

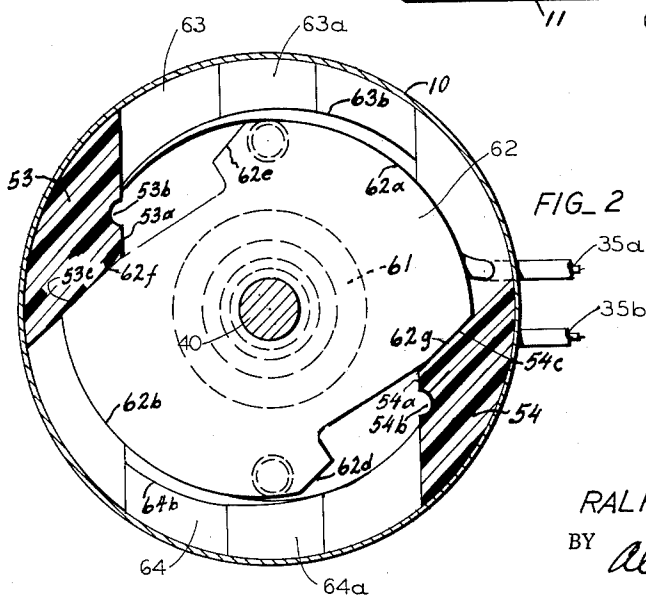
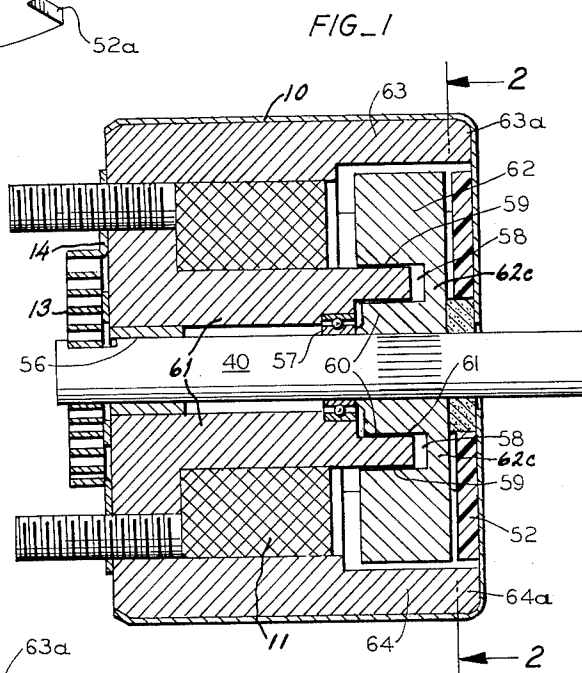
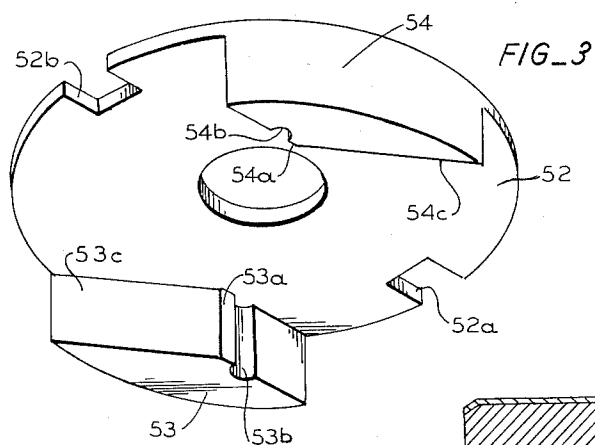
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ROTARY SOLENOID WITH IMPROVED AIR GAPS AND STOP MEMBERS

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3,229,171 ROTARY SOLENOID WITH IMPROVED AIR GAPS AND STOP MEMBERS

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This invention relates to rotary solenoids in general. More specifically this invention relates to a rotary solenoid which is provided with an improved core and armature structure.

An object of this invention is to provide an improved rotary solenoid core and armature structure that is made so that bearing wear is minimized.

Another object of this invention is to provide an improved rotary solenoid construction in which the air gaps between the rotatable armature and the magnetic core are arranged to minimize the radial and axial pull on the armature shaft.

Still another object of this invention is to provide an improved rotary solenoid in which the angle of rotation may be adjusted simply by substituting readily removable stop members which are of sound deadening material.

Other and further objects of this invention will be apparent to those skilled in the art to which it relates from the following specification, claims and drawing.

In accordance with this invention, there is provided an improved rotary solenoid construction of the type disclosed in Patent No. 2,950,424. This rotary solenoid is provided with a core of magnetic material which includes a central pole piece around which the magnetizing coil is positioned. A shaft for supporting the rotatable armature is positioned in a hole formed in the central core member, and this armature is adapted to rotate with the opposite ends thereof adjacent to the outer pole faces of the core structure. The central core is provided with an annular end member which extends into an annular recess formed in the armature. The ring shaped air gaps formed between the outer and inner surfaces of this annular member and opposed surfaces of the armature are made relatively small so that only sufficient clearance is provided therebetween such as will prevent frictional contact therebetween. These air gaps are at different radial distances from the center of the shaft and they are concentric with the axis of the shaft. Also the armature is proportioned so that the magnetic flux passing from the central core member to the armature, or vice-versa, will tend to divide itself substantially equally between these two annular air gaps. Also the air gap between the end of the annular member of the central core and the inner surface of the annular recess in the armature is made substantially longer than the aforesaid ring-shaped air gaps on the inner and outer surfaces of said annular member so that practically no magnetic flux passes between the end of the central core member and the inner surface of said annular recess so as to reduce the axial pull on the armature and armature shaft whereby this axial pull is minimal.

This air gap structure results in a device in which the shaft bearings may be reduced in size because the radial and axial thrust on the shaft during rotation of said shaft have been greatly reduced.

This rotatable solenoid is also provided with stop members of sound-deadening material such as nylon, Delrin and the like, which are provided for limiting the rotation of the armature. These stop members are made integral with a disc of similar material which is adapted to be supported from the ends of the outer pole pieces

and it may be held in position on these outer pole pieces by suitable notches formed therein. This disc-shaped member is adapted to fit into the cover of the device and it is held assembled with the outer pole pieces of the core structure by the cover.

Other features and further details of this invention will be set forth in the specification, claims and drawing in which, briefly:

FIG. 1 is a sectional view of an embodiment of this invention;

FIG. 2 is a sectional view taken along the line 2-2 of FIG. 1; and

FIG. 3 is a perspective view of the disc-shaped member supporting the armature stops.

Referring to the drawing in detail, there is illustrated a rotary solenoid employing an outer cover or housing 10 fitting rather snugly over the outer surfaces of the pole pieces 63 and 64, and disc 52 which supports the armature stops 53 and 54. The pole pieces 63 and 64 are of like magnetic polarity which is induced therein when the coil 11, which is made up of a plurality of turns of insulated magnet wire, is energized by connecting the leads 35a and 35b thereof to a source of current supply. This coil 11 is lodged in a donut-shaped recess that is provided in the core structure, and the inner core member 61 of the core structure is positioned in the center of the coil. A suitable hole is provided in the center of the inner core member 61 for the shaft 40 which is rotatably supported therein by means of the sleeve bearing 56 and the ball bearing 57. A coil spring 13, having the inner end thereof attached to the shaft 40 and the outer end attached to the disc member 14, is provided to urge the shaft and armature counter-clockwise so that the armature is normally in its open air gap position.

The armature 62 is attached to the shaft 40 and the arcuate end faces 62a and 62b thereof are arranged to cooperate with the arcuate faces 63b and 64b, respectively, of the outer magnetic poles 63 and 64, respectively. The arcuate ends 62a and 62b of the armature 62, and the arcuate faces 63b and 64b of the pole pieces 63 and 64, respectively, are shaped as described and claimed in Patent No. 2,950,425 so that the lengths of the air gaps between the armature end faces 62a and 62b, and pole faces 63b and 64b, respectively, are uniform throughout the areas thereof and uniformly decrease as the armature is rotated to its closed position when coil 11 is energized by a suitable electric current.

The air gap between the central core member 61 and the armature 62 may be considered as divided into three parts, 58, 59 and 60, in which the air gaps 59 and 60 are made just long enough to prevent rubbing contact between the armature 62 and the pole piece 61. These air gaps thus are thin sheet-like annuli which have different radii with respect to the center of the shaft 40 which also forms the center of these annular gaps. These gaps 59 and 60 are made of substantially the same lengths. Thus the magnetic flux between the central pole member 61 and the armature 62 distributes itself substantially equally between these two air gaps 59 and 60.

The magnetic flux between the center pole piece 61, which passes through the air gap 59 and armature 62, toward the outer pole pieces 63 and 64 takes substantially radial paths between the gap 59 and the outer ends of the armature 62 before it passes through the gaps between the armature and the outer pole faces 63 and 64. The magnetic flux passing from the center pole member 61 through the air gap 60 and into the armature, however, must take a turn through the armature in the direction parallel to the shaft and then pass radially through the armature portion 62c before taking a substantially radially

disposed path toward the ends 62a and 62b of the armature. Thus sufficient iron must be left in the part 62c of the armature to accommodate this magnetic flux without increasing the reluctance of this magnetic path to a point where the magnetic flux will tend to take the path including the air gap 59 in preference to the path including the air gap 60. Also, the air gap 58 is made of a substantially greater length than that of either of the air gaps 59 or 60 so that practically no magnetic flux goes through this air gap 58. The purpose of this is to reduce the magnetic attraction between the end of the central core member 61 and the inner face of the annular recess in the armature 62, and this is accomplished by making the annular air gap 58 of a length substantially greater than the length of either air gap 59 or 60.

Proportioning the air gaps 58, 59 and 60 as described distributes the magnetic forces between the central pole member 61 and armature 62 such that the size of the ball bearing 57 may be greatly reduced because the axial and radial forces thereon are reduced to a minimum. This result is produced by balancing out the radial forces in the air gaps 59 and 60 and by increasing the air gap 58 in relation to the air gaps 59 and 60 so that the axial force on the shaft is reduced to a minimum. Inasmuch as the magnetic flux in the air gap 59 passes outward away from the center of the shaft, and the magnetic flux through the air gap 60 at the same time passes toward the center of the shaft, the net force of attraction between the opposing surfaces in these air gaps results in substantially zero radial force on the shaft if the fluxes passing through these air gaps are substantially equal.

This device is also provided with a disc-shaped member 52 of sound deadening material such as nylon, Delrin and the like, which is provided with recesses 52a and 52b and armature stops 53 and 54. Disc-shaped member 52 is positioned so that the recess 52a is around the projection 63a of the outer pole piece 63 and recess 52b is around the projection 64a of outer pole piece 64. When the disc-shaped member 52 is in this position, the armature stop 53 and armature stop 54 are positioned as shown in FIG. 2 so that face 53a of stop 53 is in position to engage face 62e of armature 62, and face 54a of stop 54 is in position to engage face 62d of the armature when the coil 11 is energized and said armature is rotated to close the air gap between the ends thereof and the pole faces of the outer poles 63 and 64.

Faces 53a and 54a are provided with reliefs 53b and 54b, respectively, so that as the armature impacts these faces material of the stop faces is not extruded out of the faces and builds up small ridges that might grip the armature and prevent the spring 13 from rotating it to its normal position in which the sides 62f and 62g of the armature engage the sides 53c and 54c, respectively, of the stops.

The sides of the armature 62 are recessed as shown to reduce the magnetic flux passing from these sides to the faces of the outer pole pieces. The parts of these recessed sides may be shaped so as to present surfaces thereof to the stop surfaces 53c and 54c of the stops of substantially larger area than shown in FIG. 2, if desired. Also the stops 53 and 54 may be made larger or smaller depending on the angle of rotation of the armature desired.

While I have shown and described a preferred embodiment of the invention, it will be understood that the invention is capable of variation and modification from the form shown so that its scope should be limited only by the scope of the claims appended hereto.

What I claim is:

1. In a rotary solenoid the combination of a core of magnetic material, said core having a central pole member and outer pole members, a rotatable armature disposed between said outer pole members, means including a friction-reducing bearing supporting said armature on said central pole member, the end of said central pole

member being in the shape of an annulus, said armature having an annular recess for receiving said annulus of said central pole member so that the areas of the annular air gaps between said armature and said central pole member on both sides of said annulus are constant during rotation of said armature, the radially disposed air gaps between said annulus and said annular recess being just sufficient to prevent rubbing of the opposing surfaces in said air gaps, said air gaps being constructed so that the magnetic flux passes therethrough in opposing directions so that the radial forces on said armature supporting bearing produced by the magnetic flux in said radially disposed gaps are substantially neutralized throughout rotative movement of said armature.

2. In a rotary solenoid the combination of a core of magnetic material, said core having a central pole member and outer pole members, a rotatable armature, a shaft for supporting said armature on said central pole member so that the ends of said armature cooperate with said outer pole members, the end of said central pole member being in the shape of an annulus, a friction-reducing bearing for said shaft positioned in the end part of said pole member adjacent to said annulus, said armature having an annular recess for receiving said annulus of said central pole member so that the areas of the annular air gaps between said armature and said central pole member on both sides of said annulus are constant during rotation of said armature, the radially disposed air gaps between said annulus and said annular recess being just sufficient to prevent rubbing of the opposing surfaces in said air gaps, the air gap between the ends of said annulus and the innermost surface of said recess being of substantial length so that very little of the magnetic flux between said armature and said central pole member passes therethrough whereby the axial thrust on said shaft and said friction-reducing bearing is minimized and the major part of said magnetic flux passes through said radially disposed gaps during the entire rotative movement of said armature and the radial forces on said shaft and friction-reducing bearing produced in said radially disposed gaps are substantially neutralized.

3. In a rotary solenoid the combination of a core of magnetic material, said core having a central pole member and opposing outer pole members, an armature, means for supporting said armature on said central pole member, the end of said central pole member being in the shape of an annulus, said armature having an annular recess for receiving said annular shaped end of said central pole member, the radially disposed air gaps between said annulus and said annular recess being just sufficient to prevent rubbing of the opposing surfaces in said air gaps, the air gap between the end of said annulus and the innermost surface of said recess being of substantial length so that very little of the magnetic flux between said armature and said central pole member passes therethrough and the major part of said magnetic flux passes through said radially disposed gaps so that the radial forces on said armature supporting means produced in said radially disposed gaps are substantially neutralized, a disc-shaped member, means for supporting said disc-shaped member, said last mentioned supporting means including projections on said opposing outer pole members of said core fitting into recesses formed in said disc-shaped member, and stops of a tough plastic sound deadening material attached to said disc-shaped member and projecting into the path of rotation of said armature to limit the rotation thereof.

4. In a rotary solenoid the combination of a core of magnetic material having a centrally disposed member and outer pole pieces, a coil positioned on said centrally disposed member for setting up a magnetic field in said core, a rotatable armature positioned with the ends thereof adjacent said outer pole pieces, means for supporting said armature on said centrally disposed member, said

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armature and said centrally disposed member having a pair of radially disposed air gaps therebetween through which the magnetic flux passes in the opposite radial directions so that the radial forces on said armature resulting therefrom are substantially neutralized, a disc-shaped member, means for supporting said disc-shaped member on said core, and stops of a tough plastic sound deadening material attached to said disc-shaped member and projecting into the path of rotation of said armature to limit the rotation thereof, being provided with reliefs in the faces thereof engaged by said armature so that repeated impacting of said faces by said armature does not extrude

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material out of said stop faces to build up ridges therein for gripping said armature.

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