Oct. 10, 1933. C. A. MUDGE 1,929,755

ELECTRICAL MACHINERY

Filed Jan. 20, 1930 7 Sheets-Sheet 1

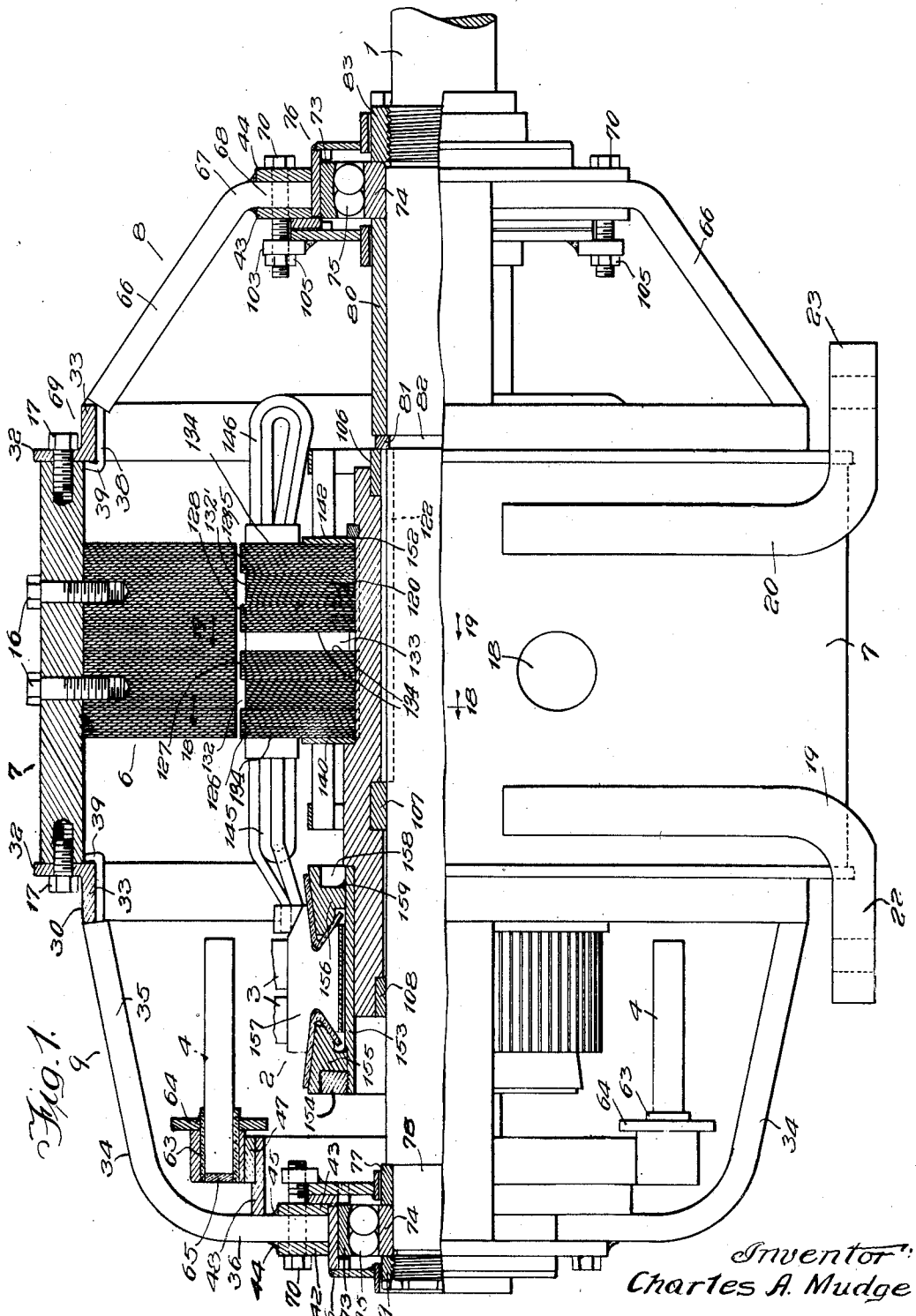


Fig. 1.

Witness:
William P. Kilroy

Inventor:
Charles A. Mudge

By Brown Jackson Boettcher & Dennis
Attys

Oct. 10, 1933. C. A. MUDGE 1,929,755

ELECTRICAL MACHINERY

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Fig. 6.

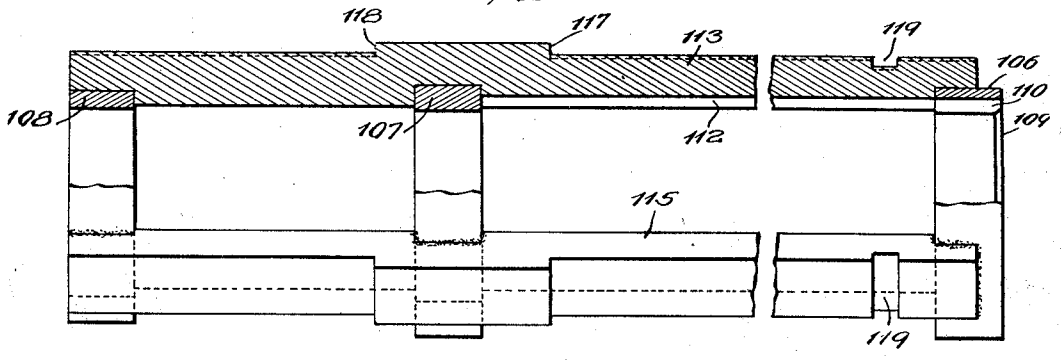



Fig. 7.

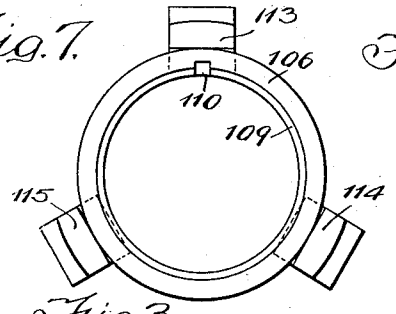



Fig. 4.

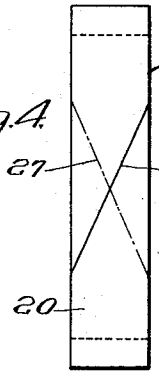



Fig. 5.

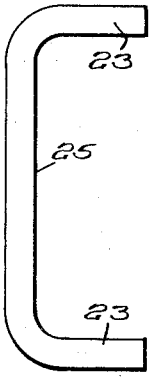



Fig. 3.

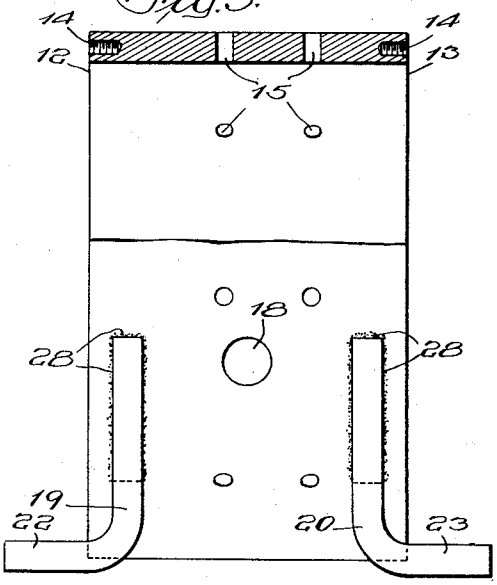
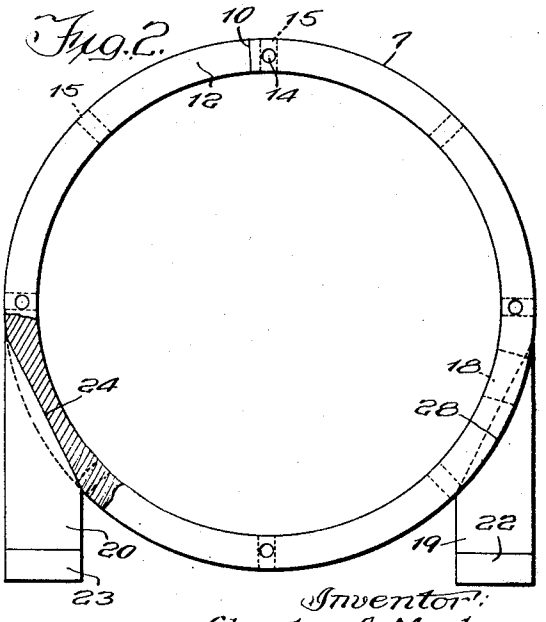



Fig. 2.




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Oct. 10, 1933. C. A. MUDGE 1,929,755

ELECTRICAL MACHINERY

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Fig. 8.

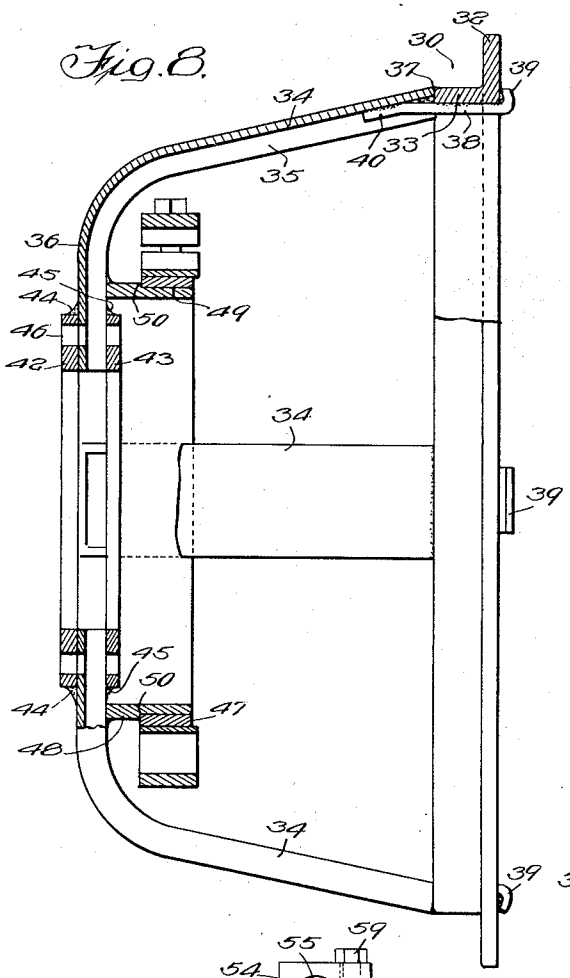



Fig. 9.

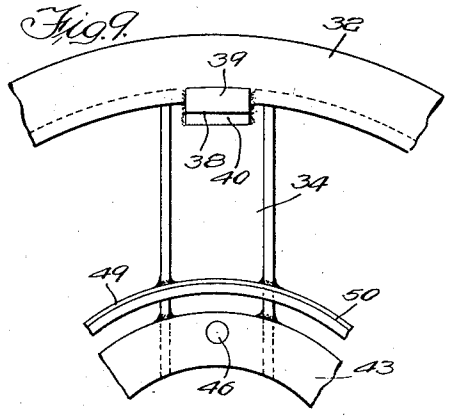



Fig. 10.

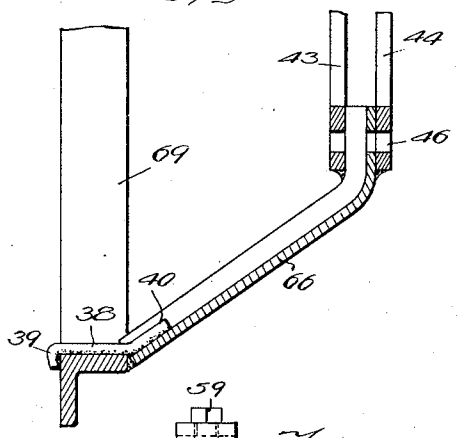



Fig. 11.

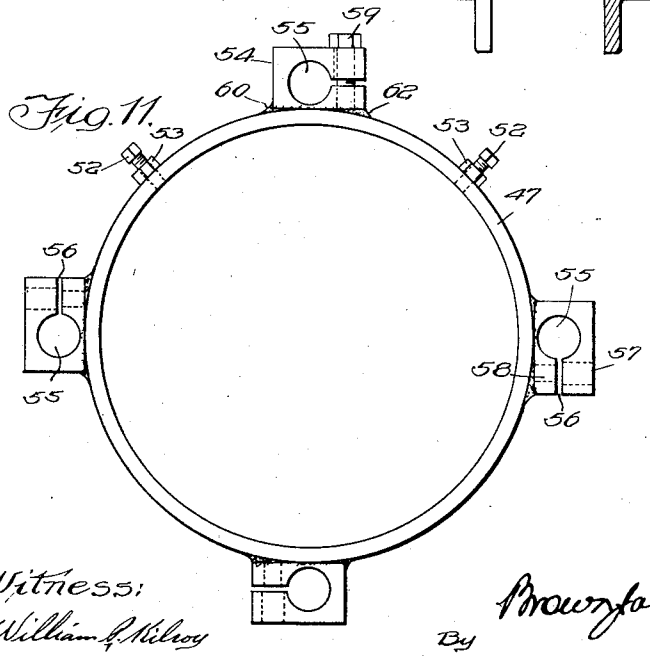



Fig. 12.

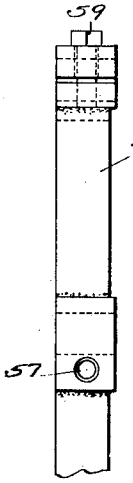
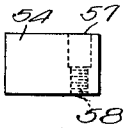



Fig. 13.




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Oct. 10, 1933. C. A. MUDGE 1,929,755

ELECTRICAL MACHINERY

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Fig. 14.

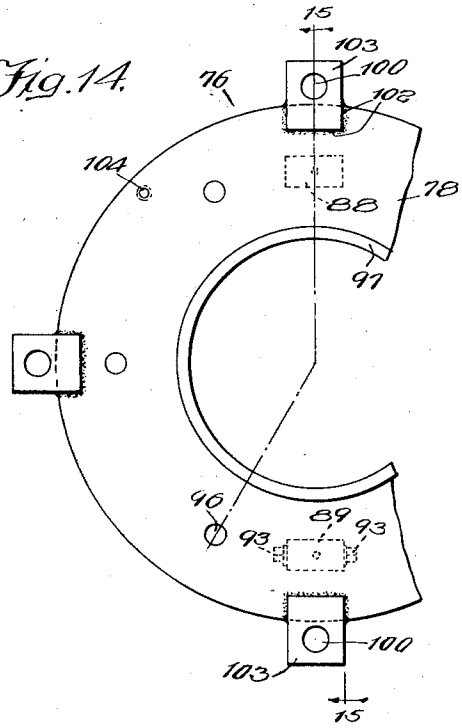



Fig. 15.

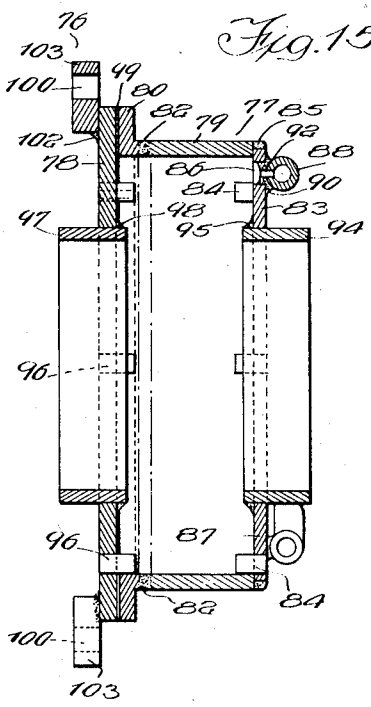



Fig. 17.

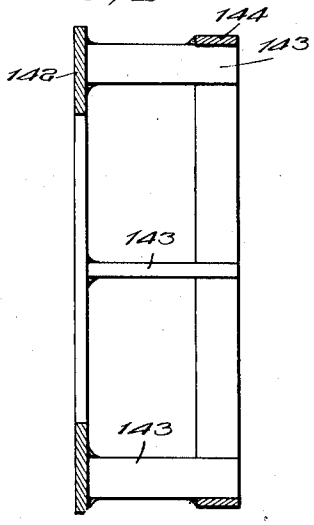
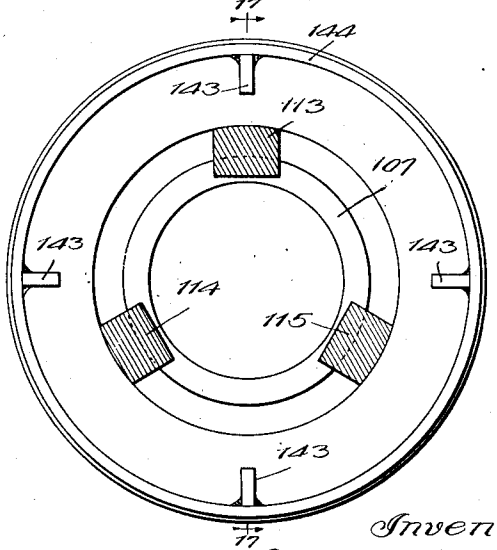



Fig. 16.




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Oct. 10, 1933. C. A. MUDGE 1,929,755

ELECTRICAL MACHINERY

Filed Jan. 20, 1930 7 Sheets-Sheet 5

Fig. 18

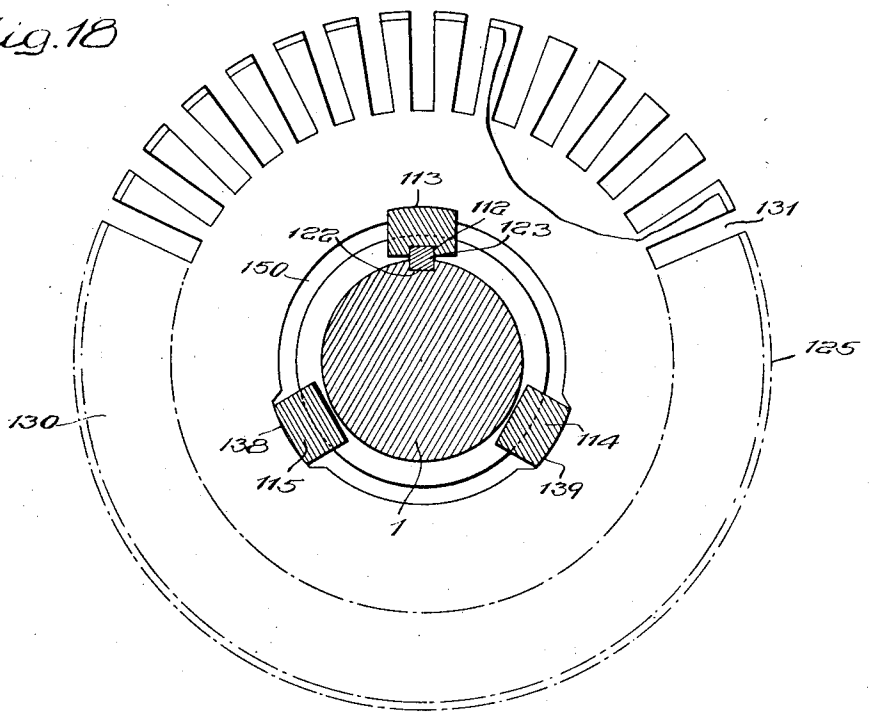
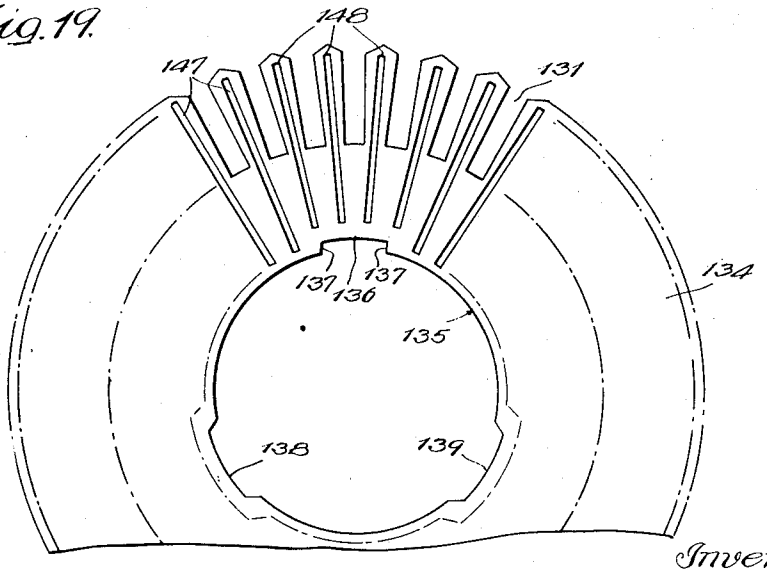



Fig. 19.




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Oct. 10, 1933. C. A. MUDGE 1,929,755

ELECTRICAL MACHINERY

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Fig. 20.

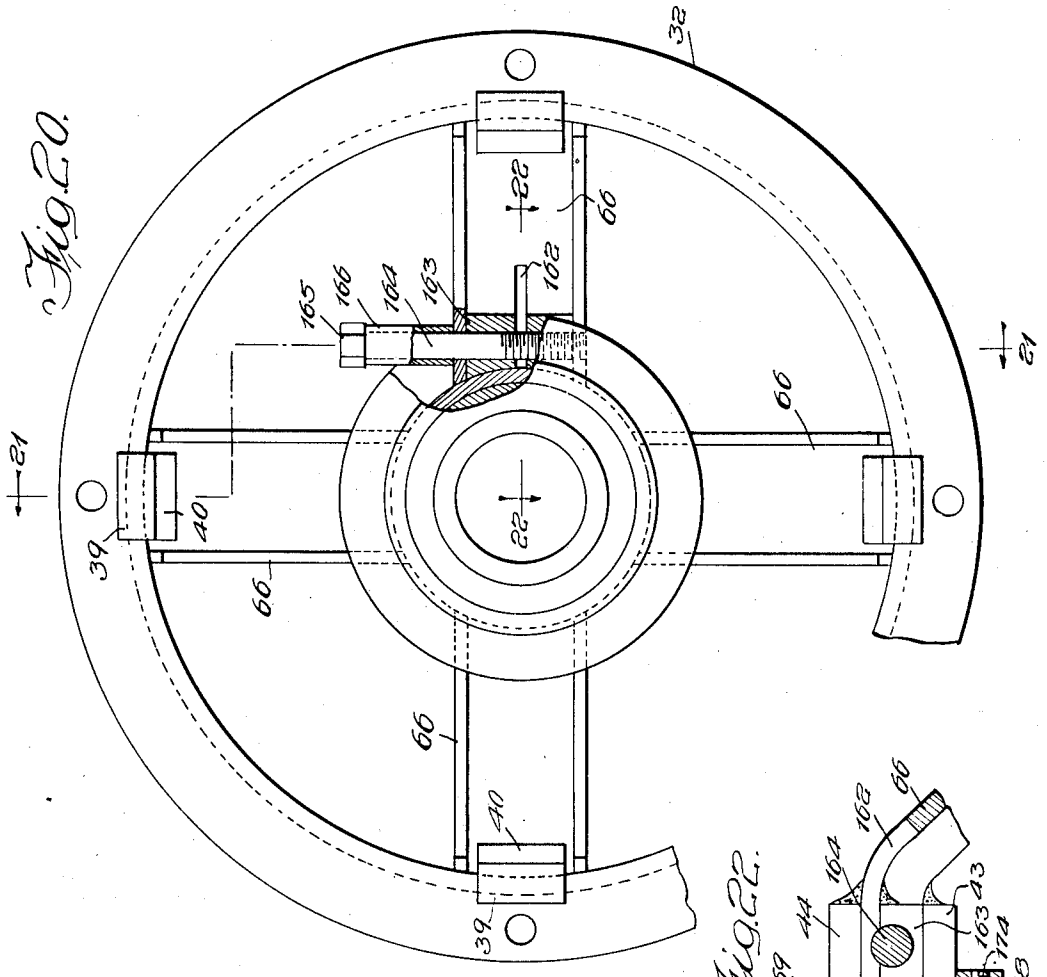
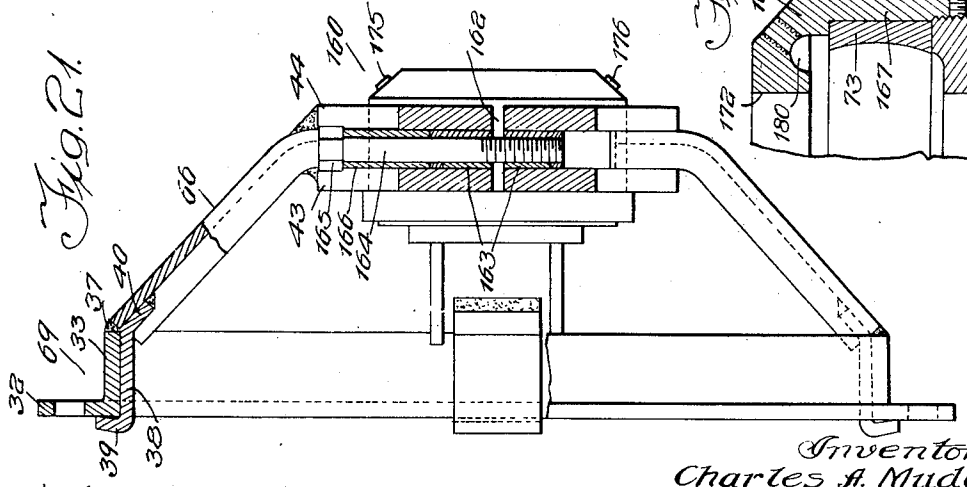



Fig. 22.




Fig. 21.




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Oct. 10, 1933. C. A. MUDGE 1,929,755

ELECTRICAL MACHINERY

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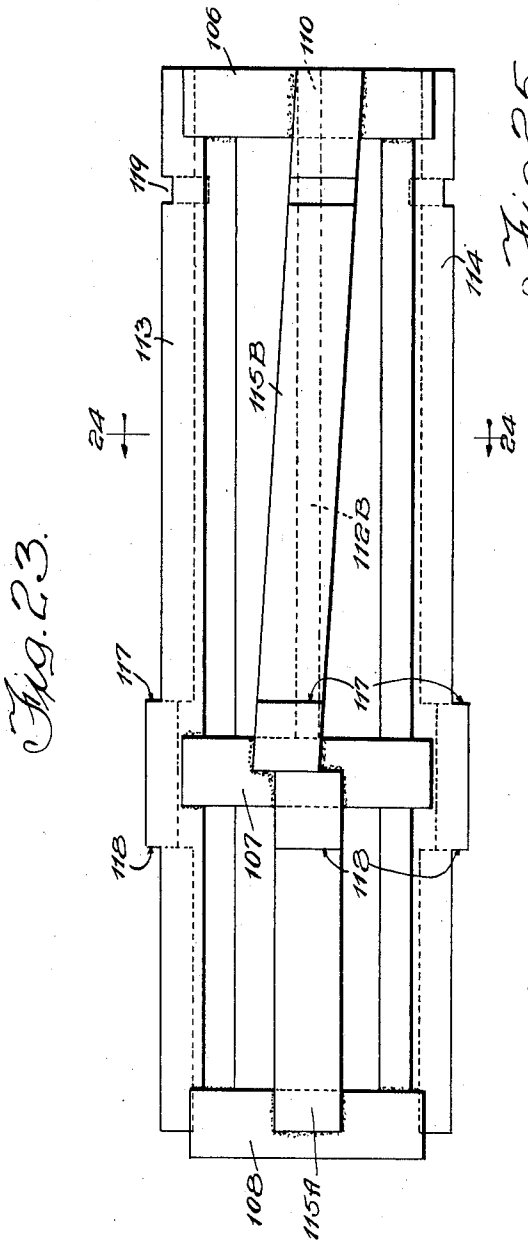



Fig. 23.

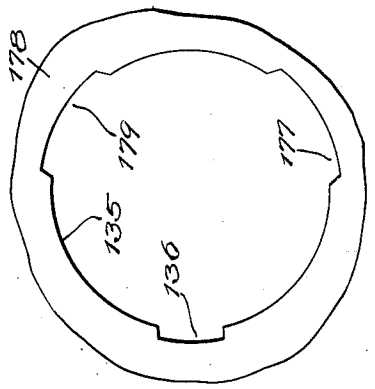



Fig. 25

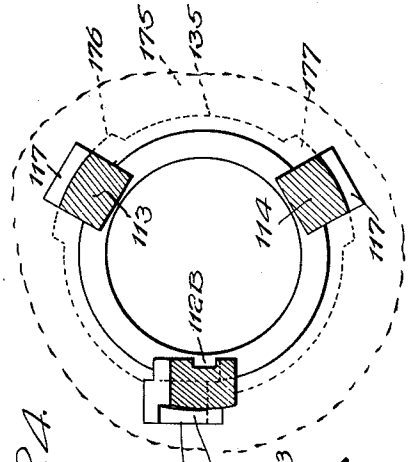



Fig. 24.

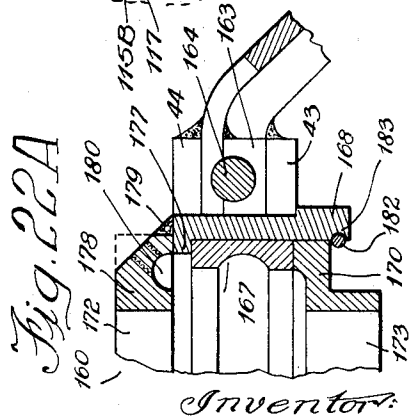



Fig. 22A

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Inventor:
Charles A Mudge

Patented Oct. 10, 1933 1,929,755

# UNITED STATES PATENT OFFICE

1,929,755

## ELECTRICAL MACHINERY

Charles A. Mudge, Elizabeth, N. J., assignor to Electro Dynamic Company, Bayonne, N. J., a corporation of New Jersey

Application January 20, 1930. Serial No. 421,991

30 Claims. (Cl. 171—206)

My invention relates to rotary electrical machinery and the like.

While the preferred embodiment herein shown is a direct current motor it is to be understood that the invention is not to be limited to direct current machinery nor to electric motors. The invention comprehends a plurality of novel features which may be employed in this, as well as other connections, and the following disclosure is not intended to be limiting, but to be explanatory.

I propose, according to the present invention, to construct a dynamo electric machine or the like, with large electrical capacity and employing a minimum of material, and I propose, also, to produce the same as economically as possible.

One of the chief features leading to this result is the building up of a machine largely by the use of structural parts of wrought metal welded together. Another chief feature of the invention resides in a design of the armature structure which provides a high degree of ventilation and a compact assembly.

In the machine which I herein illustrate and describe I have constructed the field frame and bearing brackets largely of structural parts welded together. This provides several advantages, among others the following:

1. The resultant construction is light in weight. Reduction in weight is an advantage in itself and reduces the material cost.

2. For a given weight the structure is stronger. This may be readily understood from the fact that wrought metal has a greater strength and uniformity than castings.

3. Castings require a foundry for their production. Structural materials can be secured readily on the open market without waiting for castings and hence a smaller stock need be carried by the manufacturer and production can be increased or decreased more readily.

4. Where the parts are assembled and welded, less machine work is required. This is particularly advantageous in the construction of machines of various sizes. For example, large size machines employing castings may require special machinery which is expensive, particularly if employed only occasionally.

The armature structure exhibits a highly advantageous feature of great importance. For reasons of economy it is desirable to make the armature as compact as possible. The limiting factor heretofore has not generally been the flux density, but the ability to radiate the heat losses, due both to magnetic reversals and the heating of the copper. That is to say, the amount of magnetic material required to carry the necessary magnetic flux through the armature has not been limited by the overworking of the iron magnetically, but by overheating, due to eddy currents and the heat of the copper. The insulating materials of the machine are the limiting factors in regard to heat; hence, temperature rise is a most critical factor in regard to the armature. The limits of the copper in the armature are likewise determined by the permissible temperature rise.

Heretofore, the region between the commutator and the adjacent end of the armature has been difficult to ventilate and has generally become a hot spot that has limited the capacity of the machine. By my invention this region is now adequately ventilated by positive draft, with consequent improvement of the capacity of the machine.

I have provided a novel form of armature structure and mounting therefor which not only is simple and effective mechanically but also provides an exceptionally effective cooling system that permits the armature to be worked at higher electrical and magnetic densities than have heretofore been permissible.

According to this feature of the invention I build up an armature barrel, upon which the laminations are mounted.

In armatures of relatively small diameter, as heretofore constructed, the laminations are assembled directly upon the shaft. This is because there is a limited amount of active magnetic material between the armature slot and the shaft.

The usual way of ventilating these armature cores is to punch the laminations with recesses where they fit on the shaft, these recesses allowing the air to pass therethrough. The preferred form of my device contemplates the use of two or more rings of a size adapted to be fitted onto the shaft with a press fit and having three or more strips of metal welded at their ends to these rings. The strips, or bars, are of a greater length than the axial depth of the active magnetic material, so that air may enter between the end ring of the barrel and the sides of the magnetic material and then be passed outwardly through ducts in the magnetic material to cool the armature structure.

Also in the construction of this barrel upon which the laminations are mounted I provide means for transmitting the torque between the laminations and the shaft directly through one of these bars or strips. This single strip forms a

key set into a keyway in the shaft and likewise forms a key set into the magnetic material or laminations, forming a connection between them. The other bars or strips forming staves or sides of the barrel serve to connect the rings and also to space radially the magnetic laminations concentrically with the shaft. The one key bar or strip serves not only as a key but also as a spacer to assist in holding the laminations coaxial with the shaft. This key bar may be skewed when it is desired to skew the slots of the armature.

Further features of my invention reside in the construction of the armature end plates for supporting the laminations endwise on the shaft, these end plates providing fan blades for increasing the radial flow of air for cooling purposes.

Other and further features of the invention will be apparent from the following detailed description and drawings, in which I have illustrated a specific embodiment of the invention.

In the drawings:—

Figure 1 is a side elevation and quarter section of an electric motor embodying my invention.

Figure 2 is an end view, with parts broken away, of the field frame and mounting feet.

Figure 3 is a side elevational view, partly in section, of the field frame shown in Figure 2.

Figure 4 is a front elevational view and

Figure 5 is a side view of a blank which is cut on either one of the diagonal lines indicated in Figure 4 to produce the mounting feet or brackets shown in Figs. 2 and 3.

Figure 6 is a side elevation with a quarter section broken away, of the armature barrel.

Figure 7 is an end view of the same.

Figure 8 is a side elevational view, with parts broken away, of the end frame or bearing bracket for the commutator end of the machine shown in Figure 1.

Figure 9 is a fragmentary end view of the same, taken from the right of Figure 8.

Figure 10 is a fragmentary section through the bearing bracket on the pulley end of the machine shown in Figure 1.

Figure 11 is an end view of the brush ring which appears in section in Figure 8.

Figure 12 is a side view taken from the right of Figure 11.

Figure 13 is a side elevational view of the block out of which the split clamps for the brush holder pins are formed.

Figure 14 is an end view of the bearing cartridge, or housing, as viewed from the left of Figure 13.

Figure 15 is a section taken on the line 15—15 of Figure 14, of the bearing housing.

Figure 16 is an end view taken from the right of Figure 17 of the armature end plate, the same being shown as mounted upon the armature barrel.

Figure 17 is a section taken on the line 17—17 of Figure 16 of the armature end plate.

Figure 18 is a cross-sectional view through the armature taken on approximately the line 18—18 of Figure 1, showing the laminations mounted upon the armature barrel and the armature barrel, in turn, mounted upon the shaft. The windings are omitted from the slot for the sake of clearness.

Figure 19 is an elevational view of one of the armature core stampings upon which the vent blocks are mounted.

Figure 20 is an inside end view of a modified form of bearing bracket and cartridge construction.

Figure 21 is a side elevational view of the same, partly in section, showing the split clamp form of hub.

Figure 22 is a fragmentary section taken on the line 22—22 of Figure 20. Fig. 22—A is a modification of the same.

Figure 23 is a side-elevational view of a modified form of the barrel.

Figure 24 is a cross-section of the same taken on the line 24—24 of Figure 23 and showing in dotted line the inner periphery of a lamination mounted thereupon and

Figure 25 is a fragmentary view of an armature core lamination used on the barrel shown in Figure 23.

Referring first to Figure 1, wherein I have shown in quarter-section and side elevation a specific embodiment of the invention comprising a direct current motor. This motor has a shaft 1, the pulley end of which shaft is to the right, the pulley not being shown, and the commutator end being to the left. The commutator is indicated at 2 and the brushes have been indicated fragmentarily at 3, these brushes being mounted upon suitable brush-holder rods 4, in any suitable manner well known to those skilled in the art.

The armature 5 is mounted upon the shaft 1 and it cooperates with a series of pole pieces 6, the windings of which have been omitted for the sake of clearness, mounted upon a field frame yoke 7.

*Field frame*

The field frame yoke 7 has secured thereto bearing brackets, or housings as they are sometimes called, 8 and 9. These bearing brackets are of slightly different construction in view of the fact that the bracket 8 is for the pulley end and the bracket 9 for the commutator end of the machine.

The field frame or yoke 7 is constructed as follows. A piece of flat stock that is of suitable iron is rolled into the shape of a tube or cylinder and the ends thereof are butt welded. If desired, the ends may be merely tacked together by welding and the joint put at, or approximately the center of one of the poles, as shown at 10 in Figure 2. If it were possible to secure on the open market tubing of the size required, such, for example, as a 20½ inch outside diameter and 1⅛ inch thickness of wall, such tubing could be employed by merely cutting off rings therefrom. After the ring is formed, either as by rolling up flat stock and welding or by any other method, the inside is machined and the ends thereof are machined to provide the finished end surfaces 12 and 13, against which the bearing brackets 8 and 9 are clamped. A series of holes 14—14 are drilled into the body of the ring, preferably at equally spaced intervals, these holes extending parallel to the axis of the ring and being tapped to receive tap screws or studs. Likewise, the ring is drilled radially to provide pairs of holes 15—15 to pass tap screws or studs 16—16 as shown in Figure 1, these studs extending into the pole pieces 6 to secure the poles to the yoke 7. An opening 18 is drilled or otherwise cut through the cylindrical wall of the ring 7 to provide an opening through which the leads may be extended. This may be covered by a suitable terminal box or conduit, connected to the yoke ring 7.

After the ring is formed and preferably before finishing, four slots are cut in the walls for the attachment of the brackets or legs 19 and 20, the

feet 22 and 23 of the legs 19 and 20 facing in opposite directions.

These slots or keyways are cut with a straight bottom wall and parallel side walls to give a rectangular groove, this groove being of varying depth as plainly indicated in Figure 2, in view of the fact that the bottom 24 of the groove forms a chord to the circle defining the outer peripheral wall of the ring. In one example of my invention, where the wall thickness is approximately $1\frac{1}{16}$ inch, the groove is ½ inch deep at its greatest depth.

These grooves are formed on the lower half of the ring at a suitable location and angle to bring the outer edges of the legs 19 and 20 substantially tangent to the horizontal diameter of the ring when the legs are in vertical position.

The legs or foot brackets are made up as follows. A piece of rectangular stock is cut to suitable length and bent into the shape of a shallow U to form the piece shown at 25 in Figure 5. The vent-up ends 23—23 become the feet 23 shown in Figures 2 and 3 and are preferably disposed at substantially right angles to the main body of the bar. For a set of four legs two such members 25 are formed and then the bottom of the U, that is, the main body of the bar between the ends 23—23 as shown in Figure 5 is cut as by a milling saw on the line 26 shown in Figure 4 in full line, to produce the legs 20 with foot portions 23, and the other member 25 is cut on the line 27 as shown in broken line on Figure 4 to produce the legs 19 and feet 22. In other words, the legs are lefts and rights.

The thickness of the body of the bar 25 is just equal to the width of the slot 24 and the width of the bar 25 is so coordinated to the length of the slot 24 and the angle at which it is formed and the bar is cut that the diagonal face of the bracket substantially fills the full length of the slot to produce a neat and finished appearance. Obviously, the relations may be varied without departing from my invention but it is functionally important to have the bar of substantially the exact width of the slot so as to secure the necessary strength and it is also functionally necessary to have the slot extend a substantial distance into the body of the ring in order to secure the bracing effect which my invention provides. That is to say, by setting the brackets into the slot and then welding around the edges of the slot to unite the cylindrical surface of the ring 7 and the vertical parts of the foot brackets 19 or 20, as indicated by the line of welding 28 (see Figure 3) the metal of the bracket secures a definite gain or hold in the body of the ring 7 which greatly reduces the stress upon the line of welding. Welded metal is often brittle and particularly weak in tension though it may be very strong in compression. By the provision of the gain or notch into which the end of the leg is set the line of weld may be substantially relieved of undue stress in tension for any force acting normal to the plane of the paper in Figure 2 upon the leg 19 or 20, in view of the fact that a substantial lever arm exists between the outer peripheral part of the notch and the bottom of the notch. I am aware that it is old to cut the edge of the leg to the circular shape of the ring and then to provide a peripheral weld about the meeting edges, but my invention is far superior in strength to such prior arrangement. Also, the accurate location of the legs on the frame is facilitated by the accurate cutting of the notches into which the legs are forced.

In the field frame shown in Figures 1, 2 and 3 there are four main poles and four inter-poles. These poles and pole pieces may be formed as disclosed in my co-pending application, Serial No. 421,637, filed January 18, 1930 and, briefly, consists of the following, namely, a number of laminations of suitable transformer steel or the like are punched out of sheet metal and assembled in register, these punchings having registering grooves along the edges, which grooves receive a line of welding metal which unites all of the laminations rigidly into a block of any desired formation, that is, rectangular or skewed, or in any other shape desired. I refer here to my co-pending application for a full disclosure of the same for the purpose of explanation. I do not wish to limit the present invention to the use of such pole pieces, as obviously, other forms of pole pieces may be employed in the present machine.

*Bearing brackets or housings*

The bearing bracket or housing member for the commutator end of the machine is shown in Figures 1, 8 and 9. The bearing bracket for the pulley end is shown in Figures 1 and 10.

Referring first to the bearing bracket for the commutator end, the construction is as follows. I form a ring 30 of angle iron with one leg of the angle disposed in a plane at right angles to the longitudinal axis of the bracket and of the shaft which it supports. The other leg 33 becomes a cylinder. This ring 30 is formed by bending a piece of structural angle iron into a ring shape and welding together the meeting ends.

Then a series of arms 34—34, preferably four in number, are formed of solid rectangular section or of channel bar section. Obviously, instead of structural materials secured on the open market, these might be rolled or formed of special stock if so desired, however, structural shapes may be readily procured on the open market and since their function in the present structure is mechanical, namely, to serve as rigid or substantially rigid supporting pieces, commercial bars serve the purpose. These arms 34 are formed of channel bar with the flanges turned inwardly and are bent so as to provide a diagonal portion 35 and a radial portion 36, joined by a suitable bend.

The outer end of each bar is joined to the cylindrical flange 33 by a line of welding indicated at 37 where the end of the web of the bar abuts against the cylindrical flange 33, of the ring 30. In order to reinforce this connection I provide an angle piece 38 which has a main body portion extending substantially parallel to the axis of the machine and bent-up ends 39 extending substantially radially. These angle pieces are used whether the arms are channel shaped or of solid section. The opposite end 40 is inclined inwardly to substantially the inclination of the portion 35 of the arm 34, so that said end 40 may lie flat against the web of the channel bar or the inner face of a flat bar and be welded thereto. The main body portion is welded to the cylindrical leg 33 of the ring 30 and likewise the bent-up end 39 is welded at its sides to the radial face of the radially extending flange 32. Care is taken not to extend the weld beyond the sides since this angle piece 38 performs another important function, namely, that of providing a piloting or centering shoulder to center the bearing brackets with respect to

the ring 7 and to relieve the bolts 17 which hold the brackets on the ends of the ring 7 from shear.

Such angle pieces 38 are formed of flat bar stock, bent to suitable shape and welded in place to reinforce the joint between the arm 34 and the ring 30 in each case, also to provide the piloting projection 39 afforded by the bent-up end. This provides a strong joint between the ring and the spider arms 34 and since the back of the channel is outward these flat angle pieces are concealed.

The radially extending ends 36, in the present case four in number, are spaced far enough away from the ring 7 to provide ample room for the commutator and brushes and the means for supporting the brushes.

Rings 42 and 43, of flat stock, are placed upon the outside and upon the inside of the part 36 and welded thereto. The welds are preferably at the corners formed by the outer peripheries of the rings 42 and 43 and the adjacent surface of the arms 34, as indicated by reference numerals 44 and 45. These rings 42—43 are preferably of the same thickness, for example, 3/8 of an inch in the present instance, allowing sufficient stock for machining to accurate dimensions when the bearing bracket is completed.

The radial flange 32 of the ring 30 is drilled at, for example, four equidistant points so as to register with the holes 14 in the ring 7, whereby the cap screws 17 may secure the bracket upon the ring 7.

The rings 42—43 are drilled to provide the holes 46 extending preferably through the arms 34 for the attachment of the bearing cartridges later to be described, according to one form of my invention.

For the mounting of the brushes 3—3, suitable insulated brush-holder rods 4—4 are provided and these are supported on an adjustable ring 47, which in turn is supported upon a stationary ring 48, welded to the arms 34. The ring 48 is a cylindrical ring concentric with the rings 42—43 and having its adjacent edge welded to the arms 34—34. The opposite end of the ring 48 is machined as by turning in a lathe to provide a cylindrical seat or bearing 49 to receive the brush-supporting ring 47. A shoulder 50 limits the position of the brush ring 47 on the supporting ring 48. One or more set-screws such as 52, provided with a lock-nut 53 may be mounted in suitable tapped hole in the brush ring 47, as shown in Figure 11, for adjustably clamping the brush ring 47 upon the supporting ring 48. The brush ring 47 carries four split clamping blocks 54 which are formed of rectangular blocks of metal, drilled to provide the holes 55 and then slotted as indicated at 56 to form split clamps. The upper part of the split clamp is drilled as indicated at 57 and the lower part drilled and tapped as indicated at 58, so as to receive a clamping screw 59 as shown at the top of Figure 11. The slotting is performed after the machining and drilling, since the slotting reduces greatly the rigidity of the block. The blocks are then welded on to the rings as indicated by the line of welds at 60 and 62 in Figure 11. The rods 4 are provided with a sleeve of insulating material as indicated at 63 in Figure 1 and an insulating collar 64 as indicated in Figure 1. The ends of the sleeves 63 are plugged by plugs of insulation 65, so that the brush-holding rods 4 are completely insulated where they are gripped by the split clamping blocks 54. Alternatively, unitary moulded flanged caps may be provided to hold the ends of the rods which may be threaded into said caps.

The pulley end bracket frame is constructed in a similar manner. The arms 66 which are formed of channel stock do not extend as far out to the right as the bars 35 do to the left, since the commutator is disposed at the left, as viewed in Figure 1. Otherwise, the construction of this bearing bracket is the same as that shown at the left of Figure 1. The bars 66 are bent sharper, as indicated at 67, to bring the radially extending ends 68 into proper position and the inclination of the outer ends is sharper. Hence, the ends of the flat angle pieces 38 for joining the ring 69 to the arm 66 are shaped accordingly.

The manner of forming the ring 69 of angle bar and welding it to the arm 66 is the same as previously described. Likewise, the manner of mounting the flat rings 43 and 44 upon the radially extending ends 68 of the arm 66 is the same as previously described and the rings and arms are likewise drilled to receive the clamping bolts 70—70 for holding the bearing cartridge in place.

The bolts 70—70 pass loosely through the holes 46 in each case for the purpose of clamping the bearing cartridge in place, as will be described later.

After the bearing brackets are welded together they are machined to bring the surfaces into accurate registry with the required dimensions. However, very little machining is necessary. The machining comprises chiefly finishing the radial surface of the radially extending angles 32 down to the ends 39 of the angle pieces 38 so as to finish these piloting projections and fit them to the inside periphery of the ring 7. Likewise, the inner surface of the ring 43 is machined to provide the accurate distance horizontally between the inner face of the radially extending flange 32 and the radially extending face of the ring 43. The inner periphery of the rings 43 and 44 is finished for a close fit with the bearing cartridge later to be described.

*Bearings*

I shall now describe the specific bearing construction herein employed. While I employ a specific form of bearing it is to be understood that this specific form of bearing is not necessarily related to the other details of construction previously described and hereafter to be described, as the construction and use of these bearings is itself novel.

I employ, for mounting the shaft 1 in the brackets 8 and 9, self-aligning ball bearings having the outer races 73 and the inner races 74, with a double row of balls 75 between them. The inner race has two grooves for aligning the balls and providing a definite track for them, whereas the outer race has a spherical surface so that the bearings are self-aligning for small inaccuracies. Self-aligning bearings are not essential. Bearings employing a single row of balls may be used.

The bearings are housed in cartridges 76, these cartridges being of the same construction at each end. The inner race 74 at the left is clamped between a suitable collar 77 which abuts against a rounded shoulder 78 on the shaft 1, and a nut 79 which threads upon the end of the shaft 1, this nut 79 being preferably castellated and having a cylindrical peripheral surface, as has also the collar 77, for cooperation with cylindrical flanges on the bearing cartridge 76.

At the right the inner ring or race 74 is clamped between a sleeve 80 mounted upon a shaft and

abutting against a ring 81 of square cross-section, seated in a square groove 82 in the shaft 1 and a castellated nut 83 threaded upon the shaft 1. The sleeve 80 and nut 83 are cylindrical upon the outside and fit relatively closely with the cylindrical flanges of the bearing cartridge 76. The bearing cartridge is constructed as shown in detail in Figures 1, 14 and 15.

*Bearing cartridge*

The bearing cartridge comprises a housing portion 77 and an end plate or cover plate 78. The housing portion comprises a tubular steel ring 79 which may be a piece of commercial tubing or a piece of flat bar or sheet stock rolled into cylindrical form, with the adjacent ends welded together.

This tubular portion 79, when formed, is slightly larger than the finished dimensions. A flat steel ring 80 is then formed, this ring having an internal diameter substantially the same as the inside diameter of the tubular member 79. These two parts are placed in a fixture and are then welded together by a line of welding indicated at 82. The ring 80 is thicker than its finished dimensions and it will be observed that in Figure 15 the finished barrel is shown so that a part of the right hand radial face of the ring 80 has been cut away and the outer peripheral part of the weld likewise has been cut away in finishing the cylindrical peripheral surface of the member 79.

Another ring 83, having an outside diameter slightly less than the outside diameter of the piece 79 and extending radially inwardly to provide a flange, is drilled and provided with a series of pins 84, which pins serve the purpose of piloting the flat ring 83 with respect to the tubular member 79, is then welded to the tubular member 79 by a line of welding indicated at 85. This line of welding is at the corner between the end of the member 79 and the outer periphery of the flat ring 83. The ends of the pins 84 are also preferably welded in place, these pins being driven into the holes formed in the plate 83. Welding is not essential in that case.

The plate 83 is provided with an opening at 86 and at 87 for the connection of a pipe coupling. This may be a ⅛ inch standard wrought-iron gas pipe coupling providing a connection for a lubricator. Such a pipe coupling 88 is welded in register with the opening 86 and a similar coupling 89 is welded in register with the lower opening 87, as indicated by the welding material 90. A hole is then drilled through the welding material and through the wall of the pipe coupling to provide a lubrication pasageway from the inside of the coupling to the inside of the housing. The lower coupling 89 is preferably plugged by a standard wrought-iron pipe plug 93, to close off the same. Any suitable form of lubricating connections may be coupled to the filling coupling 88 and the lower coupling employed as a drain coupling.

A tubular sleeve 94, which may be a piece of standard steel tubing cut to proper length, is mounted within the inner periphery of the flat ring 83. The outer diameter of the sleeve 94 is substantially equal to the inside diameter of the flat ring 83 and the tubular member 94 projects inwardly slightly beyond the left-hand wall of the ring 83, and a line of welding 95 disposed in the corner between these two members, peripherally, unites the sleeve 94 to the ring 83.

Preferably, the sleeve 94 and the pipe couplings 88 and 89 are welded together before the ring 83 is welded to the tubular member 79.

The housing member 77 is preferably machined externally to finish the periphery of the flange 80 and both sides of the same and to finish the cylindrical surface of the ring 79. The inside periphery of the ring 80 and of the tubular member 79 is finished to the outside diameter of the ball race 73 and this finish is carried over to the right, as viewed in Figure 15, to include the ends of the pins 84, if necessary, so as to provide an accurate dimension between the ends of the pins 84 and the left-hand surface of the ring 80. This accurate dimension is desired in order to hold the outer race 73 in an axial direction between the pins 84 and similar pins 96 serving a similar purpose on the cover plate 78.

The cover plate 78 comprises a flat ring having an outside diameter substantially equal to the outside diameter of the ring 80 and having an inside diameter substantially equal to the inside diameter of the ring 83.

A tubular member 97, which is the same piece as 94, is projected through the opening in the cover plate 78 and is welded along the line 98 shown in Figure 15 to unite these two parts. The pins 96 are accurately finished with reference to the right hand side of the plate 78 where it engages the flange 80. A thin vellumoid or like sealing washer 99 is clamped between the flange 80 and the cover plate 78 to close the housing to retain lubricant. The plate 78 has four lugs which are formed of blocks of steel drilled and tapped as indicated at 100, these blocks being welded to the cover plate 78 upon the outside of the same as indicated by the welds 102. The blocks may be first welded in place and thereafter accurately drilled and tapped on a proper radial and circumferential spacing. Instead of detached blocks a complete ring may be welded to plate 78.

These tubular members 94 and 97 provide axially extending flanges for excluding foreign matter from the bearings and preferably the bearings are filled with grease.

The pins 96 serve as piloting projections for registering the cover plate 78 with respect to the housing 77 of the cartridge, and the two parts, namely, the housing part and the cover part, 77 and 78, may be held together in suitable register and assembled position by means of a small, counter-sunk head-screw 104. The cartridge 76 is in each case not dependent upon the screw 104 to be held properly in alignment, it merely serving to keep the parts together until the clamping screws 70, which pass loosely through the hub of the corresponding bearing bracket, can be threaded through the lugs 103 and drawn up tight.

Since the outside of the cartridge is accurately machined, radially and cylindrically, and likewise the hub is accurately machined, cylindrically and radially on its inner surface, these parts are accurately brought into alignment. Such inaccuracies as are unavoidable are taken care of by the self-aligning bearings. Lock-nuts such as 105 may be provided on the ends of the bolts 70 if desired.

*Alternative bracket and cartridge construction*

In Figures 20, 21 and 22 I have shown an alternative form of bracket and cartridge construction. The bracket is constructed substantially as described in connection with Figures 1, 8, 9 and 10. The bearing bracket shown in Figures 20 to 22 inclusive is for the pulley end of the motor.

In this case, instead of drilling holes through

the rings or washers 43—44, which are welded to the inner ends of the arms 66—66, I form the hub as a split clamp embracing the outer cylindrical part of the bearing cartridge. In the particular construction herein shown I cut a slot 162 through both rings and through the corresponding end of the arm 66. While I have shown the slot as formed in the arm 66 which is formed of a channel bar, it is to be understood that the arms 66 may be made of rectangular section, that is, of a solid rectangular section, if desired. Where the channel bar is employed for construction of the arms 66 a block 163 is first welded in place on the inside of the channel so as to make said end of the arm solid between the two washers 43 and 44. A hole is then drilled through the lower end of the arm and then counter-bored to substantially the center of the arm and then the lower end of the arm tapped to receive the clamping screw 164.

The block and arm and the rings 43 and 44 on each side of the same are slotted by a saw or milling cutter to form the hub and arm into a split clamp. The clamping bolt 164 is provided with a relatively long shank so as to bring the head 165 outside of the space between the washers or flat rings 43 and 44 and a sleeve or collar 166 is placed over the shank of the bolt and bears against the side of the arms, so that tightening up of the bolt 164 draws the sides of the slot 162 towards each other, thereby shrinking the circumference of the hub and gripping the bearing cartridge 160 firmly by a peripheral grip.

While I have described a specific manner of slotting the hub so as to form a split clamp it will be apparent at once to those skilled in the art that I may weld a solid block to the two rings 43 and 44 between arms 66—66, this block being drilled and tapped before it is welded in place and then it may be slotted to constitute the split clamp heretofore mentioned.

It is to be observed, that the form herein illustrated is preferable, in that the slot does not entirely remove the hoop strength of the hub, since the ends of the rings 43 and 44 are not entirely free, being connected together through the web of the channel bar of which the arm 66 is formed. Whether the arm is formed of channel or solid bar is immaterial; the slot, if cut through the hub and into the arm, insures that the slotted ends of the rings 43 and 44 move together substantially as a unit, so far as radial motion is concerned and a more even and satisfactory grip is secured upon the cylindrical exterior surface of the cartridge 160.

On the commutator end the bracket arm has the brush-supporting ring welded thereto. The slot 166 is cut through the hub, the arm and the brush-supporting ring. The solid brush-supporting ring which carries the split clamp blocks is provided with set-screws securing the same upon the first brush-supporting ring.

The body of the cartridge 160 may be built up as shown in Figure 22—A or, in the smaller sizes, may be made of a forging or cut out of solid metal, if desired. As shown in Figures 20 to 22, inclusive, the housing portion of the cartridge comprises a cylindrical portion 167, having a radial flange 168 which is adapted to rest against the inside ring 43 and an inwardly extending flange portion 169 providing a shoulder between which and the cover plate 170 the outer race 73 is secured. The outer race 73 is just loose enough within the cartridge to permit of slow or creeping rotation.

The housing portion has a longitudinally extending sleeve portion 172 and the cover plate 170 has a similar longitudinally extending sleeve portion 173 fitting closely to the shaft but not engaging the same. The sleeve portion 173 of the cover plate 170 may be slabbed off, or formed in polygonal form if desired, for the engagement with a suitable wrench, or, in the larger sizes, lugs may be welded to the said sleeve portion 173 for engagement by a spanner wrench.

The flange portion 168 provides a shoulder for limiting the axial position of the cartridge within the split clamp of the hub and a grub-screw 174 threaded into said flange 168 and engaging the threads on the plate 170 holds the said cover plate against accidental motion.

The cartridge, in the larger sizes, may be built up of pieces of tubing and flat washers as previously described. Lubricant filling and draining openings are provided at the top and bottom of the outer flange portion 169, these openings being normally closed by plugs 175 and 176.

The modification shown in Figure 22—A shows how the cartridge may be built up for larger sizes than that shown in Figure 22. In this construction the housing portion, instead of being cut from a solid block or from a forging is built up of a tubular portion which provides, after machining, the outwardly extending flange 168 and the inwardly extending flange 177.

A flat ring of metal 178, the outer corner of which is indicated in dotted lines, is then joined to the tubular piece by welding as indicated at 179. The said outer corner is removed in the machining operation. A lubricant distributing groove 180 is formed in said piece 178 and the drilled and tapped openings into which the pipe plugs 175—176 fit, communicate with said groove.

The cover plate 170, instead of being threaded into the tubular part 167 may be held in place by an expanding key ring 182 engaging in a groove 183 in said piece 167. The plate 170 may obviously be held in by other means as, for example, a bayonet joint.

On the commutator end the outer end of the ring is preferably closed by an ornamental cover plate.

The space between the arms 66 and the rings 43 and 44 may be filled in for the sake of appearances by means of wooden blocks or other filling blocks, if desired, or, alternatively, a sheet metal cover member with legs extending over the rings 43—44 between the arms 66—66 may be provided.

*Armature barrel*

The armature barrel as shown in Figures 1, 6 and 7 is an important part of my invention. This barrel comprises three steel rings 106, 107 and 108, the rings 106 and 107 being of substantially the same initial dimensions and the ring 108 being of a smaller outer diameter but of substantially the same width as the other rings. The rings are all of the same inside diameter and are preferably prepared by cutting off pieces of tubing of suitable size. The ring 106 is chamfered at its left edge for the purpose of forcing the finished barrel upon the shaft 1, for a suitable press fit. The ring 106 is also provided with a keyway 110 which registers with a keyway 112 formed in the bar 113.

This keyway 112 is cut in the bar 113 prior to assembly upon the rings 106, 107 and 108. The barrel is provided with three longitudinal bars or staves, 113, 114 and 115, these bars being suitably notched as by crosswise milling, to locate them definitely with respect to the rings 106, 107

and 108 and to space said rings. The spacing of the rings 106 and 107 is such as to cause them to lie endwise beyond the armature laminations, as will be described later.

These bars are spaced apart 120 degrees in the present instance, a three point support for the laminations being thereby provided. The cross notches formed on the inside surfaces of the bars need not be arcuate to fit the peripheral surface of the rings, since satisfactory results are secured by straight notches providing space for welding metal to unite the surface of each of the rings to the surface of the bar. The insides of the rings are accurately fitted to the outside diameter of the shaft and the bars have their inner surfaces spaced slightly away from the surface of the shaft in order to clear the same and to obviate the necessity for machining the inside surfaces of the bars after they are united to the rings. The outer surfaces of the bars are, after the bars and rings are united, finished to provide a cylindrical exterior surface along the major part of the length, leaving shoulders at 117 and 118 with the outside surface of the bars unfinished between these shoulders. These bars are, for example in the machine illustrated in Figure 1, formed of steel 1" x 1" x 15⅞" long. A square groove 119 is cut near the right hand end of the barrel as viewed in Figure 6, the left-hand wall of the same being spaced from the ring 106 approximately the same distance that the shoulder 117 is spaced from the ring 107 for centering the laminations between these two rings, although accurate spacing is not essential. The space between the shoulder 117 and the groove 119 is occupied by the armature laminations 120, as may be seen in Figure 1. The finished surface at the left of the shoulder 118 is designed to receive the tubular frame of the commutator 2. The shaft 1 is provided with a keyway 122, as shown in dotted lines in Figure 1 and shown in section in Figure 18, and a suitable key 123 thereby keys the bar 113 to the shaft 1, without transmitting a stress through the ring, as will appear more fully hereinafter.

*Armature laminations*

The magnetic material of the armature is built up of laminations, which of itself is not new, but the manner of mounting these laminations and of providing the ventilating duct for the armature is believed new, and is an important feature of the present invention.

In the building up of the magnetic ring of the armature I employ three different stampings. The first stamping is shown at 125 in Figure 18 and it is of maximum diameter, forming the portion 126, the portion 127, the portion 128 and the portion 129 of the magnetic material. The second lamination, shown superposed on the first lamination in Figure 18, is a stamping 130 which has the same slots 131 as the stamping 125 and is otherwise identical with the same except that it is of a smaller outside diameter in order to provide the peripheral grooves 132 and 132' for receiving the banding wire for holding the conductors in the slots 131.

On the opposite ends of the active magnetic material and on opposite sides of a centrally located set of ducts 133 I employ the stampings 134. While I have shown only one set of ducts at 133 the armature may have as many as may be required.

The inner peripheral formation of these various stampings is the same. They all have a common central opening 135, that is, a hole of the same diameter and they are each provided with an accurately located notch, or keyway 136, the side walls of which are parallel to each other as indicated at 137. Two other notches 138 and 139 are formed on the inner periphery and all three of these notches have a circular bottom wall of the same radial distance from the center so that the bottom of the notch in each case lies upon the same circle. This is to permit them to be accurately centered upon the machine cylindrical surface of the bars 113, 114 and 115. The notches 138 and 139 are wider than the corresponding width of the bars 114 and 115 so that there is no tendency of the notches to bind upon said bars 114 and 115 when they align themselves accurately upon the bar 113, which serves as a key for all of the laminations to register the slots 131. It will be seen that by having all the laminations keyed upon the bar 113 and this bar being then keyed by means of the key 123 directly to the shaft 1, no torque is transmitted through the welds or through the rings which form the barrel.

It will be apparent at once that this barrel provides three lands or longitudinally extending ridges upon which the laminations are supported with the inner peripheries of the laminations spaced away from the corresponding surface of the shaft so as to provide ventilating ducts. While it would be possible to mount the laminations upon lands formed integral with the shaft or welded thereupon or otherwise formed, the construction which I provide has a number of distinct advantages.

First, it may be built up out of structural material and hence be much less expensive than a solid shaft from which a great deal of material would need to be cut away.

Next, by having the bars spaced slightly from the surface of the shaft 1, sufficient relief is provided that only the rings 106, 107 and 108 rest against the surface of the shaft and the barrel, with its supported armature, is thereby more easily placed upon the shaft, as by a pressed fit, which is the case in the present construction.

It will be observed also that the barrel may be made up otherwise than by the employment of rings and bars, as, for example, by cutting the barrel out of a tubular blank.

The laminations are mounted upon the bars with the end stampings or laminations 134, which are of slightly greater thickness than the thickness of the main body of laminations, upon each side or flank of the laminations and upon each side of the duct 133. In addition to these outside laminations of greater thickness, special end plates 140 and 142 are disposed upon the outside of the laminations. These end plates 140 and 142 are flat rings of substantially the same inside diameter as the outside diameter of the bars 113, 114 and 115. There is no necessity for keying the rings 140 and 142 upon the bars, although this may be done if desired. The rings 140 and 142 have flat bars 143 welded thereto, these bars extending in an axial direction and having the greatest length of their cross-section disposed substantially radially so as to form fan blades. The outer ends of the blades 143—143 are held together by a common ring 144 which supports the outer ends of these blades against the centrifugal stress to which they may be subjected. Thus a blower is formed at each end of the active magnetic material. These blowers serve to cool the end windings shown at 145 and 146, project-

ing at each side from the active magnetic material.

The cooling ducts at 133 are formed in a manner illustrated in Figure 19. Thin flat bars, which may be cut from bar stock or punched of sheet metal stock, as indicated at 147, are disposed edgewise between a pair of laminations such as 134, being welded, preferably, to one of such laminations or to both of them, to define radially extending cooling passageways between them, and forming a centrifugal blower. The ventilating blocks or plates 147 extend inwardly to a point adjacent the inner periphery 135 of the laminations 134 and the outer ends extend adjacent the outer periphery, these blocks or bars being disposed between slots 131.

Over the notches such as 136, 138 and 139 the shorter bars 148 are disposed so as to permit the opening of the inner ends of the ducts formed between the bars to have free access with the ventilating duct 150 which lies within the inner periphery 135 of the laminations.

While I have shown only one set of ventilating ducts in the armature core it will be understood that for an armature of greater axial length, two or more such ventilating ducts 133 may be formed in the armature in order to cool the same.

These ventilating ducts, in conjunction with the spider construction are highly efficacious, in that the armature iron and copper may be worked at higher densities than has been permissible with prior practice.

Upon the left-hand end of the magnetic material the laminations and end plate 140 bear against the shoulder 117, Upon the right-hand end the laminations and end plate 142 are confined by a suitable split ring 152, which rests in the notch 119 in the bars and serves as a key restraining endwise expansion of the compressed laminations.

*Alternative form of barrel and laminations*

In order to provide skewed armature slots for the armature conductors the barrel may be arranged to have one of the bars or staves thereof disposed at an angle, that is, skewed to the axis of the barrel so that the laminations will be aligned in such a manner as to provide skewed slots. As shown in Figures 23 and 24, one of the bars, for example 115, is cut. This bar is cut in line with the ring 107 and the part 115—A which lies under the commutator and connects the two rings 108 and 107 is parallel to the axis of the barrel. The other end of the bar 115—B is skewed. It is initially a straight bar of rectangular cross-section, for example, square, but it is disposed in skewed relation as shown in Figure 23. The central part of the section of the bar 115—B lies directly in line with the portion 115—A. The ends of the bar 115—B, therefore, lie upon opposite sides of the line of the bar 115—A as is plainly shown in Figure 23. The bar 115—B is welded in place in a suitable jig or fixture which brings it accurately in the desired position. This bar 115—B has a keyway 112—B cut therein as shown in Figures 23 and 24 to line up with the keyway which is cut in the ring 106. This keyway 112—B is lined up with the keyway 110 in the ring 106 before the bar 115—B is welded to the rings 107 and 106.

After the bars are welded to the rings the outsides of the bars are machined to a cylindrical dimension upon each side of the ring 107. In the present instance the cylindrical dimension at each end is the same but this is not necessarily the case. Shoulders 117 and 118 on each of the bars are left for defining the positions of the armature iron and of the commutator, respectively. Likewise, a square groove or notch 119 is cut for receiving a keying ring previously described.

The laminations are provided on their inner periphery 135 with three notches, namely, the notch 136 which closely embraces the skewed bar 115—B and the wider notches 176 and 177 which are wide enough to permit the same lamination to be placed anywhere within the space between the shoulder 117 and the right hand end of the barrel. In other words, the notches 176 and 177 are as wide at least as the projected width of the skewed bar from the shoulder 117 to the right hand end as viewed in Figure 23. The bottoms of the notches 136, 176 and 177 are curved to conform to the cylindrical exterior of the bars so as to center the laminations accurately upon the barrel. The method of assembly and use of the laminations is as previously described.

*Commutator*

Upon the left hand end of the barrel I mount the commutator 2. This commutator is constructed as follows. A tubular base or frame 153, formed of a piece of steel tubing or the like is threaded at the left-hand end to receive the ring 154. The two wedge rings 155 and 156 are substantially identical, having tapered surfaces facing each other for gripping the commutator bars 157, with suitable formed rings of insulation interposed. The back sides of the rings 155 and 156 are recessed as indicated at 158 and the ring 156 is welded to the tubular base 153 by a line of welding indicated at 159 in the recess 158. The threaded ring 154 rests in the recess formed in the front wedge ring 155 and forces the said ring 155 towards the fixed back ring 156 to grip the commutator bars 157 in position.

This tubular member 153 is forced upon the finished surface of the left-hand end of the barrel and is stopped by the shoulder 118 with the end ring 108 of the barrel substantially under the central part of the tubular frame member 153. Since this frame member 153 grips the barrel and since the ring 108 rests solidly against the shaft 1, it will be seen that the most rigid supporting part of the barrel with respect to the tubular base member 153 is substantially centrally of the same. No particular stress, other than centrifugal stress, comes upon the commutator and its various parts, hence keying of the same is not necessary.

The commutator may be constructed as disclosed and claimed in my co-pending application, Serial No. 425,143, filed February 1, 1930, with a conducting portion formed upon the outside of each bar 157, or each bar may be otherwise formed as is known to the prior art.

The barrel, preferably, has the laminations and the commutator assembled thereupon. The windings are put in the slots and suitably confined by a banding wire or the like and connected to the commutator, then the finished armature structure is pressed upon the shaft 1 from left to right, as viewed in Figure 1, until the ring 106 abuts against the square ring 81 in the groove 82.

The advantages of the aforedescribed construction will, I believe, now be apparent to those skilled in the art.

I do not intend to be limited to the precise details shown and described, nor do I intend to limit the construction of one feature with respect to another, to any greater extent than is explicitly stated in the appended claims.

I claim:

1. In combination, a shaft, a barrel member thereupon comprising a pair of rings embracing said shaft, a plurality of bars substantially parallel to the axis of the shaft secured to said rings and a bar secured to said rings and being skewed with respect to said first mentioned bars, and magnetic laminations having slots upon the outer peripheries thereof for receiving conductors and having keyways for embracing said skewed bar upon their inner peripheries.

2. In combination, a shaft for an armature, a spider on said shaft comprising a pair of rings embracing the shaft and a series of longitudinally extending bars welded to said rings, said rings being spaced apart a greater distance than the axial thickness of the armature laminations and a key seated in one of the bars and in the shaft.

3. In combination, an armature shaft, a cage mounted thereupon, said cage comprising a pair of rings, a series of bars connecting said rings, said rings being separated by a distance greater than the axial thickness of the armature laminations, a key keying one of the bars to the armature shaft and armature laminations mounted upon said bars, said laminations being keyed upon said one bar.

4. In an armature structure, a shaft, laminations embracing the shaft, a series of axially extending bars disposed between the inner peripheries of the laminations and the outside of the shaft, said laminations being keyed to one of said bars and said one bar being, in turn, keyed directly to the shaft.

5. In combination an armature shaft, an armature spider mounted thereupon, said spider comprising a plurality of rings embracing said shaft, a plurality of longitudinally disposed bars secured upon said rings, said bars having shoulders for clamping the armature laminations between them and means for keying one of said bars to said shaft.

6. In combination an armature shaft having a groove therein, a ring set in said groove to provide shoulders, an armature spider comprising three rings, two of which are spaced apart a greater distance than the endwise thickness of the armature laminations, a series of bars connecting said rings, said spider being pressed upon the armature until one of said rings engages the aforesaid shoulder and a spacing sleeve for spacing of bearings mounted upon the shaft and engaging the first named ring.

7. An armature structure comprising a shaft, an armature spider comprising a pair of rings spaced apart a greater distance than the axial thickness of the laminations, a series of bars mounted upon said rings, said bars providing a radially extending shoulder for engagement by the armature laminations at one end, a groove formed in the outer peripheries of said bars and a split ring disposed in said groove for engagement with the opposite end of the laminations.

8. An armature structure comprising a shaft, an armature spider comprising a pair of rings spaced apart a greater distance than the axial thickness of the laminations, a series of bars mounted upon said rings, said bars providing a radially extending shoulder for engagement by the armature laminations at one end, a groove formed in the outer peripheries of said bars and a split ring disposed in said groove for engagement with the opposite end of the laminations and end plates disposed between said shoulder and the armature laminations at one side and between the split ring and the armature laminations at the other side, said end plates having a series of fan blades secured thereto.

9. An armature end plate comprising a flat ring, a series of flat sided bars welded at their ends substantially at right angles to the surfaces of the plate and adjacent the outer periphery thereof and a thin, tubular ring secured to the free ends of said bars.

10. In combination, a shaft, an armature barrel mounted on the shaft, said armature barrel providing shoulders between which the armature laminations are disposed, armature laminations between said shoulders, armature end plates between said shoulders and the laminations, a plurality of flat sided bars welded to the end plate and extending parallel to the axis of the shaft, said bars forming fan blades and rings for securing the outer ends of said fan blades together.

11. In combination, an armature shaft, a barrel mounted upon the same, said barrel comprising two end rings and an intermediate ring, a series of longitudinal bars secured to said rings, said barrel embracing the shaft and being keyed thereto, the bars being machined to a cylindrical surface on opposite sides of the intermediate ring, armature laminations mounted on a cylindrical surface on one side of the intermediate ring and a commutator having a tubular frame embracing the cylindrical surface on the other side of the intermediate ring.

12. In combination, an armature shaft, a barrel mounted upon the same, said barrel comprising two rings and a series of longitudinal bars secured to the rings, a shoulder extending radially formed on said bars and a commutator having a tubular frame member embracing the aforesaid bars at one side of said radial shoulder.

13. In combination, a shaft having a keyway and having a radial shoulder at the end thereof, a barrel comprising three rings, namely, two end rings and an intermediate ring, a plurality of longitudinally extending bars welded to said rings, one of the end rings and one of said bars having a continuous keyway cut therein, which keyway is adapted to register with the keyway in the shaft, a circumferential groove in the shaft adjacent one end of the keyway and a ring disposed in said groove.

14. In combination, a shaft having a keyway, a circumferential groove adjacent one end of the keyway, a ring set in said groove, a barrel member comprising a pair of end rings, a series of longitudinally extending bars welded to said rings, one of the end rings and one of said bars having a continuous keyway cut thereinto, said keyway being adapted to register with the keyway in the shaft, said bars having a radial shoulder adjacent one of said rings and having a groove adjacent the other ring, armature laminations having central openings, said laminations being passed over said barrel and confined between said shoulder and said groove.

15. In combination, a shaft having a keyway, a circumferential groove adjacent one end of the keyway, a ring set in said groove, a barrel member comprising a pair of end rings, a series of longitudinally extending bars welded to said rings, one of the end rings and one of said bars having a continuous keyway cut thereinto, said keyway being adapted to register with the keyway in the shaft, said bars having a radial shoulder adjacent one of said rings and having a groove adjacent

the other ring, armature laminations having central openings, said laminations being passed over said barrel and confined between said shoulder and said groove, said laminations having shoulders for embracing the sides of the bar which contains the second named keyway.

16. In combination, a barrel having a series of longitudinally extending ridges, armature laminations embracing the barrel and having internal notches embracing said ridges, radially extending shoulders for confining the laminations endwise of the ridges, end plates between the laminations and radial shoulders and fan blade members secured to said end plates.

17. In an armature, laminations comprising sheet metal stampings having slots on the outer periphery and having three relatively wide notches on the inner periphery, said notches having circular bottom walls and one of said notches having square shoulders between the inner periphery and the bottom of the notch, to form a keyway.

18. In an armature, armature stampings comprising a sheet metal disc having slots on the outer periphery, radially extending metal strips disposed between the slots and welded to the side of said stamping, the inner periphery of the stamping having a series of relatively wide notches, one of said notches having parallel sides for registering the stamping in predetermined position.

19. In combination, a shaft having a series of bars extending longitudinally, an armature comprising a plurality of stampings, said stampings having peripheral slots and having a plurality of notches upon the inner periphery corresponding in number with the number of bars on the shaft, the depth of the bars being substantially in excess of the depth of the notches in order to provide ventilating passageways between the inner peripheries of the laminations and the shaft, one of the notches in the laminations accurately embracing one of the bars to register the armature slots accurately with each other and to serve as a keyway for keying the laminations to the shaft, and the other notches loosely embracing other bars.

20. In combination, a shaft having longitudinally extending bars, an armature comprising a plurality of sheet metal stampings having slots on their outer periphery and notches on their inner periphery, said notches registering with the bars, the depth of the bars being greater than the depth of the notches to provide a ventilating passageway between the inner periphery of the stampings and the shaft, two adjacent laminations being separated and radially extending sheet metal strips disposed between said pair of laminations, said strips being welded to one of the laminations.

21. In combination, a barrel member comprising a pair of coaxial rings adapted to embrace a shaft, a pair of bars secured to said rings, said bars extending substantially parallel to the axis of said rings, a bar secured to said rings and being skewed relative to said axis, said bars having their outer surfaces lying in substantially a common cylinder, and laminations embracing said bars.

22. In combination, a barrel member comprising a pair of coaxial rings adapted to embrace a shaft, a pair of bars secured to said rings, said bars extending substantially parallel to the axis of said rings, a bar secured to said rings and being skewed relative to said axis, said bars having their outer surfaces lying in substantially a common cylinder, and laminations embracing said bars, said laminations having wide notches on their inner peripheries for receiving said straight bars and having key notches relatively closely embracing said skewed bar and being keyed thereby to the barrel member.

23. In combination, a barrel member comprising a pair of coaxial rings adapted to embrace a shaft, a pair of bars secured to said rings, said bars extending substantially parallel to the axis of said rings, a bar secured to said rings and being skewed relative to said axis, said bars having their outer surfaces lying in substantially a common cylinder, and laminations embracing said bars, said laminations having wide notches on their inner peripheries for receiving said straight bars and having key notches relatively closely embracing said skewed bar and being keyed thereby to the barrel member, and a shaft embraced by said rings, said skewed bar and said shaft being provided with means for keying them together.

24. In combination, a barrel comprising three coaxial rings, longitudinally extending bars connecting said rings and being secured thereto and a skewed bar connecting two of said rings and being secured thereto, said bars having outer faces disposed in substantially a common cylinder concentric with said rings.

25. In combination, a barrel comprising three coaxial rings, substantially parallel bars extending longitudinally and connecting all three rings, a short bar substantially parallel to said other bars connecting one of the end rings with the middle ring and a straight bar, skewed relative to the axis of the rings joining said middle ring and the other end ring.

26. In combination, a barrel comprising three coaxial rings, substantially parallel bars extending longitudinally and connecting all three rings, a short bar substantially parallel to said other bars connecting one of the end rings with the middle ring and a straight bar, skewed relative to the axis of the rings joining said middle ring and the other end ring, the outer sides of the bars on one side of the middle ring being machined to define cylindrical surfaces coaxial with said rings.

27. In combination, a barrel comprising three coaxial rings, substantially parallel bars extending longitudinally and connecting all three rings, a short bar substantially parallel to said other bars connecting one of the end rings with the middle ring and a straight bar, skewed relative to the axis of the rings joining said middle ring and the other end ring, the outer sides of the bars on one side of the middle ring being machined to define cylindrical surfaces coaxial with said rings, the side edges of said said skewed bar being parallel to each other.

28. In combination, a barrel comprising three coaxial rings, substantially parallel bars extending longitudinally and connecting all three rings, a short bar substantially parallel to said other bars connecting one of the end rings with the middle ring and a straight bar, skewed relative to the axis of the rings joining said middle ring and the other end ring, the central part of said skewed bar lying substantially in endwise alignment with said short bar.

29. In combination, a barrel comprising three coaxial rings, substantially parallel bars extending longitudinally and connecting all three rings, a short bar substantially parallel to said other

bars connecting one of the end rings with the middle ring and a straight bar, skewed relative to the axis of the rings joining said middle ring and the other end ring, said skewed bar having a keyway formed on its inner side parallel to said axis of the rings.

30. In combination, a shaft, a barrel member thereupon comprising a pair of rings embracing said shaft, a bar secured to said rings and being skewed with respect to said shaft, and magnetic laminations having keyways for embracing said skewed bar upon their inner periphery.

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