March 22, 1960 A. HUFNAGEL 2,930,012

INDUCTIVE APPARATUS

Filed Jan. 20, 1958

2 Sheets-Sheet 1

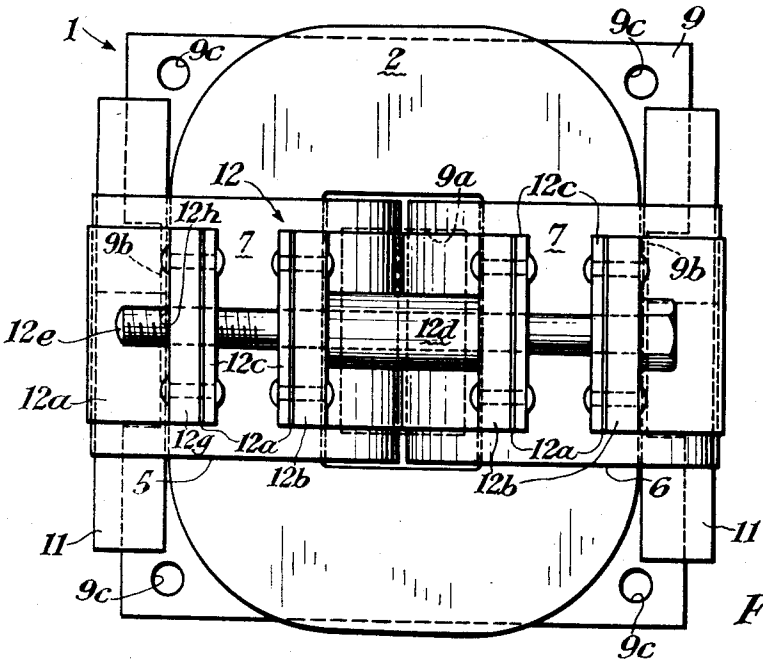


Fig. 2.

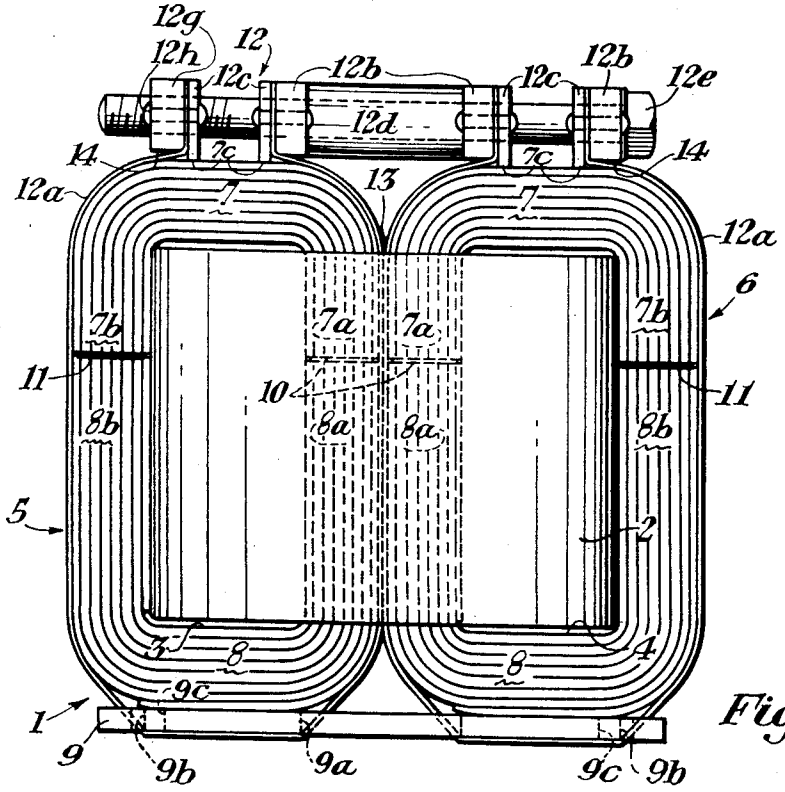


Fig. 1.

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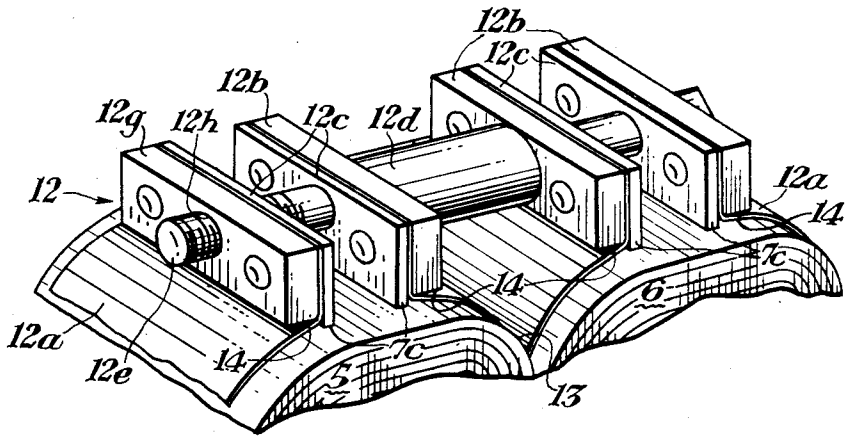


Fig. 3.

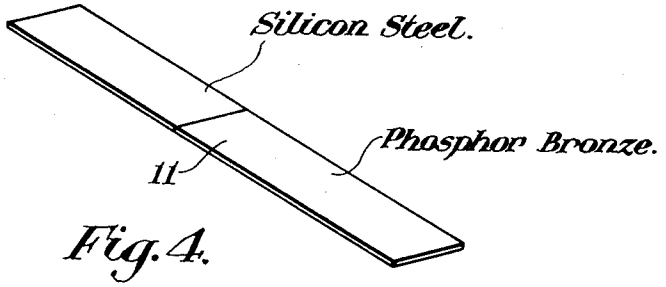


Fig. 4.

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INDUCTIVE APPARATUS

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Application January 20, 1958, Serial No. 710,112

6 Claims. (Cl. 336—178)

My invention relates to inductive apparatus, and particularly to an improved construction for reactors, transformers, and the like having cores made of highly efficient grain oriented magnetic steels.

Iron core reactors are widely used in decoding units for coded train control and coded wayside signal applications. Generally, in such a decoding unit, a reactor is connected in series with a fixed condenser, and the resultant tuned circuit is adjusted to the desired frequency by varying an air gap in the magnetic structure of the reactor.

Two forms of adjustable core reactors which have heretofore been widely used are shown and described in Letters Patent of the United States No. 1,869,364, granted August 2, 1932 to Leslie R. Allison, for Reactors, and No. 2,446,624, granted August 10, 1948 to Leslie R. Allison, for Reactance Devices, both assigned to the same assignee as the present application. Both of these reactors utilize opposing pairs of flat E-shaped laminations mounted with their legs confronting each other so as to form air gaps between them. The laminations are made of the usual type of transformer steel.

Since these reactors were developed, newer magnetic materials have become available having lower magnetic losses than heretofore obtainable, when the flux is in a particular direction therein. In order to cause the flux to traverse these materials in the proper direction, the materials are rolled into strips which are wound into a multi-layer, closed magnetic loop usually held together by a banding strap. A core formed in this manner does not readily lend itself to the manufacture of a reactor having an adjustable air gap for circuit tuning purposes, and one object of my invention is to provide an economical reactor design which will enable these newer magnetic materials to be used in tuned circuits.

Another object of my invention is to provide a reactor having a winding linking a wound layer type of core, including one or more air gaps, and in which the entire structure is secured together by straps held in place by a single clamping bolt.

Another object of my invention is to provide inductive apparatus of the type described that is compact and rugged, and which employs simple and easily manufactured parts.

A further object of my invention is to provide a novel form of reactor, including means for varying the inductance of the reactor at the time of assembly, and which may be readily returned in the field to meet a particular circuit requirement.

Other objects, purposes, and characteristic features of my invention will be in part obvious from the accompanying drawings and in part pointed out as the description proceeds.

In practicing my invention in accordance with one embodiment thereof, I provide a pair of magnetic cores each formed by winding a single, flat steel strip in multi-layers to form a closed magnetic loop. Each core is then separated to form upper and lower U shaped members having confronting legs with confronting faces normal to the axes of the legs. The lower U shaped members are placed in juxtaposition on a base plate, the axes of the confronting legs of the members being normal to the plate. Fixed and adjustable shims are placed on the faces of the inside and outside confronting legs, respectively. A preformed coil is disposed about the inside legs of the lower members, and the upper U shaped members are then positioned so that their legs confront the legs of the lower U shaped members with the shims interposed therebetween. The cores, coil plate and shims are rigidly secured in an assembled position by enclosing straps, securing blocks and a spacer bushing, all of which are apertured to receive a common bolt which is threadably engaged by one of the blocks.

In tuning a reactor so constructed, the bolt is loosened to permit longitudinal movement of the adjustable shims until the desired level of inductance of the reactor is obtained. The bolt is then tightened to firmly secure the parts in their adjusted positions.

It is to be understood that my invention is not to be restricted to a reactor, but is applicable, in its broader aspects, to transformers and inductive apparatus requiring a core of the class described for its operation.

I shall describe one embodiment of my invention, and shall then point out the novel features thereof in claims.

In describing my invention, reference will be made to the accompanying drawings, in which corresponding parts are identified by corresponding reference characters and in which:

Fig. 1 is a front elevational view of a reactor assembly embodying my invention.

Fig. 2 is a top plan view of the reactor assembly shown in Fig.1.

Fig. 3 is an enlarged perspective view of the retaining assembly of the reactor shown in Figs. 1 and 2.

Fig. 4 is an enlarged perspective view of a bimetallic shim employed in the reactor.

Referring to Figs. 1 and 2, a reactor assembly **1** is shown comprising a coil **2** of conventional construction mounted in winding spaces **3** and **4** formed by two core loops **5** and **6** placed side by side.

The core loops **5** and **6** are each wound of continuous strips of grain oriented magnetic steel providing high electrical efficiency so long as the flux traverses the material in a lengthwise direction, and are then separated into upper U shaped members **7** and lower U shaped members **8** having the legs **7***a* and **7***b* and **8***a* and **8***b*, respectively, with confronting faces normal to the axes of the legs **7***a* and **7***b* and **8***a* and **8***b*. The confronting faces of legs **7***a*, **7***b*, **8***a* and **8***b* are ground smooth to keep magnetic reluctance to a minimum.

A base plate **9** supports the lower U shaped members **8**. The base plate **9** has a central aperture **9***a* and is recessed at **9***b* on opposing sides parallel to the lengthwise direction of the strip stock forming core loops **5** and **6**. Mounting holes **9***c* are formed in each corner of base plate **9** to facilitate securing the reactor assembly **1** to any desired support structure. The lower U shaped members **8** are placed in juxtaposition on base plate **9** in such a manner that the inside legs **8***a* are adjacent, and the axes of legs **8***a* and **8***b* are normal to plate **9** (Fig. 1).

Fixed shims **10** and adjustable shims **11** are placed on the faces of legs **8***a* and **8***b*. The fixed shims **10** may be of either magnetic or nonmagnetic material, depending upon the general level of inductance required in the reactor. The adjustable shims **11** are bimetallic and comprise a portion of suitable magnetic material, such as silicon steel, and a portion of nonmagnetic material, such as Phosphor bronze, joined in end-to-end relation by any convenient means, such as butt welding (see Fig.

4). The shims 10 and 11 have the same thickness, so that when the reactor is assembled and members 7 and 8 are drawn tightly together, full surface contact will take place between the shims and confronting faces of legs 7*b*—8*b* and 7*a*—8*a*, respectively.

Apertures 3 and 4 formed by core loops 5 and 6 receive coil 2. After coil 2 is disposed about adjacent inside legs 8*a* of lower members 8, upper U shaped members 7 are positioned with respect to members 8, so that confronting faces of legs 7*a* and 8*a* and 7*b* and 8*b* confront fixed shims 10 and adjustable shims 11, respectively (Fig. 1).

Referring now to Figs. 2 and 3, assembled core loops 5 and 6, coil 2, and plate 9 are secured together by a retaining assembly 12. The assembly 12 comprises straps 12*a*, encircling the periphery of each of the core loops 5 and 6, blocks 12*b* and 12*g*, plates 12*c*, a spacer bushing 12*d* and a bolt 12*e*. Each end of straps 12*a* is secured between a block 12*b* or 12*g*, and a plate 12*c* by any convenient means, for example, by rivets (Fig. 3).

The straps 12*a*, blocks 12*b* and 12*g*, plates 12*c*, and spacer bushing 12*d* are provided with aligned apertures to receive the bolt 12*e*. The aperture 12*h* in the block 12*g* is threaded to engage threads provided on bolt 12*e*, whereby all of the parts may be secured together by means of the bolt 12*e*. On both block 12*g* and bolt 12*e* a large number of threads with a small clearance tolerance are used so that a lock nut is not required to retain the bolt in its tightened position. Spacer bushing 12*d* is provided to maintain a rigidly braced assembly which tends to prevent core loops 5 and 6 from bowing at a top center position 13 defined by adjacent legs 7*a* of upper U shaped members 7 (see Figs. 1 and 3).

As best shown in Figs. 1 and 3, plates 12*c* bear on core loops 5 and 6 at 7*c*, and blocks 12*b* and 12*g* bear on straps 12*a* at 14. The thickness of straps 12*a* added to the height of block 12*b* or 12*g* equals the height of plates 12*c*. This arrangement permits block 12*b* or 12*g* and straps 12*a* to form a nearly right angle with core loops 5 and 6, when firmly secured, so as to rigidly retain reactor assembly 1. The blocks 12*b* and 12*g*, in bearing on straps 12*a*, force straps 12*a* to bear against core loops 5 and 6, thereby maintaining the shape and position of the core loops.

As shown in Figs. 1 and 2, one of straps 12*a*, having its ends secured between block 12*b* or 12*g* and plate 12*c*, encircles the periphery of core loop 5 and secures core loop 5 to base 9 by engaging recess 9*b* and passing through aperture 9*a*. In a similar manner core loop 6 is secured to base 9. Spacer bushing 12*d* is then placed into position as shown in Figs. 1, 2 and 3, and bolt 12*e* is inserted within the aligned apertures in straps 12*a*, block 12*b*, plates 12*c*, and spacer bushing 12*d*, and retaining assembly 12 is tightly secured through the threaded engagement of bolt 12*e* and block 12*g*.

With reactor assembly 1 and retaining assembly 12 constructed and arranged in the manner described, bolt 12*e* is initially not fully tightened, thereby permitting a longitudinal movement of bimetallic shims 11 (see Fig. 2). The positions of bimetallic shims 11, between legs 7*b* and 8*b*, are varied simultaneously in a longitudinal direction to obtain the desired tuning by varying the reluctance of core loops 5 and 6. The bimetallic shims 11 are varied simultaneously to prevent unbalanced magnetic fluxes in the two core circuits. With the nonmagnetic portions of bimetallic shims 11 in core loops 5 and 6, the reluctance will be at a high value, equivalent to the reluctance of an air gap. From test data taken on an experimental model, it was found that as the magnetic portions of bimetallic shims 11 are moved into core loops 5 and 6 at 7*b*—8*b*, the inductance of reactor assembly 1 increases in a fairly linear fashion. The linear relation continues until there is so much of the magnetic portions of bimetallic shims 11 within core loops 5 and 6 that the magnetic portions of the shims are no longer saturated. A further insertion of the shims will increase the inductance to a progressively lesser extent, because the cross-sectional areas of the inserted magnetic portions are now approaching the cross-sectional areas of the core loops. For this reason, the magnetic portion of bimetallic shims 11 need not be as long as the nonmagnetic portion. The positions of bimetallic shims 11 are varied within core loops 5 and 6 until the circuit is found to be in tune and reactor assembly 1 is then locked securely in place through threaded engagement between bolt 12*e* and block 12*g*.

Should it be necessary to retune reactor assembly 1 in the field, it is a relatively easy matter to loosen bolt 12*e*, reposition bimetallic shims 11 to a new level of inductance by the method previously described, and then retighten bolt 12*e* so reactor assembly 1 is rigidly secured.

Although I have herein shown and described only one form of a reactor embodying my invention, it is to be understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. A reactor, comprising, in combination, a base plate having a centrally located opening, a pair of multi-layer wound magnetic cores each having first and second generally U shaped members in a confronting relation with confronting legs and confronting faces, each of said first U shaped members being disposed on said base plate and having adjacent inside legs and spaced apart outside legs normal to said base, a coil disposed about said inside legs and confined by said first and second U shaped members in said confronting relation, adjustable shims disposed between confronting faces of said outside legs and fixed shims disposed between confronting faces of said inside legs, first and second straps each having first and second ends, first and second blocks and plates, said first ends of said straps being secured between said first blocks and plates, each of said straps passing along the outside edge of one of said cores, then under said base plate, through said opening and along the inside edge of the said one of said cores, said second ends being secured between said second blocks and plates to secure said cores to said base plate, a spacer bushing disposed between adjacent second ends of said straps to position said cores on said base plate, a bolt received within aligned apertures in said straps, blocks, plates and spacer bushing, and one of said first blocks threadably engaging said bolt, whereby said reactor may be rigidly held together or loosened to permit adjustment of said adjustable shims to vary the inductance in said reactor.

2. In a reactor, grain oriented magnetic strip material having maximum flux carrying properties in the direction of the grain orientation of said material and wound in multi-layers to form a pair of cores, each of said cores comprising first and second U shaped members in a confronting relation having confronting legs with confronting faces, a mounting plate having a centrally located opening, said plate engaging a closed end of said first U shaped members which form a pair of adjacent inside legs and a pair of spaced apart outside legs normal to said plate, a coil disposed about said inside legs and confined by said first and second U shaped members in said confronting relation, fixed shims disposed between confronting faces of said inside legs, and adjustable shims disposed between confronting faces of said outside legs, a retaining strap running along the outside edge of each of said cores, passing under said plate, through said opening, and running along the inside edge of each of said cores, and having ends terminating adjacent the closed ends of said second U shaped members, and adjustable means for securing said ends, whereby said reactor can

be rigidly held together or loosened to permit adjustment of said adjustable shims to vary the inductance of said reactor.

3. In an inductor, a pair of substantially rectangular cores each comprising two generally U shaped pieces having abutting joints between the respective ends of the two pieces, said cores being arranged relative to each other to form substantially parallel outer legs and a pair of adjoining inner legs, at least one shim disposed between respective abutting joints of the inner and the outer legs of said cores, a coil disposed about said inner legs of said cores, a support plate for said cores and a hole in said plate, means for securing each of said cores to said plate running along the outer edge of each of said cores and under said plate, through said hole in said plate, and along the inner edge of each of said cores, the ends of each of said securing means terminating adjacent each other and having secured thereon enlarged portions for reinforcing said ends, means for spacing the inner ones of said ends of said securing means a predetermined distance apart, said spacing means, said ends of said securing means, and said enlarged portions each being provided with an aperture, and a single bolt for moving the ends of each of said securing means toward each other passing through said apertures and becoming threadably engaged to the last one of said enlarged portions through which said bolt passes.

4. Inductive apparatus of the class described comprising a pair of substantially rectangular cores each comprising two generally U shaped core members having abutting joints, said pairs being arranged relative to each other forming two spaced apart outside legs and two inside legs in juxtaposition, at least one shim disposed between respective abutting joints of the inside legs and the outside legs of said pairs of core members, a coil mounted on said inside legs, a mounting plate engaging adjacent bight portions of two of said core members and a hole in said plate, straps for binding each of said cores to said plate, each of said straps being adapted to extend along the outer edge of the outside legs of each of said cores and under said plate, through the hole in said plate, and along the inner edge of the inside legs of each of said cores, the ends of each of said straps terminating adjacent each other and having secured thereon means for reinforcing said ends, means for spacing the innermost ends of each of said straps a predetermined distance apart, said spacing means, the ends of said straps, and said reinforcing means each being provided with a hole, and fastening means passing through said holes and being adapted to adjustably engage the last one of said reinforcing means through which said fastening means passes, whereby by loosening said fastening means, adjusting the positions of said shims at said outside legs, and retightening said fastening means the reluctance of said core can be varied to provide any desired value of inductance in said core.

5. Inductive apparatus, comprising, in combination, four generally U shaped magnetic core members, each of said members having its legs confronting the legs of one other of said core members to form first and second pairs of core members, said first and second pairs of core members being disposed in parallel planes with one side of each of said pairs forming adjacent inside legs, a coil mounted on said inside legs, a mounting plate for said pairs of core members disposed normal to the axes of the legs of said core members, a pair of straps each being adapted to substantially encircle one pair of said core members and being further adapted to engage said plate to thereby rigidly hold that pair of core members against said plate when the ends of the strap associated therewith are drawn together, first means mounted to the ends of said straps for reinforcing said ends, means for spacing the inner ends of said straps a predetermined distance apart, said spacing means, said first means, and said strap ends each having a hole, and means for drawing the ends of each of said straps toward each other being adapted to pass through said holes and being further adapted to threadably engage the last one of said first means through which said last named means passes.

6. In a reactor, a substantially rectangular magnetic core comprising a pair of generally U shaped core members having confronting legs forming abutting joints, a mounting plate for said core members disposed in juxtaposition with the bight portion of one of said core members, at least one shim disposed between the abutting joints of said legs, a coil mounted on confronting legs of said core members in such manner that the shim between the abutting joints of the other of the confronting legs is accessible for adjustment, a strap being adapted to substantially encircle said core and being further adapted to engage said plate so that the force holding said shims in place is progressively increased as the strap ends are drawn toward each other, a hole in each of said strap ends, and means for moving the strap ends toward each other, thereby tightening said strap about said core, said last named means being in the form of a single bolt adapted to pass through said holes and being further adapted to threadably engage said strap ends so that when said bolt is loosened the shim may be positioned to change the reluctance of said core and thereby change the inductance of said coil.

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