United States Patent

Wiesner

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[54] **MAGNETIC CIRCUIT FOR AN INDUCTOR OR TRANSFORMER**

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[52] **U.S. Cl.**...............................**336/178,** 336/212, 336/216

[51] **Int. Cl.**...**H01f 27/24**

[58] **Field of Search**..................336/178, 165, 212, 234, 216

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[57] **ABSTRACT**

The magnetic circuit of a ballast for fluorescent lamps has an airgap whose effective width is locally reduced by an insert of ferromagnetic material, whereby the magnetization curve of the circuit at low values of the magnetizing force has two angularly offset, substantially rectilinear portions. The insert is readily manufactured to close tolerances and may facilitate assembly of the ballast and reduce hum as the ballast ages.

11 Claims, 5 Drawing Figures

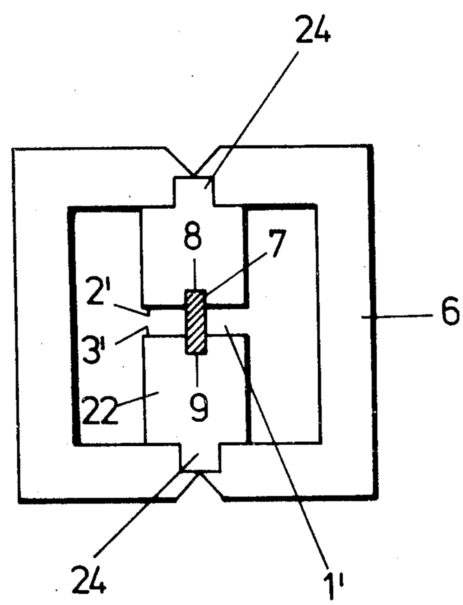


Fig. 1

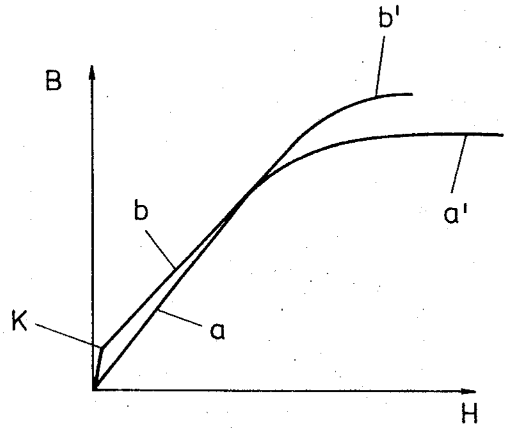


Fig. 2

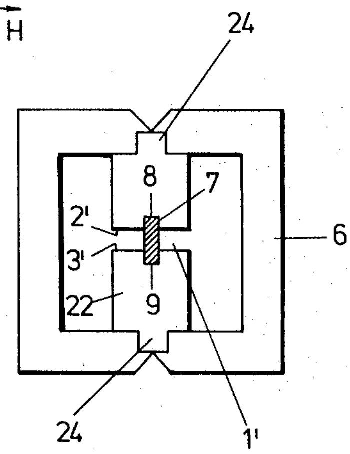


Fig. 4

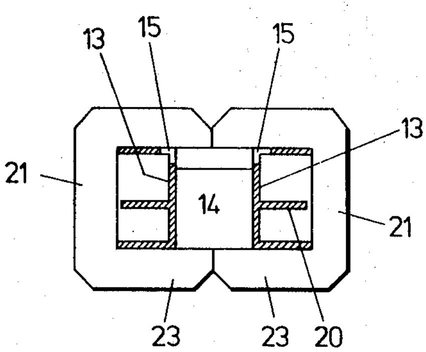


Fig. 3

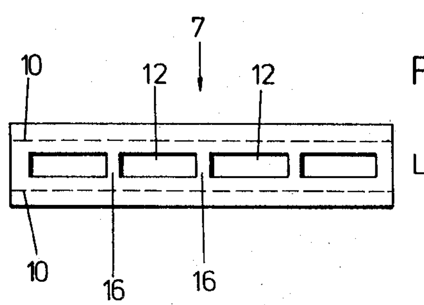
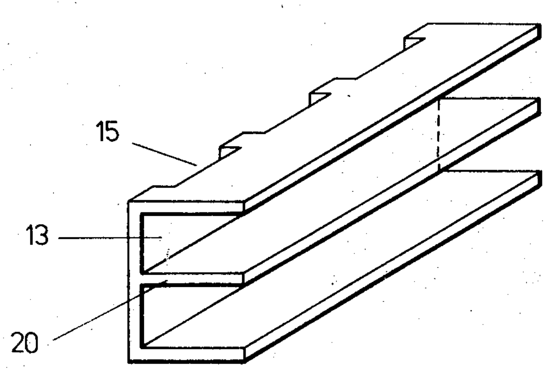


Fig. 5



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MAGNETIC CIRCUIT FOR AN INDUCTOR OR TRANSFORMER

This invention relates to magnetic circuits for inductors or transformers, and particularly to improvements in magnetic circuits having an airgap.

It is known to provide magnetic circuits assembled from laminations of soft iron or silicon steel with airgaps of varying width. The magnetization curve of a core assembly provided with such an airgap has two substantially rectilinear, angularly offset sections in the range of low magnetization forces, and such core assemblies are preferred in ballasts for fluorescent lamps and in like applications.

Known core assemblies for ballasts are assembled from stacked laminations having respective integral projections on the edges of the laminations which jointly constitute a face of the stack bounding the gap. The width of the gap is very small. The laminations are normally prepared from sheet stock on punch presses. Very close tolerances must be maintained on the press tools in order to produce projections of adequately reproducible characteristics. The cost of tool maintenance significantly contributes to the cost of the laminations and of the ballast as a whole.

It has now been found that the manufacturing difficulties described above can be avoided by providing an insert of ferromagnetic material contiguously juxtaposed to one face of a set of stacked laminations which bounds the airgap on one side in such a manner that the insert projects into the airgap in a direction from the one face toward the other set of laminations whose face bounds the other side of the gap. The flux-carrying, effective cross section of the insert in a plane intermediate the two faces is much smaller than the area of either face, and the insert is located in the magnetically active zone of the circuit.

The part of the airgap which is constricted or bridged by the insert carries practically the entire magnetic flux at low values of the magnetizing force whereas the shape of the magnetization curve is determined predominantly by the configuration and spacing of the exposed parts of the two spacedly opposite lamination faces as a condition of saturation is approached.

The insert of the invention may be secured to other elements of the magnetic circuit in a simple manner and without requiring fasteners, and is readily shaped to precise dimensions. The magnetic characteristics of a core assembly may be changed conveniently by merely replacing the insert and without modifying any other element of the assembly, and without requiring a new set of tools for punching the core and yoke laminations.

Other features and many of the attendant advantages of this invention will be appreciated readily as the same becomes better understood by reference to the following detailed description of preferred embodiments when considered in connection with the accompanying drawing in which:

FIG. 1 shows magnetization curves of magnetic circuits for a choke;

FIG. 2 shows a first embodiment of this invention in front elevational section on a plane of magnetic flux;

FIG. 3 illustrates an insert of the device of FIG. 2 in side elevation on a larger scale;

FIG. 4 shows a second embodiment of the invention in front elevational section in a plane of magnetic flux; and

FIG. 5 illustrates an insert of the apparatus of FIG. 4 in an enlarged perspective view.

Referring now to the drawing in detail, and initially to FIG. 1, there are shown magnetization curves of two chokes. In a conventional choke, the magnetization curve which represents the flux density B as a function of the intensity H of the magnetizing force has an approximately rectilinear part *a* at low values of H and B, and an arcuate part *a'* as it approaches saturation values. In a choke equipped with a magnetic circuit of the invention, the part *b* of the magnetization curve at low values of B and H has a point of discontinuity K which separates two angularly offset, substantially rectilinear sections of the curve. The curve has an arcuate part *b'* at higher values of H approaching saturation.

In the magnetic circuit for a choke illustrated in FIG. 2, two identical sets of core laminations **22** have respective planar, parallel, oppositely spaced faces **2'**, **3'** which bound an airgap **1'**. Shallow grooves are formed in the two opposite faces by aligned, respective notches **8**, **9** in the laminations of the two sets.

A unitary strip or flat bar **7** of ferromagnetic material, that is, soft iron or silicon steel, is longitudinally coextensive with the core laminations **24** at right angles to the plane of FIG. 2, and its edges are respectively received in the notches **8**, **9**.

The magnetic circuit is completed by two stacks of U-shaped yoke laminations **6**. Each stack is channel shaped, and the free edges of the channel flanges are tapered and shaped for conforming engagement with projections **24** on the core laminations **22** directed away from the airgap **1'**.

The strip or bar **7** is shown in more detail in FIG. 3. Its edges are received in the notches **8**, **9** to a depth indicated by broken lines **10**. The central portion of the strip **7** which is bounded by the lines **10** is formed with a row of elongated apertures or passage **12** enclosed on all sides by the ferromagnetic material, the passages extending therethrough and being so dimensioned that the combined area of the apertures in a cross-sectional plane perpendicular to the plane of FIG. 4 is greater than the combined, corresponding cross-sectional area of the bridging portions **16** of the strip **7** which longitudinally bound the apertures **12**.

Because the height of the inserted strip **7** is greater than the width of the airgap **1'** between the lines **10** in FIG. 3, and the strip **7** engages both stacks of core laminations **22**, it materially contributes to the mechanical strength of the core assembly which is shown in FIG. 2 without its associated coil windings and outer fastening elements. Each turn of the windings partly extends through the two spaces defined between the yoke laminations **6** and the core laminations **22** in the fully assembled choke or ballast.

The inserted strip or bar **7** is preferably made of material having a lower saturation value than the material of the laminations **6**, **22**. The saturation of the insert causes the discontinuity K in the magnetization curve, as shown in FIG. 1. It is also advantageous that the magnetostrictive properties of the material constituting the inserted bar or strip **7** be different from those of the core laminations **22** so that dimensional changes in response to induction forces be compensated and hum in the choke be reduced or eliminated.

In the modified choke of the invention illustrated in FIG. 4, there are provided two inserts **13** for partly bridging an airgap between a stack of core laminations **14** and respective first flange portions **23** of two stacks of yoke laminations **21** analogous to the laminations **6** in FIG. 2. The core laminations **14** are square. One edge of each lamination engages the contiguously juxtaposed second flange portions of the yoke laminations **21**. The opposite edge is part of the core face which bounds the airgap, and the two opposite remaining edges are respectively contiguously adjacent the web portions of the generally channel-shaped inserts **13**.

The flange portions of the inserts **13** are spaced for conforming engagement with inner faces of the flange portions **23** of the yoke laminations **21**, and the length of the flange portions of the inserts are such that they reach the web portions of the yoke laminations **21**. A partition **20** is spacedly interposed between the flange portions of each insert **13**. The edge portion of each insert **13** at the juncture of one flange portion with the web portion is formed with a row of slots **15**, best seen in FIG. 5, and the two slotted edge portions are arranged on either side of the airgap between the exposed face of the core of stack lamination and the opposite face constituted by terminal parts of respective flange portions **23** on the two stacks of yoke laminations **21**.

The inserts **13** are assembled with the core laminations **14** by the coil or coils wound about the core through the spaces between the flange portions and the partition **20** of each insert. The partition provides a separation of two coils or coil parts if so desired, but may be omitted where not required.

The inserts 13 protect the wound coil against damage prior to and during assembly with the yoke laminations 21.

It is a common feature of the core laminations 22, 14 that the length of their exposed edges extending in the direction of magnetic flux is approximately equal to the transverse spacing of these edges, and a corresponding relationship exists between the faces of the core stack. Such laminations can be formed by stamping from sheet stock with a minimal scrap loss. The space made available for the windings by this core configuration permits the ratio of iron to copper in the choke to be selected for optimum efficiency at lowest cost.

It should be understood, of course, that the foregoing disclosure relates only to preferred embodiments of the invention, and that it is intended to cover all changes and modifications of the embodiments of the invention chosen for the purpose of the disclosure which do not constitute departures from the scope and spirit of the invention set forth in the appended claims.

What is claimed is:

1. In a magnetic circuit for an inductor or transformer including a plurality of sets of stacked laminations, respective oppositely spaced faces of two sets bounding an airgap, the improvement which comprises:

a. an insert member of ferromagnetic material contiguously juxtaposed to each of said faces and bridging said airgap in a direction from one of said faces toward the other face,

b. said insert member being located in the magnetically active zone of said circuit and formed with passages, enclosed on all sides by said ferromagnetic material, extending therethrough transversely of said direction,

c. the flux carrying, effective cross section of said insert member transverse to said direction being much smaller than the area of each of said faces.

2. In a circuit as set forth in claim 1, one of said faces being formed with a groove, said insert member being partly received in said groove.

3. In a circuit as set forth in claim 2, the height of said insert member in said direction being greater than the width of said gap between said faces.

4. In a circuit as set forth in claim 1, the area of said apertures in a cross-sectional plane perpendicular to said direction being greater than the cross-sectional area of said insert member in said plane.

5. In a circuit as set forth in claim 1, having a core portion and a yoke portion, said portions jointly bounding a space adapted to receive a portion of a wire winding extending about said core portion, said insert member being substantially channel shaped and having a web portion contiguously juxtaposed to said core portion and two flange portions spaced in said direction and projecting from said core portion into said space transversely of said direction, an edge portion of said insert member formed with said passages extending along the juncture of said web portion with one of said flange portions and projecting beyond said one face, said one face being a face of said core portion.

6. In a circuit as set forth in claim 5, a partition projecting from said web portion intermediate said flange portions into said space.

7. In a circuit as set forth in claim 1, one of said sets constituting the core of said inductor or transformer and the other set constituting a yoke in said circuit and being substantially U-shaped in the plane of magnetic flux in said circuit.

8. In a circuit as set forth in claim 1, said circuit defining a plane of magnetic flux, one of said sets constituting a core in said circuit and having two additional faces extending in said direction and intersecting said plane, the spacing of said additional faces being approximately equal to the dimensions of said additional faces in said direction.

9. In a circuit as set forth in claim 1, said insert member being a unitary body of said material and elongated transversely of said direction.

10. In a circuit as set forth in claim 9, said ferromagnetic material differing from the material constituting the laminations of one of said sets in the intensity of induction required for saturation.

11. In a circuit as set forth in claim 9, said ferromagnetic material differing from the material constituting the laminations of one of said sets in its magnetostrictive properties.

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