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ACTUATOR WITH MULTIPLE DISC TYPE LOCKING MEANS

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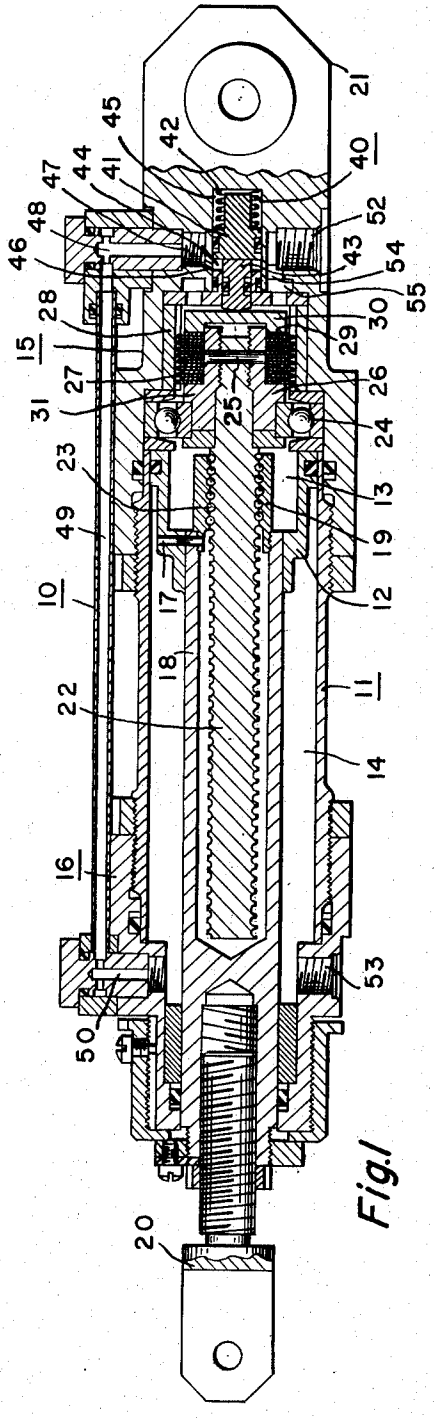


Fig.1

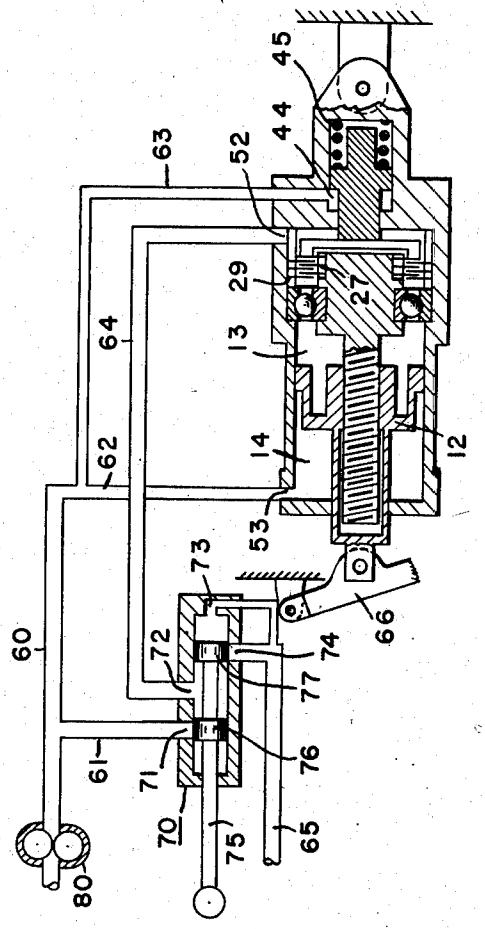


Fig.2

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ACTUATOR WITH MULTIPLE DISC TYPE LOCKING MEANS

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This invention pertains to actuators, and particularly to releasable locking means for fluid pressure operated actuators.

Heretofore, fluid pressure operated actuators of the type including a cylinder having disposed therein a reciprocable piston capable of fluid pressure actuation in either direction, have included various types of locking means for preventing relative movement between the piston and cylinder in the absence of fluid pressure application to the cylinder. However, the locking means heretofore employed, such as the toothed type lock disclosed in my Patent No. 2,643,642, issued June 30, 1953, and the friction type lock disclosed in my copending application, Serial No. 394,660, filed November 27, 1953, now Patent No. 2,774,336, issued December 18, 1956, require relative movement between the locking elements to release or engage the locking means. Accordingly, there is a resultant time lag during release and engagement of the locking elements, which time lag is undesirable in certain types of actuator installations, particularly those in which the movements of the load device associated with the actuator must be accurately controlled. This invention pertains to an improved locking device in which there is no appreciable elapse of time in releasing, or engaging, the locking means. Accordingly, among my objects are the provision of instantaneously engageable and releasable locking means for an actuator; the further provision of means to release the locking means upon the application of pressure fluid to the actuator; the further provision of a control system for an actuator having releasable locking means and unequal piston areas; and the still further provision of a fluid pressure operated actuator incorporating the locking means of this invention.

The aforementioned and other objects are accomplished in the present invention by providing locking means, which may be engaged by the application of an axial force and released by removing the axial force. Specifically, the actuator includes a cylinder having disposed therein a reciprocable piston capable of fluid pressure actuation in either direction. The piston includes a rod portion, which projects through one end of a cylinder for connection to either a relatively movable load device, or a fixed support. The other end of the cylinder is provided with a fixture, which, likewise, may be attached to either the fixed support, or the load device. In either event, only relative linear movement between the piston and cylinder is required to adjust the load device, the piston and cylinder being restrained against rotation.

The piston carries a non-rotatable hollow member, which constitutes the nut of the well known ball-screw and nut coupling. A rotatable member, in the form of a screw shaft, is rotatably supported in the cylinder and extends through the non-rotatable hollow member, the operative connection between the members being constituted by a plurality of circulating balls. The arrangement of actuator parts is such that linear movement of the

piston is dependent upon and effects rotation of the screw shaft relative to the nut. One end of the screw shaft carries a plurality of longitudinally spaced brake discs, which are engageable with a plurality of alternately spaced stationary brake discs carried by the cylinder. The two sets of brake discs are always in engagement, the discs being of the bicycle brake type. The two sets of discs constitute the locking means for restraining rotation of the screw shaft in the absence of fluid pressure application to the cylinder, an axial force being exerted on the brake discs through a thrust collar, by means of a compression spring .

When the actuator is inactive, the spring force exerted on the brake discs through the thrust collar is sufficient to restrain the screw shaft against rotation due to torque reaction. That is, the axial thrust of the spring force precludes relative rotation between the intermeshing discs. The actuator also includes a lock release cylinder having disposed therein a lock release piston, the lock release piston being operable to remove the thrust of the spring on the thrust collar, upon the application of pressure fluid to the lock release cylinder. When the axial force of the spring is removed, the brake discs carried by the screw shaft are free to rotate relative to the stationary brake discs.

The actuator is connected with a fluid pressure system through suitable valving means, which are operable to direct pressure fluid to the lock releasing cylinder at all times when the system is operative. Inasmuch as relative axial movement between the locking elements, constituted by the brake disc is not required to release, or engage, the locking means, it will be appreciated that upon the application of fluid pressure to the lock release cylinder, thereby releasing the axial spring force, the locking means will be instantaneously released. Conversely, when pressure fluid is not applied to the lock release cylinder, the spring force will immediately be operable to engage the locking means so as to restrain rotation of the screw shaft.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred embodiment of the present invention is clearly shown.

In the drawing:

Fig. 1 is a view, partly in section and partly in elevation, of an actuator including the locking means of this invention.

Fig. 2 is a schematic diagram of a control system for an actuator of the type disclosed herein with the actuator hydraulically locked.

With particular reference to Fig. 1, an actuator **10** is shown comprising a cylinder **11** having disposed therein a reciprocable piston **12** capable of fluid pressure actuation in either direction. The piston **12** divides the cylinder **11** into an extend chamber **13** and a retract chamber **14**. It should be noted that the area of the piston exposed to the extend chamber is greater than the piston area exposed to the retract chamber. The cylinder **11** has attached thereto at opopsite ends a head cap assembly **15** and a tail cap assembly **16**.

The piston **12** is of cup-shaped configuration, and, as shown in Fig. 1, is connected by means of a cross pin **17** to a rod portion **18** having a centrally disposed longitudinal recess, and a hollow member **19** having an internal spiral groove of semi-circular cross section. The hollow member **19**, or nut, is constrained for linear movement with the piston by reason of its connection through pin **17**, and the entire piston assembly including the nut and the rod are restrained against rotation relative to the cylinder **11** by virtue of the fact that the rod **18** extends through the tail cap assembly **16** and is attached

to a fixture 20, which may be connected to either a relatively movable load device or a fixed support. The head cap assembly 15 is, likewise, formed with a fixture 21, which means the cylinder 11 may be attached to either the fixed support, or the relatively movable load device. Thus, both the cylinder and piston assembly are restrained against rotation, and adjustments of the load device, not shown, may be effected by relative linear movement therebetween.

The hollow nut 19 engages a member, or screw shaft, 22 having an exterior spiral groove of semi-circular cross section, through the agency of a plurality of circulating balls 23. Suitable passage means, not shown, are formed on the nut 19 to enable circulation of the balls 23 during relative rotation between the nut and screw shaft. The screw shaft 22 is rotatably supported within the cylinder 11, or more particularly within the head cap 15 by means of a bearing assembly 24, the bearing assembly 24 being of the combined radial and thrust type. Thus, the screw shaft 22 is restrained against longitudinal movement relative to the cylinder 11.

By reason of the threaded interconnection between the piston assembly and the screw shaft, it will be appreciated that reciprocable movement of the piston assembly will effect rotation of the screw shaft 22. Moreover, reciprocation of the piston 18 is dependent upon rotation of the screw shaft 22, and, hence, if rotation of the screw shaft 22 is restrained, movement of the actuator piston will be prevented. Accordingly, the improved locking means of this invention are adapted to selectively restrain rotation of the screw shaft 22 so as to lock the actuator.

As is seen in Fig. 1, the end of the screw shaft adjacent the bearing support 24 is rigidly connected by means of a cross pin 25 to an annular member 26, which has attached thereto a plurality of axially spaced brake discs 27. A portion of the annular member 26 is encompassed by a stationary annular member 28, which also carries a plurality of spaced brake discs 29, which are disposed in the spaces between the brake discs 27. The intermeshing brake discs 27 and 29 are arranged to have an axial force imposed thereon by means of a thrust collar 30, which is operative to exert an axial force on the brake discs by reason of their being confined between the thrust collar and a shoulder 31 on the member 26. The locking means constituted by the brake discs 27 and 29 are of the type which are effective to preclude relative rotation therebetween when subjected to an axial force, and are automatically released to permit relative rotation therebetween when the axial force is removed. Thus, with this type of locking means, it becomes unnecessary to move one of the brake elements relative to the other, as has heretofore been necessary with either a friction brake or a dog toothed type brake.

The advantages of incorporating locking means of the type disclosed herein are readily apparent. However, one of the more important advantages resides in the fact that there is no appreciable elapse of time during engagement and release of the locking means, since relative movement between the brake discs is not required to either release or engage the same. In actuators designed heretofore, employing either a friction lock or a toothed lock, a rather substantial period of time elapses after means for engaging the locking device is actuated and before the locking means becomes effective to restrain rotation of the screw shaft. This time lag has been found to be undesirable in certain types of aircraft installations inasmuch as the load device associated with the actuator cannot be accurately positioned. However, with an actuator of the type disclosed herein, as soon as the operator discontinues the application of pressure fluid to the actuator cylinder, the locking means are instantaneously operative to restrain rotation of the screw shaft, and thus lock the piston and load device in the selected position.

The means for engaging and releasing the improved locking device of this invention will now be described. As is shown in Fig. 1, the head cap assembly 15 is formed with a central recess 40, which constitutes a cylinder having disposed therein a reciprocable piston 41 capable of fluid pressure actuation to the right, as viewed in Fig. 1, and capable of spring actuation to the left, by means of a coiled compression spring 42. The head surface of the lock release piston 41 engages a thrust pin 43, which thrust pin has operative engagement with the thrust collar 30. The lock release cylinder 40 is divided by the piston 41 into a lock release chamber 44 and a spring chamber 45. The lock release chamber 44 is connected by a passage 46 to a passage 47, which communicates with a passage 48 having connection with a conduit 49, which is, in turn, connected through a passage 50 to the retract chamber 14. The tail cap assembly 16 is formed with a retract port 53. The extend port 52 communicates with the extend chamber 13 through openings 54 and 55 and, thence, through the space between annular member 28 and the brake disc 29 and through the intervening spaces between the ball bearings of bearing assembly 24 to the extend chamber.

Thus, whenever pressure fluid is applied to the retract chamber 14, pressure fluid is admitted to the brake release chamber 44 so as to effect movement of the lock release piston 41 to the right, as viewed in Fig. 1, thereby removing the force of spring 42 from the thrust pin 43 and the thrust collar 30, and in so doing, releasing the locking means so as to permit rotation of the screw shaft 22. Conversely, when pressure fluid is not applied to the lock release chamber 44, the spring 42 will instantaneously urge the piston 41 to the left, thereby exerting an axial force on the brake discs 27 and 29 through the thrust pin 43 and thrust collar 30, so as to engage the locking means and restrain rotation of the screw shaft 22.

With reference to Fig. 2, a control system for effecting operation of the actuator will be described. The system includes a pressure supply conduit 60 which is connected to any suitable pressure source, such as pump 80. The pressure conduit is connected with branch conduits 61, 62 and 63; conduit 61 communicating with a port 71 of a control valve 70; conduit 62 communicating with the actuator retract port 53; and conduit 63 communicating with the lock release chamber 44. The valve 70 includes a plunger 75 having a pair of spaced lands 76 and 77, the plunger being capable of manual reciprocation within a valve casing 78 having ports 71, 72, 73 and 74. Port 72 is connected by a conduit 64 to the extend actuator port 52, while ports 73 and 74 are connected to a drain conduit 65. As shown in Fig. 2, the actuator piston is connected to a load device 66 while the cylinder is restrained against movement.

The pressure maintained in conduit 60 and applied to the brake release chamber 44 is sufficient to overcome the load of spring 45 and thereby release the locking means, constituted by brake discs 27 and 29. When the plunger lands 76 and 77 close ports 71 and 72, respectively, the actuator will be locked hydraulically. Moreover, if the pressure should fail in conduit 60, the actuator will be locked mechanically. The actuator may be retracted by interconnecting the valve ports 72 and 74 which connects the extend chamber 13 to drain through port 52, conduit 64, ports 72 and 74 and conduit 65, while the retract chamber 14 is connected to the pressure conduit 60 through conduit 62 and port 53. The actuator may be extended by interconnecting valve ports 71 and 72 while port 74 is blocked therefrom. Thus, pressure fluid will be applied to the extend chamber 13 from conduit 60 through conduit 61, ports 71 and 72, conduit 64 and port 52. At the same time, pressure fluid is applied to the lock release chamber 44 through conduits 60 and 63, and to the retract chamber 14 through conduits 60, 62 and port

53. However, by reason of the fact that the area of piston **12** exposed to the extend chamber **13** is greater than the area of piston **12** exposed to the retract chamber **14**, the actuator piston will move to the left as viewed in Fig. 2. This result occurs inasmuch as the total pressure acting on the piston **12** in the extend chamber is greater than the total pressure acting on the piston **12** in the retract chamber, since the unit pressures are equal and the piston areas are unequal.

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

What is claimed is as follows:

1. A control system for a fluid pressure operated actuator of the type comprising a cylinder having disposed therein a reciprocable piston capable of fluid pressure actuation in either direction, said piston dividing said cylinder into two chambers and having a smaller area exposed to one chamber than to the other chamber, and releasable locking means operatively connected with said piston for preventing movement thereof in the absence of fluid pressure application to said one chamber exposed to the smaller piston area, including in combination, a source of fluid pressure, a conduit connecting said source with said one chamber, a valve having a first port connected with said source, a second port connected with said other chamber, and a third port connected to drain, and a valve plunger for blocking said first and third ports so as to trap fluid in said actuator and prevent piston movement, said valve plunger being operable to interconnect said second and third ports to effect piston movement in one direction, said valve plunger also being operable to interconnect said first and second ports to effect piston movement in the other direction.

2. A control system for a fluid pressure operated actuator of the type comprising a cylinder having disposed therein a reciprocable piston capable of fluid pressure actuation in either direction, said piston dividing said cylinder into two chambers and having a smaller area exposed to one chamber than to the other chamber, and releasable locking means operatively connected with said piston for preventing movement thereof in the absence of fluid pressure application to said one chamber exposed to the smaller piston area, including in combination, a source of fluid pressure, and valve means connected with said source and with said actuator, said valve means being operable to effect piston movement in one direction by applying pressure fluid of the same potential to both actuator chambers and operable to effect piston movement in the other direction by connecting said other chamber to drain while pressure fluid is applied to said one chamber.

3. A control system for a fluid pressure operated actuator of the type comprising, a cylinder having disposed therein a reciprocable piston capable of fluid pressure actuation in either direction, said piston dividing said cylinder into two chambers and having a smaller area exposed to one chamber than to the other chamber, a member rotatably supported in said cylinder and operatively connected to said piston so as to rotate in response to piston movement, and releasable locking means operatively connected with said rotatable member for

preventing rotation thereof and hence locking the piston against movement in the absence of fluid pressure application to said one chamber exposed to the smaller piston area including in combination, a source of fluid pressure, a conduit connecting said source with said one chamber, a valve having a first port connected with said source, a second port connected with said other chamber and a third port connected to drain, and a valve plunger for blocking said first and third ports so as to trap fluid in said actuator and prevent piston movement, said valve plunger being operable to interconnect said second and third ports to effect piston movement in one direction, said valve plunger also being operable to interconnect said first and second ports to effect piston movement in the other direction.

4. A control system for a fluid pressure operated actuator of the type comprising, a cylinder having disposed therein a reciprocable piston capable of fluid pressure actuation in either direction, said piston dividing said cylinder into two chambers and having a smaller area exposed to one chamber than to the other chamber, a member rotatably supported in said cylinder and operatively connected with said piston so as to rotate in response to piston movement, the operative connection between said rotatable member and said piston including a nonrotatable element carried by said piston and having threaded engagement with said member, and releasable locking means operatively connected with said rotatable member for preventing rotation thereof and hence locking said piston against movement in the absence of fluid pressure application to said one chamber exposed to the smaller piston area, including in combination, a source of fluid pressure, a conduit connecting said source with said one chamber, a valve having a first port connected with said source, a second port connected with said other chamber and a third port connected to drain, and a valve plunger for blocking said first and third ports so as to trap fluid in said actuator and prevent piston movement, said valve plunger being operable to interconnect said second and third ports to effect piston movement in one direction, said valve plunger also being operable to interconnect said first and second ports to effect piston movement in the other direction.

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