

Nov. 15, 1960

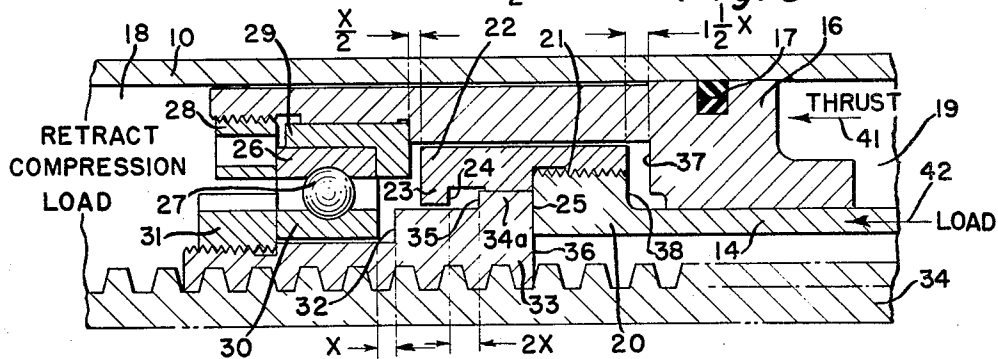
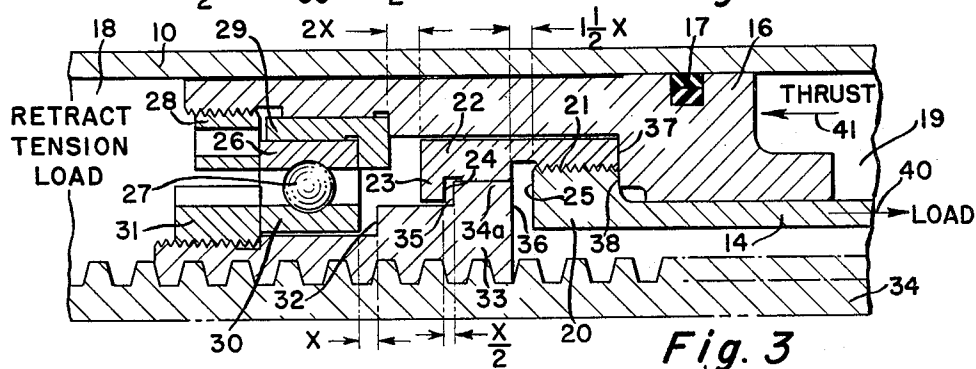
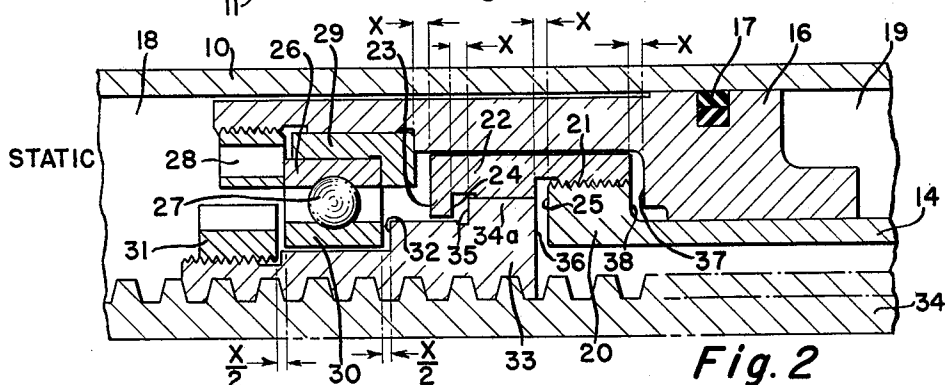
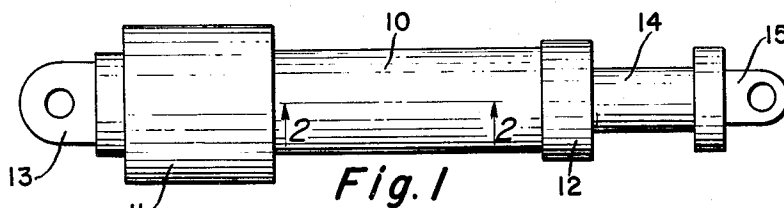
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2,960,069

SELF-LOCKING ACTUATOR

Filed Dec. 26, 1957

2 Sheets-Sheet 1



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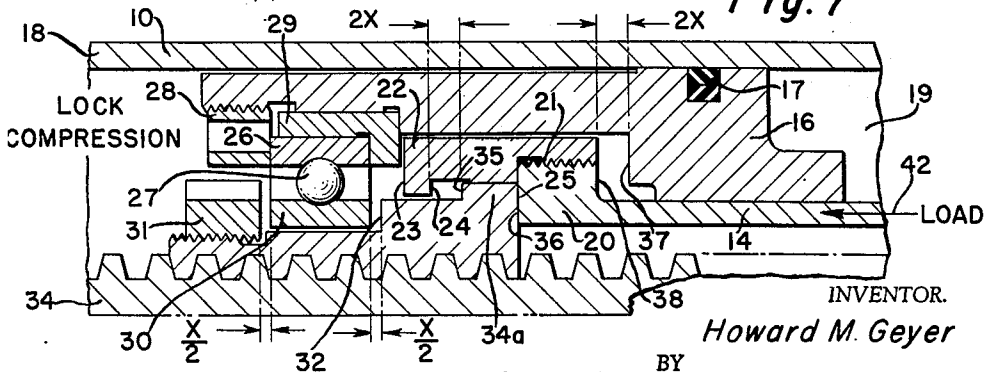
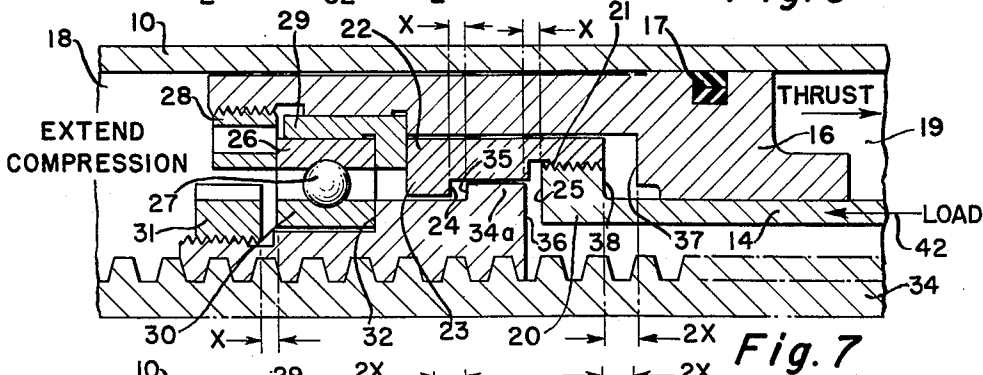
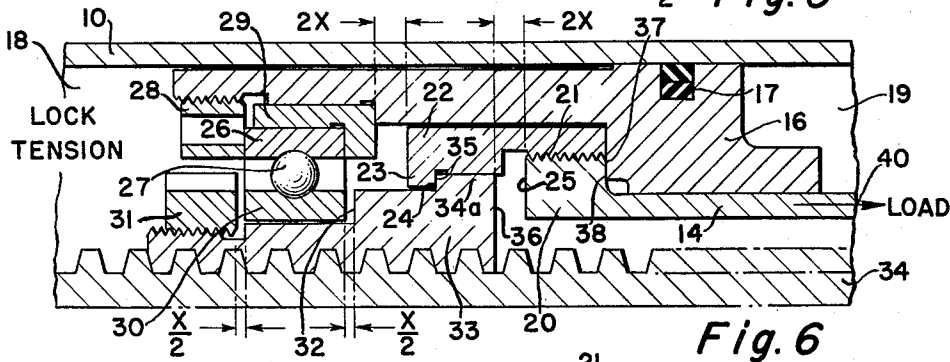
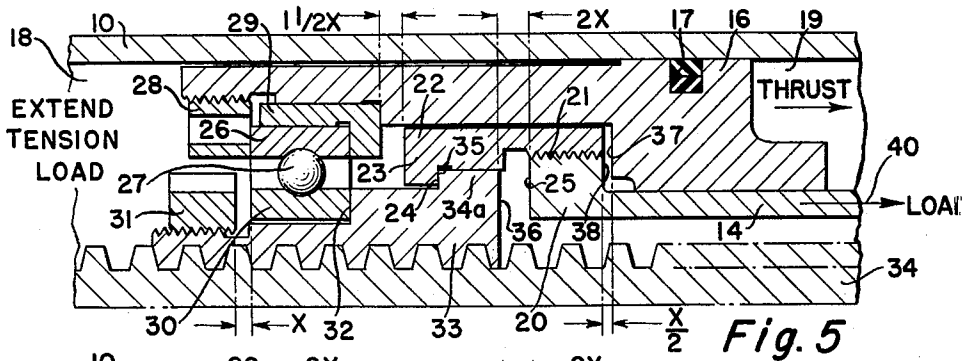
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2 Sheets-Sheet 2



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2,960,069

SELF-LOCKING ACTUATOR

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The present invention pertains to actuators, and particularly to fluid pressure operated self-locking actuators.

Heretofore, it has been proposed to incorporate load sensitive locking means in fluid pressure operated actuators, the load sensitive locking means being constituted by a plain bearing assembly. Actuators of this type are disclosed in my copending applications Serial No. 423,180 filed April 18, 1954, now Patent No. 2,804,053, and Serial No. 455,435 filed September 13, 1954, now Patent No. 2,804,054. However, in prior actuators of this type it was necessary to embody a separate lock releasing piston thereby increasing the complexity of the actuator construction and, accordingly, increasing the cost of manufacture thereof. The present invention relates to a self-locking actuator including load sensitive locking means of the plain bearing type which are designed to be automatically released upon the application of pressure fluid to either side of the actuator piston, and irrespective of the direction of the load, namely whether it is tension or compression. Accordingly, among my objects are the provision of a self-locking actuator including means for automatically releasing the locking means by the application of pressure fluid to either actuator chamber; the still further provision of a self-locking actuator including automatic lock releasing means; the locking means being load sensitive; and the still further provision of an actuator assembly including a cylinder and a piston wherein the piston carries releasable locking means.

The aforementioned and other objects are accomplished in the present invention by incorporating a fixed screw shaft within the actuator cylinder as the reaction element for the locking means. Specifically, the actuator comprises a cylinder having a reciprocable piston therein capable of fluid pressure actuation in both directions. The piston is attached to a rod that extends without one end of the cylinder for attachment to a load device, and the other end of the cylinder is adapted for connection to a fixed support. The cylinder has coaxially disposed therein a stationary screw shaft, or reaction element, which is threadedly engaged by a nut. The nut, or rotatable member, is rotatably journaled within the piston, the nut being formed with an upstanding flange the side surfaces of which constitute plain bearing locking surfaces. The piston is mounted on the rod for limited axial movement relative thereto.

The actuator piston divides the cylinder into an extend chamber and a retract chamber, whereby when the actuator chambers are subjected to differential pressure the piston can be moved in either direction. Under static conditions, that is, when no load is applied to the actuator piston rod and there is no pressure differential across the piston, the nut will be in the center, or neutral, position wherein the plain bearing surfaces thereof do not engage the piston assembly. Since the piston assembly is restrained against rotation, the nut is free to rotate relative to the screw shaft, or reaction member, during piston reciprocation. It is pointed out that the piston rod can

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only move lineally upon relative rotation between the nut and the screw shaft. When a tension load is applied to the actuator piston rod with no pressure differential across the piston, the piston rod moves a limited distance relative to the nut whereupon one of the surfaces of the nut engages a portion of the piston rod so as to prevent rotation of the nut relative to the screw shaft thereby locking the actuator. Moreover, the greater the applied load on the actuator the greater the locking force, and hence, the locking means are termed load sensitive.

With a tension load, the locking means can be automatically released by a pressure differential across the piston acting either to extend or retract the actuator piston. Thus, if pressure is applied to the retract chamber while the extend chamber is connected to drain, the piston head is moved relative to the nut so that the nut is again in the neutral position wherein it is free to rotate relative to the screw shaft. Conversely, if pressure is applied to the extend chamber while the retract chamber is connected to drain with a tension load, the locking force is relieved through the bearing to automatically reduce the locking force and cause the load to slip the locking means. Like relationships will also obtain when the actuator piston is subjected to a compression load.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein preferred embodiments of the present invention are clearly shown.

In the drawings:

Figure 1 is a view in elevation of an actuator constructed according to this invention.

Figure 2 is an enlarged fragmentary view taken along line 2—2 of Figure 1 showing a locking means in the static condition.

Figure 3 is a view similar to Figure 2 showing the tension load and pressure applied to the retract chamber.

Figure 4 is a view similar to Figure 2 showing a compression load with pressure applied to the retract chamber.

Figure 5 is a view similar to Figure 2 showing the tension load with pressure applied to the extend chamber.

Figure 6 is a view similar to Figure 2 showing a tension load with no pressure differential across the piston.

Figure 7 is a view similar to Figure 2 showing a compression load with the extend chamber pressurized.

Figure 8 is a view similar to Figure 2 showing a compression load with no pressure differential across the piston.

With particular reference to Figure 1, an actuator is shown including a cylinder 10 having a head end cap 11 and a tail end cap 12. The head end cap 11 has an integral fixture 13 by which the actuator cylinder can be attached to a fixed support, not shown. A piston rod 14 extends without the tail end cap 12 of the actuator cylinder, and likewise includes a fixture 15 by which it can be attached to a movable load device, not shown.

With particular reference to Figure 2, it can be seen that the piston rod 14 is hollow and slidably supports a piston 16 having suitable piston ring seals 17 engageable with the inner surface of the cylinder 10. The piston 16 divides the cylinder 10 into an extend chamber 18 and a retract chamber 19. The inner end of the rod is flanged as indicated by numeral 20 and threaded as indicated by numeral 21. An annulus 22 is threadedly carried by the flange 20, the annulus 22 having a depending flange 23 having an inner surface 24. The end of the piston rod presents a surface 25, the surfaces 24 and 25 constituting locking surfaces, as will be described hereinafter.

The piston 16 carries the outer race 26 of a ball bearing assembly 27, the outer race being restrained against axial movement relative to the piston by a nut 28 and

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an annulus 29. The inner race 30 of the ball bearing assembly 27 is disposed between a nut 31 and a shoulder 32, formed on a nut 33. The nut 33 has internal threads, as shown, of the Acme type. The nut 33 thread-
edly engages a stationary screw shaft 34 attached to the head end cap 12 of the cylinder.

From the foregoing, it is readily apparent that movement of the piston 16 and the rod 14 is dependent upon rotation of the nut 33 relative to the screw shaft 34. The nut 33 is formed with an upstanding flange 34a having side surfaces 35 and 36, which are engageable, respectively, with surfaces 24 and 25.

In the static condition as shown in Figure 2, the surface 24 is spaced from the surface 35 by the distance X, and the surface 25 is spaced from the surface 36 by a like distance X. Similarly, the end of the annulus 22 is spaced from the annulus 29 by the distance X and the end surface 38 of the flange 20 on the piston rod is spaced from the surface 37 of the piston 16 by the distance X. At the same time, the left hand end of the inner race is spaced from the nut 31 by the distance X/2 as is the right hand end of the inner race from the nut 32. In a typical actuator construction, the distance X is equal to .010 inch.

With reference to Figure 3, the load acting on the piston rod 14 is in the direction of arrow 40, and thus is a tension load. Moreover, pressure is being applied to the retract chamber 19 in the direction of arrow 41 while the extend chamber 18 is connected to drain. If the effective force of the pressure in the retract chamber 19 exceeds the effective force of the load acting in direction of the arrow 40, the piston 16 will move from the position of Figure 2 to the position of Figure 3 wherein surface 37 of the piston engages surface 38 of the rod while the distance between the end 25 of the rod and surface 36 of the nut 33 is 1½X. The distance between the surfaces 35 and 24 is

$$\frac{X}{2}$$

whereas the distance between the end of the annulus 22 and the annulus 29 becomes 2X. In addition, the left hand end of the inner bearing race 30 engages the nut 31 while the right hand end remains spaced from the nut by the distance X. Under these conditions, neither plain bearing surface 35 or 36 engages the nonrotatable piston rod or annulus 22 so that the nut 33 is free to rotate thereby permitting movement of the piston 16 and the rod 14 to the left as viewed in Figure 3.

With respect to Figure 4, if the load on the piston rod 14 acts in the direction of arrow 42, or a compression load, while pressure is applied to the retract chamber 19 and the extend chamber 18 is connected to drain, the distance between surfaces 37 and 38 becomes 1½X, the distance between the end of the annulus 22 and the annulus 29 becomes

$$\frac{X}{2}$$

while the distance between the right hand end of inner bearing race 30 and the surface 32 of the nut 33 is X. However, the left hand end of the inner race 30 engages the nut 31 and the surface 25 of the piston rod engages the surface 36 of the nut. Under the conditions, the locking load on the nut is relieved through the bearing 27 so as to permit rotation of the nut 33 relative to the screw shaft 34, and thus allow the piston rod 14 and the piston 16 to be moved to the left as viewed in Figure 4.

With respect to Figure 6, with a tension load and no pressure differential across the piston 16, the surface 35 of the nut engages the surface 24 of the annulus 22 and restrains rotation of the nut 33 thereby preventing movement of the piston 16 and the rod 14 under the influence of the applied load. Moreover, the locking force is directly proportional to the applied load acting in the

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direction of arrow 40. Similarly, as shown in Figure 8, with a compression load as indicated by arrow 42 and no pressure differential across the piston 16, or a pressure differential less than the effective pressure of the load, the surface 36 of the nut engages the surface 25 of the piston rod thereby restraining rotation of the nut 33 and locking the piston against movement.

With a tension load as seen in Figure 5, indicated by arrow 40, the actuator piston can be extended by applied pressure to the extend chamber 18 while the retract chamber 19 is connected to drain thereby relieving the locking pressure through the bearing 27. During such movement with a tension load, the surface 35 of the nut 33 remains in engagement with the surface 24 of the annulus 22, while surface 36 of the nut is spaced from the surface 25 by the distance 2X. At the same time surfaces 37 and 38 are spaced by the distance

$$\frac{X}{2}$$

while the end of the annulus 22 is spaced from the annulus 29 by the distance 1½X and the left hand end of the inner race 30 is spaced from the nut 31 by the distance X while the right hand end of the inner race engages the nut 33. Thus, when the pressure in extend chamber exceeds the effective force of the load acting in the direction of arrow 40, the piston 16 and the rod 14 will move to the right as viewed in Figure 5.

With reference to Figure 7, with a compression load as indicated by arrow 42 and pressure applied to the extend chamber 18 while the retract chamber is connected to drain, the piston 16 moves relative to the nut 33 so that the nut is in neutral position as shown in Figure 2 wherein surfaces 35 and 36 are spaced from surfaces 24 and 25, respectively, by the distance X, while the surfaces 37 and 38 are spaced by the distance 2X. In addition, the left hand side of the inner race 30 is spaced from the nut 31 by the distance X whereas the right hand side engages the nut 33. Since the plain bearing locking surfaces of the nut do not engage the non-rotatable surfaces of the piston rod and annulus, the nut is free to rotate and the piston 16 and the rod 14 can be moved to the right as viewed in Figure 6.

From the foregoing it is readily apparent that the present invention provides an actuator assembly wherein the locking means are automatically released upon a predetermined pressure differential across the piston sufficient to overcome the applied load. Moreover, when the actuator is inactive, the piston is restrained against movement by the load with a force proportional to the applied load by the plain bearing locking means.

While the embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A fluid pressure operated actuator including, a cylinder having disposed therein a reciprocable piston capable of fluid pressure actuation in both directions, and locking means carried by the piston for preventing movement of said piston at any position of the piston within the cylinder due to an applied load in the absence of fluid pressure application to said cylinder, said locking means being automatically released upon the application of fluid under pressure to said cylinder.

2. A fluid pressure operated actuator including a cylinder, a reciprocable piston disposed in said cylinder and movable by differential pressure thereacross, and locking means carried by the piston for preventing movement thereof in the absence of a pressure differential thereacross at any position of the piston within the cylinder due to a load applied to said piston, said locking means being automatically released upon the existence of a pressure differential across said piston greater than the effective force of said applied load.

3. A fluid pressure operated actuator including a cylinder

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der, a reciprocable piston disposed in said cylinder and movable by differential pressure thereacross, a member rotatably supported within and carried by said piston and operatively connected with said cylinder such that piston movement is dependent upon rotation of said member, and locking means operatively associated with said member for preventing rotation thereof to thereby prevent movement of said piston, said locking means being automatically released upon a pressure differential across said piston in excess of the applied load.

4. A fluid pressure operated actuator including, a cylinder, a reciprocable piston disposed in said cylinder and movable by a differential pressure thereacross, a member rotatably supported within and carried by said piston and operatively connected with said cylinder such that piston movement is dependent upon rotation of said member, and releasable locking means operatively associated with said member for preventing rotation thereof to thereby prevent movement of said member, said locking means being load sensitive whereby the locking effort is proportional to the applied actuator load.

5. A fluid pressure operated actuator including, a cylinder having disposed therein a reciprocable piston capable of fluid pressure actuation in both directions, a member rotatably supported within and carried by said piston and operatively connected with said cylinder such that movement of said piston is dependent upon rotation of said member, said piston being supported for limited axial movement relative to the rotatable member, said member being engageable with said piston upon relative axial movement therebetween in either direction for restraining rotation of said member so as to lock said piston against movement.

6. The combination set forth in claim 5 wherein said actuator includes a stationary element engageable with said rotatable member.

7. The combination set forth in claim 6 wherein said stationary element comprises a screw shaft and said rotatable member comprises a nut.

8. The combination set forth in claim 5 wherein said rotatable member is formed with an upstanding flange, the side surfaces of which constitute plain bearing surfaces engageable with said piston.

9. An actuator assembly including in combination, a cylinder, a reciprocable piston disposed in said cylinder, a member rotatably supported within and carried by said piston and operatively connected with said cylinder such that piston reciprocation is dependent upon and effects rotation of said member, and releasable load sensitive locking means for preventing rotation of said member to prevent movement of said piston when the actuator is inactive.

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10. An actuator assembly including in combination, a cylinder, a reciprocable piston in said cylinder, a member rotatably supported within and carried by said piston, a reaction element in said cylinder, said rotatable member having operative connection with said reaction element whereby movement of said piston is dependent upon and effects rotation of said member, said piston being capable of limited axial movement relative to said rotatable member under applied actuator load, and means engageable with said member when the piston is moved axially relative thereto for restraining rotation thereof, said restraining force being proportional to the applied actuator load.

11. An actuator assembly including in combination, a cylinder, a hollow piston rod disposed within said cylinder and extending outside thereof, a reciprocable piston disposed within said cylinder and slidably supported on said piston rod for movement relative thereto, a non-rotatable screw shaft disposed within said cylinder and extending through said piston, a nut threadedly engaging said screw shaft and having a pair of opposed braking surfaces, bearing means carried by said piston and supporting said nut for rotation relative thereto, and a pair of braking members carried by said piston rod and engageable with the braking surfaces on said nut, reciprocation of said piston being dependent upon and effecting rotation of said nut, said braking members being engageable with the braking surfaces on said nut due to loads imposed on said piston rod so as to restrain rotation of said nut with a force proportional to the load applied to said piston rod.

12. The actuator assembly set forth in claim 11 wherein said nut has an upstanding flange, the radial faces of which constitute said braking surfaces, and wherein the braking members carried by said piston rod comprise a flanged end of said piston rod and a flanged annulus connected thereto.

13. The actuator assembly set forth in claim 11 wherein the bearing means for supporting the nut for rotation relative to the piston comprise a ball bearing assembly having an outer race immovably connected with said piston and an inner race slidably supported relative to said nut whereby the restraining force imposed on said nut can be relieved by movement of said piston relative to said piston rod.

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