Feb. 10, 1959 H. PRATT 2,873,412

ROTARY SOLENOID

Filed Sept. 7, 1957

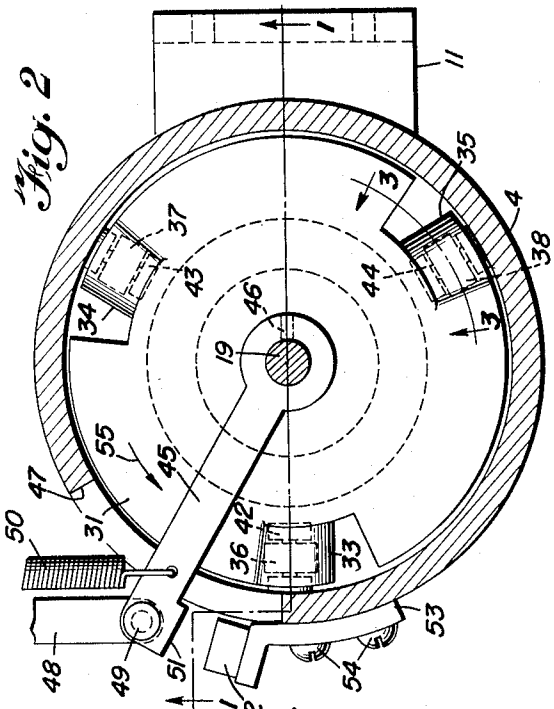


Fig. 2

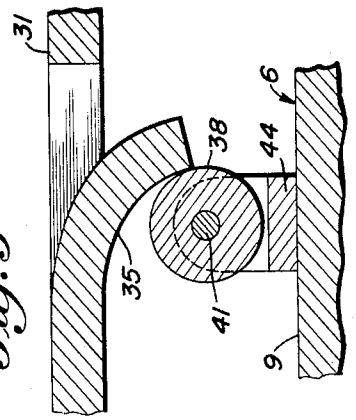


Fig. 3

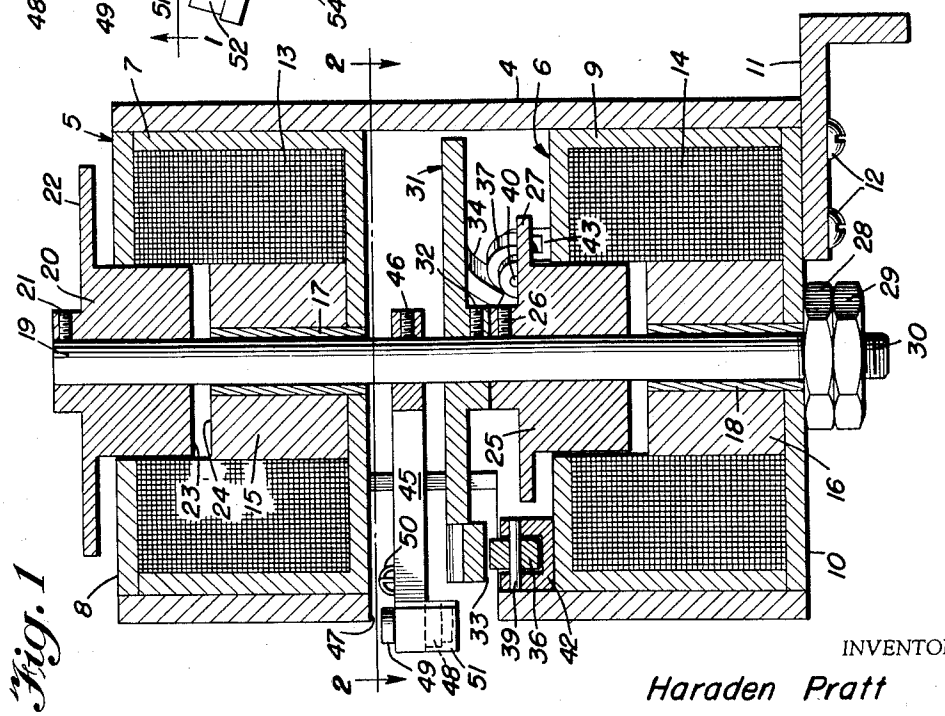


Fig. 1

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ROTARY SOLENOID

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Application September 7, 1956, Serial No. 608,475

4 Claims. (Cl. 317—192)

The present invention relates to a rotary solenoid of the type in which longitudinal motion imparted to a member by a solenoid is converted into angular motion which is utilized to perform useful work.

Rotary solenoids of the general type under consideration are not broadly new. However, so far as I am aware, there has not heretofore been available a rotary solenoid of light and compact design which was capable of withstanding frequent operation over a long period of time, which was capable of many millions of operations without replacement or repair, and which would retain its original torque characteristics throughout its useful life. There are many examples of fields of utility where such requirements are essential. For example, such rotary solenoids may be used to actuate certain elements in electrically operated typewriters or teletypewriters which must operate at high speeds for prolonged periods of time and which are required to give reasonably trouble-free operation over a period of years.

One of the primary objects of the present invention is to provide a small and compact rotary solenoid which is capable of many millions of actuations during its useful life.

Another object of the invention is to provide a rotary solenoid which will retain its original torque characteristics throughout a long, useful life.

Another object of the invention is to provide a rotary solenoid which is reasonably silent in its operation.

Another object of the invention is to provide a rotary solenoid in which the problems of lubrication are reduced to a minimum and consequently in which the rate of wear on the solenoid is substantially reduced.

Still another object of the invention is to provide a rotary solenoid in which the extent of both longitudinal and angular movement of the movable member is accurately and definitely controlled.

Other objects and advantages of the invention will be pointed out in the following detailed description of an exemplary form of the invention. This detailed description has reference to the accompanying drawing wherein:

Figure 1 is a longitudinal sectional view of a rotary solenoid assembly embodying the invention and taken generally along the line 1—1 of Figure 2;

Figure 2 is a transverse sectional view taken along the line 2—2 of Figure 1; and

Figure 3 is an enlarged fragmentary sectional view taken along the line 3—3 of Figure 2.

The rotary solenoid assembly is provided with a tubular housing 4 which is preferably of bronze or other non-magnetic material. Magnet coils designated generally by the reference numerals 5 and 6 are positioned in longitudinally spaced relationship in the housing 4. The magnet coil 5 is provided with a cup-shaped casing 7 and a closure plate 8, both of magnetic material. The magnet coil 6 is provided with a similar cup-shaped casing 9 and a closure plate 10. A supporting bracket 11 may be attached to the assembly by any suitable means such as screws 12.

Magnet coils 5 and 6 are provided with windings 13 and 14, respectively, and these windings are preferably electrically connected in parallel to assure that the coils will be energized substantially simultaneously. The magnet coil 5 is provided with a core 15 of magnetic material and the coil 6 is provided with a similar core 16. Bronze sleeve bearings 17 and 18 are positioned in central apertures in the cores 15 and 16 respectively. The sleeve bearings 17 and 18 support a shaft 19 which extends centrally and longitudinally of the housing 4 and is capable of both longitudinal and angular movement relative to the cores 15 and 16.

An armature 20 is fixed to the shaft 19 adjacent the magnet coil 5 by any suitable means such as a set screw 21. The armature 20 may be provided with a peripheral flange 22 which may engage the surface of the closure plate 8 to limit longitudinal movement of the shaft 19 in the downward direction as seen in Figure 1. Alternatively, the longitudinal movement of shaft 19 in this direction may be limited by engagement of the inner end 23 of the armature 20 with the adjacent end 24 of the core 15. An armature 25 is fixed to the shaft 19 adjacent the magnet coil 6 by means of a set screw 26. The armature 25 may be provided with a peripheral flange 27 which may have the same purpose as the flange 22. Lock nuts 28 and 29 are received on the threaded lower end 30 of the shaft 19. The lock nuts 28 and 29 are thus adjustable along the shaft 19 and they serve to limit longitudinal movement of the shaft 19 in the upward direction as seen in Figure 1 by engaging the surface of the closure plate 10.

An actuating plate designated generally by the reference numeral 31 is positioned between the magnet coils 5 and 6 and is fixed to the shaft 19 by any suitable means such as a set screw 32. The actuating plate 31 is provided with a plurality of camming surfaces for cooperating with rollers hereinafter described to impart angular motion to the shaft 19 upon longitudinal movement thereof. Three camming surfaces 33, 34 and 35 are illustrated as being spaced 120 degrees apart around the periphery of the actuating plate 31. These camming surfaces are illustrated as being formed by striking portions of actuating plate 31 out of the plane thereof to form tongues which are clearly shown in Figures 2 and 3. After the camming surfaces 33, 34 and 35 have been struck from the actuating plate 31, the plate may be suitably hardened and the camming surfaces may be accurately ground to the desired contour.

The camming surfaces 33, 34 and 35 are arranged to cooperate with rollers 36, 37 and 38, respectively. These rollers are pivotally mounted on fixed shafts or axes 39, 40 and 41, respectively, which extend radially with reference to the shaft 19. The shafts 39, 40 and 41 are fixed in U-shaped supports 42, 43 and 44 which are secured to the adjacent surface of the cup-shaped casing 9 of the magnet coil 6.

A crank arm 45 is fixed to the shaft 19 by means of a set screw 46 and extends radially from that shaft through an opening 47 in the tubular housing 4. A connecting rod 48 is pivotally connected to the outer end of the crank arm 45 by means of a pivot pin 49. The connecting rod 48 may be connected to any member which it is desired to actuate by means of the solenoid assembly. A tension spring member 50 has one of its ends attached to the outer end of the crank arm 45 and has its opposite end connected to any suitable fixed member, not shown. The outer end of the crank arm 45 is provided with a bumper portion 51 positioned to strike a cushioning member 52 which is preferably of rubber or some other suitable resilient cushioning material. Cushioning member 52 is supported by means of an adjustable bracket 53 which is secured to the tubular housing 4 by means of screws 54.

The operation of the apparatus can now be described. When the magnet coils 5 and 6 are not energized, the

spring member 50 urges the crank arm 45 in a clockwise direction as seen in Figure 2 and the elements of the apparatus occupy the positions shown in the drawing. Camming surfaces 33, 34 and 35 are in engagement with the rollers 36, 37 and 38, respectively, and the shaft 19 and all elements fixed thereto are thus in the upward position as illustrated in Figure 1. The lock nuts 28 and 29 serve to limit the extent of this upward movement. Energization of the magnet coils 5 and 6 causes the armatures 20 and 25 and consequently the shaft 19 and all elements fixed thereto to move in the downward direction as seen in Figure 1. The actuating plate 31 will move downwardly with the shaft 19 and thereupon the camming surfaces 33, 34 and 35 and the rollers 36, 37 and 38 will cooperate to cause counter-clockwise angular movement of the shaft 19 and the crank arm 45, as illustrated by the arrow 55 in Figure 2. The extent of this counter-clockwise movement of the shaft 19 and crank arm 45 may be limited by engagement of the flange 22 of the armature 20 with the closure plate 8 of the magnet coil 5, or by engagement of the inner surface 23 of the armature 20 with the surface 24 of the core 15. The extent of such counter-clockwise movement could similarly be limited by engagement of corresponding portions of armature 25 with corresponding elements of the magnet coil 6. However, such means for limiting the counter-clockwise movement would not serve to definitely stop the crank arm 45 at any particular fixed position for the reason that the shaft 19 could continue to rotate after, for example, the flange 22 engaged the closure plate 8. For this reason it is preferable that the counterclockwise movement of the crank arm 45 be limited by engagement of the bumper portion 51 with the cushioning member 52. The position of the cushioning member 52 is adjustable by changing the position of the bracket 53 relative to the tubular housing 4. The bumper portion 51 will remain in engagement with the cushioning member 52 until the magnet coils 5 and 6 are de-energized, at which time the spring member 50 will return the assembly to the positions shown in the drawing.

The rollers 36, 37 and 38 are preferably of self-lubricating material to eliminate the need for other lubrication of those rollers and of the camming surfaces. The sleeve members 17 and 18 are preferably also of self-lubricating material. The axial lengths of the rollers 36, 37 and 38 are sufficient to distribute the forces acting between those rollers and the camming surfaces 33, 34 and 35 to such an extent that excessive pressure is not exerted between those members. It will be observed that the camming surfaces 33, 34 and 35 and the rollers 36, 37 and 38 perform no function in stopping or limiting the extent of movement of the movable portions of the apparatus and those members are therefore relieved from high stresses and shock which would otherwise exist. These features contribute greatly to the useful life of the camming surfaces and rollers and to the ability of the apparatus to retain its original torque characteristics.

The slope of the camming surfaces 33, 34 and 35 preferably changes gradually in the manner best illustrated in Figure 3 so that when magnet coils 5 and 6 are first energized the angular motion imparted to the shaft 19 and crank arm 45 is relatively slow but gradually accelerates as the shaft 19 continues to move downwardly under the influence of the magnet coils. This fact serves to reduce the stresses on the camming surfaces and the rollers and additionally serves to reduce the noise of the apparatus at the instant of energization of the magnet coils 5 and 6. The cushioning member 52 acts to reduce noise of the apparatus at the end of the working stroke of the crank arm 45.

I have illustrated and described what I now consider to be the preferred form of the invention. However, it will be clear that modifications may be resorted to without departing from the broader scope of the invention as defined by the following claims.

Having thus described my invention I claim:

1. A rotary solenoid comprising a casing, a magnet coil having a core fixed within said casing, a shaft extending through said core and being both longitudinally and angularly movable relative thereto, an armature fixed to said shaft, a flange on said armature positioned to engage said casing to positively limit longitudinal movement of said shaft in the power stroke direction of movement of said shaft, stop means fixed to said shaft and positioned to engage said casing to positively limit longitudinal movement of said shaft in the return stroke direction thereof, a plurality of rollers pivotally mounted at one end of said casing on fixed axes disposed radially relative to said shaft, an actuating plate fixed to said shaft, a plurality of portions of said actuating plate sloping therefrom to form camming surfaces positioned to engage said rollers, said camming surfaces cooperating with said rollers to cause angular movement of said shaft in one angular direction upon longitudinal movement of the shaft in the direction of its power stroke, cushioning means limiting further angular movement of said shaft in said one angular direction at the end of the power stroke as determined by engagement of said flange with said casing, and spring means urging said shaft angularly in the opposite direction whereupon said rollers and camming surfaces move said shaft longitudinally for its return stroke upon de-energization of said coil.

2. A rotary solenoid comprising a casing, a magnet coil having a core fixed within said casing, a shaft extending through said core and being both longitudinally and angularly movable relative thereto, stop means fixed to said shaft to engage said casing to positively limit longitudinal movement of said shaft in both the direction of its power stroke and the direction of its return stroke, a plurality of rollers pivotally mounted at one end of said casing on fixed axes disposed radially relative to said shaft, an actuating plate fixed to said shaft, a plurality of portions of said actuating plate in the form of tongues struck from the plane thereof sloping therefrom to form camming surfaces positioned to engage said rollers, said camming surfaces cooperating with said rollers to cause angular movement of said shaft in one angular direction upon longitudinal movement of the shaft in the direction of its power stroke, cushioning means limiting further angular movement of said shaft in said one angular direction at the end of the power stroke thereof, and spring means urging said shaft angularly in the opposite direction whereupon said rollers and camming surfaces move said shaft longitudinally for its return stroke upon de-energization of said coil.

3. A rotary solenoid comprising a casing, a magnet coil having a core fixed within said casing, a shaft extending through said core and being both longitudinally and angularly movable relative thereto, an armature fixed to said shaft, a flange on said armature positioned to engage said casing to positively limit longitudinal movement of said shaft in the power stroke direction of movement thereof, stop means fixed to said shaft and positioned to engage said casing to positively limit longitudinal movement of said shaft in the return stroke direction of movement thereof, a plurality of rollers pivotally mounted at one end of said casing on fixed axes disposed radially relative to said shaft, a flat actuating plate fixed to said shaft, there being a plurality of portions of said actuating plate in the form of tongues struck from the plane thereof sloping therefrom to form camming surfaces positioned to engage said rollers, said camming surfaces cooperating with said rollers to cause angular movement of said shaft in one angular direction upon longitudinal movement of said shaft in the direction of its power stroke, said camming surfaces merging smoothly and uninterruptedly and without abrupt change in direction with the flat surface of said plate whereby upon ex-

cessive angular movement of said shaft in said one direction said rollers may roll onto said flat surface of said plate, cushioning means limiting angular movement of said shaft in said one angular direction, and spring means urging said shaft angularly in the opposite direction whereby upon de-energization of said coil said rollers and said camming surfaces cooperate to move said shaft longitudinally in the direction of its return stroke.

4. A rotary solenoid comprising a casing, a magnet coil having a core fixed within said casing, a shaft extending through said core and being longitudinally and angularly movable relative to said core and casing, said shaft being movable longitudinally in the power stroke direction of movement thereof by energization of said coil, first stop means fixed to said shaft and positioned to engage said casing to limit longitudinal movement of said shaft in said power stroke direction, second stop means fixed to said shaft and positoned to engage said casing to limit longitudinal movement of said shaft in the return stroke direction of movement, a plurality of rollers pivotally mounted on said casing on fixed axes extending

radially relative to said shaft, a flat actuating plate fixed to said shaft, portions of said actuating plate providing camming surfaces in the form of tongues sloping circumferentially and toward said rollers from the plane of said plate, resilient means urging said shaft in one angular direction to cause the slope of said tongues and said rollers to move said shaft longitudinally in said return stroke direction to the limit provided by said second stop means, movement of said shaft longitudinally in said power stroke direction by energization of said coil causing said camming surfaces and rollers to move said shaft in the opposite angular direction, and cushioning means to stop the angular movement of said shaft in said opposite angular direction after said first stop means stops the longitudinal movement of said shaft in said power stroke direction.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,873,412

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Haraden Pratt

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the drawings, containing Figures 1, 2, and 3, line 3, for "Filed Sept. 7, 1957" read -- Filed Sept. 7, 1956 --.

Signed and sealed this 16th day of June 1959.

(SEAL)
Attest:
KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE

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