No. 808,740. PATENTED JAN. 2, 1906.

J. J. FRANK.

TRANSFORMER.

APPLICATION FILED MAR. 27, 1905.

Fig. 1.

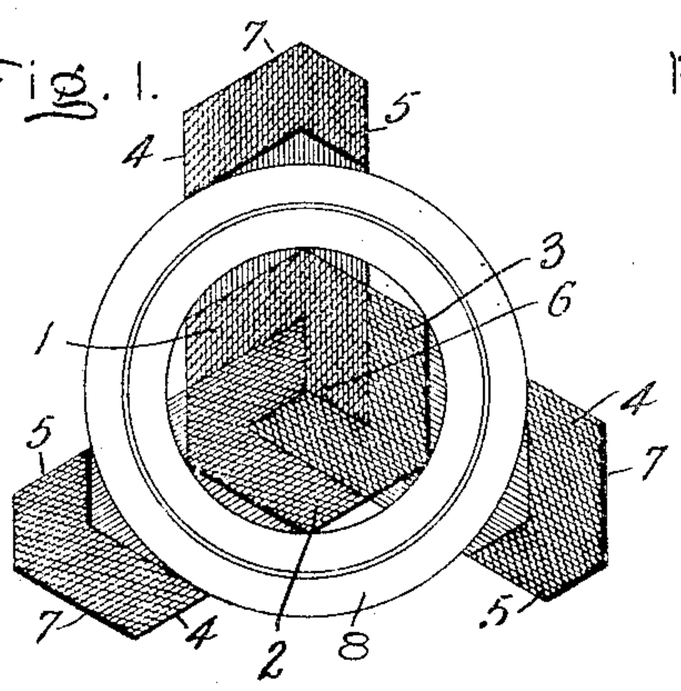


Fig. 2.

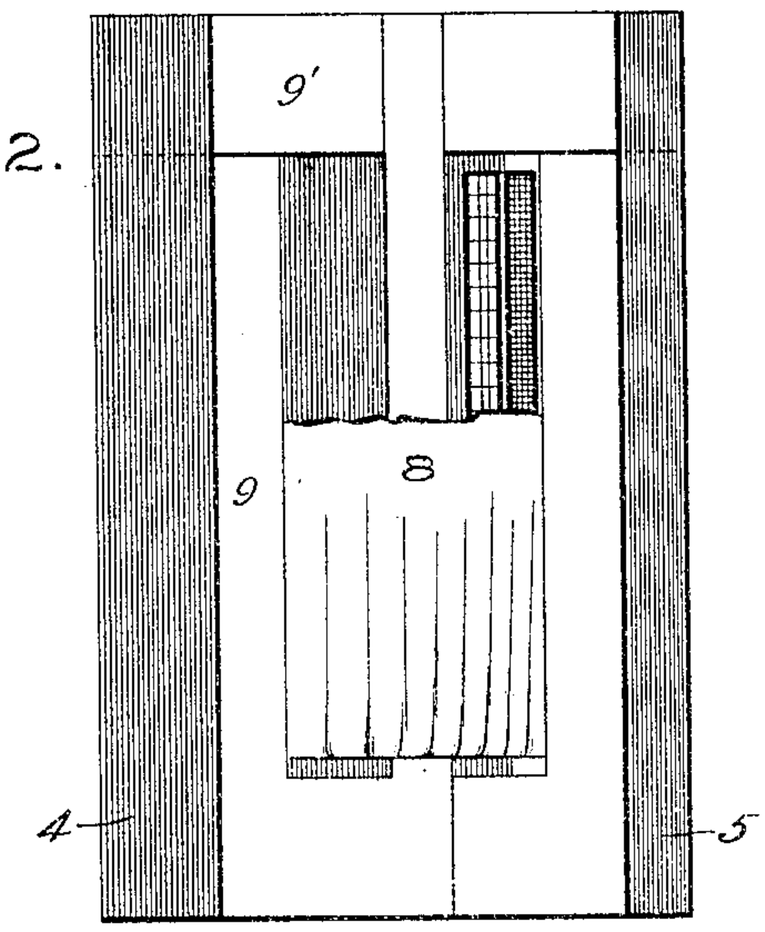


Fig. 5.

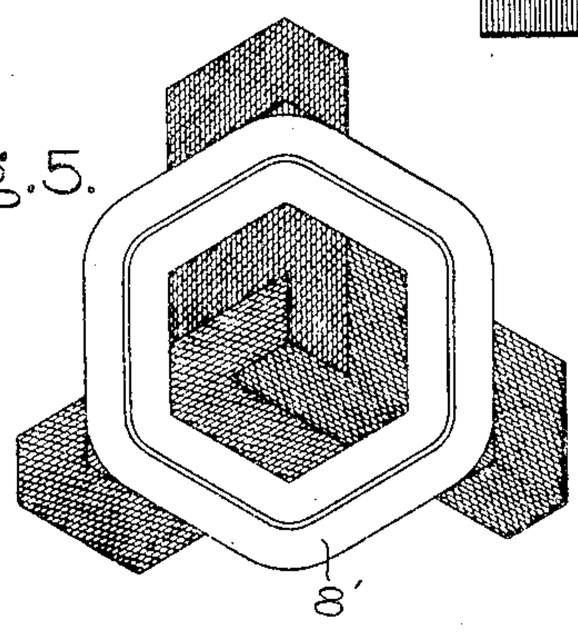


Fig. 3.

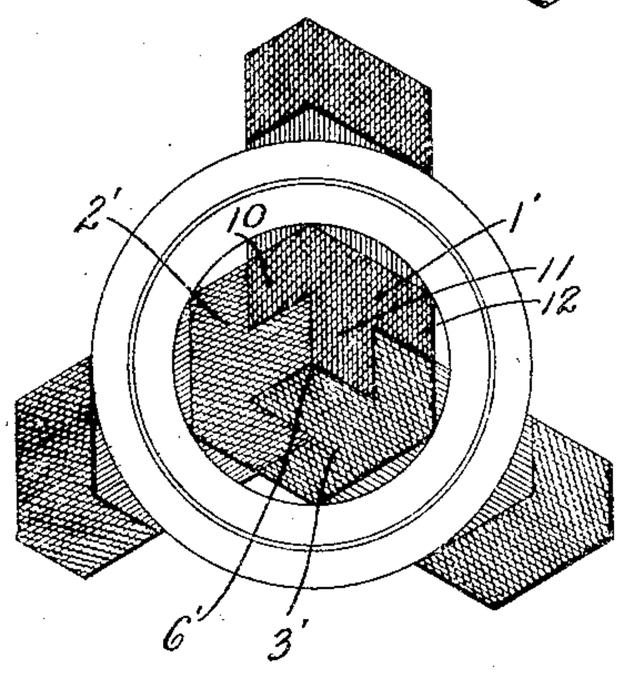
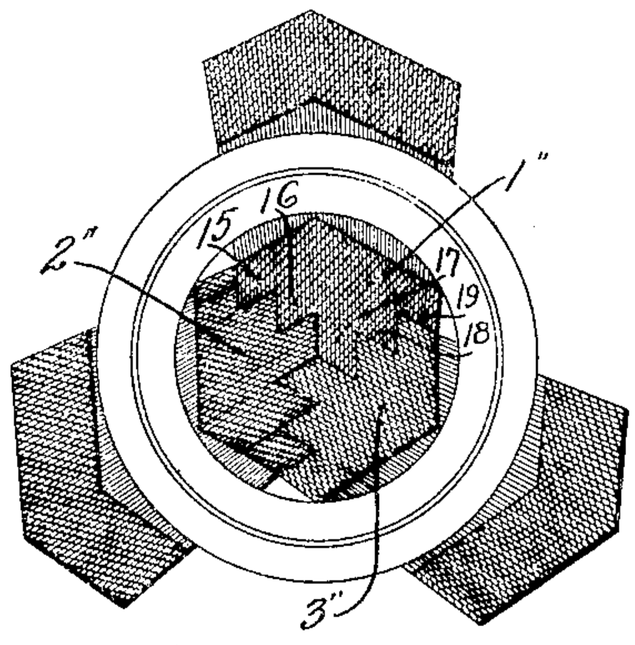


Fig. 4.



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UNITED STATES PATENT OFFICE.

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TRANSFORMER.

No. 808,740. Specification of Letters Patent. Patented Jan. 2, 1906

Application filed March 27, 1905. Serial No. 252,174.

To all whom it may concern:

Be it known that I, JOHN J. FRANK, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Transformers, of which the following is a specification.

My invention relates generally to the construction of stationary inductive apparatus, and particularly to the construction of the laminated magnetic core of transformers.

The object of my invention is the production of an efficient transformer the core of which is simply and strongly made and embodies an economical use of material.

In carrying out my invention I form the core of three main sections or units, each formed of two or more bundles or groups of laminæ. The laminæ in each bundle, which are identical, are in general rectangular in outline and formed each with a similar rectangular opening in it. The laminæ in each bundle are displaced in a direction parallel to one set of the parallel edges of the laminæ, so that the bundle has the form of an oblique prism or parallelepiped, the oblique angles of which are sixty degrees and one hundred and twenty degrees. The bundles comprising each main section or unit are in general dissimilar in form, and the bundles are assembled in forming each main section or unit so that at one side some bundles project by others. In assembling the core proper the three units are arranged to form a core comprising one central leg composed of one side of each unit and three outer parallel legs or portions. The sides of the three units which are placed together to form the central leg are those in which some of the bundles of each unit project by others, and the bundles are so proportioned and arranged that the projecting bundle portions from each section form a tenon which fits into a socket or space formed in or between the remaining portion of the central leg by the overlapping arrangement of the bundles of the other main parts. The windings of the transformer, which may be circular in outline, or substantially so, pass through the opening in each lamina to surround the central prism-shaped leg of the transformer and are inclosed or encaged by the outer legs of the core. Preferably the cross-section of each outer leg is greater than the cross-section of the corresponding portion of the inner leg. The increased cross-section of the outer legs is preferably obtained by interleaving laminæ in the form of strips between the laminæ of the outer leg. With this construction the length of turn of conductor in a transformer of given output is made small and the amount of copper is reduced. By a judicious proportioning of parts I thus obtain a transformer having a good efficiency, in which the ratio of copper to iron and the total copper used is smaller than in transformers of the same rating heretofore in common use. As is well known, copper is ordinarily worth in the neighborhood of four times as much per pound as iron. As a result, the transformer which I have invented is inherently less expensive than the transformers which have been heretofore commonly employed, while the core construction is comparatively simple in construction and possesses excellent mechanical properties. Moreover, by subdividing the return magnetic path coöperating with the central leg into three outer legs the length of the magnetic circuit of the transformer-core is reduced. This results in a decrease in the amount of iron required, thus cheapening the cost of manufacture and increasing the efficiency of the transformer.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of my invention, however, reference may be had to the accompanying drawings and descriptive matter, in which I have illustrated and described several forms in which my invention may be embodied.

Of the drawings, Figure 1 is a sectional plan showing one form of my invention. Fig. 2 is an elevation of the construction shown in Fig. 1. Figs. 3 and 4 are views similar to Fig. 1, each showing a different modification; and Fig. 5 is a view similar to Fig. 1, showing a modified form of winding.

In the construction shown in Figs. 1 and 2 the three main parts or units of the core, 1, 2, and 3, which are identical in construction, are each formed of two bundles of laminæ, 4 and 5. The bundles 4 are twice as thick—that is, composed of twice as many laminæ—as the bundle 5. The portion of each lamina in the bundle 5 forming a part of the central leg is twice as wide as the corresponding part of each lamina in the bundle 4. The units are

assembled so that the portion of the bundle 5 which overlaps the bundle 4 forms a tenon which fits into the socket formed between the edge of the bundle 5 of one of the other units and the inner edge of the bundle 4 and the overlapping portion of the bundle 5 of the remaining unit. As shown, the laminæ in the bundles 4 and 5 in each unit are successively displaced with reference to the edges of the bundles transverse to the length of the central leg to form two parallelepipedons, the oblique solid angles of which are sixty and one hundred and twenty degrees. The displacement of the laminæ in the two bundles forming part of one unit are different, however, so that the acute solid angles of the one bundle correspond in position to the obtuse solid angle of the other bundle. It will be observed that the central leg 6 thus formed is hexagonal in cross-section and that the inner and outer surfaces of each bundle 4, forming a part of each outer leg 7, is inclined to the corresponding-portion surfaces of the corresponding bundles 5. The inner surface of each outer leg is thus divided into two parts, which are parallel to the adjacent sides of the central leg and are practically, though not exactly, tangential at their middle points to the outer surface of the annular windings 8 of the transformer. The punchings composing each lamina may advantageously be formed of two parts, one of the parts 9 being U-shaped with one leg shorter than the other and the other part 9′ being in the form of a bar, which completes the rectangular form of the laminæ. It will of course be understood that the long and short legs are alternately reversed in successive laminæ. Any suitable means may be employed for assembling the laminæ together and for holding them in position. The laminæ may be insulated from each other in the ordinary manner.

In the construction shown in Fig. 3 the core is built up of three main parts or units 1′, 2′, and 3′. Each unit is composed of three bundles 10, 11, and 12, each bundle being composed of the same number of laminæ. The outer bundles 10 and 12 may be formed of laminæ of the same dimensions. The laminæ, however, in these two bundles are displaced in opposite directions. The middle bundle 11, in which the laminæ are displaced in the same manner as in the bundle 12, is shaped so that the portion forming a part of the central leg 6′ is twice as wide as the corresponding portions of the bundles 10 and 12. As is clearly shown on the drawings, the inner portions of the units fit together to form an interlocked center leg hexagonal in cross-section.

In the construction shown in Fig. 4 each unit 1″, 2″, and 3″ is formed of five bundles 15, 16, 17, 18, and 19. The laminæ in the bundles 15, 16, and 17 are successively displaced in the same direction. The portion of the bundle 16 forming a part of the central leg is overlapped by the corresponding portion of the bundle 17 and overlaps the corresponding portion of the bundle 15 by an amount equal to the thickness of each bundle. The laminæ in the bundles 18 and 19 are displaced in the opposite direction to which the laminæ in the bundles 15, 16, and 17 are displaced. The bundle 18 overlaps the bundle 19 and is overlapped by the bundle 17 by an amount equal to the thickness of each bundle. Fig. 4 clearly shows how the units interlock to form a central leg which is hexagonal in cross-section.

In the construction shown in Figs. 1, 2, and 3 the portion of each outer leg of the transformer having its inner surface in one plane substantially tangential to the windings of the transformer is twice as thick as the remaining portion, while in the construction shown in Fig. 4 the ratio of the inner surfaces of each outer leg which are inclined to each other is that of two to three. This makes the core construction somewhat more symmetrical as regards this feature and gives a slightly more efficient disposition of the core material.

In Fig. 4 I have shown the outer legs as having laminæ in the form of rectangular strips inserted between the main laminæ hereinbefore described. This fans out and makes thicker the outer legs of the core and of course reduces its magnetic reluctance. This is sometimes of considerable importance. It will be understood, of course, that this construction may be adopted with all the forms of my invention illustrated. Owing to the fact that the outer legs of the core are each formed in two parts, the inner surfaces of which are inclined to each other, the thickness of the outer leg may be very materially increased by the insertion of the strips without causing the inner edge of the laminæ to engage the outer surface of the winding.

In the construction shown in Fig. 5 the windings 8′, instead of being circular, as in the other form, are hexagonal. This arrangement allows of a more economical use of copper. It will be understood that with this construction windings may be shaped on a winding-form hexagonal in cross-section, while the windings shown in the other figures of the drawings may be shaped on forms cylindrical in cross-section.

While I have hereinbefore described somewhat in detail the best form of my invention now known to me, it will be obvious to all those skilled in the art that modifications may be made in the forms of the invention disclosed without departing from the invention itself.

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

1. A magnetic core formed of a number of similar units, each of which is composed of a plurality of bundles of laminæ, the laminæ in the different bundles being successively dis-

placed so that each bundle is an oblique prism, the laminæ in some of the different bundles in each unit being displaced in opposite directions so that the acute solid angles of one bundle correspond to the obtuse solid angles of the other.

2. A magnetic core formed of three laminated units, the planes of lamination intersecting each other at one hundred and twenty degrees, each unit being formed of a plurality of bundles, some of said bundles overlapping the others to form tenons which interlock with the other bundles.

3. In a magnetic core, a body of magnetic material formed of three units or portions, each of which is laminated in planes intersecting the planes of lamination of the other units at angles of one hundred and twenty degrees, each unit being formed of two or more bundles of laminæ, the edges of the laminæ in one bundle of each unit being parallel to the planes of lamination of another unit, and the corresponding edges of another bundle terminating in a plane parallel to the planes of lamination of the other unit.

4. In a magnetic core, a portion formed of three units, each unit being formed of two or more bundles of laminæ, the planes of lamination of each unit being at one hundred and twenty degrees angle with the planes of lamination of the other units, one bundle in each unit projecting by another bundle in said unit, the laminæ in each unit being so arranged that the plane in which the edges of one bundle in each unit terminate is parallel to the plane of lamination of one of the other units, while the corresponding edges of another bundle in the same unit terminate in a plane parallel to the plane of lamination of the second of said other units.

5. In combination, a winding substantially annular, a plurality of magnetic core-sections linked about said winding, each of said core-sections being in the form of a body composed of laminæ each of which has an opening in it through which the winding is passed, the laminæ in each body being so arranged that the opening through the body is not straight but has one portion inclined at an angle to another portion.

6. In combination, a winding substantially annular, a plurality of magnetic core-sections linked about said winding, each of said core-sections being in the form of a body composed of laminæ, each of which has an opening in it through which the winding is passed, the laminæ in each of said bodies being arranged so that the passage through the body is not straight but is formed with one portion which is substantially tangential to the portion of the winding in proximity to it, and another portion removed from the first which is substantially tangential to the portion of the winding in proximity with it.

7. In a transformer, a core comprising a prism-shaped leg or part polygonal in cross-section and one or more outer legs, the surface adjacent said prism-shaped leg formed in two parts, one of said parts being substantially parallel to one side of the prism-shaped central leg and the other part being parallel to a second side of said prism-shaped central leg.

8. In a transformer, a core comprising a prism-shaped leg or branch polygonal in cross-section, and one or more other legs, the surface adjacent said prism-shaped leg of each of the other legs being formed in two parts, one of said parts being substantially parallel to one side of the prism-shaped central leg and the other part being parallel to an adjacent side of said prism-shaped leg.

9. In a transformer, a core comprising a prism-shaped leg or branch polygonal in cross-section, and one or more other legs, the surface adjacent said prism-shaped leg of each of the other legs being formed in two parts, one of said parts being substantially parallel to one side of the prism-shaped central leg and the other part being parallel to an adjacent side of said prism-shaped central leg, and a winding surrounding said prism-shaped leg, the inner and outer surface of said winding being substantially similar to the surface of said prism-shaped leg or branch.

In witness whereof I have hereunto set my hand this 23d day of March, 1905.

JOHN J. FRANK.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.