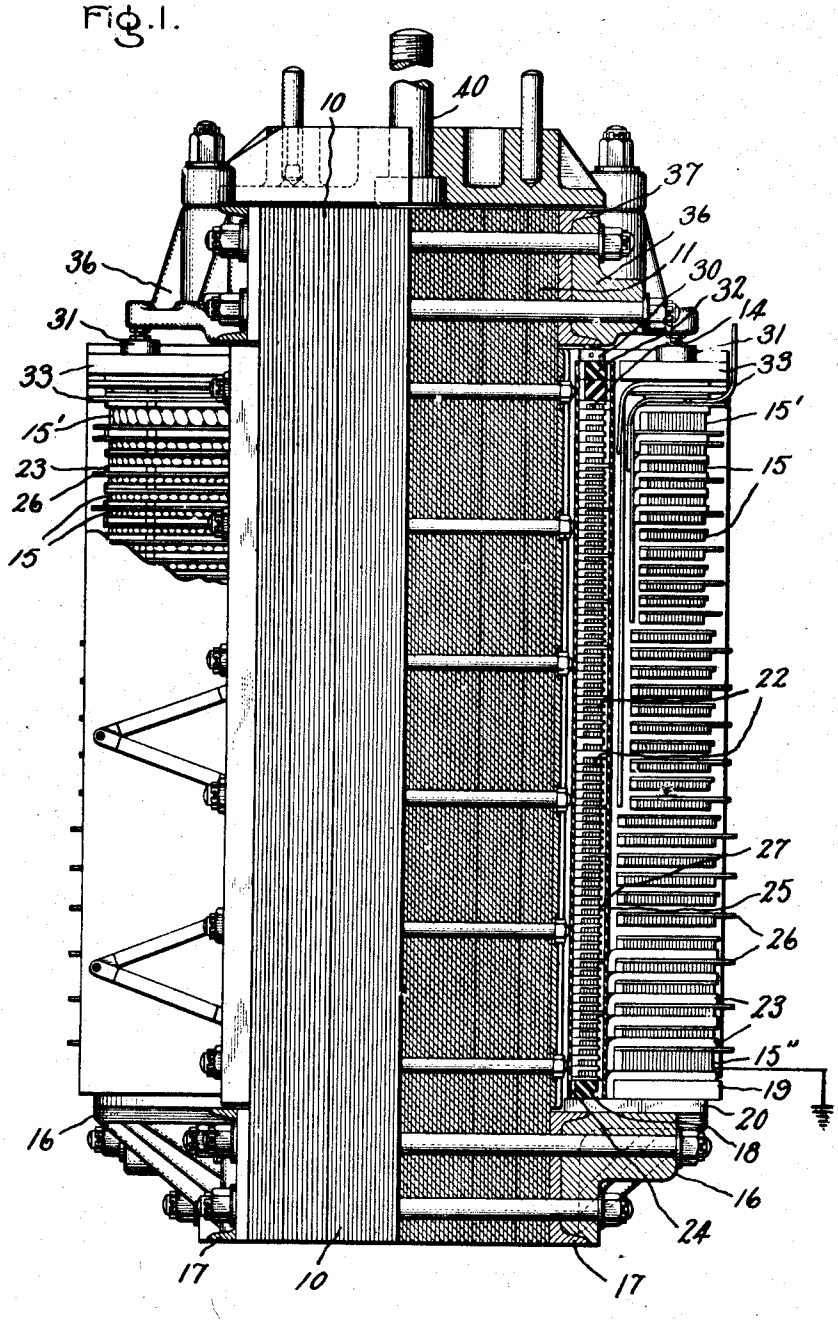
May 26, 1925. 1,539,670

A. B. HENDRICKS, JR

STATIONARY INDUCTION APPARATUS

Filed Feb. 24, 1920 3 Sheets-Sheet 1

Fig. 1.



Inventor:
Allan B. Hendricks Jr.,
by Albert G. Davis
His Attorney

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Fig 3.

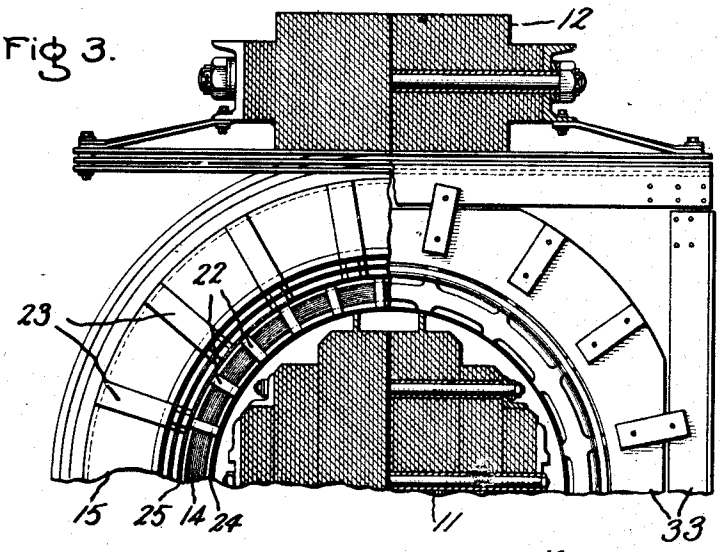

Fig. 2.

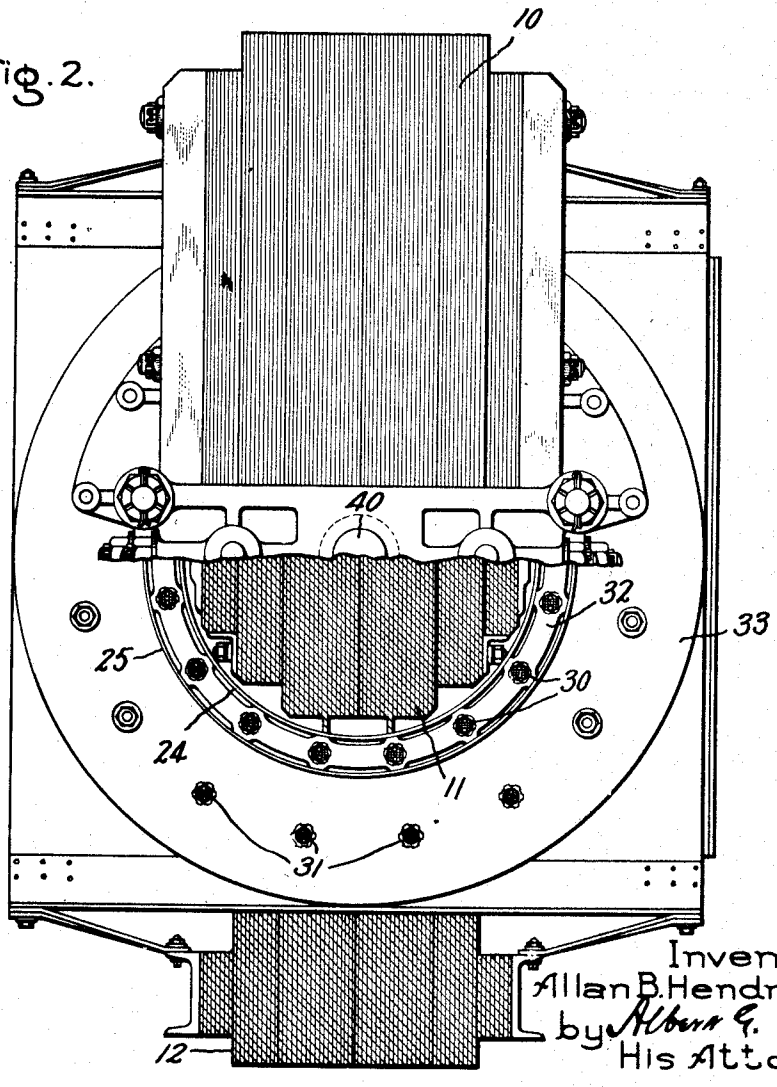

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Fig. 4.

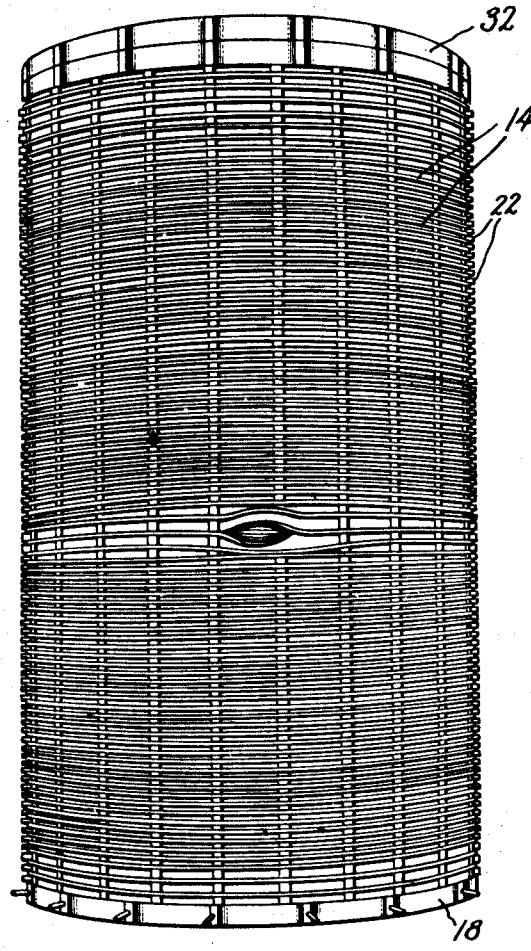


Fig. 5.

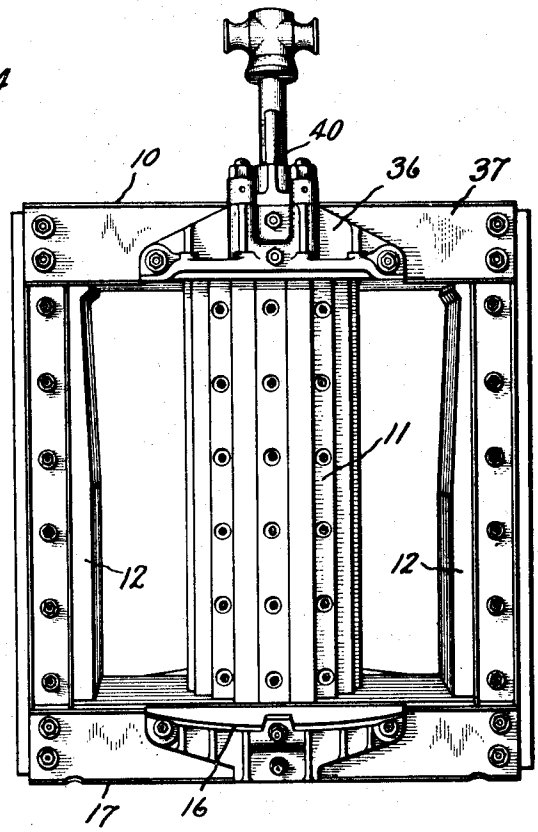
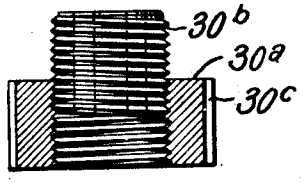


Fig. 6.



Inventor:
Allan B. Hendricks Jr.,
by Albert G. Davis
His Attorney

Patented May 26, 1925. 1,539,670

UNITED STATES PATENT OFFICE.

ALLAN B. HENDRICKS, JR., OF PITTSFIELD, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

STATIONARY INDUCTION APPARATUS.

Application filed February 24, 1920. Serial No. 360,911.

To all whom it may concern:

Be it known that I, ALLAN B. HENDRICKS, Jr., 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 transformers and the like, and has for its object an improved arrangement of parts whereby a strong and very economical construction results.

In large power transformers, the magnetic repulsion between the primary and secondary windings produces very great stresses in the core and frame supporting such windings. For large units of the type to which I contemplate applying my invention, should a short circuit suddenly occur in the system supplied by such units, these repulsive forces may then increase with such rapidity that, unless the windings are very carefully balanced, something is likely to give way.

In the practice of my invention I avoid such eventualities by providing very rugged supports for the windings in addition to providing for as nearly a complete magnetic balance between the primary and secondary, as is possible. In effecting this balance I provide a corresponding distribution of the turns of the primary and secondary along the winding axis and also locate both windings with their magnetic centers coinciding in position as nearly as possible along the winding axis.

For a more complete understanding of the nature and objects of my invention reference should be had to the following detailed description taken in connection with the accompanying drawing in which:

Fig. 1 is a view, partly in section and partly in side elevation, of a transformer constructed in accordance with my invention. Fig. 2 is a top plan view, parts of the core being broken away, showing the means for securing the windings in their proper relative positions on the core. Fig. 3 is a fragmentary sectional view showing further details. Figs. 4 and 5 are perspective views of the assembled low voltage winding and the core respectively. Fig. 6 is a detail view of an adjustable device for securing the windings in position.

Referring now to the drawings, 10 denotes a magnetic core having a central leg 11 and two side legs 12. The low voltage winding 14 and the high voltage winding 15 are concentrically arranged about the central leg 11 and are supported at their bases by abutments 16 secured to the bottom core clamps 17.

Between the windings 14 and 15 and the abutments 16 are placed spacing elements 18 and 19 for supporting the low voltage and high voltage windings in proper positions with respect to each other and also with respect to the core. Insulating blocks 20 are also shown as resting on the abutments 16 to serve as a suitable base on which to arrange the spacing elements 18 and 19.

Each of the windings 14 and 15, on account of the high duty required of it, is preferably composed of disc-coils which are spaced apart by spacing elements disposed between the coils at preferably equi-distantly spaced points; those in the low voltage winding being indicated at 22 and the ones in the high voltage winding at 23. The down turned portions of these L-spacers serve to keep the coils properly spaced from the interposed insulating cylinders 24 and 25, which serve as barriers between the core and windings and between the windings themselves. Among the high voltage coils additional annular barriers or collars 26 are disposed at suitable points. Among the low voltage coils, the L-spacers, at predetermined points, are prolonged as shown at 27 to properly space apart the insulating cylinders 24 and 25.

The lower terminal of the high voltage winding is connected to the core and grounded as indicated in Fig. 1. This end of the winding is therefore maintained at ground potential but in operation the voltage increases along the winding to its maximum value at the upper or high voltage end of the winding. Much more insulation is thus required and the space available for the winding is thus much less at its upper or high voltage end than at its lower or grounded end, the available winding space increasing in size as the voltage decreases from the high voltage end to the grounded end of the winding. Thus, the high voltage winding may have a larger number of turns per unit distance along the core at its grounded or low voltage end than at its high voltage end, the number of turns

per unit distance along the core decreasing with the available winding space and inversely with the voltage toward the high voltage end. This results in a non-uniform distribution of the high voltage winding turns along the core. Another feature of construction which contributes to the non-uniformity of distribution of the high voltage winding along the core is the presence of the large buffer coils 15′ and 15″ at the upper and lower ends of the winding. The conductor in these end coils is of larger cross section than that of the rest of the winding and it is also provided with heavier insulation to withstand the effects of high voltage transient currents entering the winding. Because of the larger cross section of conductor and the heavier insulation in these end coils, the number of turns per unit distance along the core is reduced. The high and low voltage windings are assembled with their magnetic centers coinciding to eliminate as far as possible the displacement forces between the two windings. It is desirable, however, that such forces be eliminated not only between each winding and the other as a whole but also between each section of each winding and the corresponding section of the other so as to reduce as much as possible the stresses between the different winding sections. In accordance with the invention, therefore, the turns of the low voltage winding are distributed nonuniformly along the core so that this distribution may correspond, so far as practicable, with the necessarily non-uniform distribution of the high-voltage winding.

In order that each winding may be located as accurately as possible with respect to the core and the other winding, I provide each with an adjustable securing means at the top of the winding, such means for the low voltage winding being shown at 30, while that for the high voltage winding is shown at 31. Immediately beneath these adjusting means, and between them and their respective windings are placed suitable insulating barriers and spacing devices, as shown at 32 and 33 respectively.

The securing devices 30 and 31 may have any convenient form, such as that shown in detail in Fig. 6; here 30^a denotes a nut in which a suitable screw threaded stud 30^b engages, and whose height with respect to the nut 30^a may be adjusted by means of a suitable tool adapted to engage the nut, as for instance with the rib 30^c on the nut. A desirable location and distribution of these securing means 30 and 31 to hold down the windings 14 and 15 is shown in Fig. 2. These securing means are arranged to react against an abutment 36 secured against the upper core clamp 37 in substantially a similar manner to the abutment 16 at the bottom of the core.

The abutments 16 and 36 on the core, as clearly shown in Fig. 5, make a very rugged structure capable of withstanding very severe stresses which may occur in service from any slight unbalancing of the magnetic forces between the windings 14 and 15 or which may arise from shrinkage in one or both of the windings. This arrangement of abutments for the windings greatly simplifies the core bracing, as will be readily appreciated from the drawings and at the same time admits of a simple and rugged core lifting means being secured to the core as shown at 40 without resort to any special form of core rigging.

Having now described my invention and the best means at present known to me for carrying the same into effect, I would have it understood that this is merely illustrative, and that I do not mean to be limited thereby to the precise details shown, nor restricted in the choice of recognized equivalents except as defined in my claims hereunto annexed.

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

1. In a high voltage transformer, the combination with a core, of a high voltage winding with its turns distributed non-uniformly along said core to withstand the effects of the high voltage, and a low voltage winding with its electrical center coinciding in position along the core with that of the high voltage winding, the distribution of the turns of the low voltage winding along the core substantially corresponding to that of said high voltage turns to reduce displacement forces between said windings.

2. In a high voltage transformer, the combination with a core, of a high voltage winding with one end grounded, the number of turns of said high voltage winding per unit distance along the core decreasing from its grounded end, and a low voltage winding with its electrical center coinciding in position along the core with that of the high voltage winding, the distribution of the turns of the low voltage winding along the core substantially corresponding to that of said high voltage turns to reduce displacement forces between said windings.

In witness whereof, I have hereunto set my hand this 19th day of Feb., 1920.

ALLAN B. HENDRICKS, Jr.