

Dec. 25, 1951

J. G. FORD

2,579,560

BONDED MAGNETIC CORE STRUCTURE

Filed Aug. 19, 1948

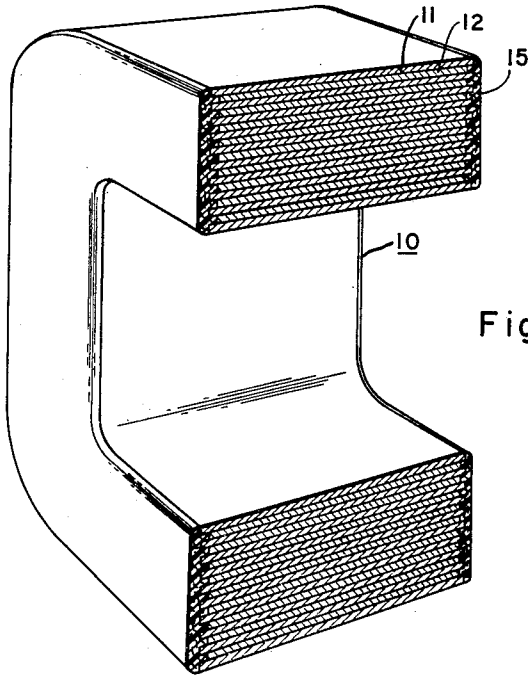


Fig. 1.

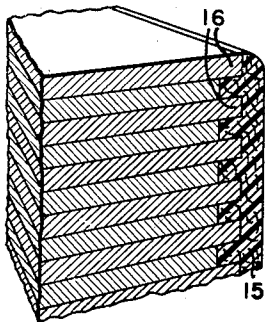


Fig. 3.

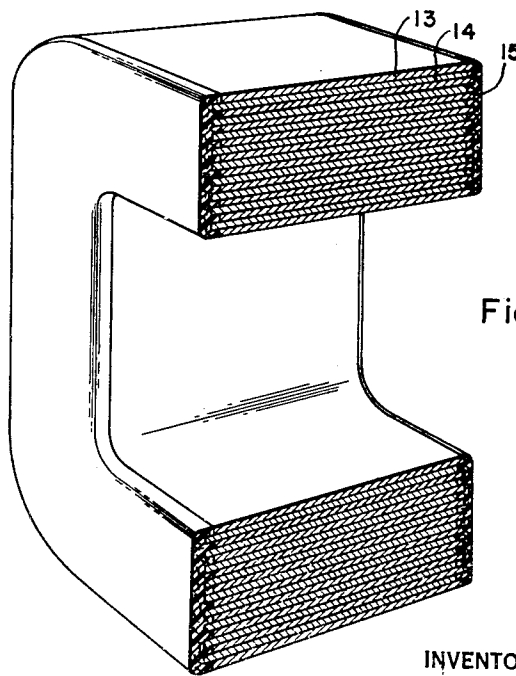


Fig. 2.

WITNESSES:

Wm. B. Sellers.
Rev. C. Groome

INVENTOR

James G. Ford.
BY *Gra W. Savage*
ATTORNEY

UNITED STATES PATENT OFFICE

2,579,560

BONDED MAGNETIC CORE STRUCTURE

James G. Ford, Sharon, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application August 19, 1948, Serial No. 45,096

10 Claims. (Cl. 175-21)

1

The invention relates generally to magnetic core structures for electrical apparatus and, more particularly, to bonded wound core structures.

With the advent of the oriented silicon steel, in order to take full advantage of the high permeability characteristics of the steel in small cores, it was found desirable to employ wound cores. After the cores have been wound it is necessary to apply the electrical windings. In one well known type of structure, the standard practice is to make preformed electrical coils and to cut the wound core into two sections and fit the core over the preformed electrical windings.

When such practice was employed, it was found desirable to bond the turns of the wound core to one another, so that when the core is cut into sections for applying to the preformed coils they will not split apart and render it difficult to apply the core sections to the preformed coils.

The standard practice in bonding the turns or laminations of the wound core to one another has been to impregnate the core after it is wound with some suitable bonding material. This practice has been reasonably successful. However, there is always a certain percentage of the cores lost due to the splitting apart of the turns or laminations. In manufacturing operations with which the inventor is familiar, as much as 2% of the cores have been lost at times due to the splitting apart of the turns or laminations. The splitting usually occurs at the edge of the core. Sometimes these splits can be repaired, and the core salvaged. In many instances, the split core cannot be repaired, and the core is a complete loss. This adds greatly to the cost of manufacturing cores for electrical apparatus and, in particular, transformers.

The object of the invention is to provide for so bonding the laminations of a wound core of electrical sheet steel that the laminations will not split apart at the edges.

It is also an object of the invention to provide for making wound cores with adequate insulation between the edges of the laminations.

The invention, accordingly, is disclosed in the embodiment thereof shown in the accompanying drawing and comprises the features of construction, combination of elements, and arrangement of parts, which will be exemplified in the construction hereinafter set forth and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in

2

connection with the accompanying drawing, in which:

Figure 1 is a view in perspective of a section of a wound core embodying the features of the invention;

Fig. 2 is a view in perspective of a section of a wound core showing a modification of the invention embodied in Fig. 1; and

Fig. 3 is a view in perspective of a portion of a wound core greatly magnified to show details of the invention.

Referring now to the drawing, the wound core section 10 illustrated in Figure 1 is part of a core made by winding together on a mandrel two strips of electrical sheet steel. The core section 10 comprises a plurality of layers or laminations bonded to one another to provide a unitary structure.

In order to provide a structure, such as illustrated in Fig. 1, two strips of electrical sheet steel are superimposed on one another so that the edges of the wider strip, such, for example, as 11, extend beyond both sides of the narrower strip 12. When the two strips are wound together into a core structure, the edges of alternate laminations of the core will extend beyond or overhang the other laminations on both sides.

Any desired type of core of this kind can be made by using a plurality of strips of different widths. In the structure illustrated in Fig. 1, the core section 10 comprises two strips wound together, however any number of strips of electrical sheet steel of different widths may be wound together to provide a core of the desired contour at the sides, that is, with the edges of some of the laminations extending beyond other laminations.

In the modification illustrated in Fig. 2, the outer turn 13 and the next adjacent turn 14 are of the same width. In winding the core structure from which the core section shown in Fig. 1 was cut, the strips which form the laminations 13 and 14 were so disposed or so offset relative to one another that one edge of each lamination 13 extends laterally beyond one edge of each lamination 14 on one side while one edge of each lamination 14 extends laterally beyond one edge of each lamination 13 on the opposite side. Thus, in the core section shown in Fig. 2, with strips of electrical sheet steel of the same width, we have provided a structure very similar to the core section 10.

The width of the strip from which the core is wound can readily be determined by one skilled in the art of making wound cores. It has been found in practice that when a structure, such as

shown in Fig. 1, is being made, if the strip or turn 11 is three inches wide, that the strip or turn 12 should be from $2\frac{3}{4}$ inches to $2\frac{1}{8}$ inches wide. This gives an overhang or extension laterally of the edge of one strip beyond the edge of the other strip of from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch. In practice, this was found quite satisfactory for this size of core.

In the modification illustrated in Fig. 2, the strips or laminations 13 and 14 are of the same width. In order to provide space at the sides of the core between the overhanging laminations for bonding material, the strips will be offset so as to give an overhang of the edge of one turn or lamination over the next turn or lamination of from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch.

The distance that one turn extends laterally beyond the other may be said to be a matter of design. However, it may also be influenced by the bonding material that it is desired to use.

After the core has been wound on the mandrel, as is common practice, it is impregnated with some suitable bonding material. The bonding material will bond the laminations 11 and 12 in the structure illustrated in Fig. 1 and the laminations 13 and 14, as illustrated in Fig. 2 into unitary structures.

The selection of the bonding material will depend on the characteristics it is desired that the core should have. The bonding material should be capable of penetrating between the laminations or turns of the core and when cured should have adequate strength to hold the turns in the same relative positions as when the core is impregnated. It should be sufficiently resilient to permit some distortion without shattering and capable of resisting predetermined temperatures without becoming soft and losing its tensile strength. Therefore, it will be seen that the selection of the bonding material is important.

A bonding material that has been used with success is disclosed in the J. G. Ford Patent 2,372,074, issued March 20, 1945. For convenience in reference, the composition of the bonding material of Patent 2,372,074 comprises polyvinyl acetal 42½%, polyvinyl acetate 42½%, and the resinous condensate of cresylic acid and formaldehyde 15%. The percentages given above are all by weight. The above composition when it is being prepared for the impregnation process is dissolved in a solvent composed of approximately two parts by weight of toluene or xylene and one part by weight of ethyl alcohol to form a 25% to 40% solution. In some cases, coal tar naphtha may be used in place of toluene or xylene.

It will be readily appreciated by anyone skilled in the art that different compositions of the same materials may be prepared to meet different requirements in the bonding operation.

In this invention in the impregnation process to bond the turns or laminations to one another, layers of bonding material 15 will be applied to the sides of the core, as shown in Figs. 1 and 2. These layers 15 of the same bonding material as used for impregnation will bond the overhanging edges of the laminations 11 to one another and to the narrower laminations 12. In the construction illustrated in Fig. 2, the layers of bonding material 15 will bond the overhanging edges of the laminations 13 on one side of the core section to one another and to the laminations 14, and the overhanging edges of the turns 14 on the other side to one another and to the turns 13.

This in effect gives layers of bonding material on each side of the core which will greatly increase the strength of the bond between the turns

and will prevent splitting at the edges which is the cause of the greatest amount of loss in the manufacture of cores.

It has also been found that by mixing a certain amount of fibrous material with the bonding material the layers 15 may be greatly strengthened. Many different kinds of fibrous material may be employed, such as asbestos, glass, cotton and other types of mineral and vegetable fibers. It will be appreciated by anyone skilled in the art that the fibers employed should be selected to meet the requirements of the problem at hand. For example, if the baking cycle applied to the core after it has been made should be as high as 140° C., then it would be unwise to use cellulosic fibers since they would deteriorate under such temperatures. When the baking temperatures are to be as high as 140° C., a mineral fiber would preferably be employed.

It has also been found that during impregnation with a bonding material carrying fibrous material that in the process of infiltration the fibers are collected at the edges of the turns of electrical sheet material. When the fibers are collected in this manner, it greatly strengthens the bond at the edges of the turns, and splitting is practically eliminated.

Other bonding materials have been employed with success. Bonding materials that may be employed are mixtures of acetals with phenolic materials in a suitable solvent, resorcinol formaldehyde resin mixed with vinyl acetate, the mixtures being dissolved in a suitable solvent and a solution of aniline resins mixed with vinyl acetate. It is also possible to use bonding materials such as different types of phenolic, aminos, and alkyd resins. Further fibrous materials may be used with any of the bonding materials.

In instances where fibrous material has been employed, it was found good practice to employ around 30% to 40% by weight of fibers calculated on the solids content of the resinous material in the bond. This may be expressed by saying that a bond containing 40% by weight of resin would contain around 16% to 20% by weight of fibrous material. The weight of the fibrous material employed will, of course, depend to some extent on the characteristics of the fibrous material used. In order to illustrate this point, we may say that two or three times as much asbestos fiber is required as cellulosic fiber. The mat formed along the edges of the turn through the accumulation of the fibers as the infiltration of the bonding material proceeds gives a very strong layer or coating of bonding material which holds the turns together.

In practicing this invention, it has been found that when the insulated strips from which the core is wound are staggered or offset in the manner described hereinbefore that lower losses result than were obtained from corresponding iron wound with the edges of the strip in line. The improved efficiency of the core results from a number of features of this improved type of core.

One of the contributing factors to the lowering of the losses in the new core results from the fact that, if in cutting the strips from which the core sections are wound burrs are formed on the edges of the strips, the burrs on the edges of one turn or lamination does not contact the edges of the next adjacent lamination since the edges of the strips are staggered relative to one another in the winding operation and the burrs on the edge of the lamination covered by an overhang-

ing edge are thoroughly insulated from the next lamination by the insulating coating or film applied to the steel in the making of it, while the burrs on edges of the overhanging laminations are spaced apart and the application of the bonding material to the sides of the core further insulates the burred edges of one strip or lamination from the next one.

It has been well known for some time that the characteristics of different parts of a strip of electrical sheet steel vary magnetically. However, when two or more strips are wound together to form a core, the characteristics of the steel are averaged out, and it has been found that the magnetic characteristics are homogeneous throughout. It has been found that the spaces between the wider laminations, or the laminations or turns having the overhanging edge, are better filled with bonding material and thus give greater strength to resist splitting.

Reference to Fig. 3, which is an enlarged view of how the core will appear, shows how the overhanging edges 16 of the turns are bonded to one another by the bonding material 15 and to the other turns to cooperate in holding the turns together in a unitary structure to resist splitting at the edges.

Since certain changes may be made in the above article and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In a wound magnetic core structure, in combination, a plurality of turns of electrical sheet steel strip wound from a plurality of strips of different widths, the strips being so disposed relative to one another that alternate turns of the wider strip extend a predetermined distance beyond the turns of narrow width at both sides to provide turns of electrical sheet steel overhanging the other turns of the electrical sheet steel on both sides, and bonding material applied to the sides of the core having the overhanging turns to bond said overhanging turns to one another and to the other turns to form a unitary core structure.

2. In a wound magnetic core for electrical apparatus, in combination, a plurality of strips of electrical sheet steel of different widths, the strips having been so disposed in winding that the wider strip extends a predetermined distance beyond the narrow strip at both sides whereby in the core structure the turns of the wider strip extend beyond the turns of the narrow strip on both sides, and bonding material applied to the sides of the core having alternate turns extending beyond the other turns, thereby to bond the furthest extending turns to one another and to the narrower turns to provide a unitary core structure.

3. In a wound laminated magnetic core structure, in combination, a plurality of strips of electrical sheet steel, the strips of electrical sheet steel being wound in superimposed relationship to one another to provide a core structure, some of the wound strips in the core structure being staggered laterally a predetermined distance relative to the other core strips providing overhanging laminations forming spiral grooves in both sides of the core structure and bonding material applied to the sides of the core structure filling the spiral grooves and bonding the lami-

nations extending beyond other laminations to one another and to the other laminations to strengthen the bonding of the laminations in the core structure.

4. In a wound laminated magnetic core structure, in combination, a plurality of strips of electrical sheet steel, the strips of steel being of different widths and wound in superimposed relation on one another to provide a core structure having a plurality of turns of all strips, the wider strip being disposed relative to the narrower strip to extend a predetermined distance on both sides of said narrower strip, the wider strip thereby providing laminations with overhanging edges on both sides of the core structure forming grooves between the turns of the wider strip and bonding material applied to the sides of the core structure having some of the lamination edges extending beyond other of the lamination edges, the bonding material extending into the grooves between the overhanging edges of the wider strip and serving to bond the overhanging edges of the laminations to one another and to the other lamination edges.

5. In a wound laminated magnetic core structure, in combination, a plurality of strips of electrical sheet steel, the strips of electrical sheet steel being wound in superimposed relation on one another to provide a core structure of a predetermined number of turns, the edges of the turns forming core sides, the strips of electrical sheet steel having been so disposed relative to one another that some of the lamination turns of the core structure extend laterally beyond other of the lamination turns a predetermined distance, the laterally extending strips forming grooves between one another and bonding material carrying fibrous material applied to the side of the core structure having some of the lamination turns extending beyond other of the lamination turns to fill the space between the adjacent overhanging edges and to cooperate in bonding all of the lamination turns to one another to provide a unitary core structure.

6. In a wound laminated magnetic core structure, in combination, a plurality of strips of electrical sheet steel of different widths wound in superimposed relationship to provide a core structure, the strips having been so disposed relative to one another that in the wound core the wider strip extends a predetermined distance on both sides of the narrower strip, thereby providing a core structure in which the edges of some of the laminations overhang the edges of the other adjacent laminations providing grooves between laminations and bonding material carrying fibrous material applied to the sides of the core structure, the bonding material entering the grooves and serving to bond the overhanging edges of the lamination turns to one another and to the other lamination turns.

7. In a wound laminated magnetic core structure, in combination, a plurality of strips of electrical sheet steel wound in superimposed relationship on one another to form a core structure, the edges of the turns forming core sides, some of the turns of the strips being disposed to extend laterally a predetermined distance beyond the other turns, the laterally extending turns forming grooves between one another and a bonding material applied to the sides of the core structure entering the grooves and serving to bond the laterally extending turns to one another and to the other turns of the core structure.

8. In a wound laminated magnetic core struc-

7

ture, in combination, a plurality of strips of electrical sheet steel of the same width wound in superimposed and staggered relationship to one another to form a core structure, the alternate turns of the core structure overhanging the next adjacent turns by a predetermined distance forming grooves on the sides of the core structure, and bonding material applied to the sides of the magnetic core structure entering the grooves and bonding the overhanging turns to one another and to the other turns of the core structure.

9. In a wound laminated magnetic core structure, in combination, a plurality of strips of electrical sheet steel the strips being disposed in offset relation throughout their length and wound in superimposed relationship to form a core having some of the turns extending a predetermined distance laterally beyond the other turns on both sides providing overhanging edges, bonding material carrying fibrous material applied to the core structure to impregnate it and build up a coating on the sides, the bonding material entering between the overhanging edges serving to bond the overhanging turns to one another and to the edges of the other turns to provide a unitary core structure.

10. In a wound laminated magnetic core structure, in combination, a plurality of strips of electrical sheet steel carrying insulating films, the strips being disposed in offset relationship and

8

wound to provide a core structure having a predetermined number of turns, the edges of the turns forming core sides, a plurality of the turns of the core structure at each side extending beyond other turns, the turns extending beyond other turns thereby forming grooves between one another and a bonding material applied to the sides of the core structure filling said grooves and bonding to one another the turns extending beyond said other turns and to said other turns.

JAMES G. FORD.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
523,572	Hassler	July 24, 1894
1,332,757	Rosner	Mar. 2, 1920
1,353,711	Bergman	Sept. 21, 1920
1,427,324	Priestley	Aug. 29, 1922
1,586,889	Elmen	June 1, 1926
1,734,208	Golladay	Nov. 5, 1929
1,867,362	Lathrop	July 12, 1932
2,220,732	Sanders	Nov. 5, 1940
2,372,074	Ford	Mar. 20, 1945
2,414,525	Hill et al.	Jan. 21, 1947
2,422,591	Sigmund et al.	June 17, 1947
2,423,869	Blessing	July 15, 1947
2,489,977	Porter	Nov. 29, 1949