

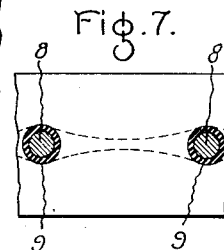
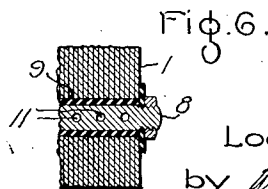
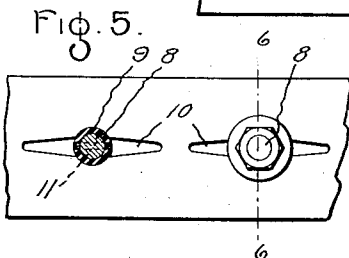
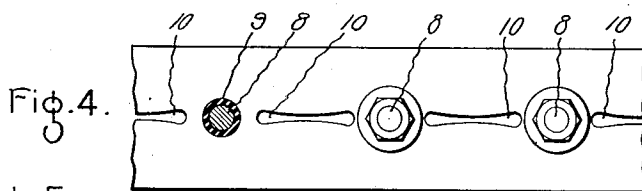
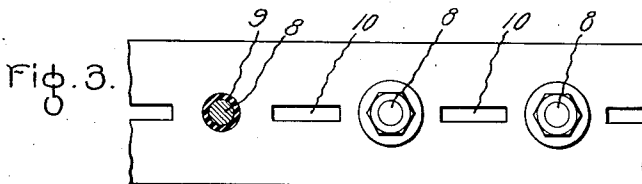
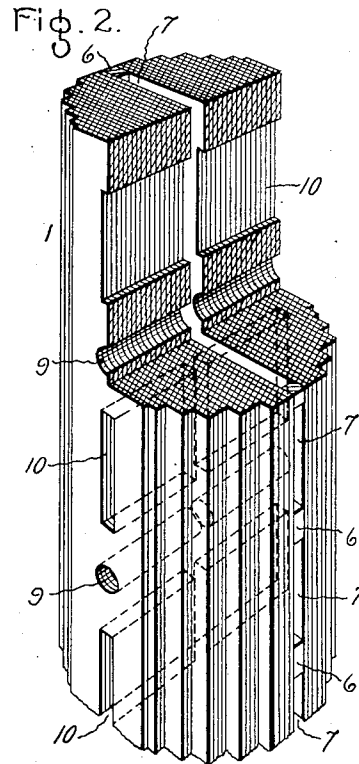
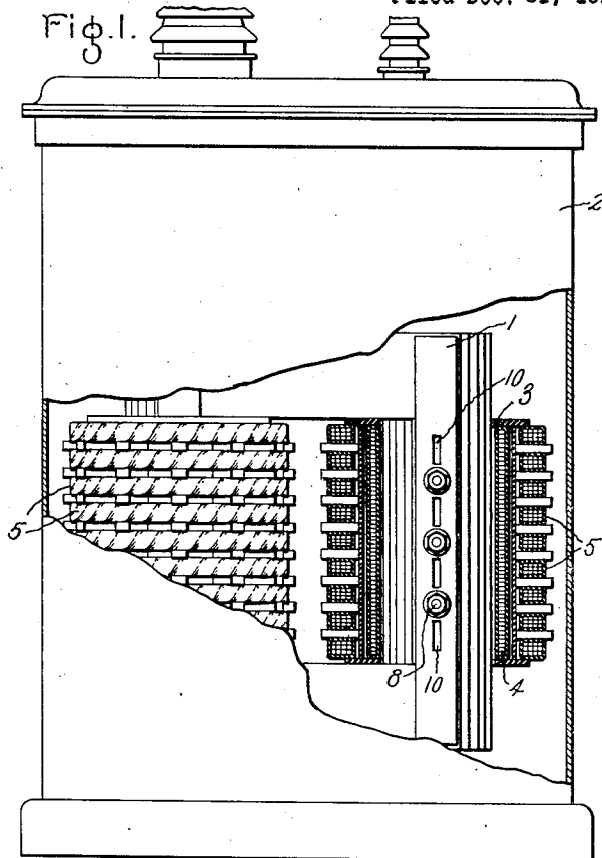
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1,546,885

L. H. BURNHAM

TRANSFORMER CORE

Filed Dec. 31, 1923



Inventor:
Locke H. Burnham,
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UNITED STATES PATENT OFFICE.

LOCKE H. BURNHAM, OF PITTSFIELD, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

TRANSFORMER CORE.

Application filed December 31, 1923. Serial No. 683,539.

To all whom it may concern:

Be it known that I, LOCKE H. BURNHAM, a citizen of the United States, residing at Pittsfield, in the county of Berkshire, State of Massachusetts, have invented certain new and useful Improvements in Transformer Cores, of which the following is a specification.

My invention relates to transformer cores.

The hysteresis and eddy current losses in the magnetic core of a transformer appear as heat which must be properly dissipated to prevent excessive temperatures in the core and the general object of the invention is to provide a transformer core structure adapted to be efficiently cooled by a cooling and insulating fluid, such as air or oil, passing over its surfaces.

The invention is particularly useful in connection with laminated cores which are of considerable size and which are therefore built up of laminations so large as to require one or more rows of bolts to hold them together. The openings provided in the laminations for these bolts obstruct the core flux and shield portions of the laminations so that these shielded portions carry little or no magnetic flux during the operation of the transformer. The bolts are, of course, generally insulated from the laminations to prevent short circuiting them. In accordance with the invention, these shielded or neutral portions of the laminations are partially removed by punching or otherwise to provide ducts in the finished core through which a cooling fluid, such as air or oil, may flow to absorb and carry away the heat generated in the interior of the core by hysteresis and eddy currents. It has been found by experiment that the removal of these small neutral portions of the laminations does not impair the efficiency of the finished core but rather tends to increase its efficiency. It is thought that one reason for this is that the small additional openings in the laminations permit the laminations to be more uniformly annealed by allowing the heated gases during the annealing process to reach all parts of the laminations more uniformly and bring them to a more uniform temperature.

Further objects and advantages will appear from the following description in connection with the accompanying drawing, in

which Fig. 1 shows a transformer of the enclosed oil immersed type, parts being broken away to reveal details of construction of the transformer core, Fig. 2 is an isometric view of a section of one of the laminated winding legs of the core, Fig. 3 is a view of a section of one face of the winding leg of a core showing one form of ventilating duct provided in accordance with the invention, Fig. 4 is a view similar to that of Fig. 3 but showing another form of ventilating duct, Fig. 5 is a view similar to those of Figs. 3 and 4 but showing still another form of ventilating duct, Fig. 6 is a sectional view on the line 6-6 of Fig. 5, and Fig. 7 shows the outlines of the flux paths past the bolts which secure the core laminations together.

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

The invention is shown in Fig. 1 as applied in the construction of the core 1 of a transformer of the oil immersed type enclosed in a casing 2. The winding legs of the transformer are each surrounded by an insulating cylinder 3 outside of which are mounted a low tension winding 4 and a high tension winding 5. The heat generated in the winding legs of the core during operation of the transformer is absorbed and carried away by oil flowing along the surfaces of the winding legs between these surfaces and the inner surfaces of the insulating cylinders 3. The surface of the core exposed to the cooling oil may be increased by separating the core longitudinally by spacers 6 as shown in Fig. 2. This provides a passage 7 through which the oil may reach and cool the interior of the core.

The core is built up of suitable laminations secured together by bolts 8 passed through bolt holes 9 in the core. The bolts in the winding legs are preferably arranged in rows parallel with the direction of flow of the oil in the passage 7 so as not to impede the flow of oil in this passage more than necessary. The bolts may be of metal covered with insulation to prevent short circuiting the laminations. The bolts 8 and bolt holes 9 form obstructions to the flow of the alternating magnetic flux in the core and the flux is diverted past them on both sides as indicated in Fig. 7 where the space indicated between the dotted lines is shielded,

wholly or partially, from the magnetic flux. Any magnetic material disposed within these shielded spaces between the bolts is therefore of little or no use for conducting the magnetic core flux. The invention takes advantage of this fact to improve the cooling of the core and to maintain a more uniform temperature throughout its mass. To this end, ventilating ducts 10 are formed in the core by removing magnetic material of the core which would otherwise be wholly or partially shielded from the core flux by the bolts and bolt holes. This may be done by punching openings in the laminations at the same time that the bolt holes are punched. These openings in the laminations and the resulting ventilating ducts 10 in the core may be of any desired form and simple rectangular openings extending in the general direction of the core flux are indicated in Figs. 1, 2 and 3.

The magnetic flux tends to spread or curve somewhat into the spaces between the bolt holes as indicated in Fig. 7 so that the shielded spaces are thinnest midway between the bolt holes. It is of course desirable that the ventilating ducts 10 be as large as practicable and the maximum size of duct with minimum interference to the flow of magnetic flux may be attained by shaping the ducts with their opposite sides or faces conforming approximately to the curved limits of the shielded spaces between the bolt holes 9. Two such forms of ducts are shown in Figs. 4 and 5 respectively. The ducts shown in Fig. 4 are formed between adjacent bolt holes, a little material being left in each lamination between each end of each duct and the adjacent bolt hole to link the two sides of the lamination together. In the form shown in Fig. 5, the ducts 10 are extensions of the bolt holes 9 and they taper gradually away from the bolt holes to conform in shape approximately to that of the spaces shielded from the magnetic core flux. A small amount of material is left in each lamination midway between the bolt holes to link two sides of the lamination together. Lateral or transverse openings 11 through the bolts as shown in Figs. 5 and 6 permit circulation of the cooling medium between the ducts on opposite sides of each bolt.

The removal of magnetic material from the core in forming the ventilating ducts 10 does not increase the magnetic flux density as this material, if present, would not carry any appreciable amount of flux.

Careful comparative tests between two cores of the same size, one with ventilating ducts arranged in accordance with the invention and the other without such ducts but exactly similar in all other details, have shown that the provision of these ducts results in a decrease in core loss. This is probably because the additional openings in the

core laminations permit a better circulation of the heated gases during the annealing process and consequently more uniformly annealed laminations. Due to the increase in cooling efficiency and to the more uniform temperature throughout the cord structure, the flux density may, however, even be very appreciably increased by reducing the size of the core with a consequent reduction in core losses and saving of material. The increased flux density results further in a saving of material and in decreased losses in the transformer windings as the use of fewer turns is possible.

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

1. A transformer including a laminated core, and means passing through openings in the core laminations for securing them together, whereby spaces within the core structure are shielded from the magnetic core flux during operation of the transformer, said core having ventilating ducts extending through said shielded spaces.

2. A transformer including a laminated core, and means through openings in the core laminations for securing them together, whereby spaces within the core structure are shielded from the magnetic core flux during operation of the transformer, said core having ventilating ducts extending transversely in the general direction of the magnetic core flux and located substantially within said shielded spaces.

3. A transformer including a laminated core, and means passing through openings in the core laminations for securing them together, whereby spaces within the core structure are shielded from the magnetic core flux during operation of the transformer, said core having ventilating ducts extending through said shielded spaces, the ventilating ducts having opposite sides conforming approximately to the limits of the shielded spaces.

4. A transformer including a laminated core, and means passing through openings in the core laminations for securing them together, whereby spaces within the core structure are shielded from the magnetic core flux during operation of the transformer, said openings for the securing means being extended in the general direction of the magnetic core flux and into said shielded spaces to provide ventilating ducts.

5. A transformer including a laminated core, and means passing through openings in the core laminations for securing them together, whereby spaces within the core structure are shielded from the magnetic core flux during operation of the transformer, said openings for the securing means being oppositely extended in the general direction of the magnetic core flux and into said shielded spaces to provide ventilating ducts,

said securing means having transverse openings between ducts.

6. A transformer core lamination having openings to receive means for securing the laminations of the core together, whereby spaces within said lamination are shielded from the magnetic core flux during opera-

tion of the transformer, said lamination having other openings within said shielded spaces to permit circulation of a cooling fluid.

In witness whereof I have hereunto set my hand this 27th day of December, 1923.

LOCKE H. BURNHAM.