March 30, 1948. G. R. ANDERSON 2,438,629

AXIAL AIR GAP MACHINE

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FIG. 1.

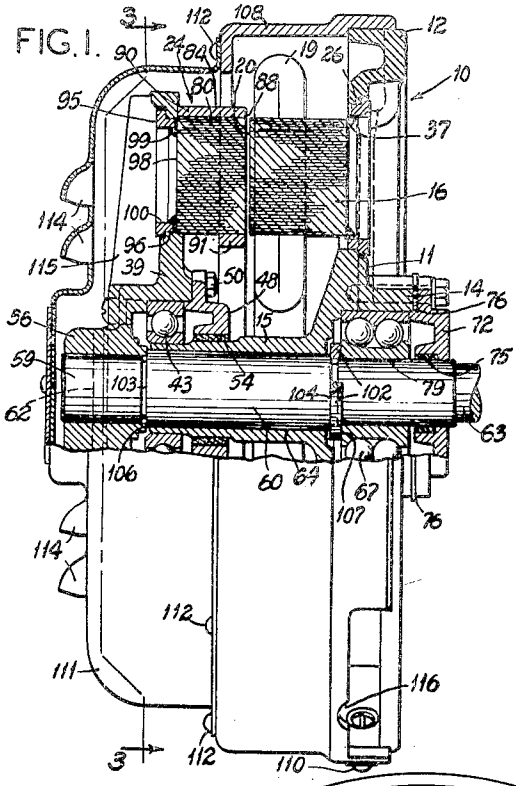


FIG. 3.

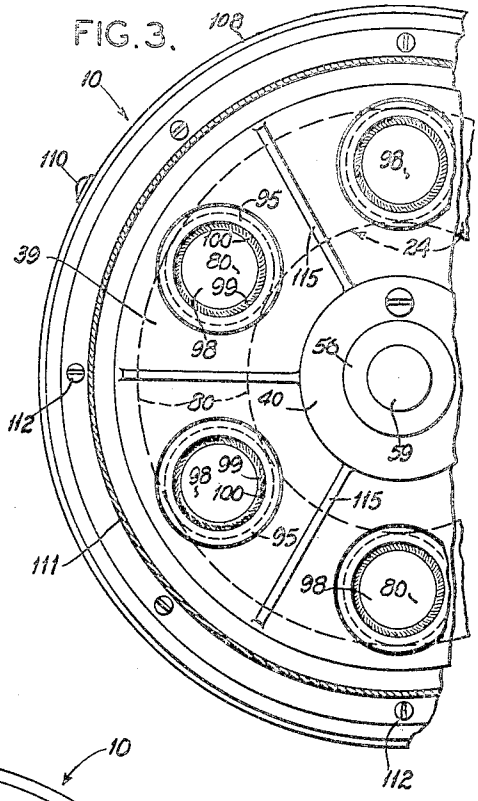
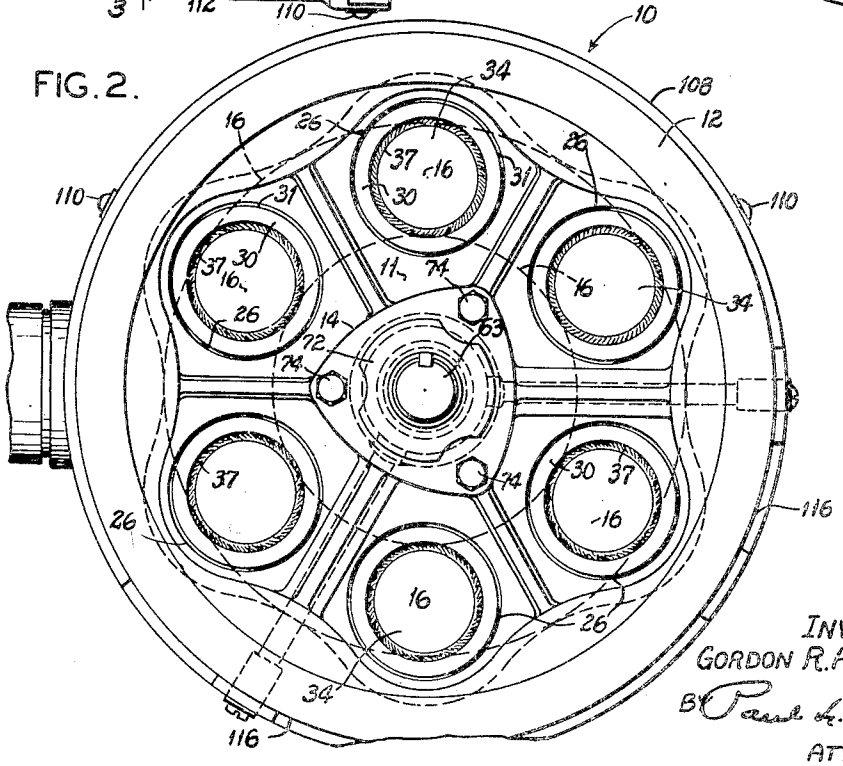


FIG. 2.



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FIG. 4.

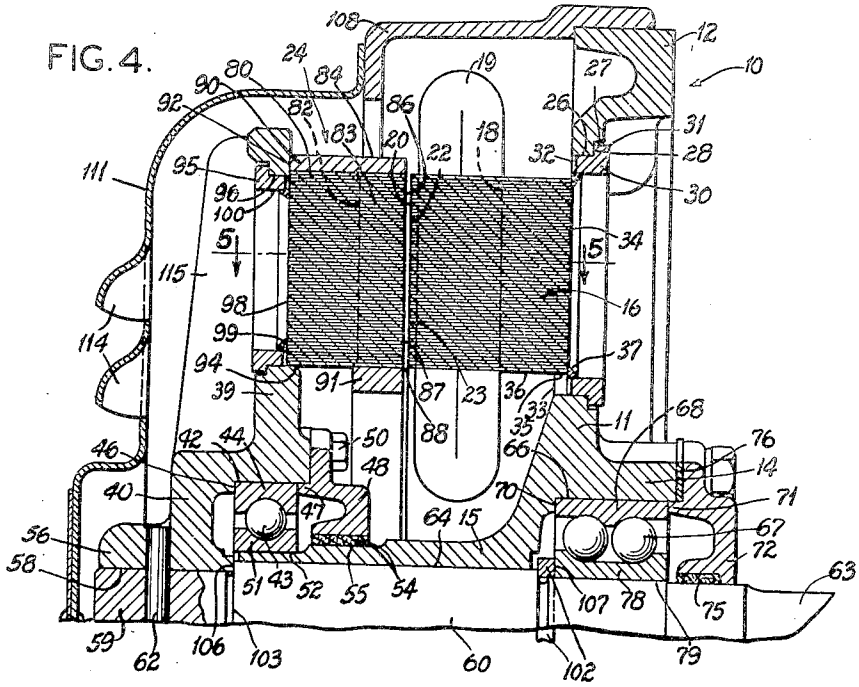
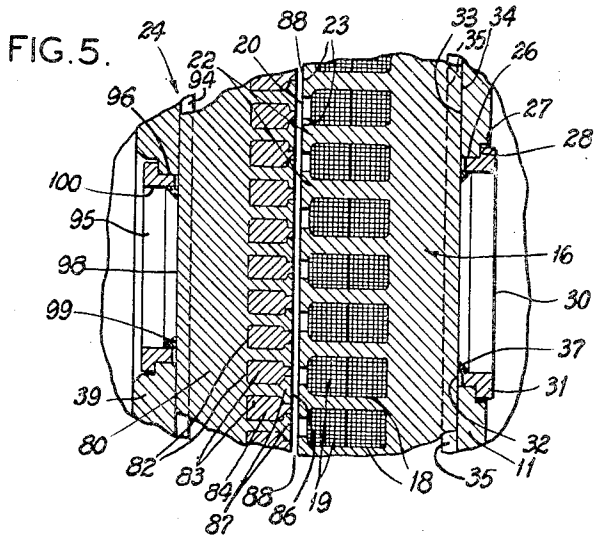


FIG. 5.



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AXIAL AIR GAP MACHINE

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Application February 28, 1944, Serial No. 524,181

16 Claims. (Cl. 171—252)

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This invention relates to improvements in electrical machines of the axial air gap type, and has particular reference to improvements in the construction of machines of this character, including an improved manner of assembling the stator and rotor members.

Objectively, the present invention concerns the provision of a compact electrical machine of axial air gap type, embodying stator and rotor structures each assembled in an improved and effective manner without the use of studs, bolts or rivets, the manner of stator and rotor assembly as presently preferred and hereinafter fully disclosed, being such as to afford and insure an accurate operative relationship of the stator and rotor; the invention further presenting improved provisions for substantially precluding relative axial displacement or shifting of the rotor and stator, whereby to assure a substantially constant axial air gap as preselected for a given machine.

Somewhat more specifically, the rotor and stator structures according to the present improvements, each includes a magnetic core assembly and a supporting frame element therefore, with separate mounting elements fixed or secured to the core preferably by a weld connection, and engaging the frame element such as to clamp the core securely in position on the frame element. In addition to the foregoing, the invention provides a mounting arrangement of the rotor structure and its supporting shaft, which is effective to prevent any appreciable relative axial displacement of the rotor and stator members, whereby the axial air gap is maintained substantially constant as preselected for a given machine. Included in and forming an element of the rotor and shaft mounting provisions attaining the foregoing objective, is a shaft collar or distance piece arranged for coaction with the shaft and the stator frame, or as herein preferred, a shaft bearing, to determine through the transverse or axial dimension of the collar, the axial extent of the air gap. Thus by substituting distance pieces of one or another transverse dimension, the extent of the air gap may be selectively predetermined as desired.

Other objects and advantages of the present invention will appear from the following description of a preferred embodiment thereof, as exemplified in the accompanying drawing, wherein:

Fig. 1 is a view in longitudinal elevation, of an electrical machine of axial air gap type, showing by longitudinal section of the major portion of the machine, the principal features of the invention embodied therein;

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Fig. 2 is an end elevation as viewed from the stator end of the machine;

Fig. 3 is a fragmentary end elevation viewed from the rotor end, as along line 3—3 in Fig. 1;

Fig. 4 is an enlarged, fragmentary section longitudinally of the machine, and

Fig. 5 is a fragmentary sectional view longitudinally of the machine, as taken along line 5—5 in Fig. 4.

Referring to the drawing by appropriate characters of reference, the axial air gap machine indicated generally by the numeral 10, is to be regarded as representative of an electric motor, generator, alternator, or the like, adapted for either horizontal shaft or vertical shaft mounting, although for the purpose of the present exemplary disclosure of the invention, the machine illustrated preferably is an electric motor of the so-called induction type, arranged for horizontal shaft mounting. As shown, the machine includes a stator frame member 11 of generally plate or disc form, embodying an overhanging peripheral rim section 12, and a central or axial hub portion 14 provided with an axially bored hub extension 15 preferably of generally cylindrical character, extending axially from one side of the hub 14. The frame extension 15 in the assembled motor, is disposed interiorly thereof, and serves to support a bearing for the machine rotor assembly, as will be presently described.

Carried by the frame 11 is a stator core element 16 preferably of a laminated construction and of annular form, arranged concentrically of the stator extension 15, the core being suitably recessed or slotted, as at 18, (Figs. 4 and 5) to receive and retain a stator winding 19. As best appears in Figs. 4 and 5, slotting of the core inwardly of its lateral face 20, results in an annular series of stator pole elements 22 presenting pole faces 23 in a common plane radially of the motor axis, for magnetic coaction with the polar elements of the rotor structure indicated generally at 24 and later to be described.

According to the present improvements, the stator assembly comprising the core 16 and winding 19, is mounted upon the stator frame 11 in a particularly novel manner. As illustrated, the frame 11 is formed to provide a number of preferably circular openings 26 (Figs. 2, 4 and 5) transversely therethrough, which may be equally angularly spaced about the frame (Fig. 2), and each of which by preference, is of a diameter somewhat greater than the radial dimension or radial thickness of the stator core 16. Each opening 26 is enlarged in the external face 27 of the

frame, to form an annular abutment or shoulder 28. A ring element 30 having an outstanding peripheral flange 31, is seated in each frame opening 26 with its flange 31 in close abutment with the shoulder 28, as shown, the ring being dimensioned such that in assembly, its peripheral surface closely contacts the wall surface defining the frame opening, and so that the inner lateral surface or face 32 of the ring lies slightly below or inwardly of the inner planar surface or face 33 of the frame 11 (Figs. 4 and 5). The core 16 on its lateral planar face 34, is then seated firmly against the inner frame face 33, with the core in a position concentrically of the motor or stator frame axis, as may be accurately determined by a frame shoulder 35 of annular extent (although incomplete in the zones of the frame openings 26 since the openings by preference, are continued through the shoulder), the shoulder serving to receive and seat thereagainst the inner peripheral marginal portion 36 of the stator core 16. As thus positioned, portions of the core face 34 overlie portions of the inner faces 32 of the several rings, but out of engagement or contact with the latter face portions. Whereupon, the core and the ring elements 30 are secured or united in assembly by fillet welds indicated at 37, effected around the inner peripheral margins 38 of the rings and against the adjacent portions of the core face 34. The rings 30 as so welded to the stator core 16, thus serve through the ring flanges 31 in abutment with the frame shoulders 28, to clamp the core firmly against the frame 11. Accordingly, and further by reason of the annular extent of the core and the ring-core welds angularly spaced about the frame, there results a positive and rigid mounting of the stator core assembly on the stator frame 11.

The foregoing improved manner of stator assembly avoids the use of studs, bolts or rivets, and presents among other advantageous features, one of considerable importance in respect to the ring-core weld connections. These not only afford a most effective rigid attachment of the stator core assembly to its supporting frame, easily and quickly attained, but avoids a direct weld of the core to the frame. Where the latter has been employed in the construction of axial air gap machines, it has been found in many instances that the supporting frame to which the weld is made, thereafter becomes warped to a lesser or greater extent, depending in part, upon the nature of the weld joints effected and the number thereof. As a consequence and when occurring also, in the rotor frame, the axial air gap is distorted such that it is not of uniform width nor in a true radial plane, and in instances of appreciable frame warping, physical contact of the rotor and stator polar elements at the gap faces thereof, may occur unless an inordinately large air gap is effected to prevent such contact. By the present provision of weld connections solely between the core and separate ring elements inserted in the frame, weld-warpage of the frame is precluded, so that with a similar contruction of the rotor assembly as will be presently described, the presently improved manner of core-frame securement facilitates attainment of an accurate assembly alignment of the rotating and stationary members of the machine, to result in a gap of uniform extent and located in a true radial plane.

Turning now to a description of the rotor assembly, the structure thereof includes a plate-like frame member or rotor disc 39 having a hub

portion 40 axially recessed as at 42, to receive a rotor bearing 43 preferably of a friction-reducing ball-race type, as shown. The outer bearing race 44 is seated in the frame recess 42 to bear against a shoulder 46 therein, and is firmly retained against displacement axially of the hub 40, by the race-abutting flange 47 of a retaining member or collar 48 suitably secured to the hub 40, as by studs or bolts indicated at 50. The inner bearing race 51 is seated upon the free end portion 52 (Fig. 4) of the stator frame hub extension 15, the end portion being reduced as shown, to accommodate the bearing race in an axially slidable relation thereon, whereby to permit limited displacement of the rotor assembly longitudinally relative to the stator assembly, for the purpose of attaining an air gap of desired axial extent, determined in a manner hereinafter to be described. In order to retain lubricant in the hub recess 42 for lubricating the surfaces of the bearing 43 therein, the collar 48 is adapted as a closure for the recess, by engagement thereof through a sealing element 54 of suitable material, with an intermediate stepped portion 55 of the stator extension 15.

The rotor frame hub 40 is extended axially beyond the zone of the bearing recess 42 therein, to provide a shaft-engaging hub element 56 having an axial bore 58 adapted to receive the reduced end 59 of a motor shaft 60. The drive connection between the shaft and rotor assembly is effected through the rotor hub element 56, preferably in the present example, by a suitable key or pin element 62 arranged transversely through the hub and shaft, as illustrated. The shaft 60 which extends outwardly beyond the stator frame hub 14 to provide a motor power take-off end section 63, is formed with an enlarged intermediate portion 64 to be received in the bore of the stator frame extension 15 preferably with a minimum operative clearance therein, the shaft portion 64 serving a purpose presently to appear.

The stator hub 14 is recessed as at 66, to accommodate a shaft bearing 67 which as here shown, is preferably of a friction reducing ball-race type and of double-thrust character to limit or substantially preclude endwise thrust displacement of the shaft. The outer race element 68 of the bearing is closely received in the frame recess, in abutment with a shoulder 70, and is effectively retained by a flange abutment 71 on a recess closure element or cap member 72. Closure 72 secured in assembly to the frame hub 14 as by suitable bolts 74, is sealed about the extension of the shaft 60 therethrough by a suitable sealing element 75, and is further sealed at its connection with the frame hub 14 as by a sealing washer 76, whereby to insure retention of bearing lubricant in the hub recess. As shown, the inner bearing race 78 engages a reduced shaft portion 79 in the zone of the stator hub 14. Thus the shaft 60 is rotatably journalled in thrust bearing 67 near the shaft power take-off end 63, and is rotatably supported at its inner end 59 through the rotor frame hub 56 and bearing 43.

With reference now to Figs. 3, 4 and 5 in particular, supported by the rotor frame 39 in a manner similar to the herinabove described support of the stator core assembly on stator frame 11, is a rotor core member 80 which like stator core 16, preferably is of a laminated, annular construction, and of a radial depth or thickness corresponding substantially to the like dimension of the stator core 16, as such best appears in Fig.

4. Radial slots 82 (Figs. 4 and 5) in the core receive therein bar elements 83 of a closed induction winding 84, and serve to define rotor polar elements 86 (Fig. 5) having pole faces 87 for coaction with the pole faces 23 of the stator core 16 through an air gap 88 of an axial extent determined as hereinafter to be described. The winding 84 comprising the bars 83, an outer circumferential end ring 90 and an inner circumferential end ring 91, is formed from suitable conductor material such as copper, aluminum, or alloys thereof, and constructed by preference as an integral structure cast in place on the core 80. The inner end ring 91 although of equal current-carrying capacity with the end ring 90, is confined in its axial or longitudinal extent, to the core zone containing the radial bars 83, so as to free the inner peripheral core margin 92 for seating upon a core-locating shoulder 94 of annular extent, formed on the rotor frame 39 outwardly adjacent the hub 40. Through the shoulder 94, the rotor core is accurately axially aligned with the stator core 16 for proper coaction of its polar elements 86 with the corresponding polar elements 22 of the stator core. Rigid retention of the rotor core and winding assembly on the rotor frame 39 is effected in the improved manner herein described for the stator structure, as by shouldered ring elements 95 seated in correspondingly shouldered apertures 96 in the frame, and secured to the planar face 98 of the rotor core by a fillet weld 99 around the inner margin 100 of each ring. The ring-weld connections thus serve to clamp the rotor core assembly to the frame 39 and to effect a secure and relatively permanent assembly of these parts. Avoidance in this way, of any direct weld to the rotor frame 39, thereby precludes any possibility of weld-warping of the rotor frame which otherwise would result in the difficulties hereinbefore discussed.

Determination of the desired axial air gap is presently effected through the rotor shaft 60, the thrust bearing 67 and a shaft ring or gap-setting collar 102. As appears in Figs. 1 and 4, the enlarged intermediate shaft section 64 defines opposite shaft shoulders 103 and 104 adjacent the shaft end 59 and the shaft bearing section 79, respectively. In assembling the motor, the rotor hub 56 is engaged with the shaft end 59 such that the hub at its inner end or margin 106, abuts the shaft shoulder 103, and in this position is secured to the shaft by the transverse pin or key element 62. The collar 102 on the other hand, is arranged about the shaft between and normally in abutment with the opposite shaft shoulder 104 and the inner end face 107 of the inner race 78 of thrust bearing 67. The gap-setting collar 102 in particular, thus determines in accordance with the axial length or thickness thereof, a definite longitudinal placement of the shaft 60, and therethrough, a correspondingly definite longitudinal placement of the rotor assembly relative to the stator assembly, such as to determine the axial extent of the air gap 88. Accordingly, by substituting collars of differing axial length, the gap may be predetermined in a given machine, to secure any desired operating characteristic as effected by the air gap length. While the presently improved gap-determining arrangement precludes longitudinal shifting of the rotor assembly in the direction to decrease the gap extent determined by the collar 102, as to the right as viewed in Fig. 1, some slight movement of the rotor and shaft assembly in the opposite direction is not here mechanically prohibited, except as such may be limited by the shaft thrust bearing 67. However, upon operation of the motor there exists a considerable magnetic attraction between the rotor and stator poles, which tends to pull the rotor toward the stator. This action definitely insures in normal operation of the motor, retention of rotor placement relative to the stator such that the gap-setting ring or collar 102 is in gap-determining abutment with the shaft shoulder 104 and end face 107 of the bearing race 78. It may be noted here that the collar 102 by preference is formed from a suitable long-wear material, such as hardened steel, in order to insure the desired gap-determining function thereof over long periods of motor operation.

Completing the motor assembly according to the present exemplary disclosure thereof, is a removable stator cover 108 suitably attached to the overhanging rim 12 of the stator frame 11, as by screws or bolts 110 (Fig. 2). Cover 108 may be of cast construction and adapted through a lap fit with the stator rim 12, to strengthen the stator structure. Enclosing the rotor portion of the machine, is a cover element 111 which by preference, is of sheet metal, and is removably attached to cover 108 by suitable screws 112 (Fig. 1). Moreover, cover 111 is formed to provide louver air openings 114 for the admission of cooling air to the rotor and stator elements within the machine. Air circulation therein may be greatly augmented by rotor frame strengthening ribs 115 which as here shown, are formed and arranged to act as air flow-creating elements upon rotation of the rotor assembly. Air discharge may occur in part, through certain of the openings 114, or as presently preferred, through one or more discharge openings at the stator end of the machine, as shown at 116, (Figs. 1 and 2).

As now will be appreciated, the present improvements attain the several objects of the invention as hereinbefore enumerated, as well as other objects and advantages now readily apparent. While the features of the invention have been illustrated and described as embodied in an axial air gap motor of the induction type, they are applicable as well, to axial air gap machines generally, and to other similar electrical apparatus.

It is to be understood of course that the construction and arrangement of parts as herein shown and described, may be altered or modified without departing from the spirit and full intent of the invention as hereinafter claimed.

I claim as my invention:

1. In an electrical machine of the character described, embodying an annular, magnetic core having an electrical winding thereon, a core-supporting frame having a core-engaging surface, a ring element having a flange, formed separately of the frame and carried thereby in a position adjacent said core-engaging frame surface with said flange in engagement with the frame, and a weld-connection between said element and said core, said element coacting with said frame to effect through said flange and weld-connection, a clamped seating of the core on said core-engaging frame surface.

2. In an electrical machine of the character described, embodying an annular, magnetic core having an electrical winding thereon, a core-supporting frame providing a core-engaging surface and having an opening in the zone of said surface, extending through the frame, a ring element having a flange thereon, seated in said frame opening and terminating therein with the ring

flange in engagement with the frame, and a weld-connection between said element and said core, the element coacting with the frame to effect through said flange and weld-connection, a clamped seating of the core on said core-engaging frame surface.

3. In an electrical machine of the character described, embodying an annular, magnetic core constituting an operative element of the machine, a core-supporting frame providing an axial hub portion, a shoulder formed on said frame, adapted for engagement with a peripheral margin of said annular core, to locate the core on the frame substantially concentrically of the hub axis, an element formed separately of the frame and carried thereby in a position relatively adjacent to but out of direct contact with said core, and a weld-connection between said element and the core, said element coacting with the frame to effect through said weld-connection, a rigid clamped support of the core on the frame.

4. In an electrical machine of the character described, embodying an annular, magnetic core constituting an operative element of the machine, a supporting frame providing an axial hub portion and having a core-engaging surface, a shoulder formed on the frame, adapted for engagement with a peripheral margin of the core, to dispose the core substantially concentrically of the hub axis, in its engagement with the core-engaging frame surface, the frame being provided with an opening therethrough in the zone of said core-engaging frame surface, an element having a flange thereon, seated in said opening with said flange in engagement with said frame, and a weld-connection between said element and core, the element coacting with the frame to effect through said flange thereof and said weld-connection, a rigid clamped seating of the core on said core-engaging frame surface.

5. In an electrical machine providing stator and rotor assemblies having opposed, coacting polar elements defining an air gap therebetween, said assemblies each including a magnetic core, a supporting frame therefor, elements formed separately of the frame and carried thereby, in relatively spaced positions thereon, and weld-connections between said magnetic core and said elements, the elements being adapted for coaction with the frame to effect through said weld-connections, a rigid clamping of the magnetic core on the frame.

6. In an electrical machine providing stator and rotor assemblies having opposed, coacting polar elements defining an air gap therebetween, said assemblies each including a circular magnetic core, a supporting frame having a core-engaging surface, elements formed separately of the frame and disposed thereon in relatively spaced postions in the zone of said frame surface, and weld-connections between said core and said elements, the elements being adapted for coaction with the frame to effect through said weld-connections, a clamped seating of the core on said core-engaging frame surface.

7. In an electrical machine providing stator and rotor assemblies having opposed, coacting polar elements defining an air gap therebetween, said assemblies each including a circular magnetic core having a planar mounting face, a supporting frame therefor, providing a planar face to receive thereagainst the planar mounting face of the core, the frame being formed to provide openings therein in the zone of its planar face, elements seated in said frame openings, and weld-connections between the core and said elements, the elements being adapted for coaction with the frame to effect through said weld-connections, a rigid clamped assembly of the core and frame.

8. In an electrical machine providing stator and rotor assemblies having opposed, coacting polar elements defining an air gap therebetween, said assemblies each including a circular magnetic core having a lateral, planar mounting face, a supporting frame therefor, providing a planar face to receive thereagainst the planar mounting face of the core, the frame being formed with openings extending substantially transversely therethrough and relatively spaced in the zone of its planar face, ring-like elements seated in said openings and terminating inwardly of the planar frame face, and weld-connections between the core and said ring elements, said ring elements effecting in coaction with the frame and through said weld-connections, a rigid clamped assembly of the core and frame.

9. The subject matter of claim 8, wherein said supporting frame includes a central hub portion, and a circular shoulder thereon, adapted for engagement with a peripheral margin of the core to dispose the latter concentrically of the hub axis.

10. In an electrical machine of axial air gap type, coaxial rotor and stator assemblies providing opposed polar faces defining an axial air gap therebetween, means rotatably supporting the rotor assembly and permitting longitudinal displacement of the rotor assembly relative to the stator assembly, said means comprising a hollow axial extension of said stator assembly and a bearing between said extension and rotor assembly, a shaft extending longitudinally of the machine through said hollow axial extension and operatively connected to the rotor assembly, a shaft bearing carried by the stator assembly, and a gap control element between the shaft and said shaft bearing, effective through the shaft and according to the axial dimension of the element, to determine longitudinal placement of the rotor assembly relative to the stator assembly, whereby to determine the axial extent of the air gap.

11. In an electrical machine of axial air gap type, coaxial rotor and stator assemblies providing opposed polar faces defining an axial air gap therebetween, means rotatably supporting the rotor assembly on the stator assembly and permitting longitudinal displacement of the rotor assembly relative to the stator assembly, said means comprising a hollow axial extension of said stator assembly and a bearing between said extension and rotor assembly, said bearing being displaceable longitudinally of the extension, a shaft extending longitudinally of the machine through said hollow extension and operatively connected to the rotor assembly, a shaft bearing carried by the stator assembly and fixed against longitudinal displacement relative thereto, and a shaft collar between and normally in abutment with the shaft and said shaft bearing, effective through the shaft, to determine according to the axial dimension thereof, longitudinal placement of the rotor assembly relative to the stator assembly, thereby to determine the axial extent of the air gap.

12. In an electrical machine of axial air gap type, coaxial rotor and stator assemblies providing opposed polar faces defining an axial air gap therebetween, said stator assembly including a disc-like stator frame member having a central

hub portion, said frame member providing an axial tubular frame extension directed inwardly of the machine from said hub portion, a shaft through said hub portion and tubular extension, a shaft bearing located between the shaft and said hub portion, said rotor assembly including a disc-like rotor frame member, bearing means rotatably supporting said rotor frame member on said tubular extension of the stator frame member, and means operatively connecting the shaft and rotor frame member.

13. In an electrical machine of axial air gap type, coaxial rotor and stator assemblies providing opposed polar faces defining an axial air gap therebetween, said stator assembly including a disc-like stator frame member having a hub portion and providing a tubular frame portion extending axially within the machine from said hub portion, a shaft through said hub portion and tubular frame portion, a shaft bearing located between the shaft and said hub portion, said rotor assembly including a disc-like rotor frame member, bearing means rotatably supporting the rotor frame on the tubular frame portion of the stator frame member and permitting axial displacement of the rotor frame thereon, and means operatively connecting the shaft and rotor frame member.

14. In an electrical machine of axial air gap type, coaxial rotor and stator assemblies providing opposed polar faces defining an axial air gap therebetween, said stator assembly including a disc-like stator frame member formed to provide a tubular frame portion extending laterally of the frame member along the axis of the rotor and stator assemblies, a bearing seated internally of one end of said tubular frame portion, a second bearing mounted externally on the opposite end of the tubular frame portion, a shaft extending through said tubular frame portion and journalled in the first said bearing, said rotor assembly including a disc-like rotor frame member having a central hub receiving said second bearing therein, said second bearing affording the sole rotative support of the rotor assembly on said tubular frame portion, and means operatively connecting said shaft and the hub of said rotor frame member.

15. The subject matter of claim 14, wherein

said second bearing mounted externally on the opposite end of the tubular frame portion, is slidable longitudnially thereon.

16. In an electrical machine of axial air gap type, coaxial rotor and stator assemblies providing opposed polar faces defining an axial air gap therebetween, said stator assembly including a stator frame member formed to provide a tubular frame portion extending laterally of the frame member along the axis of the rotor and stator assemblies, a first bearing seated internally of one end of said tubular frame portion, a second bearing mounted externally on the opposite end of the tubular frame portion and capable of limited displacement longitudinally thereon, a shaft extending through said tubular frame portion and journalled in said first bearing, said rotor assembly including a rotor frame member having a hub portion receiving said second bearing therein, said second bearing affording the sole rotative support of the rotor assembly on said tubular frame portion, means operatively connecting said shaft and the hub of said rotor frame member, and a shaft collar between the shaft and said first bearing, effective through the shaft and said second bearing displaceable longitudinally of the tubular frame portion, to determine in accordance with the axial dimension of said collar, longitudinal placement of the rotor assembly relative to the stator assembly, thereby to determine the axial extent of the air gap.

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