Jan. 8, 1929. 1,698,634

S. E. JOHANNESEN

ELECTRICAL INDUCTION APPARATUS

Filed Jan. 24, 1928

Fig. 1.

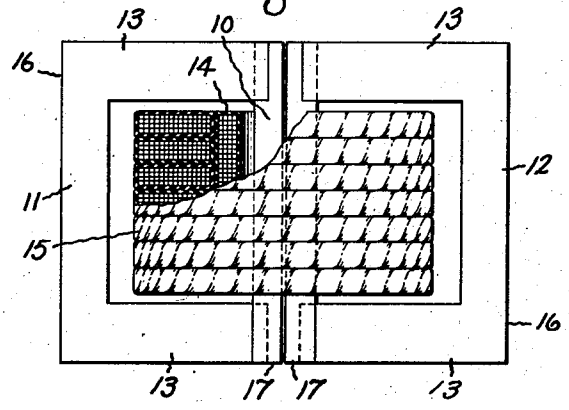
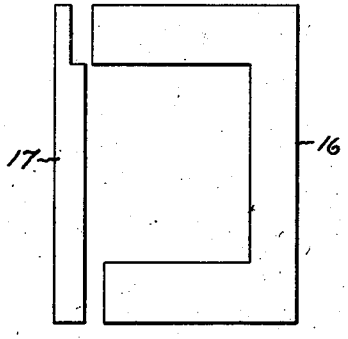


Fig. 2.



Inventor:
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UNITED STATES PATENT OFFICE.

SVEND E. JOHANNESEN, OF PITTSFIELD, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRICAL INDUCTION APPARATUS.

Application filed January 24, 1928. Serial No. 249,159.

My invention relates to electrical induction apparatus such as transformers and reactors, and more particularly to an improved magnetic core construction for this type of apparatus. Any well designed magnetic core is built up of thin laminations of magnetic material, the laminations being insulated from each other to reduce losses due to eddy currents. The magnetic material most commonly used in core laminations is a high grade of silicon steel. Certain alloys having high permeability, such as the nickel-iron alloys known as nicaloi and permalloy, have also been used in magnetic cores in some cases but the cost of these alloys has so far been so great as to make their general use prohibitive. This disadvantage due to greater cost of these alloys as compared with that of the silicon steel is partially offset, however, by the fact that the hysteresis and eddy current losses are substantially smaller. The general object of the present invention is to provide an improved magnetic core construction in which an expensive material having high permeability or low magnetic losses per unit volume and a less expensive material of comparatively lower permeability or higher magnetic losses per unit volume are both used with certain desirable advantages resulting from the combination.

The invention and its advantages will be better understood from the following description taken in connection with the accompanying drawing in which Fig. 1 shows a transformer core constructed in accordance with the invention and provided with windings, a portion of the windings being broken away to reveal the construction more clearly, and Fig. 2 shows one of the core laminations. Life reference characters indicate similar parts in both figures of the drawing.

The particular transformer shown in Fig. 1 includes a magnetic core having a central winding leg 10, two outer legs 11 and 12 and yokes 13 connecting the three core legs at their ends. The winding leg 10 is surrounded by a low voltage winding 14 and a high voltage winding 15. The core is formed in two symmetrical halves which meet along the axis of the winding leg 10. Each lamination of each half of the core is formed of a U-shaped element 16 and a straight element 17 joining the ends of the U-shaped element. The lamination elements 17 which form the winding leg 10 are composed of the more expensive material having high permeability or low magnetic losses per unit volume such as one of the well known nickel iron alloys having this property. The outer core legs 11 and 12 and the yokes 13, however, are composed of some less expensive and less permeable material such as silicon steel.

If the cross section of the winding leg 10 is twice that of each outer leg and its yokes, then, neglecting any small leakage flux, the density of the magnetic flux will be uniform in the several core parts because all the flux flows through the winding leg but only half of it through either outer leg and its yokes. For a given loss in any core part, the cross section of the part and therefore the amount of magnetic material used in the part may be substantially smaller if an expensive high permeability material is used than if a less expensive material having lower permeability is used. But the use of such expensive material in the outer core legs 11 and 12 and in the yokes 13 is not justified because the much higher cost of the material is not nearly offset by reduced losses or the possible saving in the amount of material necessary or both. The use of the better material in the winding leg 10, however, has further decided advantages. The smaller cross section of the winding leg permits the windings which surround it to be smaller so that not only are smaller amounts of copper and insulation necessary for a given number of turns but the electrical losses in the windings are reduced. The reduced size of windings in turn permits a reduction in the lengths of the outer core parts including the outer core legs 11 and 12 with their yokes 13 so that here also there is a saving in material and also a reduction in magnetic losses.

From the preceding description of the invention and its advantages, it will be apparent that decided savings in material and improvement in efficiency practically throughout the transformer structure results from the use of magnetic material having high permeability or low losses per unit volume in the winding leg or core part surrounded by a winding or windings. It will also be apparent that there is ample room for any desired cross section of the outer core parts including the outer core legs 11 and 12 and their yokes 13 without affecting in any way the amount of material or the electrical and

magnetic efficiencies in the winding leg and in the windings. The use of the better and more expensive material in these outer core parts is therefore not justified because the comparatively small advantages secured are more than offset by the much greater cost of this material as compared with a less expensive material having lower permeability or higher losses per unit volume. As indicated in the drawing, the cross section of the highly permeable winding leg may be considerably smaller than the combined cross sections of the two less permeable outer core parts which connect the ends of the winding leg.

The invention has been explained by describing and illustrating one particular application thereof but it will be apparent that various changes may be made within the scope of the invention as defined by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Electrical induction apparatus including a magnetic core, and a winding surrounding a part of said core, the core part surrounded by said winding including material having lower magnetic losses per unit volume than material in other core parts outside said winding.

2. Electrical induction apparatus including a magnetic core, said core being formed of parts having different magnetic losses per unit volume, and a winding surrounding the core part having lowest losses per unit volume.

3. Electrical induction apparatus including a magnetic core, and a winding surrounding a part of said core formed of a nickel iron alloy having high permeability, other parts of said core outside said winding being formed of material having lower permeability than that of said alloy.

4. Electrical induction apparatus including a magnetic core having a winding leg and magnetic material connecting the ends of said winding leg, and a winding surrounding said winding leg, the cross section of said winding leg being smaller than the total cross section of said material connecting its ends, and the winding leg being formed of material having a permeability higher than that of the magnetic material connecting its ends.

5. Electrical induction apparatus including a magnetic core having a winding leg and a plurality of outer legs connected to the ends of said winding leg, and a winding surrounding said winding leg, said winding leg having higher permeability than that of said outer legs.

In witness whereof, I have hereunto set my hand this 21st day of Jan., 1928.

SVEND E. JOHANNESEN.

DISCLAIMER

1,698,634.—*Svend E. Johannesen*, Pittsfield, Mass. ELECTRICAL INDUCTION APPARATUS. Patent dated January 8, 1929. Disclaimer filed September 12, 1929 by the assignee, *General Electric Company*.

Hereby disclaims the subject matter of claims 1, 2, and 5

[*Official Gazette October 1, 1929*]