

April 28, 1959

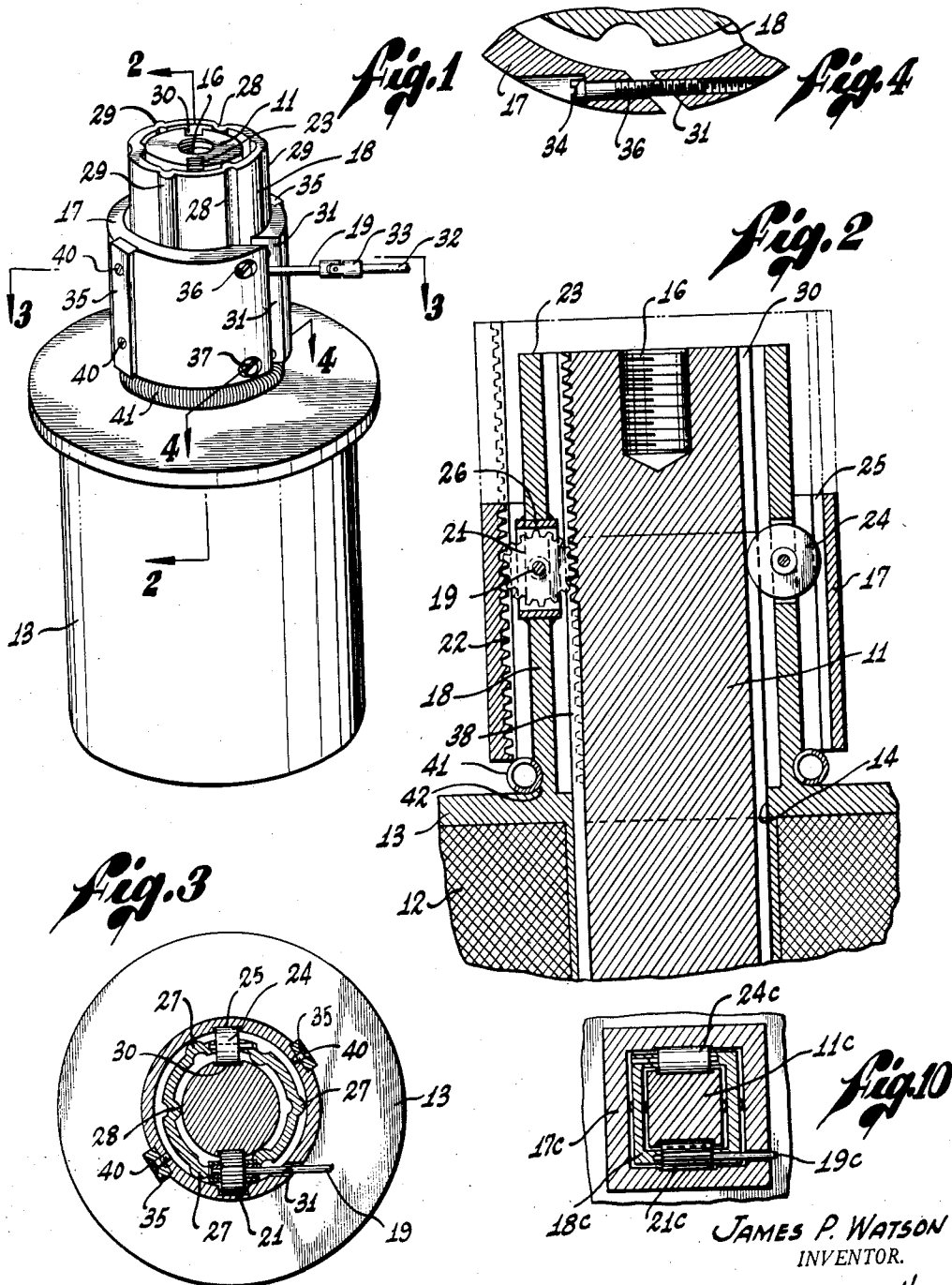
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2,884,573

ACCELERATION PROOF ACTUATING MEMBER

Filed Sept. 30, 1955

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

*Fig. 5*

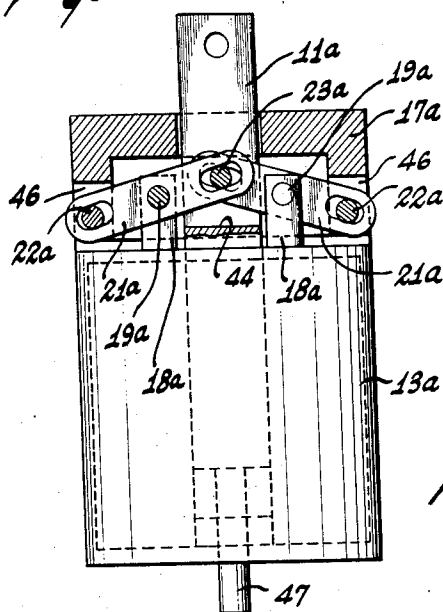


*Fig. 6*

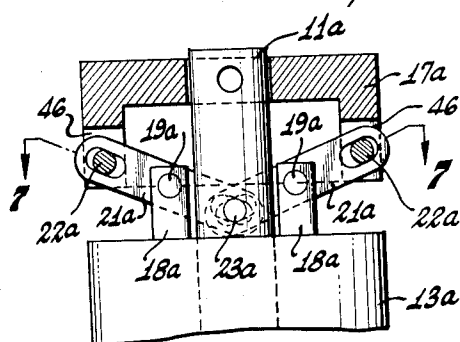


*Fig. 7*

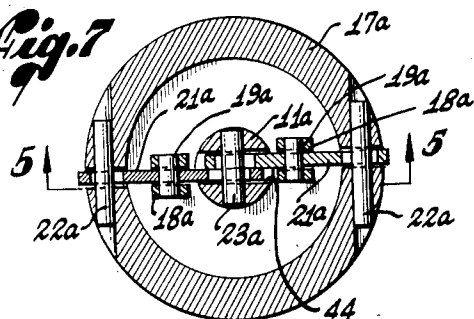


*Fig. 9*

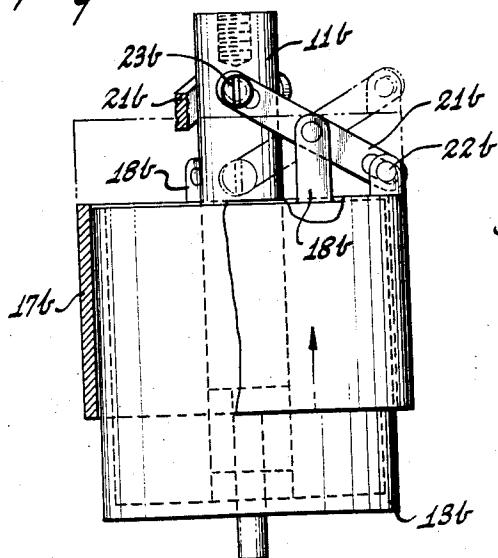
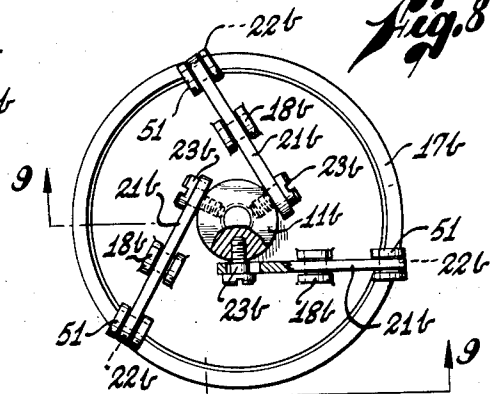


*Fig. 8*



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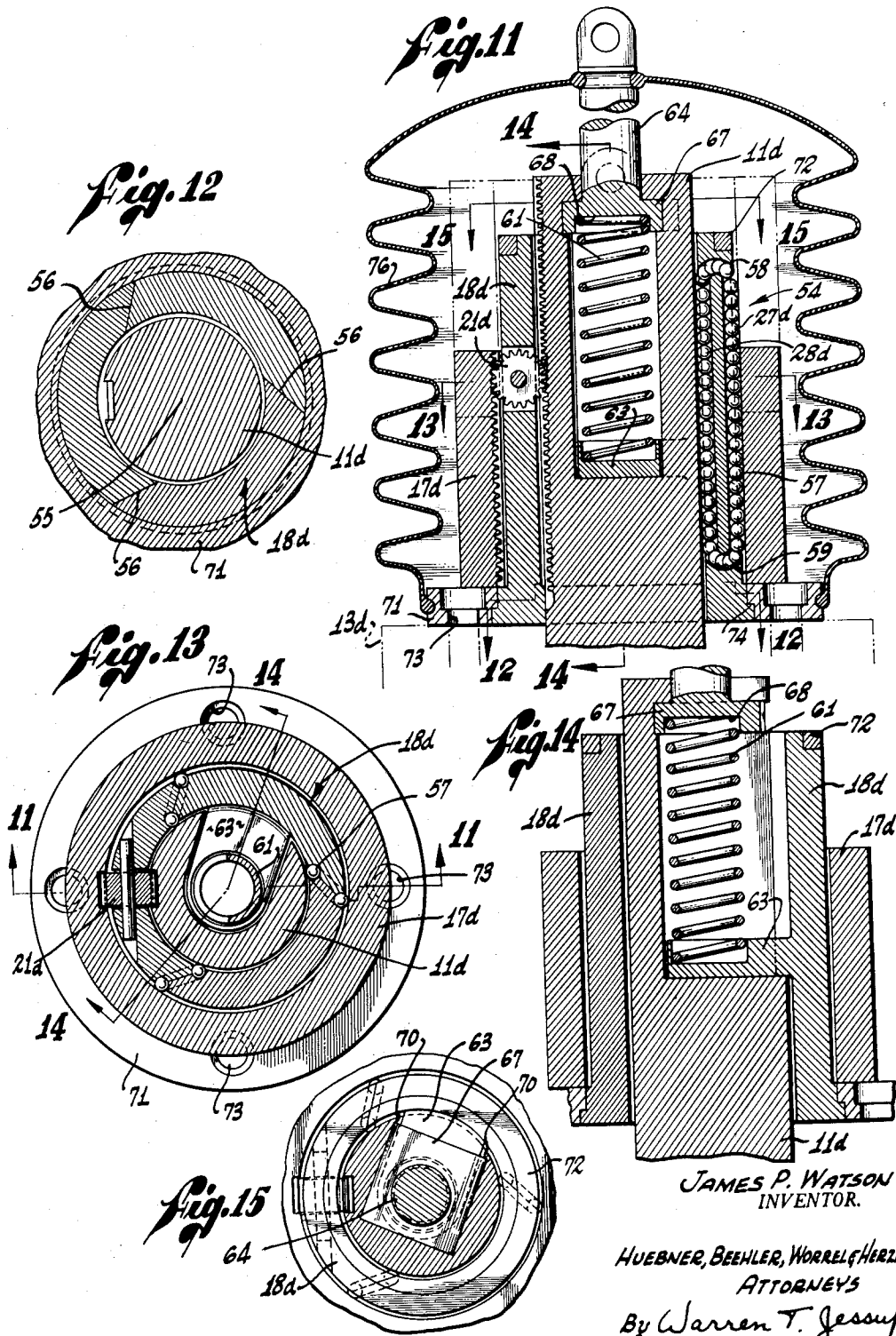
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ACCELERATION PROOF ACTUATING MEMBER

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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

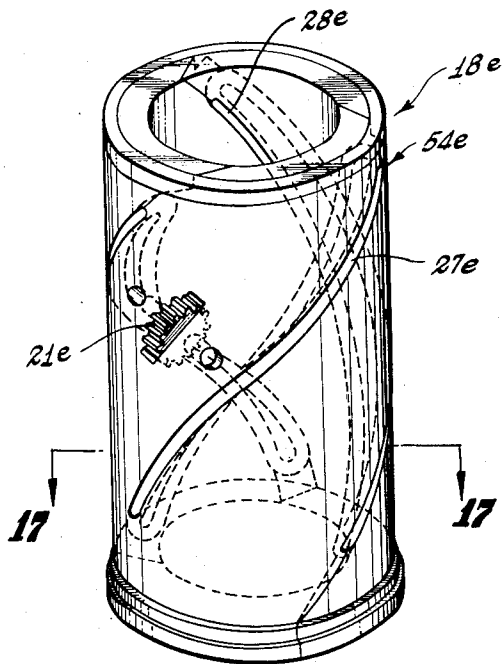


*Fig. 16*

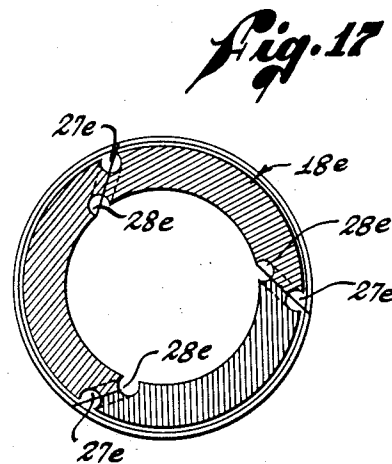


*Fig. 17*

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## ACCELERATION PROOF ACTUATING MEMBER

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Application September 30, 1955, Serial No. 537,711

9 Claims. (Cl. 317—195)

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 counterbalance or counterweight means for a reciprocally 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 reciprocally 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 reciprocally mounted 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 perspective view showing one form of the present invention;

Fig. 2 is a fragmentary longitudinal section taken on line 2—2 of Fig. 1;

Fig. 3 is a cross section taken on line 3—3 of Fig. 1;

Fig. 4 is a fragmentary section taken on line 4—4 of Fig. 1;

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Fig. 5 is an elevation partly in section showing a second form of the present invention;

Fig. 6 is a view similar to Fig. 5 illustrating the parts in another attitude of operation;

Fig. 7 is a cross section taken on line 7—7 of Fig. 6;

Fig. 8 is a top plan view of a third form of the present invention;

Fig. 9 is an elevation partly in section taken on line 9—9 of Fig. 8;

Fig. 10 is a cross section of another embodiment of the present invention illustrating an alternative which may be incorporated into any of the various forms of the invention.

Fig. 11 is a longitudinal section generally similar to Fig. 2 and illustrating another embodiment of the present invention;

Fig. 12 is a cross section taken on line 12—12 in Fig. 11;

Fig. 13 is a cross section taken on line 13—13 in Fig. 11;

Fig. 14 is a longitudinal section taken on line 14—14 in Fig. 11;

Fig. 15 is a cross section taken on line 15—15 in Fig. 11;

Fig. 16 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. 11; and

Fig. 17 is a cross section taken on line 17—17 in Fig. 16.

Referring to the drawings, the counterweight means of the present invention is shown as applied to a reciprocally mounted member in the form of a plunger 11 actuated by an electromagnet solenoid 12 disposed coaxially circumjacent the plunger 11 and contained within a case or housing 13. At least one end of the plunger 11 projects upwardly through a central opening 14 in the top wall of the housing 13, and the upper end of the plunger has a tapped axial bore 16 for receiving any suitable rod or member to be actuated by movement of the plunger 11. The plunger 11 is mounted for reciprocation in conventional fashion within the solenoid coil 12. In the typical case, suitable means are provided for biasing the plunger 11 upward, and the plunger is drawn downward against the bias by electromagnetism whenever the coil 12 is energized.

Proper operation of the solenoid requires that the plunger 11 be moved only when the coil 12 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 11 might be imparted to cause undesired actuation of the part connected to the plunger 11 in either direction, or to block normal operation in either direction.

In order to overcome and guard against such undesired actuation of the plunger 11, counterweight means are provided in the form of a counterweight disposed substantially symmetrically coaxially of the reciprocation path of the plunger 11. The counterweight is also mounted for reciprocation along said path. In the form of the invention illustrated in Figures 1—4, the counterweight is shown as being of tubular configuration in the form of a tube or cylinder 17.

The counterweight 17 is linked to the plunger 11 through the intermediacy of a standard formed by a sleeve 18 projecting upwardly from the top of the housing 13 coaxially of the plunger 11 and disposed intermediate the plunger 11 and the counterweight 17. Journaled in the sleeve 18 on a substantially tangential shaft 19 is a small gear or pinion 21, which meshes with rack teeth 22 formed on the adjacent interior surface of the coun-

terweight 17 and with rack teeth 23 formed on the adjacent surface of the plunger 11. Such engagement between pinion 21, and plunger 11 and counterweight 17, respectively, serves to transmit motion of the plunger 11 to the counterweight 17 in opposite directions. Thus, when the plunger 11 is drawn downward, the counterweight 17 is caused to move upward, and vice versa. By making the weight of plunger 11 equal to that of counterweight 17, a balanced assembly is effected, which is unaffected by acceleration forces that might otherwise cause undesired, or block normal, reciprocation of the plunger 11.

If desired, the slot or opening in the sleeve 18 in which the pinion 21 is journaled may be strengthened by means of a short radial sleeve 26 secured around the slot.

If it is desired that the respective weights of the plunger 11 and the counterweight 17 should be different, it is only necessary to provide a multiplying linkage between the two, by coupling the teeth 23 to the teeth 22 through two pinions of unequal diameter secured to the shaft 19. This expedient may also be used when it is desired to counterbalance, not only the plunger, but also the part actuated thereby, provided such part moves parallel to the plunger.

In order to keep the rack teeth 22 and 23 in firm engagement with the teeth of the pinion 21, a roller 24 is journaled in the sleeve 18 substantially diametrically of the pinion 21 and bears against the plunger 11 and counterweight 17. Tracks are provided for the roller 24 by means of shallow grooves 25 and 30 formed in the respective faces of the plunger 11 and counterweight 17, as shown in Figure 3. If desired, the roller 24 may be provided with teeth, i.e. be a pinion gear, similar to 21, engaging corresponding rack teeth in the plunger and counterweight, respectively. Such a second pinion would result in better load distribution and would also preclude false operation due to angular acceleration about the axis of shaft 19. This, however, would require precise identity between the members 24 and 21 and their respective rack teeth, which would necessitate a very accurate and precise machining operation, or an adjustable mounting of at least one set of teeth. Otherwise, there would be danger of binding, with consequent undesirable addition of impedance to the ready reciprocation of the plunger 11 and counterweight 17.

The key or spline normally required between plunger 11 and solenoid 12 is obviated, since pinion 21 and roller 24 serve to prevent turning of the plunger 11, and also of the counterweight 17.

Guide means for smooth reciprocation of the plunger 11 and counterweight 17 with respect to the standard or sleeve 18 are provided by embossing the sleeve 18 outwardly, as shown at 27, to provide longitudinal rails on which the counterweight 17 may slide; and embossing the sleeve inwardly, as shown at 28, to provide rails on which the plunger 11 may slide. This serves to keep both the plunger 11 and the counterweight 17 centered with respect to the sleeve 18 with consequent minimization of danger of binding. Lateral accelerations on the apparatus are transmitted directly from the counterweight 17 to the sleeve 18 and from the plunger 11 to the sleeve 18. The sleeve 18 thus serves to isolate the counterweight 17 and the plunger 11 from each other with respect to such lateral accelerations, which might otherwise cause binding. Since the sleeve 18 is fixed with respect to the housing 13, it is in the best position to take such lateral accelerations.

As stated, the plunger 11 is adapted to provide a longitudinal reciprocating output through its tapped bore 16. Provision of the linking pinion 21, however, provides a ready means for also taking off rotary output from the reciprocating movement of the plunger 11. This is done simply by extending the shaft 19 tangentially outward through a longitudinal slot 31 formed in the counterweight 17. The shaft 19 may be coupled to any suitable output shaft 32, having its own bearings, through a suitable universal joint 33.

When used in connection with a solenoid 12, as shown, the plunger 11 must, of course, be made of magnetic material. It is preferred to make the counterweight 17 of non-magnetic material in order to avoid deleterious magnetic action between the coil 12 and counterweight 17. While it is possible to make the counterweight 17 of a material which is non-conductive as well as non-magnetic, it is often preferable from weight and bulk considerations to make the counterweight 17 of a metallic substance which inherently has some conductivity. In this instance, it is preferred to provide a longitudinal air gap in order to eliminate circulating currents which would otherwise introduce an undesired transformer action with consequent effect on the performance of the apparatus. For this purpose, it is preferred to employ the slot 31 as a portion of the break in the electric circuit and to continue the slot upward, thus producing a continuous longitudinal gap in the counterweight 17. The sleeve 18 may also be slit for the same purpose, i.e., to prevent induced circulating currents.

The resilience of the counterweight 17 is employed for the purpose of achieving a precise fit between the rack teeth 22 and 23 and the pinion 21. This is done by making the normal or unstressed size of the counterweight 17 slightly larger than the final desired dimension. A pair of adjusting screws 36 and 37 are threaded tangentially into the counterweight 17, the screw 36 passing through the slot 31 above shaft 19, and the screw 37 passing through the slot 31 below the shaft. As shown in Figure 4, the head 34 of each screw bears against the counterweight 17 at one side of slot 31, and the screw is threaded into the opposite side. Screwing in of the screw draws the two sides together against the natural resilience of the cylinder. By proper screwing in of the screws 36 and 37, the internal diameter of the counterweight 17 may be ensmallled just the proper amount to provide a precise fit between the teeth 22—23 and the pinion 21.

As noted above, the weight 17 may also be employed to counterbalance the actuated part as well as the plunger 11. To this end the weight 17 is made adjustable by providing elongate weights 35 secured in external longitudinal grooves by screws 40.

Assembly of the counterweight means shown in Figures 1-4 is accomplished in the following manner. It will be assumed that the case or housing 13 is open at the top only, i.e., through the sleeve 18. Grooves 25 and 30 extend the full length of their respective members, and a groove 38 forms a continuation of the rack 23 on the plunger. This permits the plunger 11 to be injected into the sleeve 18, and the counterweight 17 to be placed over the sleeve 18. The counterweight 17 is placed over the standard 18 engaging the pinion 21 and wheel 24, and is dropped down until it rests against the top of the housing 13. In this position, the pinion 21 engages the upper limits of the rack teeth 22. The screw 37 is then screwed in. The plunger 11 is placed into the solenoid 12 through the sleeve 18, and the rack teeth 23 are brought into engagement with the pinion 21. Further insertion of the plunger 11 rotates the pinion 21 and lifts the counterweight 17 away from the housing 13. The structure is so dimensioned that when the plunger 11 bottoms within the solenoid 12, the pinion 21 is in engagement with the upper limits of the rack teeth 23 and with the lower limits of the rack teeth 22.

After assembly, the screws 36 and 37 are adjusted to effect proper engagement between pinion 21 and racks 22—23.

Stop means are provided to prevent the counterweight 17 from going so far down, upon upward movement of the plunger 11, that the pinion disengages from the rack teeth 23 of the plunger 11. In the present instance, such means are shown in the form of a continuous helical spring or garter spring 41. The spring 41 is placed on the assembly after the counterweight 17 has been lifted slightly from the housing 13. The resilience of the spring 41

allows it to be extended outside of the counterweight 17 beyond the stub end of the shaft 19, and dropped down to encircle the bottom portion of the standard 18. The normal resilience of the spring then causes it to seat into an arcuate groove 42 formed around the bottom edge of the sleeve 18, as shown in Figure 2. In this position, the spring 41 serves as a stop to prevent disengagement of the teeth, as explained hereinbefore. The natural resilience or springiness of the spring 41 brings about a resilient stop action against the counterweight 17 which is more desirable than would be a rigid stop.

If desired, the ring 41 may be in the form of a pliant O-ring made of homogeneous material such as rubber or neoprene, but because of high temperature considerations, a metallic garter spring, as described above, is preferred.

Other forms of the present invention are illustrated in the following figures. In Figure 5, the plunger 11a is linked to the counterweight 17a by means of a pair of arms 21a pivoted intermediate their respective ends to a standard in the form of a pair of upstanding supports 18a secured to the solenoid case or housing 13a. The upper end of the plunger 11a is bifurcated by the formation of a slot 44 through which passes transversely a pin 23a that receives the slotted ends of the arms 21a. Slots 46 are formed diametrically in the counterweight 17a to receive the outer ends of the arms 21a, which are also slotted and secured to the counterweight by a pair of pins 22a. In this way, downward movement of the plunger 11 is linked with a corresponding upward movement of the counterweight 17a. The slotting of the arms 21a permits the necessary reciprocation while still accommodating arcuate movement of the ends of the arms 21a.

In the modification shown in Figures 5-7, the counterweight 17a and plunger 11a may be readily made of different weights simply by positioning the upright supports 18a at a point which is not midway between the pins 23a and 22a. Thus, if the supports 18a are closer to the center line of the plunger 11a than to the pins 22a, the counterweight 17a is made of less weight than the plunger 11a in order to achieve the necessary counterbalancing action.

The embodiment shown in Figures 5-7 illustrates that, if desired, the lower end of the plunger 11a may project from the solenoid housing 13a, as shown at 47.

Another embodiment of the present invention is shown in Figures 8 and 9, wherein the counterweight 17b is of somewhat larger diameter than the solenoid case 13b and encircles the upper end of the case. The counterweight 17b is linked to the plunger 11b of the solenoid by three arms 21b spaced equally around the top of the solenoid and pivoted in pairs of supports 18b projecting upward from the top of the case 13b. The inner ends of the links or arms 21b are pivoted to the plunger 11b by screws 23b and the outer ends of the arms 21b are pivoted to the counterweight 17b by pins 22b pivoted in upstanding pin supports 51 extending from the upper edge of the counterweight 17b. As seen in Figure 8, the supports 51 extend inwardly over the edge of the cylinder 17b and serve as stops limiting downward movement of 17b.

Like the embodiment shown in Figures 5-7, that of Figures 8 and 9 may also be readily proportioned so as to permit the counterweight 17b to be of lesser or greater weight than the plunger 11b, if desired, simply by suitable positioning of the supports 18b.

The present invention is equally adaptable to square plungers as to round (i.e. right circular cylinder) plungers 11. Such an embodiment is shown in Figure 10, wherein the plunger 11c is shown as being square. In this case, the sleeve 18c is likewise square in cross-section as is the tubular counterweight 17c.

The embodiment shown in Figure 10 is especially suitable for use with A.C. solenoids, the plungers of which are often square or rectangular in cross-section.

In Figs. 11-15, there is illustrated still another embodiment of the present invention, which follows in general the lines of the embodiment shown in Figs. 1-3, the prin-

cipal difference being that the bosses 28 and 27 forming a bearing surface between the standard and plunger and standard and counterweight, respectively, have been replaced by elongate ball races 54. As shown in Fig. 11 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. 12, 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, end-less 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. 13, 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 port with consequent plugging up of the port is thus obviated.

As will be readily appreciated in Fig. 11, 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. This keying action thus replaces the spline or key provided by the roller 24 in the embodiment shown in Fig. 2.

A further feature of the embodiment shown in Figs. 11-15 is the change in position of the return spring for the plunger 11d, from a position within the coil 12, to a position outside of the useful coil field. While not specifically shown in Fig. 2, it will be understood that interposed between the plunger 11 and the housing 13, or some other stationary part of the apparatus, is a return spring biasing the plunger 11 outwardly.

As a rule, such return spring is 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 12 and fixed with respect to the housing 13. 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 12 decreases the amount of iron in the

plunger 11, with consequent decrease in the pull-in force.

In the embodiment shown in Fig. 11, 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 end the upper end of the slot 62 is enlarged, as shown at 66, (Fig. 15) 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. 11. The slot 62 is continued through to the upper end of the plunger 11d, being at this point ensnared properly to receive the rod 64.

The assembly thus described and illustrated in Figs. 11-15 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. 11.

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 side 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. 11-15 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. 11 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. 11 may be readily assembled without requiring an extension of the rack groove such as was required at 38 in the embodiment of Fig. 2. The roller 24 being replaced by the ball races 54, the groove 34 of Fig. 2 is, of course, completely eliminated for the entire length of the plunger 11d. As will be readily seen in Fig. 13, 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, a function fulfilled by the roller 24 in the embodiment of Fig. 2.

When the assembly shown in Fig. 11 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. 16 and 17, there is illustrated another form of the present invention which is essentially a modification of the form shown in Figs. 11-15.

In this embodiment the standard 18d of Fig. 11 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. 16 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 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. 16-17, 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. 16-17 the bias spring cannot be conveniently arranged in the manner shown at 61 in Fig. 11, 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.

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. Counterweight means for a member mounted for reciprocation, comprising: a member mounted for reciprocation along a predetermined path, a counterweight disposed substantially symmetrically coaxially of said path and mounted for reciprocation along said path, a standard having a portion disposed between said member and said counterweight, and inflexible linking means pivotally mounted to said standard portion, and engaging said member and said counterweight, for transmitting motion of said member to said counterweight in opposite directions.

2. Counterweight means for a member mounted for reciprocation, comprising: a member mounted for reciprocation along a predetermined path, a tubular counterweight disposed substantially symmetrically coaxially of said path and mounted for reciprocation along said path, a standard having a portion disposed between said member and said counterweight, and inflexible linking means pivotally mounted to said standard portion, and engaging said member and said counterweight, for transmitting motion of said member to said counterweight in opposite directions.

3. Counterweight means for a member mounted for reciprocation, comprising: a member mounted for reciprocation along a predetermined path, a tubular counterweight open at both ends and disposed substantially symmetrically coaxially of said path and mounted for reciprocation along said path, a standard having a portion disposed between said member and said counterweight, and inflexible linking means pivotally mounted to said standard portion, and engaging said member and said counterweight, for transmitting motion of said member to said counterweight in opposite directions.

roca-tion along said path, said member being adapted to project through each end of said counterweight, a stand-ard having a portion disposed between said member and said counterweight, inflexible linking means pivotally mounted to said standard portion, and engaging said member and said counterweight, for transmitting motion of said member to said counterweight in opposite directions.

4. Counterweight means for a member mounted for reciprocation, comprising: a member mounted for reciprocation along a predetermined path; a counterweight disposed substantially symmetrically coaxially of said path and mounted for reciprocation along said path; a standard having a portion disposed between said member and said counterweight; and a linking pinion pivoted to said standard portion, said counterweight and said member being provided with rack teeth engaging said pinion for transmitting motion of said member to opposite motion of said counterweight.

5. Counterweight means for a member mounted for reciprocation, comprising: a member mounted for reciprocation along a predetermined path; a counterweight disposed substantially symmetrically coaxially of said path and mounted for reciprocation along said path; a standard having a portion disposed between said member and said counterweight; a linking pinion pivoted to said standard portion, said counterweight and said member being provided with rack teeth engaging said pinion, for transmitting motion of said member to opposite motion of said counterweight, and a wheel pivoted to another portion of said standard disposed between said member and said counterweight substantially diametrically of said pinion, and bearing against said member and said counterweight to keep said pinion and rack teeth in firm engagement.

6. Counterweight means for a member mounted for reciprocation, comprising: a member mounted for reciprocation along a predetermined path; a counterweight disposed substantially symmetrically coaxially of said path and mounted for reciprocation along said path; a standard having a portion disposed between said member and said counterweight; a linking pinion pivoted to said standard portion, and having a shaft extending therefrom adapted to provide a rotary output from movement of said member, said counterweight and said member being provided with rack teeth engaging said pinion for transmitting motion of said member to opposite motion of said counterweight, and a wheel pivoted to another portion of said standard disposed between said member and said counterweight substantially diametrically of said pinion, and bearing against said member and said counterweight to keep said pinion and rack teeth in firm engagement.

7. Counterweight means for a solenoid plunger means mounted for reciprocation, comprising: solenoid plunger means mounted for reciprocation along a predetermined path; solenoid means disposed coaxially of said plunger means in which said plunger means reciprocates; counterweight means disposed substantially symmetrically coaxially of said path and mounted for reciprocation along said path; a standard having a portion disposed between said plunger means and said counterweight means; and linking means pivotally mounted to said standard portion and engaging said plunger means and said counterweight means, for transmitting motion of said plunger means to opposite motion of said counterweight means.

8. Counterweight means for a member mounted for reciprocation, comprising: a member mounted for reciprocation along a predetermined path, a counterweight disposed substantially symmetrically coaxially of said path and mounted for reciprocation along said path, a standard having a portion disposed between said member and said counterweight, and rigid linking arm means pivoted at each end respectively, to said member and said counterweight and pivoted to said standard portion intermediate said ends for transmitting motion of said member to opposite motion of said counterweight.

9. Counterweight means for a plunger comprising a solenoid, a plunger reciprocable within said solenoid and extending therefrom, a standard extending from said solenoid circumjacent said plunger, a cylindrical counterweight circumjacent said standard and reciprocable coaxially of said plunger, said plunger and counterweight having opposed rack teeth, a pinion journaled on said standard and engaging said rack teeth to couple said counterweight and said plunger, and removable stop means spacing said counterweight from said solenoid and preventing disengagement of said pinion and rack teeth.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 2,884,573

April 28, 1959

James P. Watson

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 drawings, Sheet 1, Fig. 1, change "29", three occurrences, to -- 27 --; Fig. 2, change the reference line from numeral 23 to indicate the rack teeth on plunger 11; Fig. 4, change "36" to -- 37 --; Sheet 3, Fig. 11, add numeral -- 62 -- and reference line to indicate slot in plunger 11d for accommodating spring 61; Fig. 15, add numeral "66" to indicate cross slot in plunger 11d to accommodate part 67; in the printed specification, column 2, line 22, for "Fig. 11" read -- Figs. 11 and 13 --; column 3, line 29, for "25 and 30" read -- 30 and 25 --; line 30, for "faces" read -- surfaces --; column 5, line 12, for "ring" read -- spring --; column 7, line 54, for the numeral "34" read -- 30 --.

Signed and sealed this 3rd day of May 1960.

(SEAL)  
Attest:

KARL H. AXLINE  
Attesting Officer

ROBERT C. WATSON  
Commissioner of Patents

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