

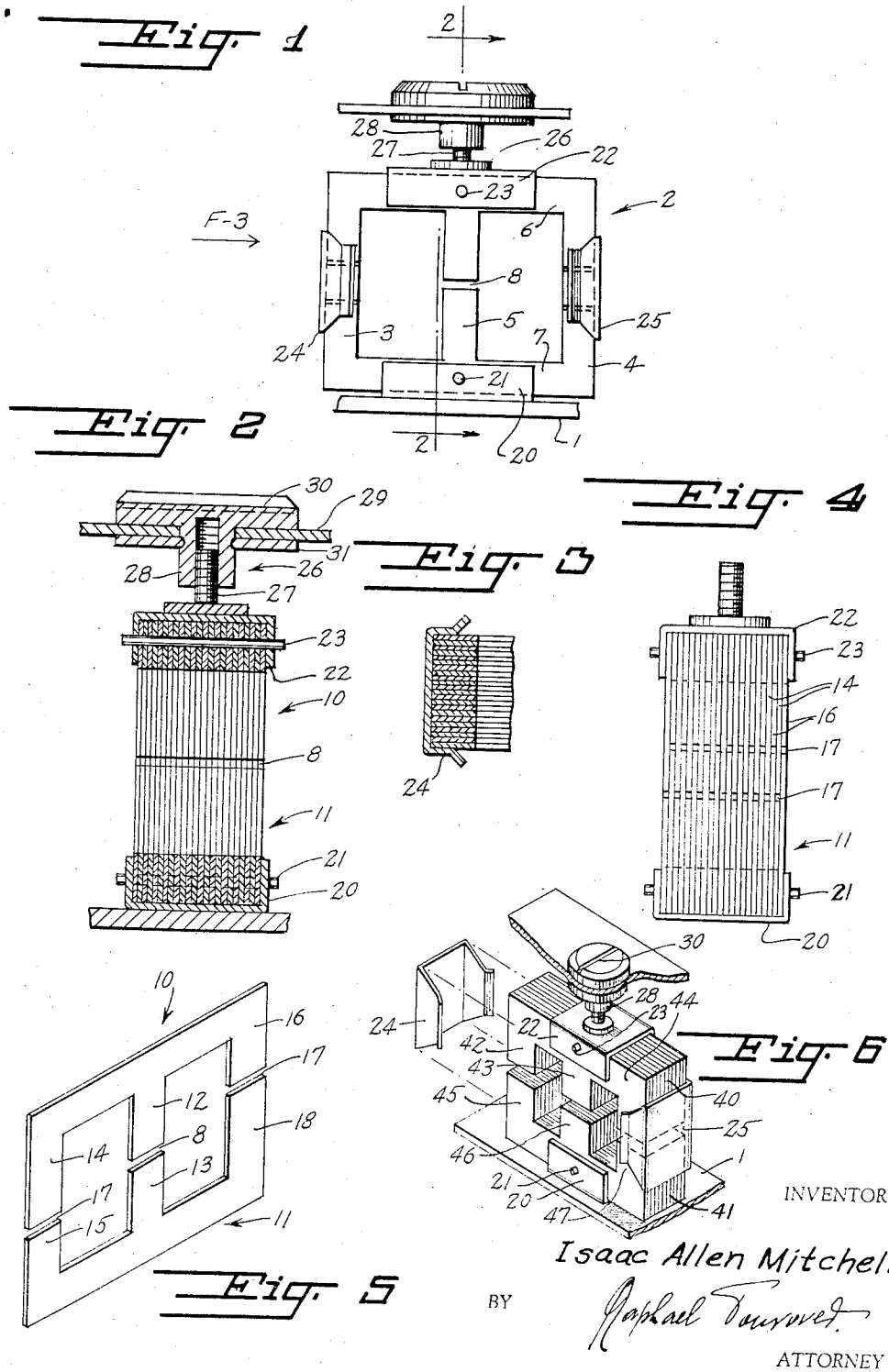
March 24, 1959

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2,879,489

INDUCTOR CORE

Filed Jan. 27, 1955



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2,879,489

INDUCTOR CORE

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Application January 27, 1955, Serial No. 484,349

4 Claims. (Cl. 336—134)

The present invention relates generally to multiple section magnetic cores for inductive devices, and more particularly to multiple section magnetic cores having provision for varying the relative positions of the core sections, wherein separate core sections are clamped together by one or more resilient clamping devices with sufficient force to prevent undesired relative motion, the relative positions of the separate core sections being varied, in order to impart desired variations of reluctance to the core, by an adjusting mechanism capable of developing forces adequate to overcome the forces developed by the resilient clamping devices.

It is commonly known that inductive devices may include cores of magnetic material. Such cores may be laminated, the laminations being of various configurations, such as E-shaped, C-shaped, F-shaped, and the like. In the alternative the cores may be solid, and in such case may be formed by molding. Such cores are commonly assembled by suitably associating two or more core sections, to form a magnetic circuit, and one or more windings are associated with the core, to form an inductor, a transformer, or the like. It may be desirable to make provision for varying the magnetic reluctance of such a magnetic core. In the case of a transformer this may vary the exciting current of the transformer, or the relative phase of input voltage to input current. In the case of an inductor, the inductance of the device, and hence its impedance, may be varied.

A large variety of devices for varying the reluctance of magnetic cores is known in the art. A common expedient is to provide a core with an air gap in the magnetic circuit of the core, the length of which may be varied to vary the reluctance of the core. Typical approaches to the problem of providing a core having a variable air gap have involved the employment of a spring means to retain one of the core elements, or the use of adjusting screws, which may be locked after being adjusted. Such structures have been found to be inherently variable under a combination of environmental conditions, involving vibration, shock, and temperature variation.

In accordance with one preferred embodiment of the present invention the core sections of a complete magnetic core are arranged to include a fixed section and a movable section. The sections are retained in position relative to one another by one or more resilient clips, which generate sufficient compressive force that the relative positions of the core sections remain fixed, once an adjustment has been made, despite shock, vibration, temperature variation, or other environmental changes. At the same time the compressive force is sufficiently weak to enable relative motion of the movable core section with respect to the fixed core section, in response to actuation by a screw or the like, which is capable of developing sufficient force to overcome the frictional forces developed by the spring clips in clamping together the two core sections.

The core sections may be held in fixed relative position by inserting elements of the separate core sections

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in one or more resilient clamps, each of the clamps common to the core sections. In this case frictional forces are developed between each core section and each clamp, which tend to hold the core sections immovable in relation to one another.

In a modification of the invention laminations of the separate core sections may be interleaved, and the resilient clamps employed to press together the interleaved laminations. Thereby, the total area subjected to compressive force is increased, and hence for a given design of resilient clamp the total frictional force developed is increased.

It is, accordingly, a broad object of the present invention to provide a novel variable reluctance magnetic core.

It is a further object of the invention to provide a novel laminated variable reluctance magnetic core, wherein the laminations are interleaved and resiliently compressed together with sufficient force to assure permanence of adjustment under a wide range of environmental conditions.

It is another object of the invention to provide a variable reluctance magnetic core, wherein the core is fabricated of a plurality of core sections which are resiliently clamped together with a force which permits relative motion of the core sections only in response to a force of greater than a predetermined magnitude, that force being selected to obviate such motion in response to variations of environmental conditions.

It is a more specific object of the present invention to provide a variable reluctance core composed of a plurality of sets of laminations, the laminations of one set being interleaved with the laminations of the other set, the sets of laminations being maintained in fixed relative position solely by one or more resilient compressive elements, which permit relative movement of the sets of laminations in response to an adequately great force, but not in response to forces of the magnitudes developed by vibration, shock and temperature variation.

It is another specific object of the present invention to provide a variable reluctance core composed of a plurality of sets of laminations, which are provided with one or more variable air gaps, the sets of laminations being maintained in fixed relative position solely by one or more resilient compressive elements, which permit relative movement of the sets of laminations in response to an adequately great force, but not in response to forces of the magnitudes developed by vibration, shock, or temperature variation.

The above and still further objects, features, and advantages of the present invention will become apparent upon consideration of the following detailed description of a specific embodiment of the invention, especially when taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a view in front elevation of an inductor core in accordance with the present invention;

Figure 2 is a view in cross-section taken on the line 2—2 of Figure 1;

Figure 3 is a view in cross-section taken on the line 3—3 of Figure 1;

Figure 4 is a view in side elevation, of the inductor of Figure 1, with certain elements removed;

Figure 5 is a view in perspective of laminations which may be employed in the practice of the invention; and

Figure 6 is a view in perspective of a modification of the invention.

Referring now more particularly to Figures 1–5 of the accompanying drawings, the reference numeral 1 denotes a portion of a supporting wall or frame, assumed stationary, and to which my novel inductor core is secured. The core 2 comprises two outer legs 3, 4, and a center leg 5, the legs being joined by top and bottom transverse

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elements 6 and 7, respectively. The center leg 5 includes an air gap 8, and on the center leg may be placed a coil of one or more windings (not shown). Variation of the length of the air gap 8 results in variation of the reluctance of the magnetic core.

The core 2 is shown as fabricated of two sets of laminations, of generally E-shape. However, the specific shape adopted for the laminations is not of the essence of the invention, and any standard types of laminations may be employed in the practice of the invention, provided they are susceptible of interleaving.

Referring to Figures 4 and 5 of the accompanying drawings, the laminations are assembled in pairs, as 10, 11, each member of a pair being identical to the other, for economy of manufacture. The center legs 12, 13 of the pair of laminations may be of identical length, but abutting outer legs, as 14, 15, may be respectively of slightly different lengths, each lamination including one relatively long leg, for example 14, and one relatively short leg, for example 15.

An air gap, as 17, is provided between abutting outer legs, 14, 15, or 16, 18, the air gap 17 being preferably at least as long as air gap 8, but not necessarily identical therewith.

When a plurality of laminations such as 10, 11, are assembled into a core, as illustrated in Figure 4 of the accompanying drawings, alternate groups of one or more laminations are reversed, so that each long leg, as 14, lies always adjacent to a short leg, as 16. Alternate interleaving of simple laminations has been illustrated for purposes of example only, and not by way of limitation. The laminations are thereby interleaved at the outer legs, to the extent that adjacent outer legs, as 14, 15, differ in length. Since the center legs 12, 13 are of identical lengths these do not interleave, and air gap 8 is maintained.

All the laminations 11, which are comprised in a core, are clamped together by a U-clamp 20, and rigidly secured to the U-clamp 20 and to each other by means of a pin 21, extending through both arms of the U-clamp 20, and through the laminations. The set of laminations 10 are similarly clamped by means of a U-clamp 22 and a pin 23.

The sets of laminations 10, 11 are clamped together resiliently, by means of spring clips 24, 25, of generally U-shaped configuration, the arms of which embrace the laminations and press them together. In the exemplified embodiment of my invention, I have illustrated the clips 24, 25 as of a particularly preferred configuration, and have located these clips in overlying relation to the air gaps 17. However, other clip configurations and sizes may be adopted, and the clips need not overlie the gaps 17, but may clamp the laminations together at any position thereof which is constructionally convenient, and which enables the requisite pressure to be exerted between adjacent interleaved surfaces. It is the function of the resilient clips 24, 25 to press the sets of laminations 10, 11 together, at their interleaved surfaces, with sufficient force that relative movement of the sets of laminations is prevented, in response to variations of environmental conditions, shock, vibration and the like.

The sets of laminations 10, 11 may nevertheless be moved relative to one another, and the frictional forces developed in response to the pressure exerted by resilient clips 24 and 25 may be overcome, in response to an adequately great force. Such a force may be exerted by a suitable screw actuator 26.

The screw actuator 26 includes an externally threaded bolt 27, secured in any convenient fashion to the base of the clamp 22, and preferably extending parallel to the plane of the laminations 10, 11 and symmetrically thereof. An internally threaded nut 28 threadably engages the bolt 27, and extends through a fixed wall 29, terminating in a slotted head 30. The wall 29 is clamped between the head 30 and a washer or other retaining

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element 31, secured about the body of the nut 28 adjacent the underside of the wall 29. The wall 29 is assumed immovable. Rotation of slotted head 30, in either sense of rotation, serves to translate the screw 27, and concomitantly the set of laminations 10. Since the set of laminations 11 is assumed fixed, translating motion of laminations 10 results in variation of the air gap 8, which varies the reluctance of the core. Since the sets of laminations 10, 11 remain in overlapping relation during their relative motion, the reluctance of the outer legs 3, 4 does not appreciably vary, the entire variation of core reluctance deriving from variation of the length of air gap 8.

Once an adjustment has been effected, by rotation of slotted head 30, the pressure exerted by resilient clips 24, 25 inherently serves to lock the laminations against undesired or inadvertent further motion. The clamping pressure, and the frictional forces developed thereby, are sufficiently great to maintain the physical relation of the sets of laminations, during shock, vibration, or other environmental conditions, but are sufficiently low, nevertheless, to permit desired adjustments in response to forces of the magnitude which may be exerted by the screw actuator 26, or equivalents thereof.

In the embodiment of my invention illustrated in Figure 6 of the accompanying drawings, two separate core sections 40 and 41 are illustrated, by way of example. The core sections 40, 41 each include three legs, 42, 43, 44 and 45, 46, 47, for example only, the abutting legs being each separated by an air gap. The separate core sections 40, 41, are clamped together by resilient clamps 24, 25, as in the embodiment of my invention illustrated in Figures 1-5 of the accompanying drawings, but no interleaving exists of the laminations comprising the core sections. The teaching of this embodiment of the invention is therefore applicable to cores which are not laminated, if desired, and to cores having any desired number of pairs of abutting legs, including one.

The frictional forces, developed in the structure of Figures 1-5 inclusive, partly between the core sections and the resilient clamps, and partly between the interleaved laminations, are developed in the structure of Figure 6 entirely between the clamps and the core sections. It follows that the specific design of the clamping elements may require to be different in the separate embodiments, in terms of clamping area, or compressive capabilities, or both.

While I have described and illustrated one specific embodiment of the present invention, it will be clear that variations of the specific details of construction may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A magnetic core having adjustable reluctance, said core comprising a pair of core sections each consisting of a plurality of laminations, each of said core sections having a base, two outside legs extending perpendicularly of said base and at least one intermediate leg extending perpendicularly of said base and subsisting between said outside legs, said intermediate legs of said core sections extending in abutting relation to provide an air gap, adjacent terminal portions of said outside legs being symmetrically interleaved by interleaving individual laminations of each leg of one core section between adjacent laminations of the corresponding leg of the other core section, means for retaining said pair of core sections in invariable relation during shock, vibration and temperature variations, said last means consisting of a pair of similar and symmetrically placed U-shaped resilient clamps, one clamp secured frictionally about each of said outside legs at their interleaved portions for pressing said interleaved laminations together, and means for varying said air gap comprising means for relatively moving said core sections against the frictional

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forces developed at the multiple adjacent interfaces of said interleaved portions of said outside legs by said resilient clamps, said last means including a threadedly engaged bolt and nut, means for securing one of said core sections immovably comprising a clamp secured symmetrically of said base of one of said core sections, said clamp being securable to a support, a further clamp secured symmetrically of said base of the other of said core sections, one of said bolt and nut being secured to an immovable support, a rotatable actuating element for said one of said bolt and nut, said rotatable actuating element having an annular slot, said immovable support extending into said annular slot, whereby said rotatable actuating member is rotatable without translation.

2. A magnetic core having adjustable reluctance, said core comprising a pair of core sections each consisting of a plurality of laminations, each of said core sections having a base, two outside legs extending perpendicularly of said base and at least one intermediate leg extending perpendicularly of said base and subsisting between said outside legs, said intermediate legs of said core sections extending in abutting relation to provide an air gap, adjacent terminal portions of said outside legs being between adjacent laminations of the corresponding leg of the other core section, means for retaining said pair of core sections in invariable relation during shock, vibration and temperature variations, said last means consisting of a pair of similar and symmetrically placed U-shaped resilient clamps, one clamp secured frictionally about each of said outside legs at their interleaved portions for pressing said interleaved laminations together, and means for varying said air gap comprising means for relatively moving said core sections against the frictional forces developed at the adjacent interfaces of said interleaved portions of said outside legs by said resilient clamps, said last means including a threadedly engaged bolt and nut, means for securing one of said core sections immovably comprising a clamp secured symmetrically of said base of one of said core sections, said clamp being securable to a support, a further clamp secured symmetrically of said base of the other of said core sections, one of said bolt and nut being secured to an immovable support and the other of said bolt and nut being secured to said further clamp, a rotatable actuating element for said one of said bolt and nut, said rotatable actuating element having an annular slot, said immovable support extending into said annular slot, whereby said rotatable actuating member is rotatable without translation.

3. A magnetic core having adjustable reluctance, said core comprising a pair of core sections, each of said core sections having a base, two outside legs extending perpendicularly of said base and at least one intermediate leg extending perpendicularly of said base and subsisting between said outside legs, said intermediate legs of said core sections extending in abutting relation to provide an air gap, adjacent terminal portions of said outside legs of one of said core sections being symmetrically located with respect to the corresponding legs of the other core section, means for retaining said pair of core sections in invariable relation during shock, vibration and temperature variations, said last means consisting of a pair of similar

and symmetrically placed U-shaped resilient clamps, separate clamps being secured frictionally about each of said outside legs, and means for varying said air gap comprising means for relatively moving said core sections against the frictional forces developed at said outside legs by said resilient clamps, said last means including a threadedly engaged bolt and nut, means for securing one of said core sections immovably comprising a clamp secured symmetrically of said base of said one of said core sections, said clamp being securable to a support, a further clamp secured symmetrically of said base of the other of said core sections, one of said bolt and nut being secured to an immovable support, and the other being secured to said further clamp, a rotatable actuating element for said one of said bolt and nut, said rotatable actuating element having an annular slot, said immovable support extending into said annular slot, whereby said rotatable actuating member is rotatable without translation.

4. A magnetic core having adjustable reluctance, said core comprising a pair of core sections each consisting of a plurality of laminations, each of said core sections having a base, two outside legs extending perpendicularly of said base and at least one intermediate leg extending perpendicularly of said base and subsisting between said outside legs, said intermediate legs of said core sections extending in abutting relation to provide an air gap, adjacent terminal portions of said outside legs being symmetrically interleaved by interleaving individual laminations of each leg of one core section between adjacent laminations of the corresponding leg of the other core section, means for retaining said pair of core sections in invariable relation during shock, vibration and temperature variations, said last means consisting of a pair of similar and symmetrically placed U-shaped resilient clamps, one clamp secured frictionally about each of said outside legs at their interleaved portions for pressing said interleaved laminations together, and means for varying said air gap comprising means for relatively moving said core sections against the frictional forces developed at the multiple adjacent interfaces of said interleaved portions of said outside legs by said resilient clamps, said last means including a threadedly engaged bolt and nut, means for securing one of said core sections immovably comprising means secured symmetrically of said base of one of said core sections, said last means being securable to a support, a further means secured symmetrically of said base of the other of said core sections, one of said bolt and nut being secured to an immovable support, a rotatable actuating element for said one of said bolt and nut, and means for supporting said rotatable actuating member for rotation without translation, whereby the other of said bolt and nut translate on rotation of said rotatable actuating member.

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