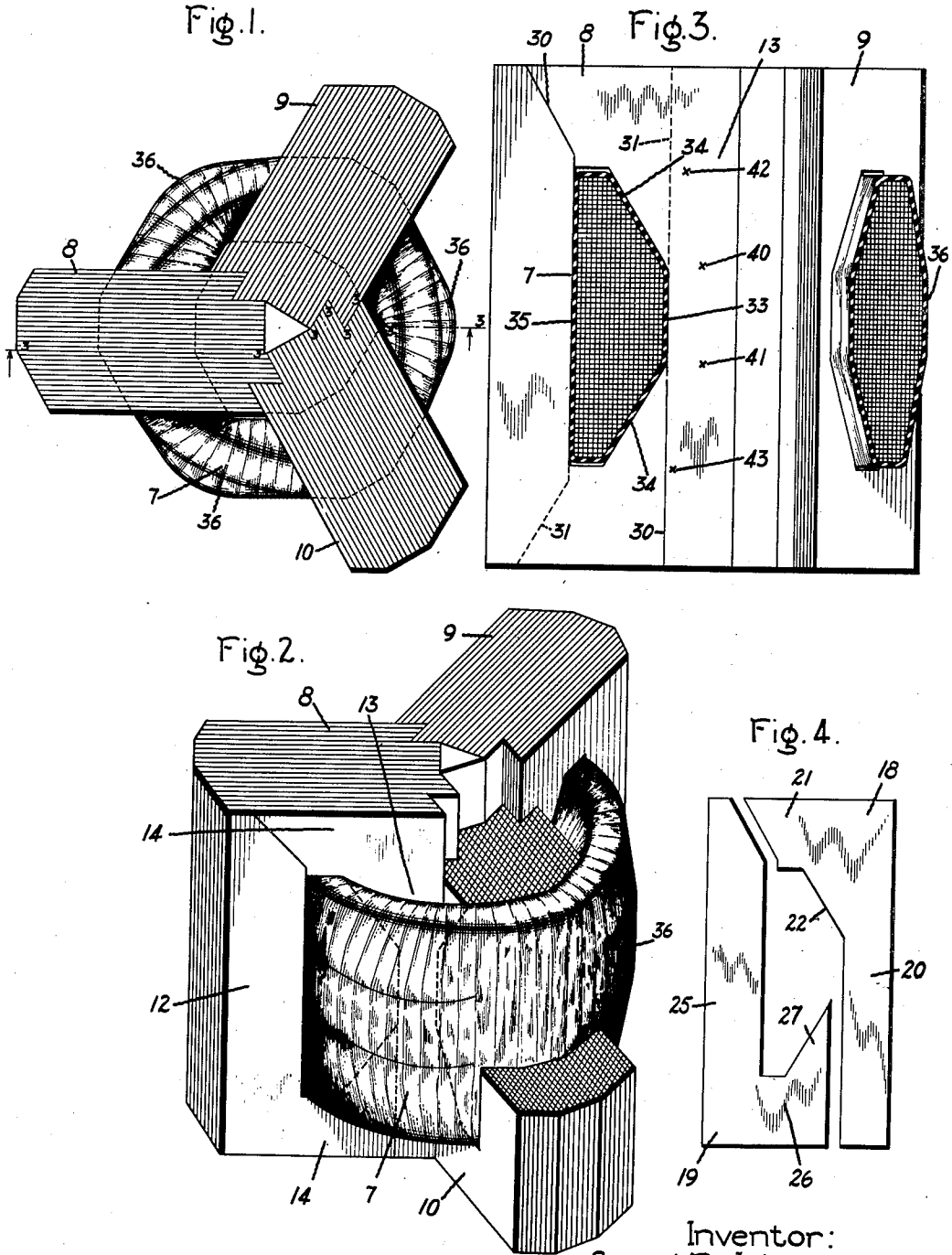


S. E. JOHANNESSEN.
STATIONARY INDUCTION APPARATUS.
APPLICATION FILED MAY 2, 1917.

1,299,953.

Patented Apr. 8, 1919.



Inventor:
Svend E. Johannesen,
by *Albush Davis*
His Attorney.

UNITED STATES PATENT OFFICE.

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

STATIONARY INDUCTION APPARATUS.

1,299,953.

Specification of Letters Patent.

Patented Apr. 8, 1919.

Application filed May 2, 1917. Serial No. 166,024.

To all whom it may concern:

Be it known that I, SVEND E. JOHANNESSEN, 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 Stationary Induction Apparatus, of which the following is a specification.

My invention relates to stationary induction apparatus, such as transformers, autotransformers, some reactances, etc., in which the core provides a substantially complete path for the magnetic flux. An object of my invention is to provide a method of operating such apparatus whereby such apparatus may be used more efficiently per weight of material than heretofore, the operating losses remaining the same. Another object of my invention is to provide stationary induction apparatus for securing the same result. Still another object of my invention is to provide stationary induction apparatus in which there is lower reactance than heretofore between different windings or between different portions of the same winding thereof. A still further object of my invention is to provide stationary apparatus in which the mean length of turn is reduced.

While my invention is broadly applicable to various types of stationary induction apparatus as indicated above, it will probably find its greatest use in transformers. I shall, therefore, for the most part, principally for the sake of simplicity, confine the following description to transformers. The broader applicability of my invention will be understood from this particular application.

It has heretofore been proposed to so operate transformers that the core legs carrying or surrounded by the windings are run at materially greater magnetic densities than the core parts which are without windings. The losses being the same in both cases, a transformer so operated employs its material more efficiently, or a transformer of a given weight has a greater capacity for given losses, than a transformer which is operated with, say, the same magnetic density throughout the whole core. To carry out this method of operation, transformers are so constructed that the cross area of the core material within the wind-

ings is smaller than the cross area of each yoke (or the sum of the cross areas of yokes in multiple) of the same device, and likewise smaller than the cross area (and the sum of multiple cross areas) of another or other core legs where there are another or other cross legs not provided with windings.

I am able by my invention to secure still greater efficiency by so operating the apparatus that different portions of the part (or parts) of a core surrounded by a winding are run at different magnetic densities. Preferably the parts of the core within both ends of a winding are run at a lower magnetic density than the middle part thereof within the same winding. This middle part may to advantage in many cases be run at a higher density than has commonly been employed heretofore, but from a broad aspect this is not an essential feature of my invention. I preferably provide apparatus for carrying out this invention by so arranging that the core material of a considerable part of the end of a (and preferably every) leg carrying a winding is larger than the average cross area of the core material of another considerable part of the same leg. Preferably the cross areas of the core material at both ends of the core leg larger than the cross areas nearer the center of the leg. One particular advantage of this construction is that many joints in the magnetic circuit which commonly occur at the ends of the core legs, are disposed in positions of comparatively lower magnetic densities than heretofore.

I am aware that it has heretofore been proposed to provide winding legs of transformers (and other stationary induction apparatus) with slots and other interruptions of the magnetic circuit to increase the reactance or magnetic leakage of the apparatus and otherwise. It is possible that in some such case some cross area of the core material adjacent an end of a winding leg has been larger than some cross area of the magnetic material nearer the center thereof. My invention is not included in such prior arrangements as may be inferred from what has gone before, and from the detailed description of one embodiment of my invention which follows; obviously, however, my invention is not necessarily so limited as to fail to include apparatus provided with slots

or other interruptions for the same purposes as heretofore, if the prior arrangements are modified in construction in the same manner or manners as more common induction devices will be modified to embody my invention. The method of my invention in one way distinguishes from such prior art in that the apparatus is so run that the average magnetic flux density over all the cross areas of some considerable part of the core material within a winding is different from the average magnetic flux density over all the cross areas of another considerable part of the core material within the same winding. Likewise the apparatus of my invention distinguishes in one way over such prior art in that the average cross area of the core material of some considerable part of a winding leg is larger than the average cross area of another considerable part of the same leg. I contemplate that the distinction of my invention over all the prior art, and the embodiment of my invention by any modification of any example of the prior art, will be readily apparent whether included in the above or not.

Preferably the apparatus is so operated that the yokes and the legs not surrounded by windings are also run at a lower magnetic density than the high density parts of the winding legs, and preferably to secure this the cross areas of the core material of the apparatus are properly proportioned to secure this result. Preferably, too, the cross areas of the core material within the windings progressively decrease from the ends of the legs toward the center thereof; this result is preferably secured by progressively decreasing the perimeters of the cross sections of the core legs from their ends, this in turn preferably being accomplished by employing laminations of varying widths within the core legs. Altogether, however, all these features are subject to much modification.

So disposing the core material that the perimeters of ends of core legs carrying windings are greater than perimeters of parts of such core legs nearer the center of said legs, accomplishes the further objects of my invention, that is, reducing the reactance between portions of the winding on each core leg and reducing the mean length of turn.

In the accompanying drawings and the following detailed description, I have illustrated and described the best embodiment of my invention that I am now aware of; the details thereof will be understood therefrom. Figure 1 is a plan view of a transformer embodying my invention. Fig. 2 is an elevation of the transformer of Fig. 1, a part of one core unit being broken away. Fig. 3

Fig. 1 taken along the line 3—3—etc., looking in the direction of the arrows. Fig. 4 illustrates the two parts or punchings comprising each lamination.

The transformer illustrated comprises a core and the winding 7. Since the specific type of winding comprises no part of my invention, I have made no attempt to illustrate this detail of the winding or any division of the winding there may be as primary and secondary parts, etc. The core is of the distributed type and comprises three sections or units 8, 9 and 10. Each unit comprises generally an outer leg 12, an inner leg 13, and two yokes 14, connecting the ends of the legs. The three sections or units of the core are distributed substantially equiangularly about the center of the core, the inner leg 13 of each core section or unit joining and intermeshing with the inner legs of the other two core sections or units to provide the center and winding leg of the transformer. The winding 7 surrounds this center and winding leg. The sections are laminated as indicated in Figs. 1 and 2. The core illustrated is of a rather peculiar construction which is described in detail in my copending application, Serial No. 166,023, filed on or about May 2, 1917. It will be understood, however, my invention is not applicable to this type of transformer core alone, but is generally applicable to various types of cores for stationary induction apparatus.

The laminations of the core are made up of parts or punchings resembling generally the parts or punchings 18 and 19 illustrated in Fig. 4. The lamination part 18 comprises the inner leg portion 20 of the lamination and also one of the yoke portions thereof, the inner leg portion 20 of the lamination comprising for the most part a rectangular part as illustrated at right angles to the yoke portion 21, the inner leg portion gradually increasing in width from the rectangular part toward the yoke portion 21. This increase in width is accomplished wholly on the edge of the lamination part 18 toward the window or winding space, as illustrated at 22. The lamination part 19 comprises an outer portion 25 of a generally rectangular shape and a yoke portion 26. The end of the yoke portion 26 is provided with a triangular projection 27 which provides the lamination part 19 with an edge toward the winding space or window quite similar to the edge of the lamination part 18 provided at 22. The yoke portion 21 of the lamination part 18 is arranged to abut against one end of the leg portion 25. The joint between the leg portion 25 and the yoke portion 21 is partly at an angle to the edge of the yoke and partly perpendicular thereto as indicated in the drawing. The portion 20 abuts against the inner edge of

the yoke portion 26 and the triangular part 27 thereof. It will appear from what has gone before that when the lamination parts 18 and 19 are placed tightly together they provide a winding space or window which in shape resembles the cross section of a truncated cone set on a rectangular base. This most clearly appears perhaps in Figs. 3 and 4. The laminations of each core section or unit are reversed relatively to each other individually or in small numbers at a time; this is indicated in Fig. 3 by the solid lines 30 and the dash lines 31 which indicate the joints in the lamination immediately behind the lamination of core section 8 shown in the figure. As appears, the reversal of the laminations is secured by arranging one, or a few laminations, with the yoke portion 21 at the top and the yoke portion 26 at the bottom and then arranging the next one or a few laminations with the yoke portion 26 at the top and the yoke portion 21 at the bottom. This reversal of the laminations is for the purpose of "breaking joints", the general idea of which is well known.

The particular shaping and arrangement of the laminations and lamination parts illustrated and heretofore described comprise no part of my invention except in so far as they provide the peculiar shaped winding space or window in the core. It will be observed that due to this peculiar shaping of the winding space, the middle part 33 of the winding adjacent the inner leg of the core is nearer the center of the transformer than end portions 34 thereof. The outer surface 35 of the winding is located in a single plane where the winding passes through a core section. Where the core is of the distributed type, as in the case illustrated, the winding may assume a peculiar external shaping adjacent 36 between the core sections, particularly if the conductor is wound directly on the core; giving the winding this peculiar external shape is no part of my invention, however.

It will appear from what has gone before that in such a transformer as I have described above, a considerable middle portion of the winding leg, that is the portion between the points 40 and 41, is run at a magnetic density which over all the cross areas of the core material of that portion averages higher than over the cross areas of the material of the end portions of the same winding leg, that is the portions between points 40 and 42 and between the points 41 and 43. Also the cross areas of the core material of the yokes 14 and the outer leg 12 are so proportioned as to run at a lower magnetic density than the portion of the inner winding leg between the points 40 and 41. This latter result has been secured by making the average width of

the rectangular portions 20 of all the lamination parts 18 less than the width of the laminations at the yokes 14 and the outer legs 12. The middle portion of the winding leg has been caused to run at a higher magnetic density than the end portions of the winding leg since the cross areas of the core material within the windings (that is, the total cross areas within the perimeters of the winding leg minus the cross areas of space unoccupied by magnetic material) progressively decrease from the ends of the leg toward the center portion thereof, and this has been secured by employing laminations which vary in width within the core leg, as at 22 and 27. Since the perimeters of the cross sections of the winding leg decrease from the ends of the winding leg toward the middle thereof, the reactance between the different windings and between different portions of any one winding are lower than it would be were the perimeters of the cross sections uniform; likewise the mean length of turn of the conductors of the winding is less than it would be under the condition of uniform perimeters of cross sections. Both of these factors, that is low reactance and short mean length of turn, have been indicated before and it should be observed that they depend upon the relations between the perimeters of the cross sections of the core, and hence conceivably these objects may be obtained although the other parts of my invention were not accomplished in the same device.

While I have described the principle of my invention and the best mode I have contemplated for applying this principle, other modifications will occur to those skilled in this art, and I aim in the appended claims to cover all modifications which do not involve a departure from the spirit and scope of my invention.

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

1. Stationary induction apparatus comprising a core providing a substantially complete magnetic circuit and a winding inclosing a portion thereof, the sum of cross areas of said core outside said winding and carrying magnetic flux in multiple, and also the average area of the core material of a considerable part of said core portion inclosed by said winding and adjacent an end thereof, being greater than the average cross area of the core material of another considerable part of said core portion inclosed by said winding.

2. Stationary induction apparatus comprising a core providing a substantially complete magnetic circuit and a winding inclosing a portion thereof, the sum of cross areas of said core outside said winding and carrying magnetic flux in multiple and also the average cross area of the core material

of a considerable part of said core portion inclosed by said winding and adjacent each end thereof, being larger than the average cross area of the core material of substantially the middle of said core portion inclosed by said winding.

3. Stationary induction apparatus comprising a distributed laminated core and a winding on the central leg thereof, the laminations of said leg being of greater width adjacent the ends of said leg than adjacent substantially the middle of said leg.

4. Stationary induction apparatus comprising a distributed laminated core and a winding on the central leg thereof, the laminations of said leg progressively decreasing in width from the ends of said leg toward substantially the middle thereof.

5. Stationary induction apparatus comprising a distributed core and a winding on the central leg thereof, said leg being of greater perimeter adjacent an end thereof than adjacent another part thereof.

6. Stationary induction apparatus comprising a distributed core and a winding on the central leg thereof, said leg being of

greater perimeter adjacent the two ends thereof than adjacent the middle thereof.

7. Stationary induction apparatus comprising a distributed core and a winding on the central leg thereof, the perimeter of said leg progressively decreasing from an end of said leg toward the center thereof.

8. Stationary induction apparatus comprising a distributed core and a winding on the central leg thereof, the perimeter of said leg progressively decreasing from both ends toward the center of said leg.

9. Stationary induction apparatus comprising a distributed core having a winding surrounding the central leg thereof, said central leg having the form of truncated prisms inverted with respect to each other in such manner that the central cross area of said leg is less than the two ends whereby the mean length of winding turn is decreased together with the average saturation of the magnetic circuit.

In witness whereof, I have hereunto set my hand this 27th day of April, 1917.

SVEND E. JOHANNESSEN.