Dec. 14, 1926. 1,610,867

J. S. LENNOX

TRANSFORMER

Filed Sept. 18, 1923

Fig. 1.

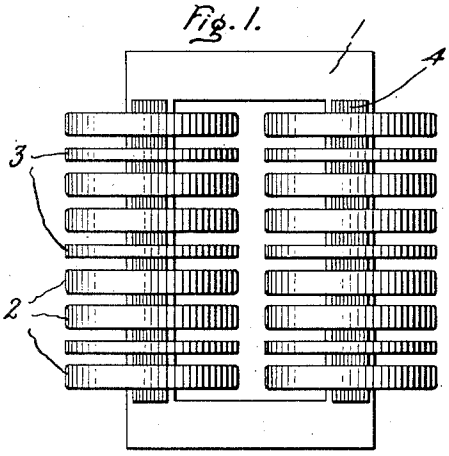


Fig. 2.

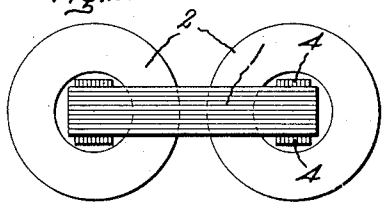


Fig. 3.

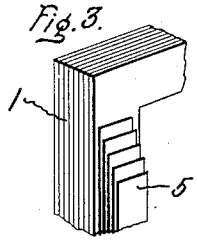


Fig. 4.

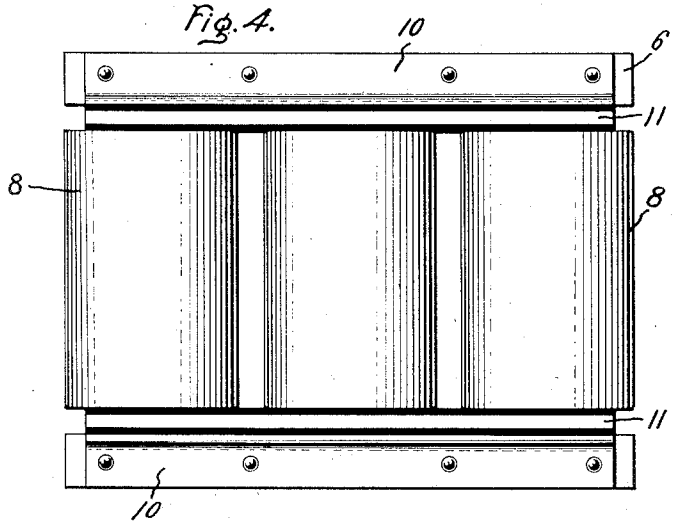


Fig. 5.

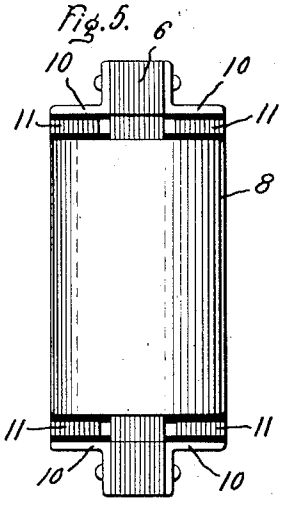


Fig. 6.

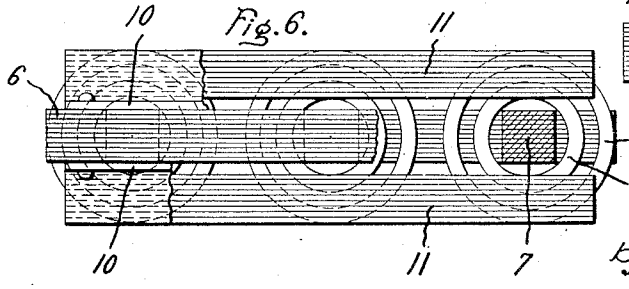
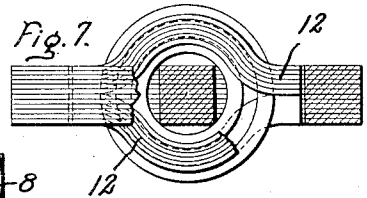


Fig. 7.



Inventor:
John S. Lennox,
by Alexander S. Lunt.
His Attorney.

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UNITED STATES PATENT OFFICE.

JOHN S. LENNOX, OF PITTSFIELD, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

TRANSFORMER.

Application filed September 18, 1923. Serial No. 663,469.

My invention relates to transformers. In the operation of a transformer, the main magnetic flux which links both the primary and secondary windings is substantially confined to the magnetic core but there is always some leakage or stray flux which leaves the windings and then finds its way back into them through paths outside the core. In some transformers, the amount of leakage flux is considerable, especially in transformers having large reactance, and it always seeks the easiest return paths which may include winding and core clamps and other structural magnetic parts which are not formed of proper material nor suitably laminated to prevent objectionable hysteresis and eddy current losses. These losses not only reduce the efficiency of the transformer but appear in the form of heat which may raise the temperature at the points where the losses occur to such an extent as to cause injury to adjacent insulation used in the transformer structure. In the case of an oil immersed transformer, the heat resulting from stray magnetic flux may cause deterioration of the oil such as to impair its dielectric strength and produce an objectionable accumulation of sediment. The general object of the invention is to provide means for reducing the losses due to the stray magnetic flux, thus increasing the efficiency of the transformer and eliminating or reducing the heating effect of this stray flux. These results are attained by providing suitable auxiliary return paths for the stray magnetic flux.

Transformer cores are usually built up of thin magnetic sheets or laminations, the resistance between the laminations serving to reduce eddy currents which would otherwise cause objectionable losses and heating. However, if the magnetic flux is permitted to enter or leave the core in a direction across the laminations, it will produce eddy currents and consequent losses and heating considerably greater than if it enters or leaves the core edgewise of the laminations so that none of the flux passes perpendicularly through any of the laminations. Another object of the invention is to reduce losses and heating by providing auxiliary laminated paths for reducing the amount of stray or leakage flux which enters or leaves the core laminations otherwise than edgewise thereof.

Other objects and advantages will appear from the following description taken in connection with the accompanying drawing in which Fig. 1 is a view in elevation of a core type transformer provided with auxiliary laminated stray flux paths in accordance with the invention, Fig. 2 is a plan view of the transformer shown in Fig. 1, Fig. 3 is a detail view showing a modification, Fig. 4 is a view in elevation of a three phase transformer provided with laminated stray flux paths in accordance with the invention, Fig. 5 is an end view of the transformer shown in Fig. 4, Fig. 6 is a plan view, partly broken away, of the transformer shown in Figs. 4 and 5, and Fig. 7 is a plan view of a shell type transformer provided with auxiliary stray flux paths in accordance with the invention.

Like reference characters refer to similar parts in the different figures of the drawing.

One form of the invention is shown in Fig. 1 in connection with a single phase core type transformer. The transformer includes a core 1 having two winding legs, each winding leg being surrounded by a stack of interleaved high tension winding coils 2 and low tension winding coils 3. By reason of the low reluctance of the core as compared with that of the air or other dielectric surrounding the windings, most of the magnetic flux produced by current in the primary coils is confined to the core. There is, however, an appreciable and often a considerable amount of so-called stray or leakage flux which is produced by the primary winding and which follows paths which are entirely or partially outside the core. The leakage flux from transformer windings of the interleaved type such as those shown in Figs. 1 and 2 leave the windings from the spaces between the primary and secondary winding sections or coils and reenter the windings through other similar spaces. This is true, of course, both inside and outside of each coil stack. The primary winding may be either the low tension or the high tension winding, depending upon whether the transformer is to step the voltage up or down. The stray flux inside each stack of windings will of course pass through the laminated winding leg of the core as this is the path of least reluctance. The effect of that portion of the stray flux which enters and leaves the core leg edgewise of the laminations is not appreciably objectionable as the reluctance between lamina-

tions confines each element of flux to a single lamination and so prevents appreciable eddy currents in the core. If any of this flux, however, is permitted to enter or leave the core leg crosswise of the laminations, it will produce eddy currents with consequent losses and heating. In accordance with the invention, therefore, auxiliary laminated magnetic members 4 are mounted on the faces of the outside core laminations to divert stray flux from paths transversely intercepting the laminations and thus to shield the core leg from flux approaching it crosswise of its laminations. The laminations of these auxiliary shielding members 4 are at right angles to the laminations of the shielded core leg so that the stray flux will enter and leave them edgewise with minimum resulting eddy currents.

Another form of auxiliary laminated member 5 is indicated in Fig. 3. This form is similar to the auxiliary members 4 of Figs. 1 and 2 but its laminations are parallel instead of at right angles to those of the core 1. The ends of the laminations are stepped, the outer lamination being shortest and those beneath it being progressively longer and longer. Stray flux approaching the core nea the end of the laminated member 5 can obviously enter the laminations through their end edges and pass through them without reaching the core 1 and without causing objectionable eddy currents. Auxiliary members of this form may be of suitable lengths and locations to bring their stepped ends into the paths of the leakage flux between the windings and core and so prevent this flux from entering the core.

Another form of the invention is shown in Figs. 4, 5, and 6 in connection with a three phase transformer having concentric cylindrical windings. The core 6 has three winding legs 7, each winding leg being surrounded by the high and low tension cylindrical windings 8 and 9 of one of the three phases. The windings are supported between core clamps 10 secured to the core yokes. The stray flux here passes through the cylindrical space between the two windings 8 and 9, returning from one end of this space to the other end through any available path or paths. Whichever the direction of the stray flux may be through the cylindrical space between the two windings on any one core leg, it is always in the opposite direction in at least one and part of the time in both of the cylindrical spaces between the windings on the other core legs so that a large part of the stray flux from any one of these winding spaces returns through one or both of the other winding spaces. Auxiliary laminated magnetic members 11 are located between the core clamps 10 and the ends of the windings 8 and 9 to provide paths of low reluctance between the ends of the winding spaces, the clamps 10 being thus shielded from the stray flux flowing between the ends of these winding spaces. The laminations of the members 11 are arranged edgewise to the direction of the flux as it leaves or enters the winding spaces to reduce eddy current losses and heating. The members 11 are insulated from the clamps 10 to prevent short-circuiting of the laminations.

A single phase shell type transformer with concentric cylindrical windings is shown in Fig. 7. An auxiliary laminated magnetic member 12 is located at each end of the cylindrical space between the two windings and at each side of the core to receive the stray flux as it leaves this space. The ends of these auxiliary members 12 are curved in against the inner faces of the core yokes so that the stray flux from one end of the cylindrical winding space may follow the adjacent auxiliary members 12 to the inner edges of the yoke laminations, thence edgewise into these laminations, then through the outer legs of the core and through the other auxiliary members 12 to the other end of the winding space. The laminations of the auxiliary members 12 are arranged edgewise to the direction of the flux as it enters them from the winding space and also as it leaves them to enter the core yoke. The stray flux is thus prevented from reaching structural parts of the transformer, such as core and coil clamps, which cannot be conveniently laminated and arranged to prevent objectionable eddy current losses.

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

1. A transformer structure including a laminated magnetic core, windings on said core, and an auxiliary magnetic member for diverting leakage magnetic flux away from a path transversely intercepting to the laminations of said core.

2. A transformer structure including a laminated magnetic core, windings on said core, and an auxiliary magnetic member for changing the direction of the path of leakage magnetic flux from a path transversely intercepting the laminations of said core to a path substantially parallel to said laminations.

3. A transformer structure including a laminated magnetic core having a plurality of winding legs, a group of windings on each of said winding legs, each of said groups comprising spaced concentric cylindrical windings, whereby leakage magnetic flux is induced through the spaces between said windings, and an auxiliary laminated magnetic member independent of said core and extending from one to another of said winding spaces.

In witness whereof, I hereunto set my hand this 13th day of Sept., 1923.

JOHN S. LENNOX.