminations, without penetrating too deeply into the yoke portions of the core.

Since numerous changes may be made in the above described apparatus and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

which are incrementally offset from layer to layer in a predetermined stepped-lap pattern.

4. The magnetic core of claim 1 wherein the average penetration of the inner leg lamination into the yoke lamination is about 25–30% of the yoke width.

5. The magnetic core of claim 1 wherein all of the innerleg laminations have the same length dimension, with the laminations being offset from one another along their longitudinal axis, to achieve the predetermined stepped-lap pattern.

6. The magnetic core of claim 1 wherein the mitered edges of certain of the inner leg laminations in the predetermined stepped-lap pattern are completely within the yoke lamination, and the remaining laminations of the pattern have a portion of the mitered edges extending outside the edges of the adjoining yoke laminations.

7. The magnetic core of claim 1 wherein each layer of laminations includes first, second, third and fourth yoke laminations, with the first and second yoke laminations being part of a first yoke portion of the core, and the third and fourth laminations being part of a second yoke portion of the core.

8. The magnetic core of claim 7 wherein the first and third yoke laminations of each layer have trapezoidal configurations, with one of the mitered edges of each of these laminations contacting the first mitered edge at the first and second ends, respectively, of the inner leg lamination.

9. The magnetic core of claim 8 wherein the second and fourth yoke laminations of each layer have substantially the configuration of a parallelogram, with each including a composite cut having first and second edges which are complementary to the extreme end and second mitered edge of the first and second ends, respectively, of the inner leg lamination.

10. The magnetic core of claim 9 wherein the position of the composite cut is incrementally changed in the second and fourth yoke laminations, from layer to layer, ac-

commodating the incremental offsetting of the ends of the inner leg laminations from layer to layer, while maintaining close fitting joints between the second and fourth yoke laminations and the first and second ends, respectively, of the inner leg lamination.

11. The magnetic core of claim 8 wherein the configuration and dimensions of the first and third yoke laminations are the same in each of the layers.

12. The magnetic core of claim 11 wherein the configuration and dimensions of the first and second outer leg laminations are the same in each of the layers.

13. The magnetic core of claim 1 wherein the inner leg laminations of the stepped-lap pattern have different length dimensions.

References Cited

UNITED STATES PATENTS

1,635,064	7/1927	Wagner	336—216X
3,153,215	10/1964	Burkhardt et al.	336—217
3,210,709	10/1965	Ellis et al.	336—217

THOMAS J. KOZMA, Primary Examiner

U.S. Cl. X.R.

29—609