

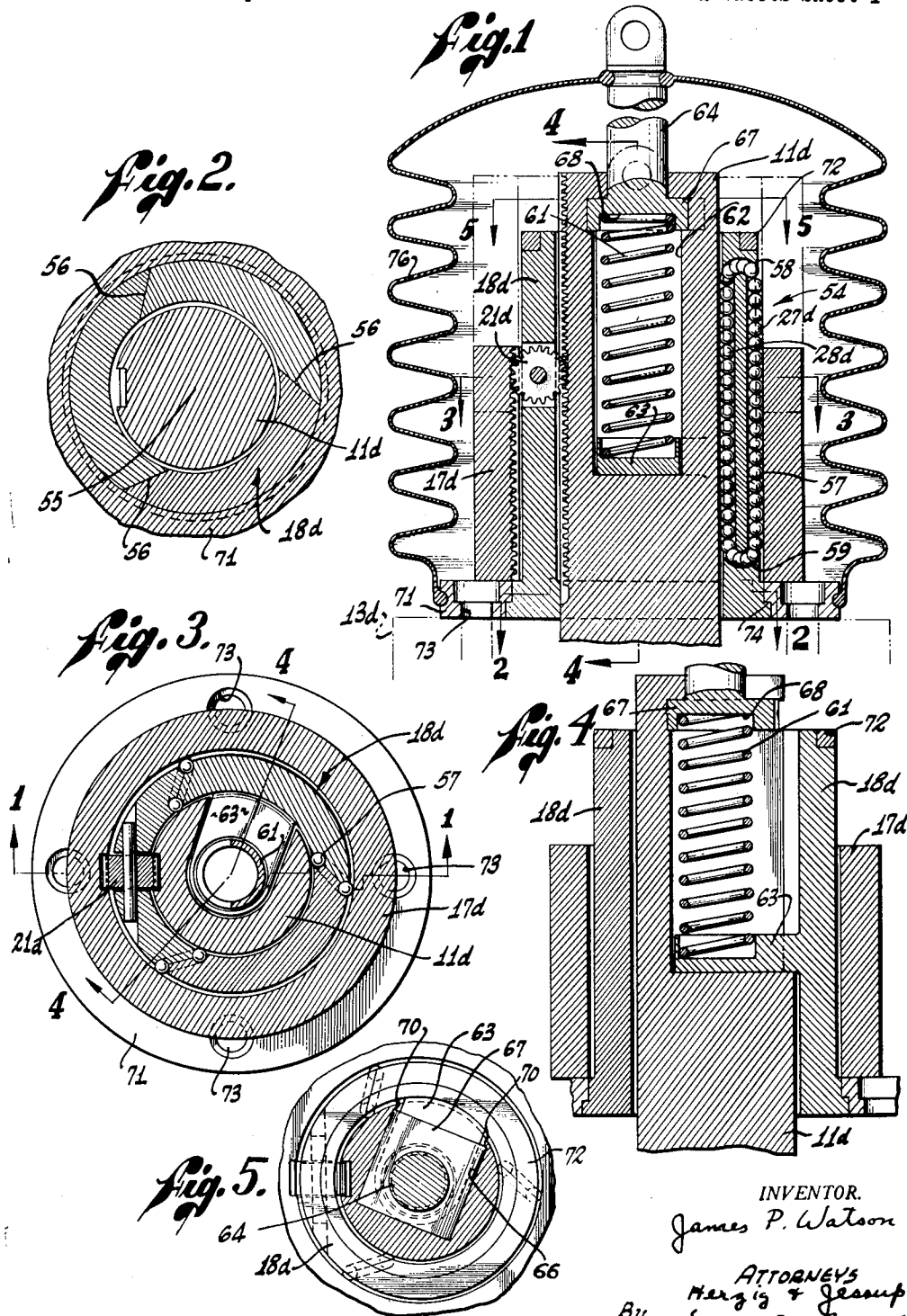
Dec. 26, 1961

J. P. WATSON
COMPOUND BEARING

3,014,382

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2 Sheets-Sheet 1



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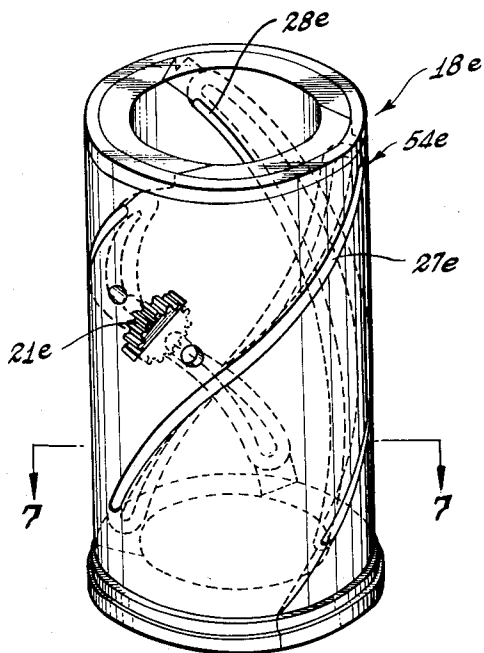


Fig. 6.

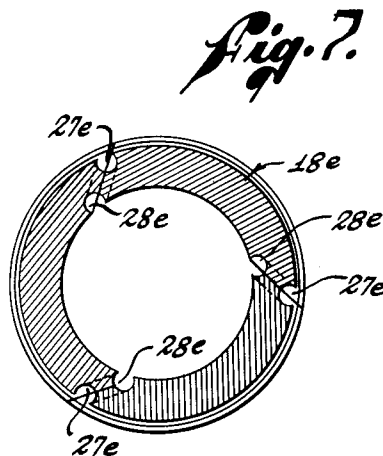


Fig. 7.

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3,014,382

COMPOUND BEARING

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Original application Sept. 30, 1955, Ser. No. 537,711, now Patent No. 2,884,573, dated Apr. 23, 1959. Divided and this application Feb. 2, 1959, Ser. No. 790,649
6 Claims. (Cl. 74-590)

This invention relates to acceleration proof actuating members, and more particularly to improved counterbalance or counterweight means for the armature of an electromagnet, such as the plunger of a solenoid.

It is an object of this invention to provide a counterbalance or counterweight means for a reciprocably mounted member which does not appreciably increase the overall volume or bulk of the completed apparatus.

It is another object of this invention to provide counterweight means for a reciprocably mounted member having such configuration that stresses and strains in the linkage between the member and its counterweight are readily absorbed in the counterweight itself, which by its very nature may be made heavy and strong, thus allowing the associated parts of the apparatus to be only slightly larger than would otherwise be required.

It is another object of this invention to provide counterweight means for a reciprocable member in which the linkage mechanism between the member and its counterweight is small in both bulk and weight, whereby the principal weight increase of the apparatus is in the counterweight itself, where it can be employed to full advantage.

It is a further object of this invention to provide such a counterweight means as above, which is simple, rugged, and economical to manufacture, assemble, and maintain.

It is a further object of this invention to provide counterweight means for a solenoid plunger which may be readily adapted and applied to existing solenoids and plungers.

It is a further object of this invention to provide counterweight means for a solenoid-operated plunger which can be applied with only a very slight increase in the overall length of the apparatus, and with no increase in diameter; or alternatively with slight increase in diameter and no increase in length.

It is another object of this invention to provide counterweight means for a solenoid-operated plunger which can be applied to a single solenoid and plunger.

It is a further object to provide an improved bearing arrangement between plunger, standard, and counterweight of the type mentioned above.

It is a still further object to provide, in an arrangement of the above type, means for producing rotation of the plunger with each stroke thereof.

It is another object to provide either linear counterbalancing along the longitudinal axis of a plunger, or rotational counterbalancing about such an axis.

In accordance with these and other objects which will become apparent hereinafter, preferred forms of the present invention will now be described with reference to the accompanying drawings, wherein:

FIG. 1 is a longitudinal section illustrating an embodiment of the present invention;

FIG. 2 is a cross-section taken on line 2-2 in FIG. 1;

FIG. 3 is a cross-section taken on line 3-3 in FIG. 1;

FIG. 4 is a longitudinal section taken on line 4-4 in FIGS. 1 and 3;

FIG. 5 is a cross-section taken on line 5-5 in FIG. 1;

FIG. 6 is a perspective view illustrating another form of the present invention, being in particular an alternative way of constructing a certain portion of the embodiment shown in FIG. 1; and

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FIG. 7 is a cross-section taken on line 7-7 in FIG. 6.

Referring to the drawings, the counterweight means of the present invention is shown as applied to a reciprocably mounted member in the form of a plunger 11d actuated by an electromagnet solenoid (not shown) disposed coaxially circumjacent the plunger 11d and contained within a case or housing 13d. At least one end of the plunger 11d projects upwardly through a central opening in the top wall of the housing 13d, and the upper end of the plunger has a rod 64 for receiving any suitable member to be actuated by movement of the plunger 11d. The plunger 11d is mounted for reciprocation in conventional fashion within the solenoid coil. In the typical case, suitable means such as spring 61 are provided for biasing the plunger 11d upward, and the plunger is drawn downward against the bias by electromagnetism whenever the coil is energized.

Proper operation of the solenoid requires that the plunger 11d be moved only when the coil is energized. Under conditions of severe acceleration occurring longitudinally of the plunger, as, for example, under shock or other high acceleration forces, sufficient force on the plunger 11d might be imparted to cause undesired actuation of the part connected to the plunger 11d in either direction, or to block normal operation in either direction.

In order to overcome and guard against such undesired actuation of the plunger 11d, counterweight means are provided in the form of a counterweight disposed substantially symmetrically coaxially of the reciprocation path of the plunger 11d. The counterweight is also mounted for reciprocation along said path. In the form of the invention illustrated in FIGURES 1-5, the counterweight is shown as being of tubular configuration in the form of a tube or cylinder 17d.

The counterweight 17d is linked to the plunger 11d through the intermediacy of a standard formed by a sleeve 18d projecting upwardly from the top of the housing 13d coaxially of the plunger 11d and disposed intermediate the plunger 11d and the counterweight 17d. Journaled in the sleeve 18d on a substantially tangential shaft is a small gear or pinion 21d, which meshes with rack teeth formed on the adjacent interior surface of the counterweight 17d and with rack teeth formed on the adjacent surface of the plunger 11d. Such engagement between pinion 21d, and plunger 11d and counterweight 17d, respectively, serves to transmit motion of the plunger 11d to the counterweight 17d in opposite directions. Thus, when the plunger 11d is drawn downward, the counterweight 17d is caused to move upward, and vice versa. By making the weight of plunger 11d equal to that of counterweight 17d, a balanced assembly is effected, which is unaffected by acceleration forces that might otherwise cause undesired, or block normal, reciprocation of the plunger 11d.

When used in connection with a solenoid, the plunger 11d must, of course, be made of magnetic material. It is preferred to make the counterweight 17d of non-magnetic material in order to avoid deleterious magnetic action between the coil and counterweight 17d.

In order to keep the rack teeth in firm engagement with the teeth of the pinion 21d, and to form a bearing surface between the standard and plunger and standard and counterweight, respectively, elongate ball races 54 are provided. As shown in FIG. 1, the cylindrical standard 18d is disposed circumjacent the plunger 11d and within the counterweight 17d. The standard 18d is made in three parts, as shown in FIG. 2, which have adjacent surfaces 56 disposed obliquely with respect to radii emanating from the center line, or axis 55, of the device. The adjacent surfaces 56 are suitably recessed or grooved, to form therebetween elongate, endless ball-races 54

filled with suitable roller members in this present instance balls 57.

Each race 54 is comprised of an inside track 28d located between the plunger 11d and the standard 18d; an outside track 27d located between the counterweight 17d and the standard 18d; an upper crossover track 58 joining the tracks 27d and 28d at their upper reaches; and a bottom crossover track 59 joining the tracks 27d and 28d at their bottom reaches.

The oblique disposition of the parting lines or surfaces 56 has the double advantage of giving a greater length for the balls 57 to make the 180° turn at 58 and 59, and of displacing the parting line from the radial pressure line which runs through the tracks 27d and 28d. Locating the ball races 54 at the parting lines or surfaces 56 permits ready machining of the races into the two adjacent surfaces, as shown in FIG. 3, and also simplifies loading of the balls into the races prior to assembly of the three parts forming the standard 18d. The necessity for a loading portion with consequent plugging up of the port is thus obviated.

As will be readily appreciated in FIG. 1, as the plunger 11d moves down within the standard 18d, the balls 57 in the inside track 28d will be rolled downward into the lower crossover 59 and thence upward into the outer track 27d. At the same time, the pressure of the counterweight 17d on the balls 57 in the outer track 27d, causes the outer balls to be rolled upward. Thus the flow of balls in the two tracks agrees with the respective movements of the plunger and counterweight, and except for the balls in the crossover tracks 58 and 59, all balls are constantly in use. Thus, there is no idle return race in which the balls must be returned unused, or dead-heading, as it were.

The tracks 27d and 28d of the race 54 are partially formed by providing a shallow, but well defined longitudinal groove in plunger 11d and counterweight 17d, respectively. This furnishes a rolling keying action preventing rotational displacement of both the plunger and counterweight with respect to the standard 18d.

A further feature of the embodiment shown in FIG. 1-5 is the positioning of the return spring for the plunger 11d, outside of the useful coil field.

As a rule, solenoid return springs are placed in complementary facing recesses, one recess being formed in the complementary face of a stop or anvil, which is stationarily mounted within the solenoid coil and fixed with respect to the housing. Such recessing of the complementary faces between the plunger and anvil, in order to accommodate the return spring, of necessity decreases the magnetic seal-in surface between the two when the plunger is fully pulled in by the solenoid. Thus the magnetic pull tending to hold the solenoid in closed position is considerably decreased. Furthermore, the formation of the recesses within the active part of the magnetic field of the coil decreases the amount of iron in the plunger 11d, with consequent decrease in the pull-in force.

In the embodiment shown in FIG. 1, the return spring 61 is placed in an elongate slot 62 formed in the side of the plunger 11d. The bottom of the spring 61 rests on a shelf 63 projecting into the slot 62 and formed integral with the standard 18d. The slot 62 is also employed as a convenient means for retaining an operating rod 64 secured to the outer end of the plunger 11d. To this and the upper end of the slot 62 is enlarged, as shown at 66 (FIG. 5), to slidably receive a head 67 formed on the bottom end of the operating rod 64 and staked to the plunger 11d at the two corners 70. The undersurface of the head 67 is recessed at 68 to receive the upper end of the spring 61, as shown in FIG. 1. The slot 62 is continued through to the upper end of the plunger 11d, being at this point ensmallled properly to receive the rod 64.

The assembly thus described and illustrated in FIGS. 1-5 is assembled and held together by means of a bottom

retaining ring 71, into which the three sections of the standard 18d are press-fitted from below, and an upper retaining ring 72 press-fitted around the upper edge of the standard 18d, into a groove formed therearound, as shown in FIG. 1.

The assembly is secured as a unit to the solenoid housing 13d by means of four bolts residing in bolt holes 73, and screwed into the top of the housing 13d. A shoulder 74 serves to longitudinally position the standard 18d within the bottom ring 71.

A loose fitting, pliant dust cover 76 is secured in place over the entire assembly, so as to keep dust and other contaminants out of the working parts; it preferably also covers the bolt holes 73 to completely seal the unit. The actuating rod 64 projects through the cover 76 so as to be connected to any suitable part to be actuated. The cover 76 is of sufficient size and pliancy so that when the plunger 11d retracts, pulling the cover downward, the sides of the cover may bulge outward to accommodate the air inside the cover, which would otherwise build up an obstructing pressure.

The embodiment shown in FIGS. 1-5 may be completely assembled apart from the solenoid proper and may, as a unit, replace a standard plunger. This is accomplished merely by removing the standard plunger from the solenoid and bolting the assembly shown in FIG. 1 to the top of the housing 13d, the plunger 11d of the assembly serving to replace the standard plunger.

In view of the fact that the standard 18d is made in three parts, the apparatus shown in FIG. 1 may be readily assembled without requiring an extension of the rack groove. As will be readily seen in FIG. 3, the ball races 54 are so positioned that one is diametrically opposite the pinion 21d, thereby serving to absorb the force exerted diametrically by the pinion 21d.

When the assembly shown in FIG. 1 is separated from the solenoid proper, the presence of the spring 61 serves as a stop, limiting downward movement of the plunger 11d, so that the pinion 21d is at all times kept in engagement with the rack-teeth on the plunger and counterweight.

In FIGS. 6 and 7, there is illustrated another form of the present invention which is essentially a modification of the form shown in FIGS. 1-5.

In this embodiment the standard 18d of FIG. 1 has been replaced by a standard 18e in which the ball-races 54e, instead of being essentially straight and parallel to the axis of the standard 18e, are skewed in helical fashion in the manner of a thread. Since the balls partially mate in corresponding helical grooves in the plunger and counterweight, respectively, it follows that each stroke of the plunger causes it to rotate as well as to move longitudinally. In similar fashion, the counterweight is also caused to rotate, and since the counterweight is moving longitudinally in a direction opposite to that of the plunger, its rotation is likewise opposite and equal to that of the plunger.

Thus, the counterweight tends to counterbalance or offset the rotational inertia of the plunger as well as the linear inertia. Such counterbalancing is not complete, since the counterweight has a greater moment of inertia and therefore its rotational inertia is greater than that of the plunger. Thus, while the magnitudes of the rotational counterbalancing are different, they are in opposite directions, and there is some tendency for counterbalancing rotationally. Complete rotational counterbalancing may be achieved by making the rotational inertia of plunger and counterweight equal, in which case linear counterbalancing would be incomplete.

The structure shown in FIG. 6 has particular applicability in those instances where it is desired to cause the operated part to rotate as well as to reciprocate longitudinally. Such might be the case, for example, with a piston which reciprocates in a cylinder. By inserting an overrunning or one-way clutch between the plunger and

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the piston rod, the rod can be caused to rotate in one direction with each stroke, and thus eliminate a tendency for grooves to be worn into the piston and cylinder.

In the embodiment shown in FIGS. 6-7, the pinion 21e linking the plunger and counterweight is canted at an angle corresponding to the pitch angle of the rack teeth in plunger and counterweight, which teeth are set at an angle corresponding to the helix angle of the races 54e.

It will be understood that in the embodiment of FIGS. 6-7, the bias spring cannot be conveniently arranged in the manner shown at 61 in FIG. 1, because the helical shape of the races 54e prevents employment of the shelf 63. Hence in this embodiment the return spring would be of the more conventional type described hereinbefore.

This is a division of application Serial No. 537,711 filed September 30, 1955, now Patent No. 2,884,573, issued April 28, 1959, applicant James P. Watson, for Acceleration Proof Acting Member.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiments, it is recognized that departures may be made therefrom within the scope of the invention, which is therefore not to be limited to the details disclosed herein, but is to be accorded the full scope of the claims.

What is claimed is:

1. Bearing means comprising a first member, a second member movable relative to said first member, a third member movable relative to said first and second members, an endless bearing race disposed between said first and second members and between said first and third members and presenting spaced surfaces between said first and second members and between said first and third members; and roller members in said race in free-rolling relationship with said surfaces and forming bearing means between said first and second members and between said first and third members.

2. Bearing means comprising a first member, a second member movable relative to said first member, a third member movable relative to said first and second members, an endless bearing race disposed between said first and second members and between said first and third members and presenting spaced surfaces between said first and second members and between said first and third members, roller members in said race in free-rolling relationship with said surfaces and forming bearing means between said first and second members and between said first and third members; and means for coupling together said second and third members.

3. Bearing means comprising a first member, a second member movable relative to said first member, a third member movable relative to said first and second members, an endless bearing race disposed between said first

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and second members and between said first and third members and presenting spaced surfaces between said first and second members and between said first and third members, roller members in said race in free-rolling relationship with said surfaces and forming bearing means between said first and second members and between said first and third members, said second and third members being disposed to move parallel to said bearing race.

4. Bearing means comprising a first member, a second member movable relative to said first member, a third member movable relative to said first and second members, an endless bearing race disposed between said first and second members and between said first and third members and presenting spaced surfaces between said first and second members and between said first and third members, roller members in said race in free-rolling relationship with said surfaces and forming bearing means between said first and second members and between said first and third members, said first member being interposed between said second and third members.

5. Bearing means comprising a tubular standard, a plunger reciprocable within said standard, a counterweight circumjacent said standard and reciprocable with respect thereto, an endless bearing race disposed between said standard and plunger, and between said standard and counterweight, and roller members in said race forming bearing means between said standard and plunger and between said standard and counterweight.

6. Bearing means comprising a tubular standard, a plunger reciprocable within said standard, a counterweight circumjacent said standard and reciprocable with respect thereto, an endless bearing race disposed between said standard and plunger and between said standard and counterweight, roller members in said race forming bearing means between said standard and plunger and between said standard and counterweight, and said bearing race being disposed on a generally helical path both internally and externally of said standard.

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