Nov. 16, 1926. 1,606,761

L. R. GUILBAUD

INDUCTANCE DEVICE

Filed July 1, 1924

Fig. 1.

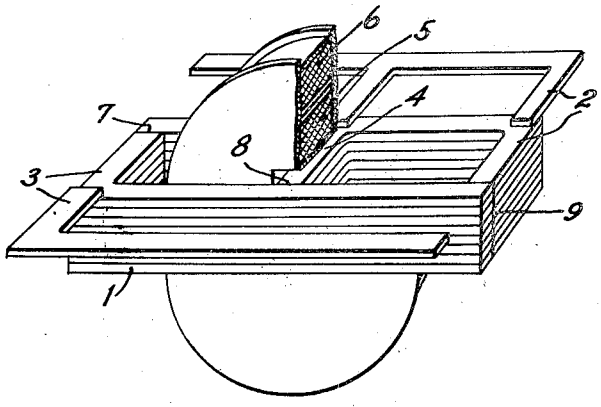


Fig. 2.

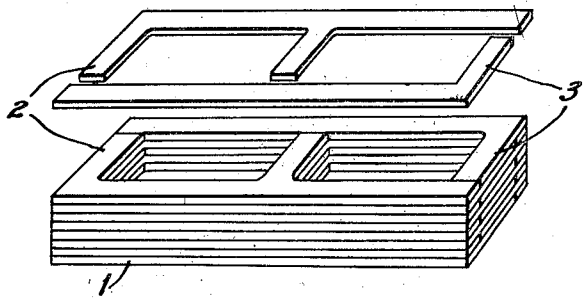


Fig. 3.

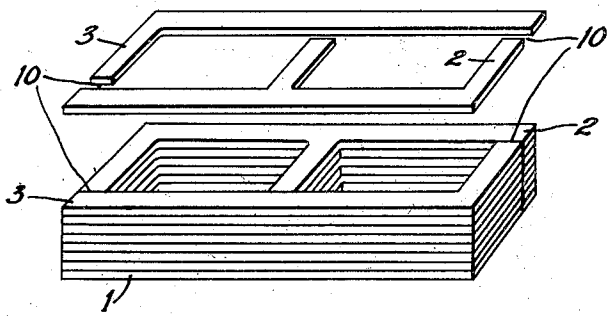
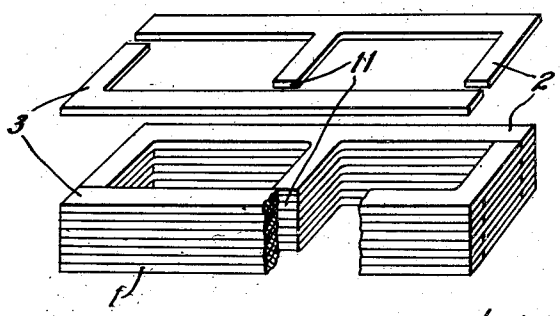


Fig. 4.



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UNITED STATES PATENT OFFICE.

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INDUCTANCE DEVICE.

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This invention relates to inductance devices known in the art as retard coils, transformers and the like, and particularly to shell-type magnetic cores for such devices.

An object of the invention in general is to provide a convenient and simple method for controlling the magnetic stability and inductance of inductance devices such as retard coils, transformers and the like, and more specifically to provide means for producing commercial shell-type laminated cores for such devices in which an increased range of magnetic stability and reluctance may be obtained.

A further object is to provide a shell-type laminated core having a reluctance intermediate between that obtainable when there is a substantially closed magnetic path in each of the limbs of the core, and when an air-gap is provided in each of the limbs of the core.

A feature of the invention comprises a stacking of the lamination sections to provide a continuous air-gap in certain of the branches of a multi-layer core and no air-gaps in others of the branches.

In inductance devices of the kind referred to above when used for carrying superimposed direct current, it is necessary that the magnetic path be provided with an air-gap or air-gaps to prevent an appreciable decrease in the inductance of the windings with increasing values of direct current. Air-gaps are readily provided in laminated cores made up of lamination sections by stacking the sections so that the joints between sections of successive layers coincide. The value of inductance and the degree of magnetic stability required for any particular purpose may be obtained by controlling these air-gaps. This control becomes especially difficult in the case of core materials of high permeability, such as permalloy, for example, which is especially sensitive to changes in magnetizing forces.

In accordance with the invention, it has been found that by various arrangements of the lamination sections, different intermediate core reluctances can be had between the no-gap condition and the condition where air-gaps are present as heretofore obtained by stacking of the lamination sections. It has been found, for example, that in the three-limb type of closed core in addition to a gap in each of the three limbs, either a gap in the central limb alone, or a gap in each of the outer two limbs only, may be obtained depending on the manner of stacking, and for each arrangement a different core characteristic is obtained. The invention thus provides a simple and effective method of obtaining graded core characteristics in cores of the same dimensions made up of identically the same laminations.

The invention is hereinafter described in connection with a transformer having a substantially shell-type magnetic core composed of a plurality of laminations. Each lamination consists of a plurality of separate pieces of core material, the points where the pieces of each layer come in contact with each other forming small air-gaps. In the embodiment to be described, the pieces forming each layer are specifically an F shaped and an L shaped strip, which, when placed together, form a two mesh magnetic core of the shell-type.

For a better understanding of the invention, reference is made to the accompanying drawings in which Fig. 1 represents a transformer in which the laminations of the core are arranged in such a way as to obtain maximum magnetic stability in the core; Fig. 2 illustrates the same number of laminations arranged in such a manner as to give the transformer windings a maximum inductance; Fig. 3 shows the same number of laminations arranged so as to obtain a magnetic stability superior to that obtained in the arrangement of Fig. 2 and an inductance larger than that obtained in the arrangement of Fig. 1; Fig. 4 shows an arrangement of the laminations to give the transformer windings an inductance and a magnetic stability intermediate between that obtainable in the arrangements shown in Figs. 1 and 2. In each of the drawings the upper two laminations are shown detached from the rest of the laminations to illustrate more clearly the arrangement of the F and L parts. Throughout the several drawings, like parts bear like reference characters.

Referring in detail to the drawings, Fig. 1 shows a transformer having a magnetic core 1 composed of a plurality of F-shaped pieces 2 and a plurality of L-shaped pieces 3. Mounted on a portion 4 of the F-shaped

pieces is a spool comprising a primary winding 5 and a secondary winding 6. It is obvious that if the laminations are arranged as in Fig. 1 with all the L-shaped pieces on one side and all the F-shaped pieces on the other side of the core, a complete air gap 7, 8, 9 is obtained in each of the three limbs of the core and the reluctance and magnetic stability of the core for a given width of air-gap are then a maximum.

If the F and L-shaped pieces 2 and 3, respectively, of the laminations are staggered one at a time, as shown in Fig. 2, each side of the core comprising an equal number of F and L-shaped pieces, then a substantially closed magnetic path is formed in each of the three limbs of the core, since at the air-gaps the magnetic flux can pass to the adjoining lamination which has no corresponding air gap, the reluctance of the air-gaps between the faces of the adjoining laminations being reduced to a minimum. With this arrangement, a minimum reluctance of the magnetic circuit and, therefore, a maximum inductance of the transformer windings is obtainable.

In the arrangement of the laminations shown in Fig. 3, the F and L-shaped pieces of the laminations are staggered so that complete air-gaps 10 are formed in the outer limbs of the core. However, in the central branch of the core a substantially closed magnetic circuit is formed, since at the air-gaps of each lamination the magnetic flux can pass to the adjoining lamination which has no corresponding air-gap, the reluctance of the air-gaps between the faces of the adjoining laminations being a minimum. With such an arrangement, the reluctance and magnetic stability of the magnetic circuit of the core will be less than that obtained in the arrangement of Fig. 4, which forms a complete air gap in the middle limb of the core and a substantially closed magnetic circuit in the outer limbs, and more than that obtained in the arrangement of Fig. 2. which forms a substantially closed magnetic circuit in all of the limbs of the core, for the reason that as has been found experimentally, complete air gaps in the outer limbs of the core have relatively less effect in increasing the reluctance of the magnetic circuit than one air gap of the same width in the central limb of the core. A probable explanation of this is the following. In the arrangement of Fig. 3, there are two magnetic paths in parallel, and therefore, any variation in the reluctance of one of them, due to irregular shearing of the laminations or imperfect contact of the F and L parts at the air-gaps, will give a reduced effect on the total reluctance of the core, as the other maganetic path will not be affected. For example, if each of the F-shaped parts of the laminations had been cut so that its middle limb was slightly longer than its outer limb, there would be an increased air-gap in one of the outer limbs of the core, and each of the L parts of the laminations would be able to move about the extremities of those middle limbs thus producing in one magnetic path an increased reluctance, and at the same time an equivalent decreased reluctance in the other magnetic path. The two effects would result in a constant reluctance for the whole core. However, it is apparent that an air-gap in the central limb of the core will affect both magnetic paths in the core, and, therefore, any change in the width of this air-gap due to irregular shearing of the lamination sections, imperfect contact of these sections, or other causes will have an increased effect on the total reluctance of the core.

Fig. 4 shows an arrangement with the F and L-shaped parts of the laminations staggered so as to form a complete air-gap 11 in the central limb of the core and a substantially closed magnetic path in each of the outer limbs of the core. The reluctance of the magnetic circuit of the core in such an arrangement will be less than that obtained in the arrangement of Fig. 1 and more than that of the arrangement of Fig. 2, and, therefore, the inductance and magnetic stability given to the transformer windings will be intermediate between that obtainable with the arrangements shown in those figures.

The four different ways of assembling the core described above will be found to cover a range of reluctance and magnetic stability sufficient for many practical purposes without the necessity of controlling too closely the width of the air-gaps in the making of the laminations. This is of particular advantage in cores of high permeability magnetic material, as in permalloy cores, for instance, in which the width of the air gap sufficient to produce the desired magnetic stability has been found to be of the order of 0.002 or 0.003 of an inch. From the foregoing, it is seen that the F and L shaped pieces of the laminations may be arranged in a shell-type core so as to obtain either one air gap in each of the outer limbs of the core and a substantially closed magnetic path in the central limb of the core, or one air gap in the central limb and substantially closed magnetic paths in the outer limbs of the core, in addition to the arrangements shown in Figs. 1 and 2 which are commonly used; and that with each different arrangement, a different characteristic is obtained for the core, with the same core pieces in each case.

Although for convenience of description, the invention has been described and illustrated in connection with transformers, it is

applicable as well to other types of inductance devices, such as retard coils and the like, having shell-type cores composed of laminations consisting of a plurality of parts, whether of the F and L shaped strips described or sections of any other shapes. By the term "magnetic stability" as used in the specification and claims is meant "sensitiveness to variations in magnetizing forces." While no windings have been illustrated in connection with the laminated cores of Figs. 2, 3 and 4, it is to be understood that either the transformer windings of Fig. 7 or any other suitable type of inductive winding may be used therewith.

What is claimed is:

1. In an inductance device having a winding, a plural-branch magnetic core therefor made of laminations each composed of sections arrangeable to control the inductance and magnetic stability by stacking the lamination sections to provide at least one branch of the core without a complete air-gap and at least one other branch of the core with a complete air-gap.

2. In an inductance device having a winding, a core therefor comprising a central limb and outer limbs, the core also comprising a plurality of layers of magnetic material, each layer consisting of a plurality of separate strips, the strips which make up the core being arranged in such a manner as to form a complete air-gap in each of said outer limbs of said core and a substantially closed magnetic path in said central limb of said core.

3. In an inductance device, a winding and core therefor, the core comprising a central limb and outer limbs, the core also comprising a plurality of layers of magnetic material, each layer consisting of a separate F-shaped strip and a separate L-shaped strip, the F-shaped and the L-shaped strips which make up the core being so arranged as to form an air-gap in said central limb and a substantially closed magnetic path in said outer limbs of said core.

4. A core for an inductance device, the core comprising a central limb and outer limbs, the core also comprising a plurality of layers of magnetic material, each layer comprising a separate F-shaped part and a separate L-shaped part, the F-shaped parts and the L-shaped parts which make up the core being so arranged as to form a complete air-gap in each of said outer limbs and a substantially closed magnetic path in said central limb.

5. A core for an inductance device the core having a central limb and outer limbs, the core comprising also a plurality of layers of magnetic material, said magnetic material having a permeability high in comparison with silicon steel core material, each of said layers comprising a separate F-shaped piece and a separate L-shaped piece, the F-shaped pieces and L-shaped pieces which make up the core being so arranged as to form a complete air-gap in each of said outer limbs of said core and a substantially closed magnetic path in said central limb of said core.

6. In an inductance device having a winding, a core therefor having a central limb and outer limbs, said core comprising also a plurality of layers of permalloy magnetic material, each of said layers consisting of an F-shaped and an L-shaped piece, the F-shaped and L-shaped pieces which make up the core being so positioned as to form a complete air-gap in each of said outer limbs of said core and a path of negligible reluctance in said central limb of said core.

In witness whereof, I hereunto subscribe my name this 25th day of June A. D., 1924.

LUCIEN R. GUILBAUD.