B. A. BEHREND.

REVOLVING FIELD MAGNET STRUCTURE.

APPLICATION FILED APR. 9, 1904. RENEWED JUNE 8, 1907.

918,498.

Patented Apr. 20, 1909.

3 SHEETS—SHEET 1.

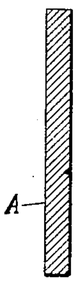


Fig. 1.

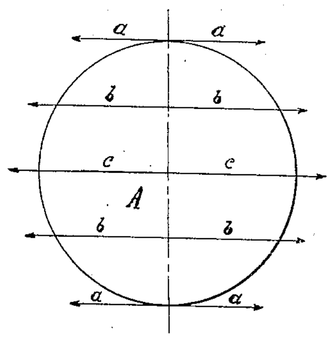


Fig. 2.

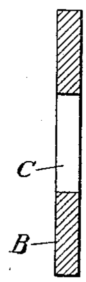


Fig. 3.

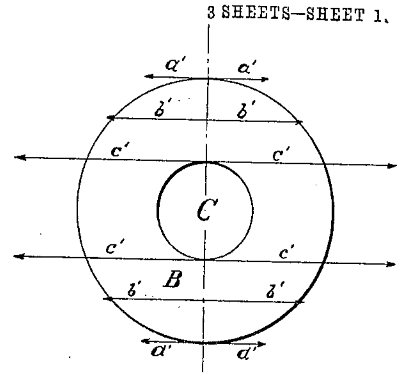


Fig. 4.

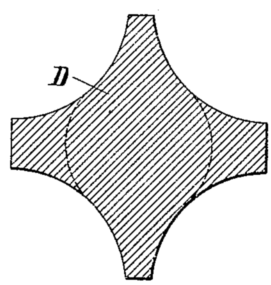


Fig. 5.

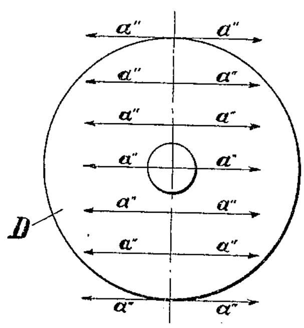


Fig. 6.

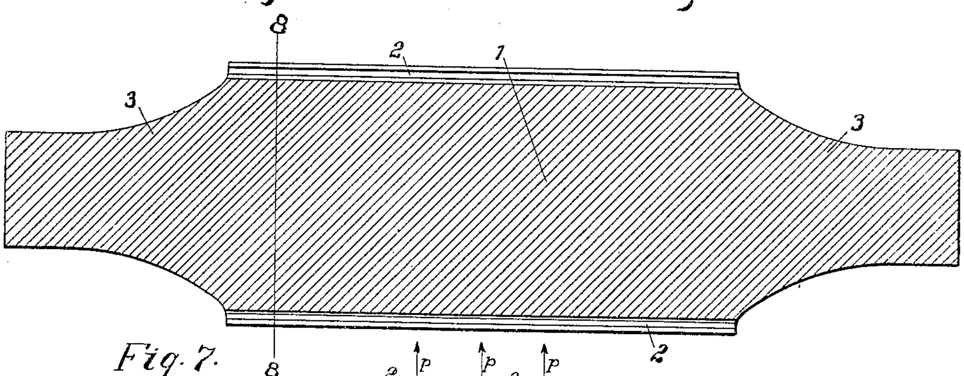


Fig. 7.

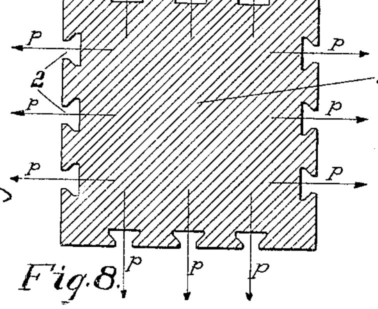


Fig. 8.

WITNESSES:

Julian S. Wooster

L. R. Sager

INVENTOR

Bernard Arthur Behrend

BY

C. V. Edwards

ATTORNEY

B. A. BEHREND.

REVOLVING FIELD MAGNET STRUCTURE.

APPLICATION FILED APR. 9, 1904. RENEWED JUNE 8, 1907.

918,498.

Patented Apr. 20, 1909.

3 SHEETS—SHEET 2.

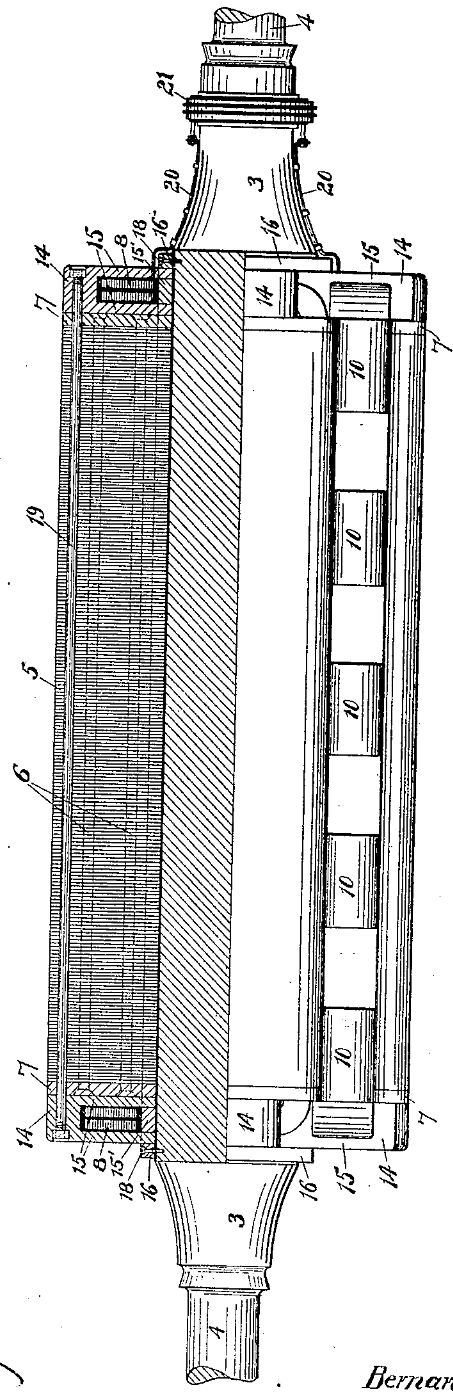


Fig. 9.

WITNESSES:

Julian S. Wooster.

L. K. Sager.

INVENTOR

Bernard Arthur Behrend.

BY

C. W. Edwards

ATTORNEY

B. A. BEHREND.

REVOLVING FIELD MAGNET STRUCTURE.

APPLICATION FILED APR. 9, 1904. RENEWED JUNE 8, 1907.

918,498. Patented Apr. 20, 1909.

3 SHEETS—SHEET 3.

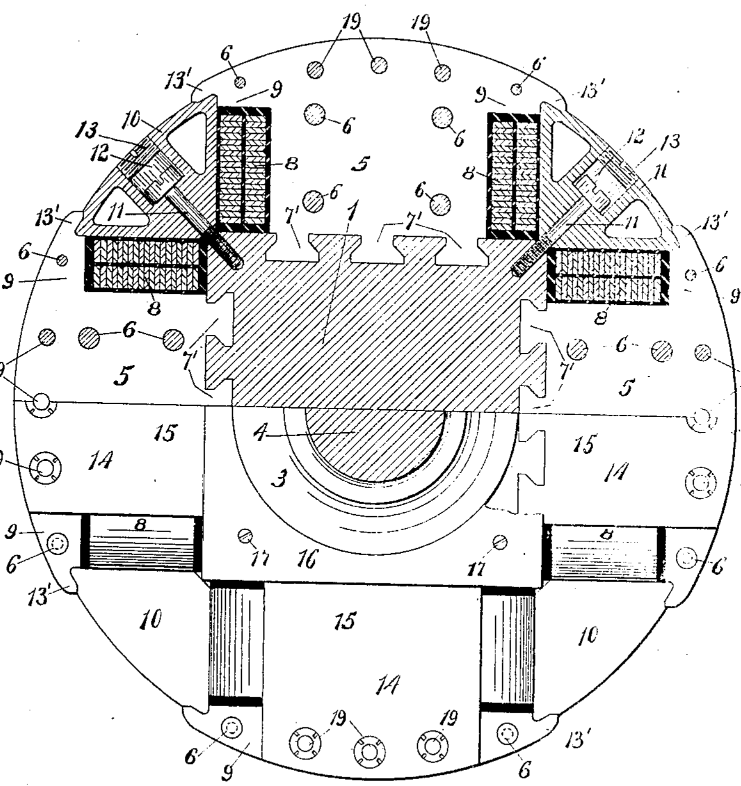


Fig. 10.

Fig. 11.

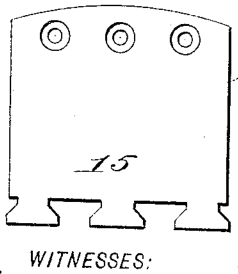
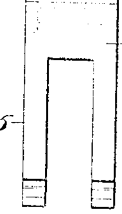


Fig. 12.



WITNESSES:

Julian S. Wooster.

S. R. Sager.

INVENTOR

Bernard Arthur Behrend.

BY

C. V. Edwards

ATTORNEY

UNITED STATES PATENT OFFICE.

BERNARD ARTHUR BEHREND, OF NORWOOD, OHIO, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE BULLOCK ELECTRIC COMPANY, A CORPORATION OF OHIO.

REVOLVING FIELD-MAGNET STRUCTURE.

No. 918,498. Specification of Letters Patent. Patented April 20, 1909.

Application filed April 9, 1904, Serial No. 202,353. Renewed June 8, 1907. Serial No. 378,062.

To all whom it may concern:

Be it known that I, BERNARD ARTHUR BEHREND, a citizen of the United States, residing at Norwood, in the county of Hamilton and State of Ohio, have invented certain new and useful Improvements in Revolving Field-Magnet Structures, of which the following is a full, clear, and exact specification.

My invention relates to dynamo-electric machines, and particularly to the construction of revolving field magnets adapted for very high speeds, such as those required of steam turbine generators.

The object of my invention is to provide such a construction of all parts of the revolving structure as to enable the same to withstand the enormous strains created at very high speeds and at the same time not in any way sacrifice the design as regards magnetic and electric requirements.

A further object is to make the construction as simple and well designed as possible consistent with obtaining the results desired.

One feature of my invention relates particularly to the structure of the shaft and the core by which its strength is greatly increased and the magnetic circuits also improved.

My invention further relates to means for supporting and protecting the field coils.

My invention will be understood by reference to the following description and accompanying drawings which illustrate one form of my invention, and the novelty thereof will be more definitely set forth in the claims.

Figures 1 to 6, inclusive, are for the purpose of explaining the principles which relate to one feature of my invention and illustrate sectional and end views of different forms of disks. Fig. 7 shows in section my improved construction of core and shaft; Fig. 8, a section on line 8—8 of Fig. 7; Fig. 9, a part section and part side view of the revolving field structure; Fig. 10, an end view of the same; and Figs. 11 and 12 are side and end views of the casting for retaining the end connections.

In order to fully understand the principles involved in my invention, it is necessary to consider the stresses which arise in a rotating disk. These principles are of the greatest importance in the design of high speed machines and only by their consideration can the best possible design be obtained.

Figs. 1 and 2 show a circular disk A which may be made of any material. I have proved experimentally, and it is also theoretically true that the bursting strains are greater at the center of the disk than at any other point. This is graphically represented in Fig. 2 in which the components of forces which tend to burst the disk when rotating at high speeds are represented by the arrows *a*, *b*, *c*; that is, considering a vertical section through the disk, the bursting component at the periphery may be represented by the arrow *a*, that at the center by the arrow *c*, and at some intermediate point by *b*. The strains at the center where they are a maximum are greatly in excess of those at the periphery, where they are a minimum. Figs. 3 and 4 show a disk B similar to disk A in which there is a central opening C. The bursting strains on a vertical section are indicated by the arrows a', b', c', that at the outer periphery being indicated by a', that at the inner periphery by c', and at an intermediate point by b'. Experiment has shown that when there is an opening as C, there is an entire change in relation of the strains to each other and cause a marked and excessive increase in the strain at the periphery of the central opening, which rapidly decreases at points a short distance therefrom. This great difference in the magnitude of the strains caused by the opening in the disk may be accounted for theoretically, although very complex formulæ are involved for calculating the strains. Moreover, it is experimentally as well as theoretically true that the magnitude and relations of the bursting strains are greatly changed by the presence of a central opening no larger than a pin-hole. The above leads to two requirements for obtaining strains of equal magnitude throughout all parts of the structure; first, the structure must be thinnest at the periphery and gradually increase in thickness until it is a maximum at the center; second, the structure must be one solid integral mass. This result is obtained in the structure shown in Figs. 5 and 6 representing a disk D tapering from the periphery so as to gradually increase the thickness, which is greatest through the center. By this construction the strains on a vertical section will be practically uniform at every point, as represented by the arrows a'', although the actual outline for this purpose is more nearly represented by the dotted lines in Fig. 5.

In applying the above principles to the revolving field structure of a dynamo electric machine, I have invented the form of core shown in Figs. 7 and 8, in which both of the above stated requirements are fulfilled. In the construction shown I provide one solid element of high magnetic permeability, which serves the function of a shaft as well as the core, being free from all joints and thus avoiding the excessive strains caused by their presence. I also taper down the ends of the core so as to give practically uniform strength to all parts. In the figures a core 1 is illustrated square in section, adapted for four poles and with the slots 2 to receive the dove-tailed projections of the pole pieces. Integral with this solid core are the tapering ends 3 which serve to greatly strengthen the central part of the core and also serve as supports for the same. The construction described is of value not only with reference to the strains created by the rotation of the core itself, but also to overcome the great additional strains indicated by arrows *p* caused by the attached pole pieces.

The full construction of a revolving field structure is shown in Figs. 9 and 10. The rectangular core 1 with the tapering portions 3 and extensions 4 is made of a single solid mass of high magnetic permeability and great mechanical strength, such as forged nickel steel. The pole pieces are built up of laminæ 5, being bolted together by the through bolts 6 between the end plates 7. The pole pieces are provided with a plurality of dove-tails 7′ which engage slots cut in the core 1. The field winding 8 is shown in this instance as a strip winding supported between the pole tips 9 and core 1. Between the poles and for the purpose of supporting the windings, I provide cast metal frames 10. These are triangular box like pieces secured to the core 1 by the tap bolts 11, the openings 12 for the heads of the bolts being closed by the screws 13, which would also serve to keep the bolts from flying out in case of breakage. Any suitable number of frames 10 may be used, depending upon the length of the pole, five being shown in Fig. 9 spaced apart from each other. The frames 10 are engaged by the projections 13′ extending from the pole tips which assist the bolts 11 in retaining the frames in place. The end connections of the coils are supported and protected by the casting 14 of steel, phosphor bronze or other suitable material. This is U shaped in section and the winding is inclosed between the arms 15 as shown in Fig. 9, the arms being provided with dove-tails for engaging the core in the same way as the laminæ. A spacing block 15′ is placed between the inner ends of the arms. A cover plate 16 is placed at each end of the core to prevent sidewise movement of the poles, the plates 16 being secured to the core 1 by end bolts 17 and radial bolts 18. The supports 14 are secured at their outer ends by means of the bolts 19 which are shown as extending through the full length of the pole piece, giving a very rigid construction. The leads 20 are brought out from the coils and connected to the usual collector rings 21, the leads being diametrically opposite for giving a more balanced structure.

It is apparent that my construction is very compact and rigid throughout and the strength is the greatest in the central core where it is most needed, as above explained. My construction presents the further advantage that the entire core serves as a path for the magnetic flux, being made of one solid mass of high magnetic permeability.

It is understood that I am not limited to the exact construction shown as changes in detail may be made without departing from the scope of the claims.

I claim as my invention:

1. In a revolving field structure, the combination with an element comprising a core, polygonal in shape, of high magnetic permeability, having extensions for supporting the same, all of one solid integral mass, of field magnet poles secured to said element.

2. In a revolving field structure, the combination with an element comprising a core of high magnetic permeability, having gradually tapering extensions for supporting the same, all of one solid integral mass, of field magnet poles secured to said element.

3. In a revolving field structure, the combination with an element comprising a core, polygonal in shape, of high magnetic permeability, having gradually tapering extensions for supporting the same, all of one solid integral mass, of field magnet poles secured to said element.

4. In a revolving field structure, the combination with an element comprising a core of high magnetic permeability, having gradually tapering extensions for supporting the same, all of one solid integral mass, of laminated field magnetic poles secured to said element by dovetails.

5. In a revolving field structure, the combination with an element comprising a core, polygonal in shape, of high magnetic permeability, having gradually tapering extensions for supporting the same, all of one solid integral mass, of laminated field magnetic poles secured to said element by dovetails.

6. In a revolving field magnet structure, the combination with the core and field magnet poles, of means for supporting the end turns of the windings, comprising U shaped members inclosing the end connections,

means for securing the inner ends of said members to the core and means for securing the outer end of said members to the pole piece.

7. In a revolving field magnet structure, the combination with the core and field magnet poles, of means for supporting the end turns of the windings, comprising U shaped members inclosing the end connections, the arms of said U shaped members having dovetail projections which engage the core and bolts for securing the outer end of said members to the pole piece.

In testimony whereof I affix my signature, in presence of two witnesses.

BERNARD ARTHUR BEHREND.

Witnesses:

LILLIAN J. BRITTON,
SANFORD KLEIN.