A. G. ELLIS AND J. L. THOMPSON.

TRANSFORMER.

APPLICATION FILED NOV. 7, 1917.

**1,317,280.** Patented Sept. 30, 1919.

Fig. 1

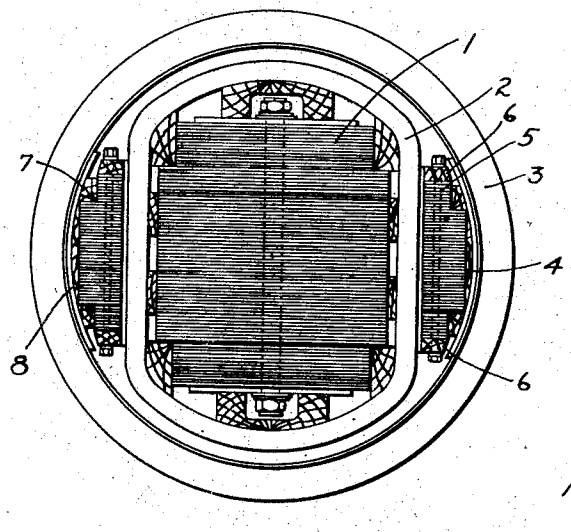



Fig. 3.

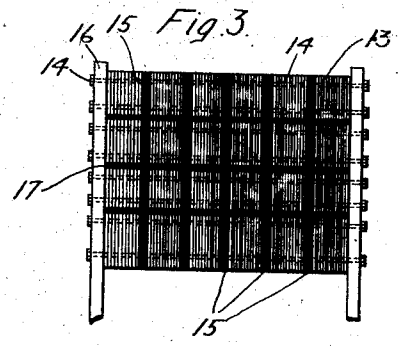
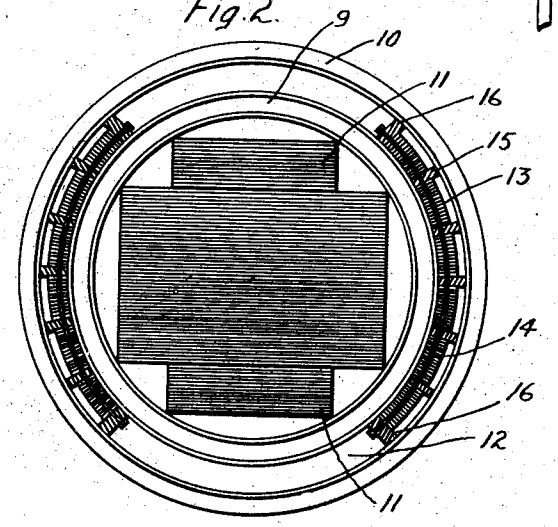



Fig. 2.




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# UNITED STATES PATENT OFFICE.

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## TRANSFORMER.

1,317,280. Specification of Letters Patent. **Patented Sept. 30, 1919.**

Application filed November 7, 1917. Serial No. 200,665.

*To all whom it may concern:*

Be it known that we, ALFRED G. ELLIS, a subject of the King of Great Britain, and a resident of Bowdon, in the county of Chester and country of England, and JOHN L. THOMPSON, a subject of the King of Great Britain, and a resident of Stretford, in the county of Lancaster, and country of England, have invented a new and useful Improvement in Transformers, of which the following is a specification.

Our invention relates to electrical transformers and it has special relation to those commonly known as core-type transformers which possess high internal reactance.

More particularly, our invention relates to a transformer having concentric primary and secondary coils between which magnetic shunts are disposed for the purpose of securing a high reactive-voltage drop in the transformer.

Heretofore, it has been the practice to construct a magnetic shunt adapted to be placed between the high and the low-tension coils of a transformer in such a manner that the planes of the laminæ comprising the shunt were parallel to the surfaces of the coils, assuming that the coils were circular. In order to increase the magnetic reluctance of such a shunt, it was divided by planes, perpendicular to the axes of the coils, into sections separated from each other by air-gaps.

It has been found that eddy currents circulate in a magnetic shunt of this character, which increase the internal losses of the transformer. It is our opinion that these eddy currents are generated by reason of the leakage magnetic flux lines emerging from the body of the magnetic shunt at right angles to the surfaces or planes of the laminæ. Of course, the extensive flat surfaces of the laminæ permit the eddy currents to reach appreciably high values.

In the present invention, we endeavor to overcome this objection to magnetic shunts formed of laminated material by arranging the laminations in such manner that the magnetic-leakage-flux lines will emerge at the exposed edges of the laminæ instead of at the side faces thereof. In this manner, the eddy currents which naturally tend to circulate in planes perpendicular to the direction of flow of the magnetic flux lines are very much reduced, with a consequent reduction in the transformer losses and, therefore, an increase in the operating efficiency.

In order to more fully understand our invention, reference may be had to the following description and the accompanying drawing, in which Figure 1 is a cross-sectional view of a core member and coils forming one leg of a core-type transformer which is provided with magnetic shunts constructed in accordance with our invention; Fig. 2 is a sectional view, similar to that of Fig. 1, showing a modified form of a portion of a core-type transformer embodying our invention; and Fig. 3 is a developed side view of a portion of one of the magnetic shunts shown in Fig. 2.

Referring to Fig. 1, a core-leg 1 of a transformer core member of rectangular cross section is embraced by an inner coil 2 having two of its opposite sides flattened in order to more closely embrace the adjacent sides of the core leg. The coil 2 is a part of the secondary or low-tension winding of the transformer. An outer cylindrical coil 3, which is a part of the high-tension or primary winding, embraces the core leg 1 and the coil 2 and thereby provides segmental spaces between it and the flattened portions of the coil 2, as shown. In these segmental spaces, magnetic shunts 4 are interposed, said shunts being formed of magnetizable laminations having their planes parallel to those of the laminæ forming the core leg 1 and perpendicular to the flat or plane faces of the inner coil 2 of the transformer. The laminæ constituting the magnetic shunts 4 are threaded on rods 5 and are clamped together to form a bundle. A magnetic shunt may be built up of a number of such bundles extending from end to end of the core leg 1, adjacent bundles being separated by intervening spacers of non-magnetic material, if desired, in order to increase the magnetic reluctance of the shunt.

The bundles of laminæ may be clamped between blocks or strips of wood, or other suitable material 6, as indicated. As shown in Fig. 1, the laminæ forming the shunts are of two sizes, as indicated at 7 and 8, so that a considerable portion of the available space may be occupied by the shunts,

Obviously, the laminæ may be of any desired number of graduated sizes. The strips 6, between which the laminæ are clamped, may be supported in any suitable manner, in accordance with the general design of the transformer to which the present invention is applied.

In Fig. 2, a secondary coil 9 and a primary coil 10 are shown as of cylindrical form and concentrically disposed about a leg 11 of a transformer core. An annular space 12 is, in this manner, provided between the primary and secondary coils. The laminæ forming the magnetic shunts 13 are threaded on curved rods 14 and are preferably arranged in two sets, each set comprising a plurality of bundles and subtending substantially one-quarter of the periphery between the coils 9 and 10. The bundles of laminæ are spaced from one another by means of insulating strips 15 and each set of bundles is securely clamped between outer end frames 16 formed of wood or other suitable insulating material. It will be observed that the planes of the laminæ comprising the magnetic shunts 14 are parallel to the axis of the core leg 11 and also that such planes, if extended, will meet in that axis. In other words, the laminæ are radially disposed with reference to the coincident axes of the coils 9 and 10.

By referring to Fig. 3, which is a developed side elevation of a portion of one of the magnetic shunts 14 of Fig. 2, it will be observed that each bundle of laminæ extends through a comparatively short distance lengthwise of the core leg 1 because the built-up column of bundles comprises insulating spacers 17 that are interposed between adjacent bundles of laminæ. Since the planes of the laminæ are substantially radial, with reference to the axis of the core member 11, and their outer edges are not tightly clamped together, they may be subject to vibration. This, however, may be prevented by dipping the loose ends of the bundles in Portland cement or other binding material which is not affected by the insulating oil in which the transformer may be immersed.

In transformers constructed according to our invention, the magnetic shunts may or may not occupy the whole of the space between the primary and secondary coils. The remaining vacant spaces may form additional cooling ducts for air or circulating paths for oil. The magnetic reluctance of the shunts may be readily adjusted by varying the number of laminæ in a bundle or by varying the number of bundles and the air spaces between them, as will be readily understood without further description.

While we have shown and described one form of our invention, it will be understood that many modifications may be made therein without departing from the scope of the appended claims.

We claim as our invention:

1. In an electrical apparatus, the combination with concentric primary and secondary coils disposed upon a laminated core member, of magnetizable laminæ interposed between said coils and having their planes approximately parallel to the coincident axes of said concentrically arranged coils.

2. In an electrical apparatus, the combination with concentric primary and secondary coils disposed upon a laminated core member, of magnetizable laminæ interposed between said coils and having their planes approximately coinciding with the planes of the flow lines of the magnetic leakage flux between said coils.

3. In an electrical apparatus, the combination with concentric primary and secondary windings disposed upon a laminated core member, of magnetizable laminæ interposed therebetween and having their planes approximately coinciding with the planes of the flow lines of the magnetic leakage flux through one of said windings.

4. An electrical transformer comprising a magnetizable laminated core member, primary and secondary coils embracing said core member, and magnetizable laminæ interposed betwen said coils, said laminæ having their planes substantially parallel with those of the laminæ forming said core member.

5. An electrical transformer comprising a magnetizable core member, primary and secondary coils embracing a leg of said core member, and magnetizable laminæ interposed between said coils, said laminæ having their planes approximately parallel to the axis of the core leg embraced by said coils.

In testimony whereof, we have hereunto subscribed our names this first day of October, 1917.

ALFRED G. ELLIS.
JOHN L. THOMPSON.

Witnesses:
A. J. CRIDGES,
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