United States Patent [19]

Barnett

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[54] **FOLDABLE OUTER EXTENSIONS OF A LAMINATED CORE STRUCTURE**

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[52] **U.S. Cl.** ... **335/297**, 179/100.2 C, 340/174.1 F, 346/74 MC

[51] **Int. Cl.** **H01f 3/00**

[58] **Field of Search**..... 179/100.2 C; 346/74 MC; 340/174.1 F; 29/603; 335/297

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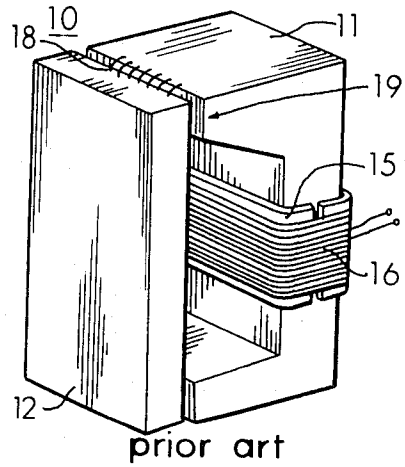
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[57] **ABSTRACT**

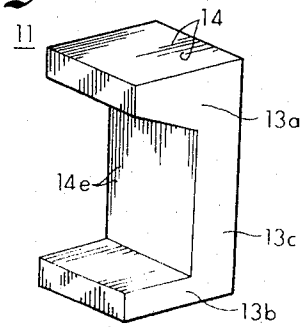
Magnetic core structures formed by stacks of laminations, of which the outermost laminations have protective extensions. The latter are folded against the edges of the inner laminations to permit windings to be wrapped around the laminations without being damaged by sharp edges of the inner laminations. The protective extensions are particularly desirable for small-scale magnetic cores that are formed by etching techniques which leave comparatively ragged edges on the inner laminations and could otherwise damage the windings.

9 Claims, 12 Drawing Figures



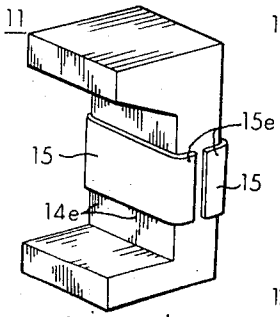
prior art

Fig. 1A



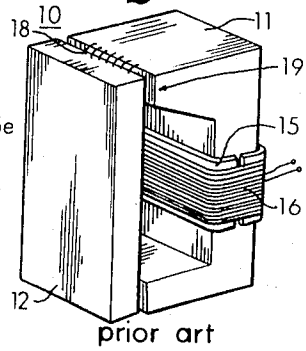
prior art

Fig. 1B



prior art

Fig. 1C



prior art

Fig. 2A

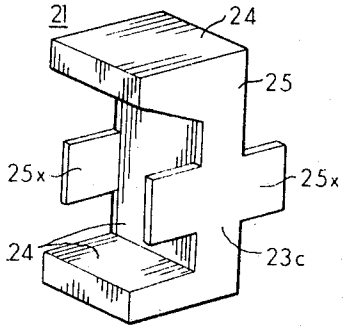


Fig. 2B

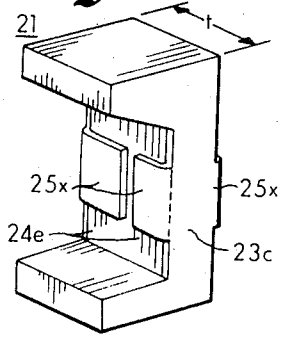


Fig. 2C

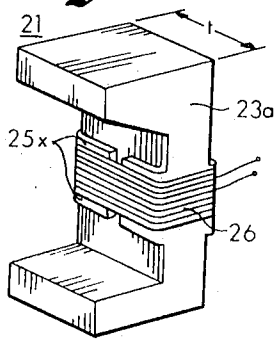


Fig. 3A

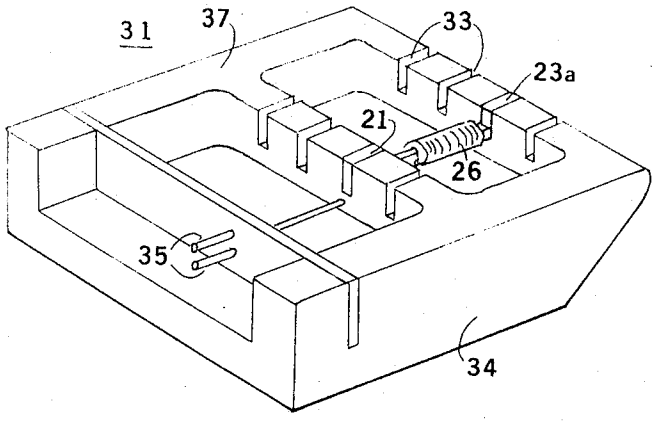


Fig. 3B

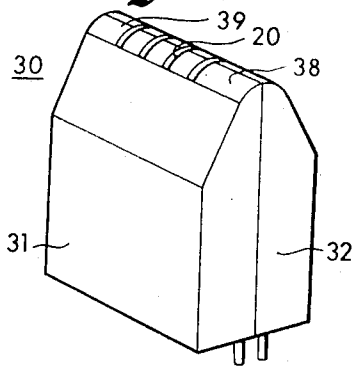


Fig. 5A

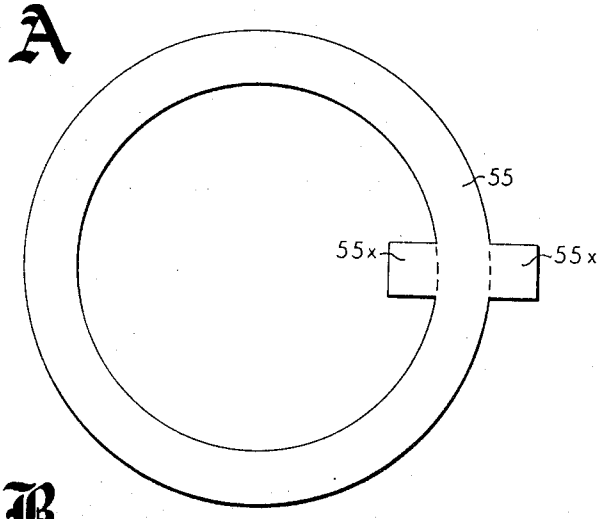


Fig 5B

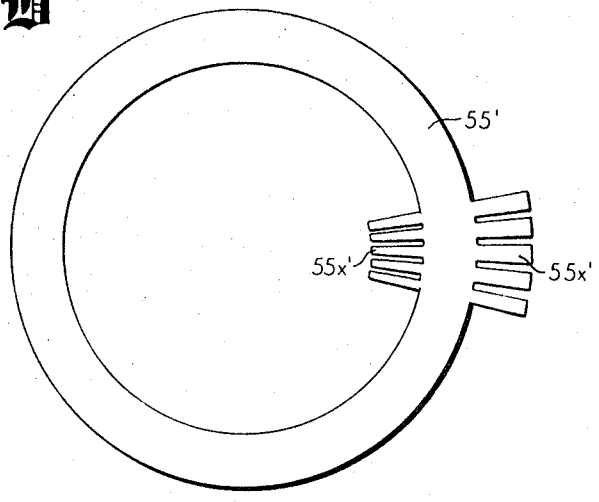


Fig. 4A

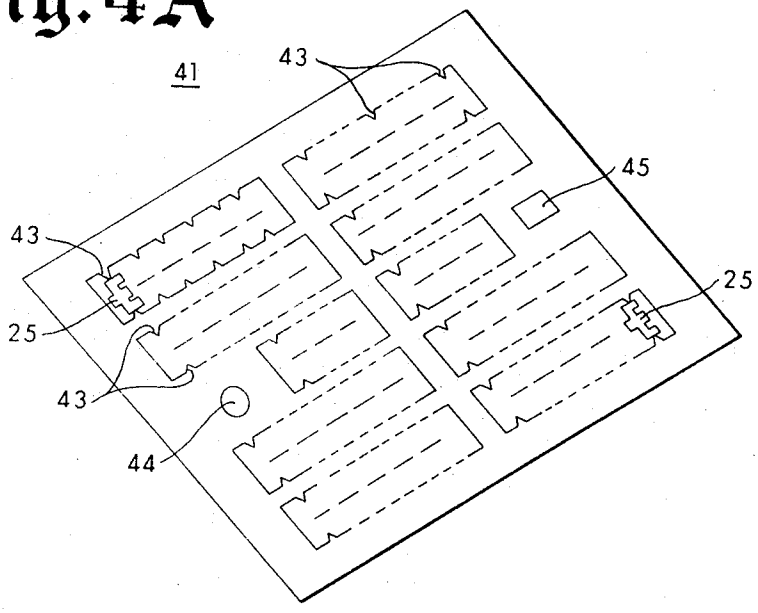
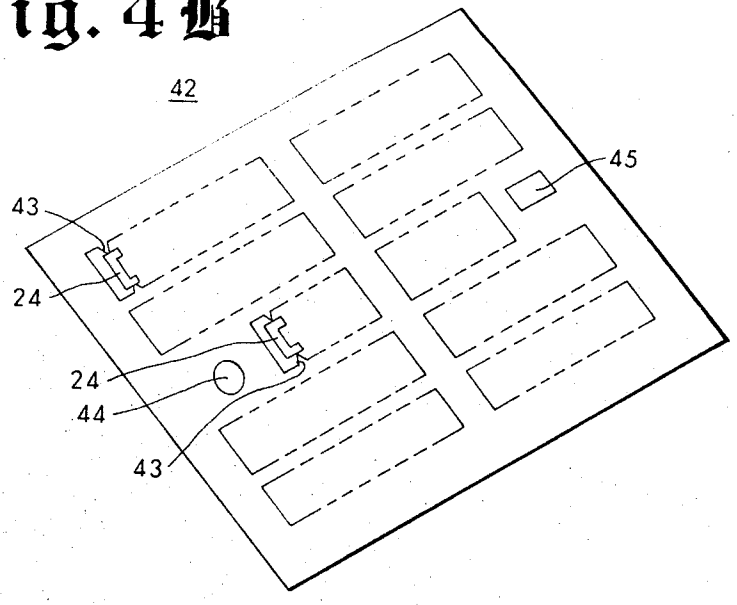


Fig. 4B



FOLDABLE OUTER EXTENSIONS OF A LAMINATED CORE STRUCTURE

BACKGROUND OF THE INVENTION

This invention relates to magnetic core structures, and more particularly, to small-scale magnetic core structures with laminations which are formed by etching techniques.

Magnetic core structures are widely employed in modern technology. Their uses range from tranducers for voice frequency circuits to memories for digital computers. In many such circuits, the magnetic structure is formed by winding a coil around a laminated core. The laminations are desirable because they reduce eddy current and hysteresis losses. When it is desired to reduce the size of a laminated core, it is common to employ etching techniques. This permits the core elements to be outlined on a comparatively large scale using a photographic master. The photographic representation can then be reduced in size and applied to a substrate or magnetic material which is coated with a mask of photo-resistant material in accordance with the outline of the element to be realized. An etchant is thereafter applied and that part of the magnetic material which is uncoated is dissolved, leaving the desired structure. By this technique, it is possible to realize miniature core elements which have accurate proportions.

Unfortunately the use of the etchant tends to produce pitted and comparatively sharp edges along the uncoated regions of the lamination. Consequently, when the laminations are subsequently stacked, preparatory to being wound with a coil, it has become common practice to wrap a protective layer around the core in order to prevent the sharp edges of the laminations from damaging the coil windings. Otherwise the edges of the laminations could cut into the insulation of the coil and have a short circuiting effect.

The customary protective layer for small-scale magnetic structures is thin mylar tape. In small-scale structures the addition of even a thin layer of mylar tape adds undesirable thickness. In addition the use of such a layer poses serious production problems. Not only is it difficult to automate the wrapping of the magnetic cores with thin mylar insulating layers, if the layers do not overlap (to avoid unnecessary bulk), they tend to open and interfere with the subsequent winding operation.

Accordingly it is an object of the invention to facilitate the realization of magnetic structures, particularly those which have laminations with sharp edges. A related object is to expedite the production of core structures using etched laminations.

Another object of the invention is to facilitate the winding of coils around magnetic core structures. A related object is to eliminate the need for insulating layers between cores and their windings, particularly in small-scale magnetic structures where such layers add undesired bulk and can impede production.

SUMMARY OF THE INVENTION

In accomplishing the foregoing and related objects, the invention provides a magnetic core structure which includes a magnetically permeable member with a protective extension that is attached to the member and is foldable with respect to it.

In accordance with one aspect of the invention, the protective extension is in the form of a thin, elongated strip which is foldable against an edge of an adjoining magnetically permeable member. When the protective member is thus folded it prevents the edge of the adjoining member from having an adverse effect, for example, on a coil wound around the members at the position of the folded, protective extension.

In accordance with another aspect of the invention protective extensions are provided on opposite sides of the associated member in order to provide protection with respect to opposite edges of an associated, adjoining member.

In accordance with still another aspect of the invention a plurality of laminar, magnetically permeable members with protective extensions are formed, typically using photo-resistant coatings and etching techniques, as interconnected groups within a frame known as a fret. Such a fret is then used to form the outermost lamination in a stack of frets containing members without protective extensions.

In accordance with a further aspect of the invention a stack of frets is used to form partial cores for which the protective extensions of the outermost laminations are folded against the edges of the inner laminations. The resulting partial cores are wound with coils in the protected regions and inserted into half shell which are combined with other half shells to form magnetic transducer heads.

DESCRIPTION OF THE DRAWINGS

Other aspects of the invention will become apparent after considering several illustrative embodiments, taken in conjunction with the drawings in which:

FIG. 1A is a perspective view of a partial magnetic structure;

FIG. 1B is a view of the structure of FIG. 1A with a conventional insulating tape layer;

FIG. 1C is a view of the structure of FIG. 1B after being wound with a coil and including auxiliary structure to complete the magnetic circuit;

FIG. 2A is a perspective view of a partial magnetic structure corresponding to FIG. 1A and including protective outer laminations in accordance with the invention;

FIG. 2B is a view of the structure of FIG. 2A showing the protective extensions folded to protect a subsequently applied winding against any sharp edges of the inner lamination;

FIG. 2C is a view of the structure of FIG. 2B with a coil wound upon the protected portion of the structure;

FIG. 3A is a perspective view of a half shell in which a structure in accordance with the invention has been positioned;

FIG. 3B is a perspective view of a transducer head employing the half shell of FIG. 3A as one constituent;

FIG. 4A is a perspective view of a fret of outer laminations for magnetic structures in accordance with the invention;

FIG. 4B is a perspective view of a fret of inner laminations for magnetic structures formed using the fret of FIG. 4A;

FIG. 5A is a plan view of an alternative magnetic structure in accordance with the invention; and

FIG. 5B is alternate form of the magnetic structure of FIG. 5A.

DETAILED DESCRIPTION

Turning to the drawings, FIG. 1A shows a partial magnetic core **11** of the kind commonly used in prior art audio frequency circuitry, for example, in magnetic transducers for the recording and reproduction of information on magnetic media, such as tape.

The partial core **11** is commonly known as a C section because of its overall configuration, which includes a central leg **13***c* and two outer legs **13***a* and **13***b*. In the use of the core **11** a coil (not shown in FIG. 1A) is wound around the central leg **13***c* and another partial core (not shown in FIG. 1A) is used to bridge the magnetic circuit between the outer legs **13***a* and **13***b*.

The partial core **11** is formed by thin laminar members **14** of magnetically permeable material, which are insulated from one another and held together adhesively. When a current flows in a coil wound around the core, magnetic flux is established. As is well known, the use of a core of magnetically permeable material permits the attainment of high flux densities and the enhancement of desired magnetic effects. The core is laminated in order to reduce the eddy current and hysteresis losses that would otherwise exist.

In order to protect the coil which is wound upon the central leg **13***c*, it is common practice to first wrap the leg with a protective layer, such as the layer **15** shown in FIG. 1B. Otherwise the relatively sharp edges **14***e* of the individual laminations **14** could cut into the wire of the coil. This is particularly important when the core **11** is used in forming comparatively small-scale magnetic structure for miniature magnetic recorders and reproducers. For example, when the laminations are on the order of 50 mills in height with a leg width of about 25 mills and a lamination thickness of 0.5 mill, it is customary to form the laminations by etching techniques in which unwanted metal is dissolved. This process leaves edges which are comparatively sharp and pitted, so that the layer **15** becomes particularly important.

In order to avoid adding unnecessary bulk to the core **11**, it is desirable for the layer **15** of FIG. 1B to be as thin as possible, while still providing the desired protection against the sharp edges **14***e* of the individual laminations. Mylar tape has been found suitable, but unless the ends **15***e* of the protective layer **15** are overlapped, adding extra bulk to the core, the ends tend to separate before the winding **16** is applied, as shown in FIG. 1C. Even if the coil **16** is wound without overlap of the ends **15***e*, the layer **15** adds an extra, undesired layer to the core **11**.

To form a complete core **10**, the partial core **11** of FIG. 1C is shown employed with a second partial core **13**. The particular partial core **12** of FIG. 1C is in the form of an I section, but will be understood that other types of sections may be employed as well. In the use of the complete core **10**, a fringing magnetic field **18** is established across an air gap **19** when the core is in contact with a medium such as magnetic tape. During magnetic recording, for example, a current in the coil **16** establishes the field **18** which acts on the tape. During magnetic reproduction the tape acts on the core and establishes the field **18**.

Numerous attempts have been made to eliminate the need for the tape layer **15** in FIG. 1C. These include the use of lacquer and coating compositions in an attempt to fill the pores at the jagged edges **14***e* of the laminations and the use of shrink fit tubing. These techniques have been unsuccessful.

In accordance with the invention, however, the difficulties that have been experienced with insulating layers, and the disadvantages of applying shrink-fit tubing and lacquers and coatings to the coil leg are overcome as indicated in FIG. 2A for the partial core **21** by providing protective extensions **25X** that are integral with the outermost laminations **25** and extend from opposite sides.

To protect a coil that is to be wound around the central leg against the effects of the sharp edges, the extensions **25X** are folded against the edges **24***e* of the inner laminations **24** as shown in FIG. 2B. Since the edges **25***e* of the outer laiminations **25** face one another after the extensions are folded, they also do not remain in a position to interfere with a winding subsequently applied to the central leg **21**.

Suitable protection is provided when the extensions **25***x* have approximately the same width as half of the thickness *t* of the core **21**. The extensions **25***x* are shown as having rectangular configurations, but others may be employed as well.

The protected partial core **21** is completed by being wound with a coil **26** as shown in FIG. 2C. As a result of the protective extensions **25***x*, the coil **26** is protected against adverse effects from the edges **24***e* of the inner laminations **24**, as well as the edges **25***e* of the outer liminations **25**. Moreover, the protective effect is achieved without adding to thickness *t* of the core **21**.

As a result, the partial core **21** is more readily accommodated by the half shell **31** shown in FIG. 3A. The half shell **31** includes a set of grooves **33**, one for each partial core, of which only one partial core **20** is shown in position, with the outer surface of the leg **23** coincident with the outer surface **34** of the half shell **31**. The ends of the winding **26** of the partial core **20** extend to terminals **35** at the back **36** of the shell **30**. After the remaining grooves **33** have been filled, the windings attached to terminals, the cores are potted in place and inner face **36** is given a smooth finish to facilitate mating to another half shell **32** and produce the transducer head **30** shown in FIG. 3B.

It will be understood that the half shells **31** and **32** compliment each other, so that a partial core **21** with a winding is placed in a groove of a shell **31** and a partial core **22** without a winding is placed in the corresponding opposite grove of the mating shell **32** to complete the magnetic circuit.

The resulting transducer head **30** of FIG. 3B has four cores **20** and is thus a four-channel device. One-half of each core **20** is in one of the half shells **31**, and the other half of the core is in the other half shell **32**. An air gap **39** is at the plane of separation between the half shells **31** and **32** and is promoted by the insertion of a thin non-magnetic shim (not shown). The head **30** is used to record and reproduce signals on a strip of magnetic tape (not shown) which is moved in the vicinity of the face **38**.

In commercial production of magnetic core in accordance with the invention, such as the partial core **21** of FIG. 2C, it is desirable to produce a multiplicity of the cores simultaneously. For that purpose a "fret" **41** as shown in FIG. 4A is employed. The fret **41** includes a frame **42** within which there are a plurality of individ-

ual outer laminations **25** that are attached to the frame by narrow connectors **43.** The fret is advantageously formed from a thin sheet of magnetically permeable material, such as mumetal, which is coated on both faces with a photoresist material, such as the composition sold and marketed by the Eastman Kodak Company of Rochester, New York under the trade name KPR. After the photoresist coating is applied, light is projected through a negative master containing the desired pattern of fret laminations. An etchant is then applied.

The coating that remains on opposing laminar surfaces serves as insulating film when the laminations are stacked to form cores.

The photoresistant technique permits relatively small scale laminations to be produced with comparatively accuracy from masters which are prepared on a large scale and are then reduced in size by photographic techniques. It will be understood that the fret **41** may be produced in other ways, for example by stamping.

The outer lamination fret **41** includes registration apertures **44** and **45** to assure proper alignment of the fret when it is stacked with other frets, for example, the inner lamination fret **42** of FIG. **4B**, which includes a set of inner core laminations **24.**

A number of inner frets **42** are stacked between outer frets **41** and held together by adhesive applied between laminations. The result is a set of partial cores **21.**

The invention may also be applied to toroidal cores by employing outer laminations **55** and **55'** as shown in FIGS. **5A** and **5B**. In FIG. **5A** the protective extensions **55***x* are rectangular flaps. In FIG. **5B** the protective extensions **55***x'* are sets of fingers.

While various aspects of the invention have been set forth by the drawings and the specification, it is to be understood that the foregoing detailed description is for illustration only and that various changes in parts, as well as the substitution of equivalent constituents for those shown and described may be made without departing from the spirit and scope of the invention as set forth in the apended claims.

What is claimed is:

1. A magnetic core structure which comprises a magnetically permeable laminar member, and a protective extension for said structure attached to said member and foldable with respect thereto, wherein said laminar member is the outer most member of a stack of laminations and said extension is foldable against the edges of the inner laminations.

2. A magnetic core structure as defined in claim **1** wherein said protective extension is in the form of a thin, elongated strip which is integral with said member and is foldable against an edge of any adjoining laminar member to protect said structure from the effects of said edge.

3. A magnetic core structure as defined in claim **1** further including

a second protective extension attached to said member and foldable with respect thereto.

4. A magnetic core structure as defined in claim **1** wherein said laminar member is one of a group of laminar members constituting a fret.

5. A magnetic core structure as defined in claim **4** wherein said fret is superimposed upon at least one other fret constituted by a group of laminar members without protective extensions.

6. A magnetic core structure as defined in claim **1** wherein said extension is folded.

7. A magnetic core structure as defined in claim **6** wherein said stack of laminations forms a partial magnetic core and said core is wound with a coil.

8. A magnetic core structure as defined in claim **7** wherein the coil wound core is inserted into a half shell.

9. A magnetic core structure as defined in claim **8** wherein said half shell is joined with another half shell to form a magnetic head.

* * * * *