# United States Patent

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[54] **CLOSED LOOP SERVOACTUATOR**
**3 Claims, 3 Drawing Figs.**


[52] **U.S. Cl.** ..... **91/368,** 91/45
[51] **Int. Cl.** ..... **G05b 6/06**
[50] **Field of Search** ..... 91/368, 382, 380



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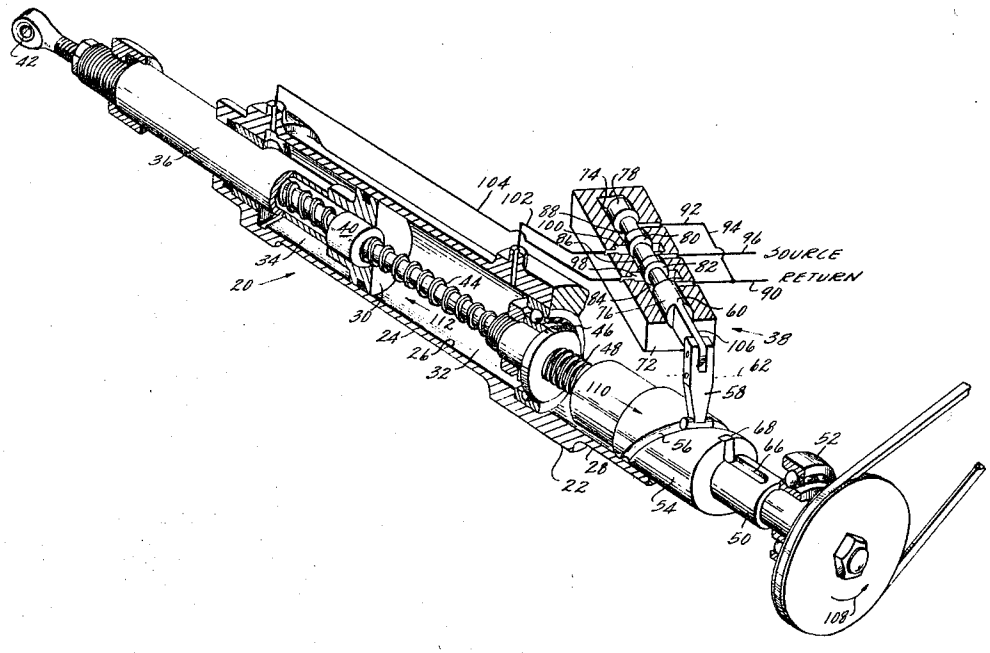
**ABSTRACT:** An actuator having an integral position servo is disclosed in which the input and feedback means comprise a rotatable input shaft, a feedback shaft which rotates in response to axial translation of the actuator piston, and a rotatable and translatable cylindrical member having a groove on its surface which is engaged with the operating lever of a servovalve, the cylindrical member being translatable in response to either of said input and said feedback shafts to operate the servovalve.

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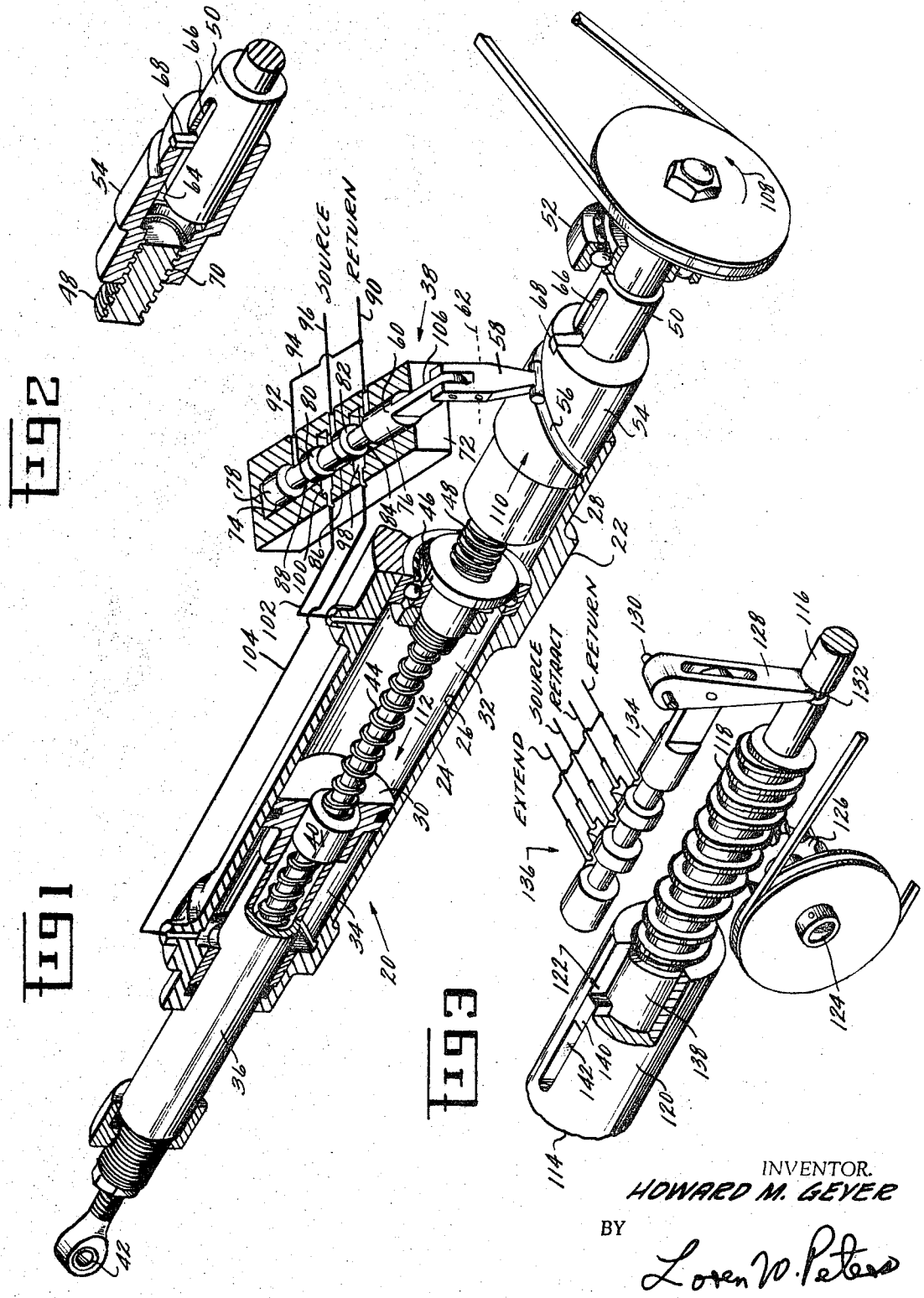


Fig 2

Fig 1

Fig 3

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# CLOSED LOOP SERVOACTUATOR

## BACKGROUND OF THE INVENTION

This invention relates to actuators, and more particularly to actuators having an integral closed loop position servo.

In many applications for hydraulic actuators, it is desirable that the actuator include an integral position servo so that the actuator extension position will be proportional to an input signal applied at the actuator. An actuator with an integral position servo provides several advantages. Among these are the capability of synchronizing the operation of several such actuators by synchronizing their inputs; and in applications where a closed position loop is required by the actuator is remotely located from its control, the capability of providing position control without necessity for complex mechanical feedback means between the actuator and its control.

The prior art contains several actuators with integral position servos, such as for example that shown in U.S. Pat. No. 2,886,008, issued May 12, 1959 to H. M. Geyer et al. The device cited and other prior art devices are, however, subject to considerable mechanical simplification to improve reliability maintainability, and manufacturing cost.

## OBJECTS OF THE INVENTION

It is an object of this invention, therefore, to provide an actuator having a mechanically simplified integral position servo.

## DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject of this invention, the invention will be better understood by reference to the text below and the accompanying drawing in which:

FIG. 1 is a perspective sectional view of an actuator;

FIG. 2 is a partially fragmented perspective sectional view of the input and feedback means included in the actuator of FIG. 1; and

FIG. 3 is a perspective view of an alternate form of the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates in section an actuator 20 embodying the present invention. The actuator 20 comprises a body member 22 which includes a cylinder 24 having a cylindrical bore 26 therein and an extended head end 28 for containing the servocomponents a piston 30 defining an extend chamber 32 and retract chamber 34 in the cylinder 24 and including a cylindrical rod 36 extending through one end of body member 22, a servovalve 38 mounted to the head end 28 of the actuator 20, and means for providing input and feedback to servovalve 38. Piston 30 includes a high lead threaded insert 40 which is rotationally secured thereto, and piston 30 itself is prevented from rotating relative to body member 22 by a combination of the attaching means 42 fastened to the outer end of piston rod 36 and the clevis member (not shown) to which piston rod 36 is attached for actuation thereof. A high lead screw 44 is journaled in body member 22 by means of a bearing 46 supported therein adjacent the head end of cylindrical bore 26 and is engaged with threaded insert 40 in such a manner that axial movement of piston 30 will cause lead screw 44 to rotate through an angle which is proportional to the said axial movement. The lead screw 44 includes a second threaded portion 48 which extends beyond bearing 46 in the direction of the head end 28 of actuator 20 and is threadably engaged with the servovalve 38 input-output means.

The servovalve 38 input-output means comprises an input shaft 50 which is rotationally supported in a bearing 52 in the head end 28 of actuator 20, a cylindrical member 54 having a groove 56 on its surface, member 54 being engaged at one end with input shaft 50 so as to be axially slidable and rotationally interlocked therewith and threadably engaged at its other end



with the second threaded portion 48 of screw shaft 44 an operating lever 58 which is engaged at its one end with groove 56 and is engaged at its other end with a piston 60 in servovalve 38, the operating lever 58 being pivotally connected at a point 62 intermediate its two ends to body 22 of actuator 20.

Referring to FIG. 2, input shaft 50 slidably extends into a hole 64 which is concentric with the outer surface of cylindrical member 54. Relative rotation between input shaft 50 and cylindrical member 54 is precluded by the combination of an axial slot 66 on the enlarged surface of input shaft 50 and a key means 68 which is secured to cylindrical member 54 and is slidable in slot 66. Alternatively, mating splines or other means could be provided with the enlarged end of the input shaft and the cylindrical member to accomplish the same function.

The inner end of cylindrical member 54 contains internal threads 70 which engage the threaded portion 48 of screw shaft 44. Thus when input shaft 50 is rotated in response to an external control signal, cylindrical member 54 is caused to translate relative to screw shaft 44 and, assuming that piston 30 is temporarily located in a given position, cylindrical member 54 also translates relative to body member 22 of actuator 20. Referring again to FIG. 1 this translation combined with the threading action of spiral groove 56 on operating lever 50 causes operating lever 50 to pivot about point 62 and moves the servovalve piston 60 to direct pressurized hydraulic fluid to either extend chamber 32 or retract chamber 34, depending upon the direction of motion of servovalve piston 60. Feedback to null the servopiston is accomplished when screw shaft 44 rotates in response to movement of piston 30 and causes threaded extension 48 to retract with threads 70 and translate cylindrical member 54 in a direction opposite that caused by the input.

The servovalve 38 comprises a body member 72 having a cylindrical bore 74 in which piston 60 is slidable. Piston 60 includes lands 76, 78 at its ends which sealingly engage bore 74 to prevent leakage of hydraulic fluid therefrom and a pair of intermediate lands 80, 82 spaced from each other and from end lands 76, 78. That portion of piston 60 which connects the lands 76, 78, 80, 82 has a reduced cross section so as to provide annular fluid passages 84, 86, 88 between the reduced cross section stem and the servo valve 38 cylinder walls. Body member 72 includes a port 90 disposed between the first end land 76 and the first intermediate land 82 and a second port 92 disposed between the second end land 78 and the second intermediate land 80, the two ports 90, 92 being interconnected by suitable passageway means 94 to a hydraulic return. A third port 96 is provided in body member 72 disposed between the intermediate lands 80, 82 and is connected to a hydraulic source. Two annuli 98, 100 are provided in body member 72 at locations which correspond to the positions of the two intermediate piston lands 80, 82 when piston 60 is in a null position. These annuli 98, 100 have a width which is only very slightly less than the axial length of lands 80, 82 and are connected by suitable conduits 102, 104 to extend chamber 32 and retract chamber 34 respectively. The end of piston 60 containing first outer land 68 includes an extension 106 which is pivotally connected to operating lever 58 hereinbefore described.

Operation of actuator 20 is as follows. If the direction of input is as indicated by arrow 108, cylindrical member 54 will translate as shown by arrow 110 and simultaneously rotate spiral groove 56 to cause further translation of the lower end of operating lever 56, servovalve piston 60 will be directed in a direction away from the operating lever end of the servovalve 38, causing the first intermediate land 82 to uncover the first annulus 98 and expose it to fluid return which connects retract chamber 34 to return by conduit 104. At the same time the second intermediate land 80 moves to expose the second annulus 100 to hydraulic source port 96, there by providing fluid pressure to extend chamber 32 through conduit 102. An oppositely directed input would, of course, have a directly opposite affect.

Upon the admission of pressurized fluid to extend chamber **26**, piston **30** begins to move in the direction indicated by arrow **112**. This axial translation of piston **30** causes a corresponding rotation of screw shaft **44** proportional to the piston's movement, which rotation correspondingly causes translation of cylindrical member **54** relative to screw shaft **44** by means of the threaded engagement of the threaded extension **48** of screw shaft **44** with the inner end of cylindrical member **54**. Assuming that input shaft **50** is now in a steady rotational position, there will also be a translation of cylindrical member **54** relative to actuator body **22** in a direction opposite to that caused by input rotation of input shaft **50**, which will cause operating lever **58** to pivot in a direction to shut off the supply of fluid to extend chamber **32**. Should piston **30** overshoot the position demanded by the input, the servovalve piston **60** will move to a position which allows pressurized fluid to enter retract chamber **34** and which drains extend chamber **32**, and piston **30** will thus be directed back toward the position demanded by the angular position of input shaft **50**. Depending upon the dynamic characteristics of the system, this cycling will repeat a few times until piston **30** is at or very near the demanded position.

Reference is now made to FIG. **3** which illustrates an alternate embodiment of the present invention. Only the input, feedback, and servovalve means are shown, the remainder of the actuator being constructed similarly to that shown in FIG. **1**. The actuator includes a screw shaft **114**, similar to the one shown in FIG. **1**, which is similarly supported by the bearing mounted at the head end of the actuator bore. The input feedback means comprises (**1**) a cylindrical member or shaft **116** rotationally and slidably supported by a suitable bearing (not shown) at the head end of the actuator, (**2**) a worm **118** concentric with the cylindrical member **116** and fixedly connected therewith, (**3**) a hollow cylindrical collar **120** concentric with the screw shaft **114** and integrally connected therewith, (**4**) means **122** for slidably supporting and rotationally interlocking worm **118** with hollow cylindrical collar **120**, (**5**) an input shaft **124** journaled in the body of the actuator at right angles to the axis thereof, (**6**) a worm wheel **126** secured to said input shaft **124** and meshing with worm **118**, and (**7**) an operating lever **128** which is pivotally connected at **130** to the actuator body member, has its other end engaged with a groove **132** in cylindrical member **116**, and is pivotally connected intermediate its ends to a piston **134** in servovalve **136**, which has a construction identical with that shown in FIG. **1**.

The means by which hollow cylindrical collar **120** on the end of the screw shaft **114** is slidably engaged and rotationally interlocked with worm **118** can be seen by reference to the cutaway view of hollow collar **120**. Worm **118** contains on its inner end an enlarged cylindrical portion **138** and a key **140** extending from a portion of its cylindrical surface, and the hollow cylindrical collar **120** includes a corresponding slot **142** cut substantially along its length. The dimensional relationships between the hollow cylindrical collar **120**, the cylindrical portion **138** is freely slidable in hollow cylindrical collar **140**. As explained in connection with FIG. **1**, mating splines or other suitable rotational locking means could be substituted for the structure shown.

In operation, an input rotation of input shaft **124** from an external source will cause rotation of worm wheel **126** and a corresponding translation of worm **118** and cylindrical member **116** due to the rack and pinion interaction between worm **118** and the worm wheel **126**. Translation of cylindrical member **116** and of groove **132** on the surface thereof will cause operating lever **128** to pivot about pin **130** and cause a corresponding movement of the servovalve piston **134**, thereby directing high pressure fluid to either the extend or retract chamber of the actuator in a manner similar to that described in connection with FIG. **1**. A responsive movement of the actuator piston will ensue, which will cause a proportionate rotation of screw shaft **114** and, by virtue of the rotational interlocking of screw shaft **114** and worm **118**, will cause worm **118** to be threaded axially on worm wheel **126** in a direction opposite the input translation. This will cause the servovalve piston **134** through the linkage comprising operating lever **128**, to seek a null position. As was explained in connection with FIG. **1**, any overshoot of the piston beyond its demanded position will cause servovalve **136** to reverse flow of high pressure fluid between the extend and retract chambers, thereby causing the piston to return toward its demand position.

In summary, an actuator having a mechanically simple, integrally mounted position servo which incorporates as its primary actuating member a rotatably and axially slidable grooved cylindrical member has been described. Two embodiments of the invention have been illustrated; however, it is not intended that the invention be limited to the embodiments described, all reasonable equivalents thereof being intended to fall within the scope of the appended claims.

I claim:

**1**. An actuator comprising:

A. a cylinder;

B. a piston slideable within said cylinder and defining an extend and retract chamber therein;

C. a screwshaft rotatably supported in said cylinder and operatively connected to said piston so as to rotate in response to translation thereof;

D. valve actuating means supported by said cylinder, said actuating means comprising:

1. a translatably and rotatably supported cylindrical member including a groove on its surface;

2. input means for causing translation of said groove with respect to said cylinder, said input means comprising:

a. an input shaft rotatably supported in said cylinder with its axis normal to the axis of said cylinder;

b. a worm wheel secured to said input shaft; and

c. a worm coaxially connected to said cylindrical member and meshed with said worm wheel;

3. feedback means for causing a reverse translation of said groove with respect to said cylinder, said feedback means being connected with said screwshaft and comprising, means for rotating said worm comprising a hollow cylindrical collar fastened to said screwshaft, a cylindrical portion included on said worm and slideably disposed in said hollow collar, and key means for preventing relative rotation between said collar and said cylindrical portion while permitting relative translation therebetween; and

E. valve means for selectively directing pressurized fluid into one of said extend and retract chambers and venting the other of said chambers.

**2**. An actuator comprising:

a cylinder;

a piston positioned for reciprocation within said cylinder and defining an extend and retract chamber therein;

a screwshaft rotatably supported in said cylinder and operatively connected to said piston so as to rotate in response to translation thereof;

valve means for selectively directing pressurized fluid into one of said extend or retract chambers and for venting the other of said chambers;

valve actuating means supported by said cylinder, said actuating means comprising;

an input shaft coaxially aligned with said screwshaft;

a cylindrical member positioned so as to surround at least a portion of said input shaft;

said cylindrical member including means for producing rotation thereof upon rotation of said input shaft and translation thereof upon rotation of said screwshaft;

said cylindrical member containing a groove spirally oriented on the outer surface thereof;

lever means connected on one end of said spiral groove and on an opposite end of said valve means; and

whereby rotation of said input shaft causes said valve means to reposition said piston, and the associated rotation of said screwshaft causes said cylindrical member to automatically reposition said valve means to a null position.

3. An actuator as recited in claim 2 further characterized in that said translation producing means for said cylindrical member comprise;

an externally threaded extension portion of said screwshaft positioned between that portion of said screwshaft which is rotatably supported by said cylinder and the input shaft; and

an internally threaded portion of said cylindrical member.