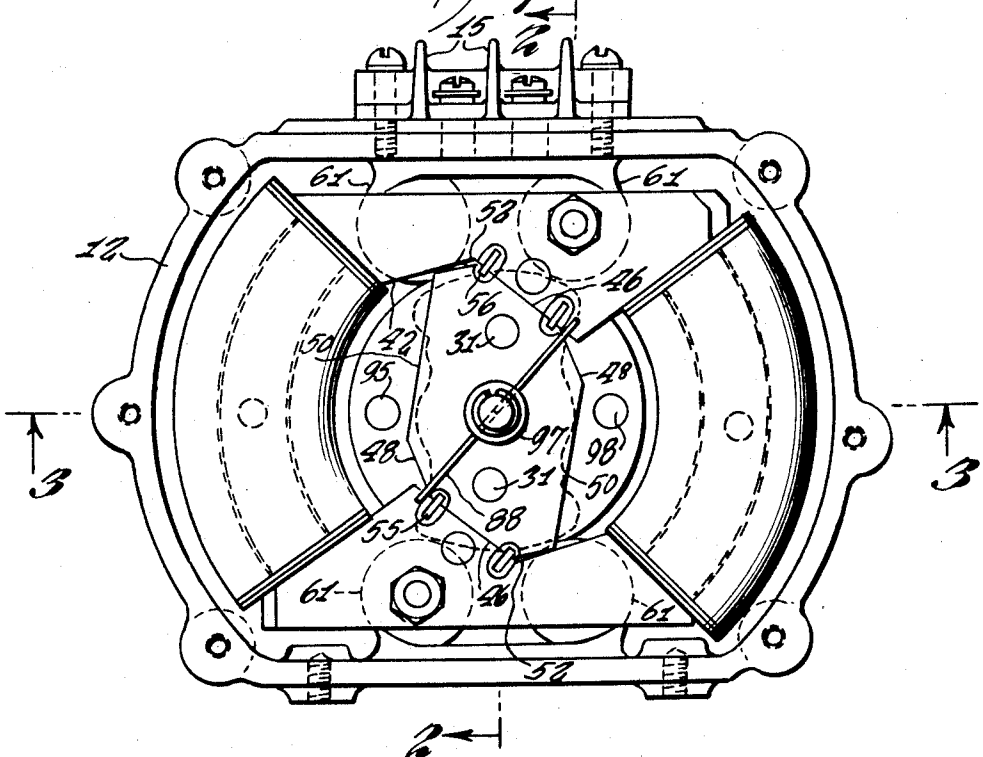
Aug. 5, 1958 H. H. WOLFF 2,846,623

RELAYS AND SOLENOIDS

Filed June 21, 1955 3 Sheets-Sheet 1

Fig. 1



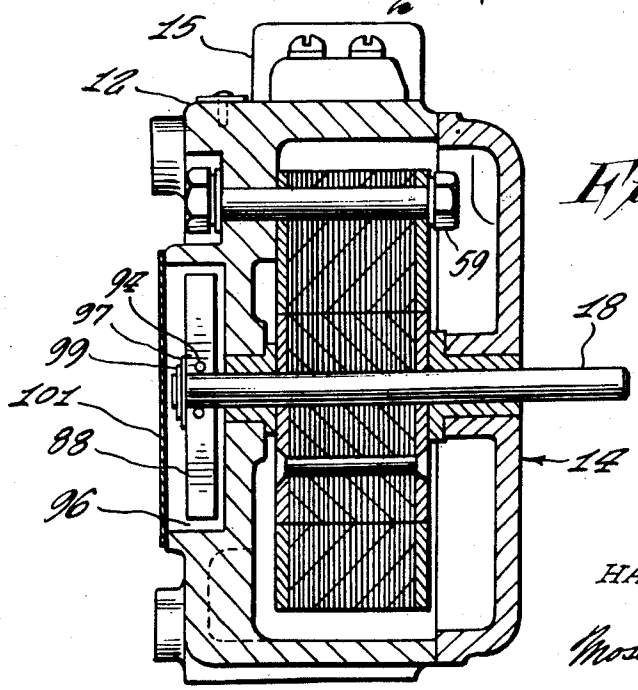


Fig. 2

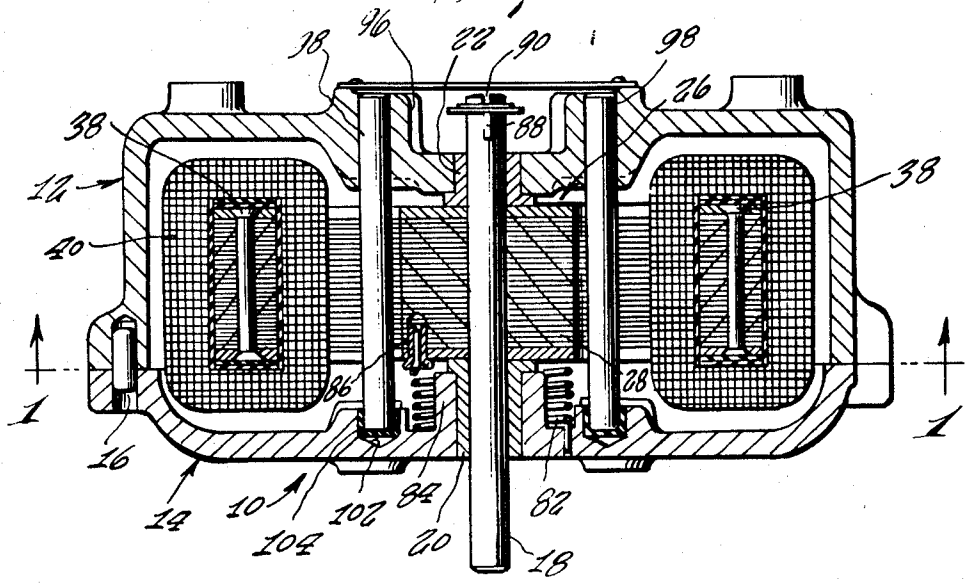
INVENTOR.
HANNS H. WOLFF
BY
Moses, Holte, Crews & Berg
ATTORNEYS

Aug. 5, 1958 H. H. WOLFF 2,846,623

RELAYS AND SOLENOIDS

Filed June 21, 1955 3 Sheets-Sheet 2

Fig. 3



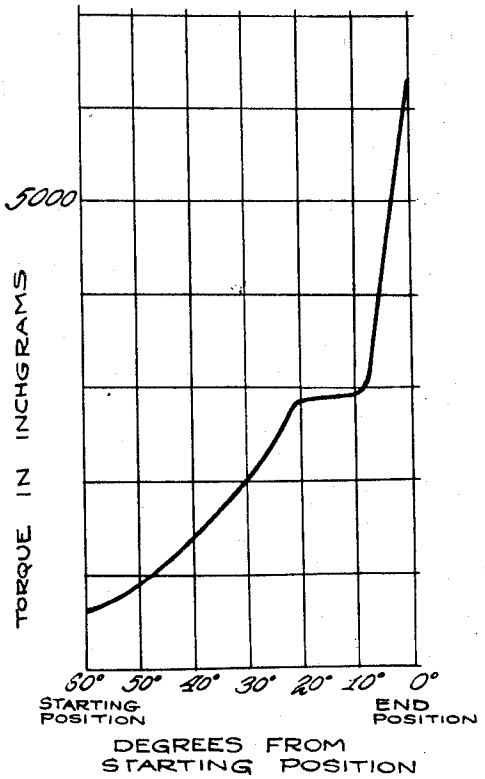


Fig. 4

INVENTOR.
HANNS H. WOLFF
BY
Moore, Holte, Crews & Betty
ATTORNEYS

Aug. 5, 1958 H. H. WOLFF 2,846,623

RELAYS AND SOLENOIDS

Filed June 21, 1955 3 Sheets-Sheet 3

Fig. 5

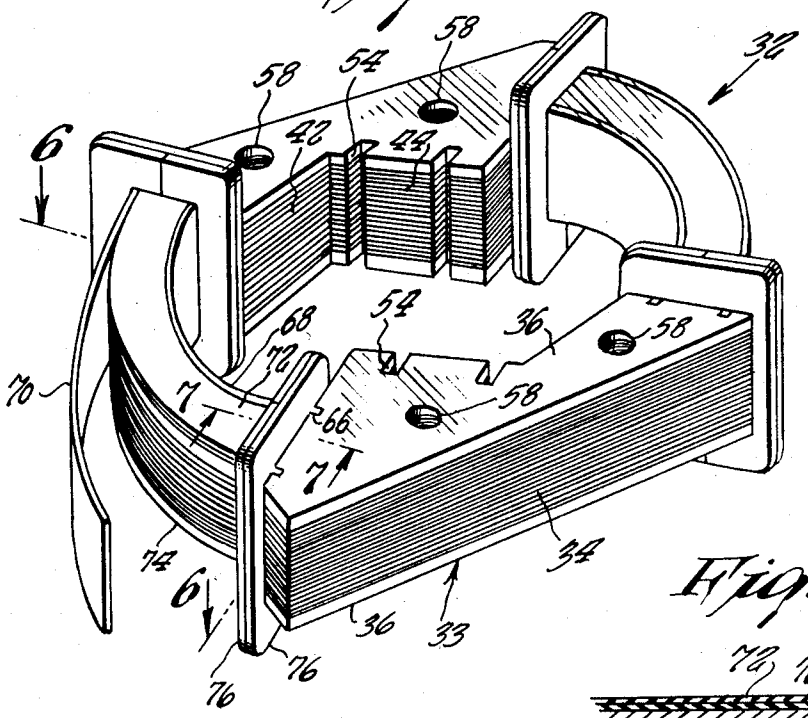


Fig. 7

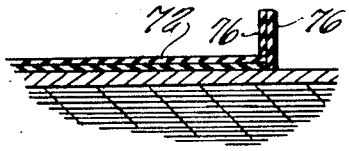


Fig. 6

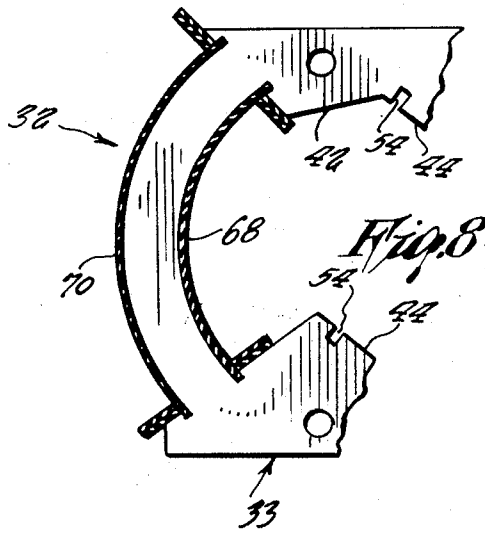
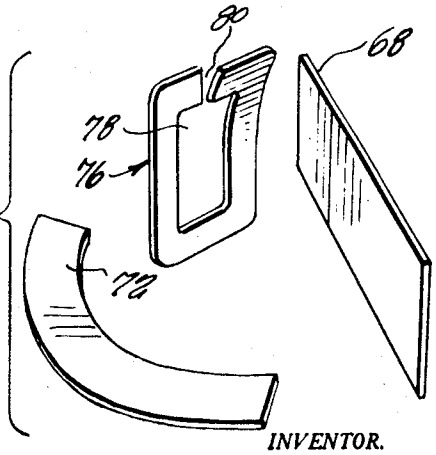


Fig. 8



INVENTOR.
HANNS H. WOLFF
BY
Moses, Holte, Crews & Berry
ATTORNEYS

United States Patent Office 2,846,623 Patented Aug. 5, 1958

2,846,623

RELAYS AND SOLENOIDS

Hanns H. Wolff, Matawan, N. J., assignor to Leetronics, Inc., a corporation of New York

Application June 21, 1955, Serial No. 517,010

17 Claims. (Cl. 317—180)

This invention relates to rotary solenoids, and more particularly to rotary alternating current solenoids. The present invention is in the nature of an improvement upon the invention disclosed and claimed in my pending application, Serial No. 517,027, filed June 21, 1955, for Relays and Solenoids. The invention is illustratively shown as embodied in a structure like that disclosed in Figs. 14 to 19 and 25 of said pending application.

The primary object of the present invention is to provide improved restoring characteristics in a device of the kind referred to. In the structure of the prior application, a rotary armature is made to move to the fully actuated position against the continually increasing resistance of a coil spring. In the limit position the coil spring acts with maximum force to restore the armature to the normal, unactuated position. Even so, the return movement of the armature is slow to get under way when the energizing current is cut off, chiefly because of the retaining force exerted by the residual magnetism of the solenoid.

It is not desirable that the armature return sluggishly to the off position. It is accordingly a primary object of the invention to provide supplementary spring means arranged to be put under stress only as an incident of the final forward movement of the armature to the fully actuated position, and effective as soon as the current is cut off, to give the armature a quick start from that position.

Other objects and advantages will hereinafter appear.

In the drawing forming part of this specification:

Fig. 1 is a vertical sectional view of an illustrative rotary solenoid embodying the invention, the section being taken on the line 1—1 of Fig. 3, looking in the direction of the arrows but showing the rotor in a different rotation position from that of Fig. 3;

Fig. 2 is a vertical sectional view of the apparatus of Fig. 1, taken on the line 2—2 of Fig. 1, looking in the direction of the arrows;

Fig. 3 is a horizontal sectional view of the apparatus of Fig. 1, taken on the line 3—3 of Fig. 1, looking in the direction of the arrows, but, as already noted, showing the rotor in a different position from that of Fig. 1;

Fig. 4 is a graph showing the torque in inch-grams as ordinates and showing degrees of rotation from the end position as abscissas;

Fig. 5 is a perspective view of the stator of the illustrative rotary solenoid, with one strip of external insulation shown swung away from its assigned position to reveal underlying structure;

Fig. 6 is a fragmentary sectional view taken on the line 6—6 of Fig. 5 looking in the direction of the arrows;

Fig. 7 is a fragmentary sectional view taken on the line 7—7 of Fig. 5 looking in the direction of the arrows; and

Fig. 8 shows a group of insulation pieces employed in the stator.

The solenoid 10 comprises flanged casing members 12 and 14, which are secured to one another by driven pins 16 after the assembly has been completed. The

casing member 12 is provided at the top with heat radiating fins 15. A rotor shaft 18 is rotatably supported in bearing bushings 20 and 22. The shaft 18 extends through the casing member 14 to the exterior thereof for connection to any suitable operative member. A laminated armature 26 is fixed on the shaft 18. The armature is composed of highly permeable laminae 28 and steel end plates 30, the assembly being held together by rivets 31.

The casing also encloses a stator 32. The stator 32 comprises a ring 33, which consists of a laminated body 34 of highly permeable material and steel end plates 36 which are secured to the body members 34 and to one another by rivets 38. The ring includes diametrically opposed arcuate sections upon which coils 40 are wound. The ring also includes joining portions which extend from one arcuate portion to the other. Each joining portion may have a straight outer face as shown, but it is formed with straight, angularly related faces 42 and 44, the latter faces constituting the faces of pole pieces.

The faces 42 and 44 desirably make an angle of the order of 125° with one another. The rotor, as seen in Fig. 1, is in the form of an irregular octagon, being formed with opposed pairs of parallel faces 46—46, 48—48, 50—50 and 52—52, as shown. The faces 46 and 52 desirably make an angle of the order of 129° with one another. The disposition of the faces of the rotor relative to the faces 42 and 44 of the stator is such that energization of the coils 40 causes torque to be applied to the armature until the faces 46 have been carried into continuous contact with the pole faces 44 of the stator, as shown in Fig. 1. In this condition of the parts the faces 52 have been carried through the condition of parallelism with the faces 42 and into divergent relation to the faces 42, as shown.

Each stator face 44 of the ring 33 is formed with channels 54 to receive a brass ring 55 which serves as a shading coil. The shading coil operates to produce a magnetic shift of phase of a portion of the magnetic flux through the magnetic system to such a degree as to importantly reduce the tendency to hum or chatter. Each rotor face 46 has channels 55 formed in it corresponding to the shading coil channels 54. In the fully actuated condition illustrated in Fig. 1, the channels 55 stand opposite the channels 54.

The purpose of the shading coils is to reduce the chattering of the rotor in the end position. They are effective in accomplishing this result, because the magnetic flux to the pole pieces is made to consist of two or more streams which have a phase shift against each other and thereby reduced the fluctuation of the forces acting between the pole pieces.

The ring 33 is formed with two bores 58 through which it is attached to the casing member 12 by headed bolts 57 and nuts 59.

The casing member 12 is formed with internal bosses 61. Two of these embossed areas are bored to pass the shanks of bolts 57, while the other two bosses are ground away sufficiently to clear the ring 33.

In Figs. 5 to 8, novel and efficient means is shown for insulating the coils 40 from the ring 33. As seen in Fig. 5, the connecting portions of the ring have substantially radial faces disposed toward the arcuate portions of the ring. Vertical channels 66 are provided in these faces to receive the extremities of inner and outer similar insulating strips 68 and 70. Upper and lower identical pairs of arcuate insulating strips 72 and 74 are provided to cover the top and bottom faces of the arcuate portion of the ring and to space the ring from the associated coil 40.

A pair of retaining plates 76 is provided at each end of the arcuate portion of the ring 33, the plates

76 being also formed of flexible insulating material. Each plate 76 is of generally rectangular form and is formed with a rectangular opening 78 which is shaped to receive and snugly sit upon the insulating strips 68, 70, 72 and 74 which surround an arcuate section of the ring 33. Each plate 76 is split at 80 along its vertical median line at one end of the opening 78, the split extending from the opening through the nearest outer edge of the plate. Each plate 76 is sufficiently deformable to permit it to be placed around the ring as shown, but is sufficiently elastic to recover its original shape when so applied. Two plates 76 are employed at each end of the arcuate ring portion, one plate having its split end disposed at the lower side and the other having its split end disposed at the upper side.

The strips 68 and 70 are first put in place upon an arcuate ring section, and the outer plates 76 are then applied. The insulating strips 72 and 74 are then held in place while the inner plates 76 are applied. The inner plate 76 at each end has its opening 78 long enough to receive the plates 72 and 74 along with the arcuate portion of the ring, but the outer plate 76 at each end has a shorter opening 78, just long enough to receive the ring. The plates 72 and 74 are just long enough to fill the space between the outer plates 76, the arrangement at one end being shown in detail in Fig. 7.

The pole piece configuration shown in Fig. 5 has the advantage that good starting and good end torques may both be realized. This is because the starting torque is mainly controlled by one pole piece section, whereas the end torque is mainly controlled by the other pole piece section. The torque developed by the solenoids throughout its range of movement as shown graphically in Fig. 4. It will be observed that as the armature swings away from the starting position, the torque increases at a slightly increasing rate through approximately the first 42° of travel, that it then holds substantially unchanged for about 10°, and then more than doubles in value during approximately the last 8° of travel.

The solenoid is opposed throughout its travel by a coil spring 82. The spring surrounds a bearing boss 84 of the casing member 14 and has its opposite ends anchored respectively in the casing member 14 and in the rotor 26, the latter connection being effected through an insulating plug 86. As the spring is put under stress, it resists turning of the solenoid with uniformly increasing force. The torque exerted by the solenoid builds up more rapidly than the resistance of the spring, except in the range from 42° to 52°. There is at all times ample torque to overcome the spring resistance, so long as the current is on.

A supplementary leaf spring 88 is provided on the rotor shaft 18, being lodged in a diametrically extending slot 90 formed in one end of the shaft 18. The spring 88 is carried by the shaft 18 in a recess 96 at the outer side of the casing member 12. The spring 88 is held in abutting relation to the slot base by a washer 97 and a split ring 99. The spring 88 has a drive fit in the slot 90 and is further held against movement in the direction of its length by bumps 95 which are formed in it at opposite sides of the shaft 18. The spring 88 is free to swing with the armature until the armature nears the end of its forward or operated movement. Just a few degrees short of the end of such movement the spring ends are intercepted by the walls of the recess 96. Since the spring is resilient, it does not abruptly stop the rotor, but it does oppose the final movement of the rotor with a strong force. The armature is finally arrested by engagement of the rotor faces 46 with the pole piece faces 44. A disc 101, secured to the casing member 12, covers the spring 88 and the rotary parts associated with it.

The spring 88 cushions the final movement of the armature. The primary purpose of the spring 88, however, is to overcome the residual magnetism of the solenoid and to give the armature a quick start back toward the point of beginning when the current flow is interrupted.

Stop rods 98 are provided for arresting the return movement of the armature. The rods 98 are composed of non-magnetic materials. They are passed through bores 100 formed in the casing member 12 and have their entering ends received in recesses 102 of the casing member 14. The ends of the rods 98 are separated from the casing member 14 by insulation 104.

I have described what I believe to be the best embodiments of my invention. I do not wish, however, to be confined to the embodiments shown, but what I desire to cover by Letters Patent is set forth in the appended claims.

I claim:

1. A rotary solenoid comprising, in combination, a stator, a rotor, a casing enclosing the stator and the rotor, spring means invariably opposing electromagnetic actuation of the rotor, opposing abutment members carried respectively by the casing and the rotor and engageable with one another in the final forward movement of the rotor, at least one of said abutment members being resiliently deformable and serving to give the rotor a quick start in the return direction against the residual magnetism of the solenoid when the current flow is discontinued.

2. A rotary solenoid comprising, in combination, a stator, a rotor, a casing enclosing the stator and the rotor, spring means invariably opposing electromagnetic actuation of the rotor, a supplemental, leaf spring carried by the rotor in position to be intercepted by the casing and put under stress in the final forward movement of the rotor, and serving to give the rotor a quick start in the return direction against the residual magnetism of the solenoid when the current flow is discontinued.

3. A rotary solenoid comprising, in combination, a stator, a rotor, a casing, spring means constantly connecting the rotor with the casing and invariably opposing electromagnetic actuation of the rotor, and an abutment spring member carried by the rotor in position to be intercepted by the casing and put under stress in the final forward movement of the rotor, and serving to give the rotor a quick start in the return direction against the residual magnetism of the solenoid when the current flow is discontinued.

4. A rotary electro-magnetic actuator comprising a stator, a rotor, a casing enclosing the rotor and the stator, said stator including at least two diametrically opposed arcuate sections having coils wrapped therearound, means to insulate said coils from said arcuate sections, at least two diametrically opposed pole piece joining portions having straight outer faces and angularly related inner faces, said inner faces constituting the pole piece faces and means to interconnect said pole piece joining portions and said arcuate sections into a permeable ring and means to reduce chattering of the rotor in its end position, pole piece faces carried by said rotor and being complemental to the pole piece faces of the rotor, and other faces carried by each said rotor and said stator contiguous with their respective pole piece faces and each forming an angle therewith, to increase the torque sharply during the last few degrees of rotor rotation upon energization of the said coils.

5. A rotary electro-magnetic actuator as in claim 4, wherein said insulating means for each arcuate section includes a first pair of insulating strips, one strip above and one strip below the arcuate section, a second pair of insulating strips, one strip on each side of the arcuate section, at least four end plates of flexible resilient material having centrally disposed openings therethrough adapted to receive and snugly sit upon the extremities of said first and second pair of insulating strips and a split along the vertical median of each end plate extending from said center opening through the nearest outer edge.

6. A rotary electro-magnetic actuator as in claim 5, wherein said joining means includes a pair of vertical channels in each end of each of said pole piece joining sections adapted to receive the extremities of said second pair of insulating strips.

7. A rotary electro-magnetic actuator as in claim 6, wherein said chatter reducing means includes vertical slots in at least two diametrically opposed faces of said rotor, at least two vertical slots in diametrically opposed pole piece faces coincident at the end of the rotor movement with said vertical slots in said rotor and a shading coil disposed in said pole piece face slots.

8. A rotary electro-magnetic actuator comprising, in combination, a rotor and a stator, the stator comprising a permeable ring having pole segments formed with contiguous pole pieces which are directed inward toward one another at an angle of substantially 125 degrees, arcuate segments connecting the pole segments, the pole segments having flat faces disposed towards the arcuate segments and formed with parallel slots adjacent the inner and outer arcuate faces of the arcuate segments, windings disposed in surrounding relationship to the respective arcuate segments and insulating means spacing and insulating the windings from the ring comprising strips of insulating material disposed in contact with the inner and outer faces of the arcuate segments and having their ends received in the inner and outer slots respectively, and strips of insulating material disposed in contact with the top and bottom faces of the arcuate segments from end to end thereof and pairs of flexible elastic insulating plates disposed at opposite ends of each arcuate segment, each plate having an opening to receive and lift the arcuate segment together with the surrounding insulating strip and each having a slot extending from said opening to an adjacent outer edge of the plate, said rotor having pole segments complemental to said stator pole segments with contiguous pole pieces which are greater than 125 degrees.

9. A rotary electro-magnetic actuator as in claim 8, wherein the plates of an associated pair have their slots disposed at opposite sides of the enclosed arcuate segments.

10. A rotary electro-magnetic actuator as in claim 9, wherein at least two parallel channels are formed in at least two directly opposite stator pole pieces, shading coils disposed to extend through said stator channels and said rotor being formed with similarly related parallel channels which lie opposite the first mentioned channels when the rotor is in fully operative position whereby chatter is reduced.

11. A rotary alternating current solenoid comprising, in combination, a stator having at least a pair of adjacent faces disposed relative to each other at a predetermined angle, a rotor movable relative to said stator and also having a pair of faces complemental to said stator faces but disposed relative to each other and at an angle greater than the angle of said stator faces so that the solenoid develops a high and sharply rising torque near the end of its forward movement, a casing enclosing the stator and the rotor, and an abutment spring member carried by the rotor in position to be intercepted by the casing and put under stress to cushion the arrest of the rotor in the final forward movement thereof, said abutment spring member serving also to give the rotor an initial quick start in the return direction against the holding force exerted by the residual magnetism of the solenoid when the current flow is discontinued.

12. A rotary solenoid of the kind set forth in claim 11, and wherein a second spring member aids the abutment spring member during its arrest and initial quick start action and continues in the latter action throughout a period of restoration of the rotor to its normally deenergized position.

13. Rotary solenoid apparatus adapted to retard final movement of a rotor in one direction and to provide initial quick start return rotation of the rotor against the residual magnetism of the solenoid when current flow therein is discontinued, said apparatus including a supporting structure having a stator, a rotor movably mounted in said structure and having a shaft with a lateral slot in one end thereof, and a resilient elongated leaf spring having a portion thereof fixedly secured in said slot and extending to yieldably engage the supporting structure only during a few degrees of angular displacement in the final forward rotational movement of the rotor.

14. Apparatus as set forth in claim 13, and wherein said stator has a pair of adjacent pole faces and said rotor has a pair of adjacent pole faces complemental to said stator adjacent pole faces, the adjacent pole faces of the rotor being at an angle to each other and greater than the angle of the adjacent pole faces of the stator.

15. Apparatus as set forth in claim 14, and wherein the angle of the adjacent pole faces of the stator is substantially 125 degrees.

16. Rotationally operative apparatus having means adapted to retard final movement of a rotor in one direction and to provide initial quick start return rotation of the rotor against the residual magnetism of the solenoid when current flow therein is discontinued, which apparatus includes a supporting structure having a stator, a rotor movably mounted in said structure and having a shaft with a lateral slot in one end thereof, a first spring means comprising a resilient elongated leaf spring having a portion thereof fixedly secured in said slot and extending to engage the supporting structure only during a few degree of angular displacement in the final forward rotational movement of the rotor, and a second spring means at all times urging said rotor to its position of deenergization.

17. Apparatus as set forth in claim 16 and wherein said stator and said rotor each have a pair of flat complemental pole faces, the angle of the stator pole faces being at 125 degrees to each other, one pole face each of the stator and the rotor being parallel to each other when the solenoid is energized and the rotor and stator pole faces are engaged.

References Cited in the file of this patent

UNITED STATES PATENTS

682,377	Wurmb	Sept. 10, 1901
2,349,647	Boisseau et al.	May 23, 1944
2,540,294	Schleicher	Feb. 6, 1951
2,563,271	Price	Aug. 7, 1951