Jan. 21, 1964 J. E. COMBS 3,118,349

ACTUATOR CYLINDER

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FIG-1

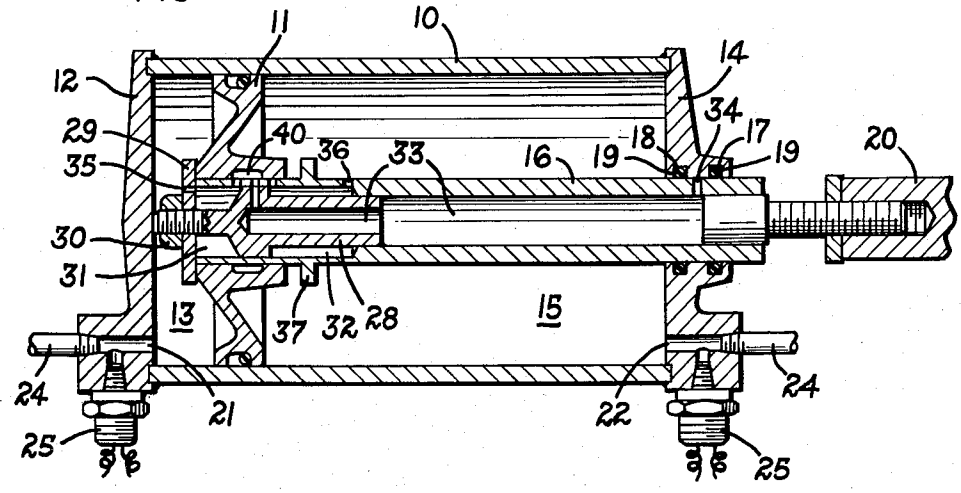


FIG-2

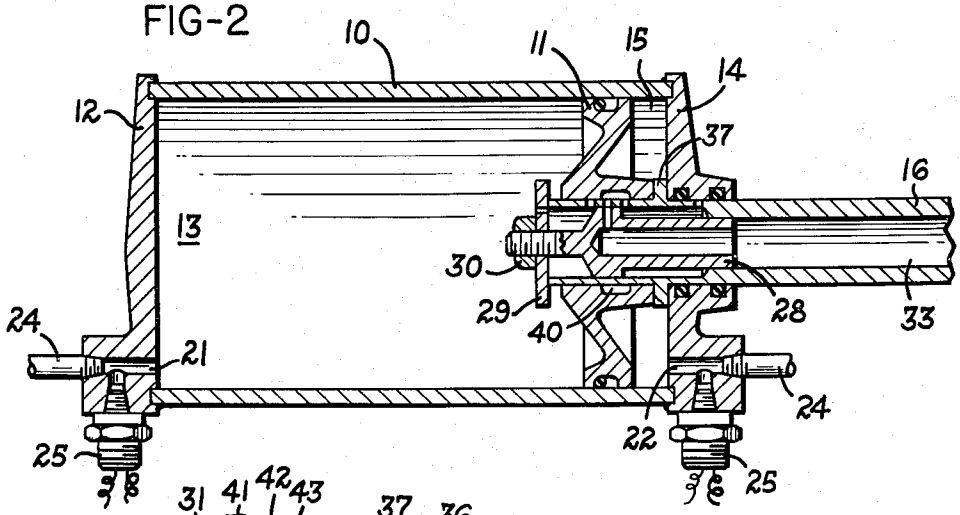
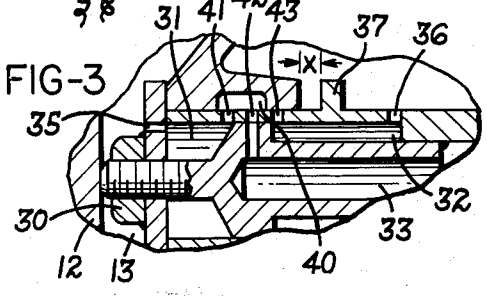


FIG-3



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ACTUATOR CYLINDER

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FIG-4

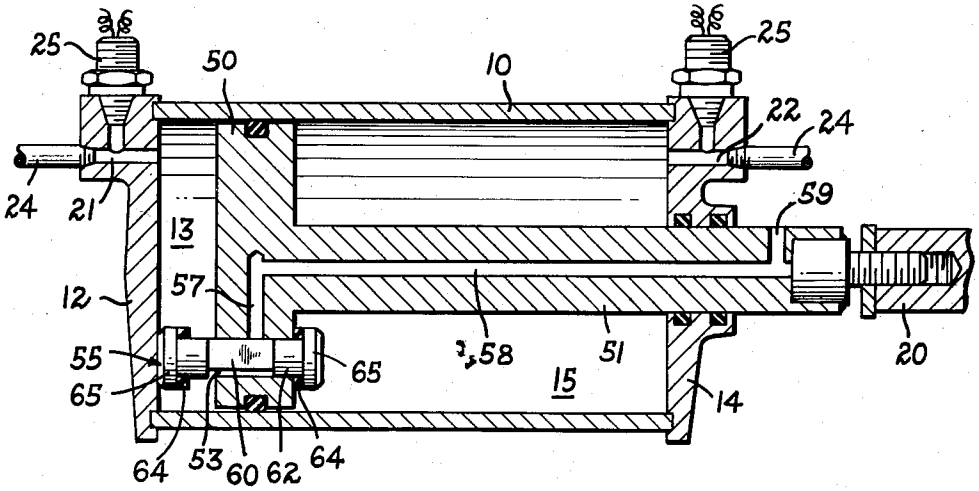


FIG-5

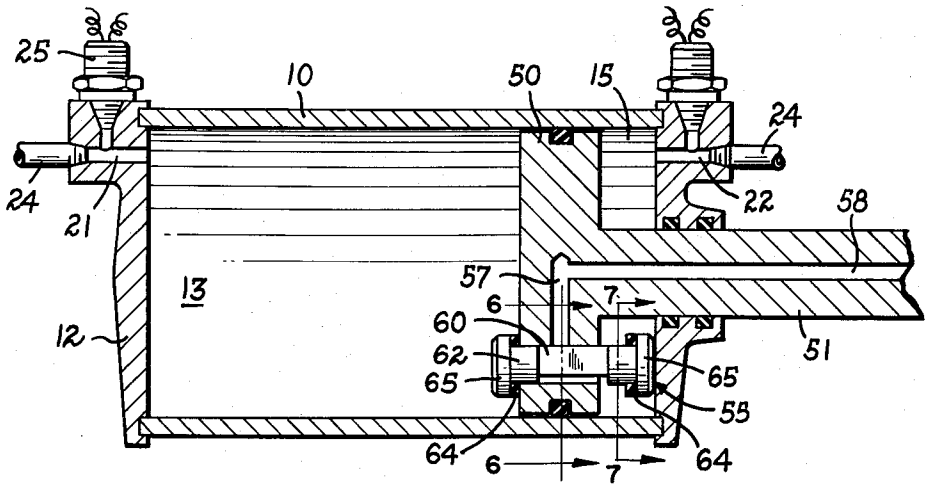


FIG-6

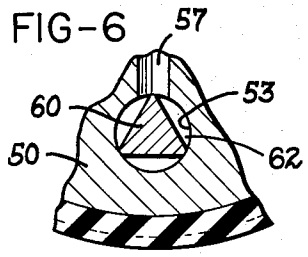
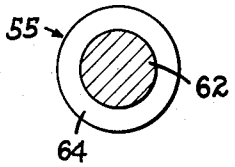


FIG-7



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3,118,349
ACTUATOR CYLINDER

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6 Claims. (Cl. 91—404)

This invention relates generally to fluid motors and particularly to double acting fluid actuators.

Numerous requirements exist for automatic pneumatic or hydraulic actuators which do not require a control or selector valve and which are capable of being activated by one or more pressure sources so that, for example, operation of the device can be tested by a secondary pressure source prior to activation of the primary pressure source. In addition, these cylinders must consume a minimum of space, be light in weight without sacrificing operational efficiency, and include apparatus for cushioning the terminal movements of the stroke of the cylinder.

Accordingly, a particular object of the invention is to provide an improved actuator assembly which can be operated from either of two separate fluid systems, one of which is normally utilized to test the operation of the device while the other is used to operate the device during actual use thereof.

Another object of this invention is to provide an improved fluid operated actuator assembly which will automatically lock itself in either of two extreme positions thereby positioning the apparatus connected to the output of the assembly in either of two preselected positions.

Another object of the invention is to provide an explosive squib actuated power cylinder assembly having a minimum number of moving parts, which automatically cushions the terminal movements of its output member without wear to the actuator components and which will position and maintain such output member in either of two preselected positions.

Another important object of this invention is to provide an actuator which can be operated through one or more cycles by utilizing explosive squibs or other sources of pressurized fluid without the necessity of a selector valve to control the flow of such fluid to or from the actuator.

Additional objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawing—

FIG. 1 is a longitudinal cross-section view of the invention illustrating the piston and connected output member in a retracted position;

FIG. 2 is a cross-section view similar to FIG. 1 but showing the piston in its other position;

FIG. 3 is an enlarged fragmentary view of the exhaust control valve in the position shown in FIG. 1;

FIG. 4 is a longitudinal cross-section view of another embodiment of the invention illustrating the piston and output member in a retracted position;

FIG. 5 is a sectional view similar to FIG. 4 but showing the piston in an extended position;

FIG. 6 is a fragmentary sectional view essentially along the line 6—6 of FIG. 5; and

FIG. 7 is a sectional view along line 7—7 of FIG. 5.

Referring to the drawings, which illustrate preferred embodiments of the invention, FIG. 1 shows a cylinder or housing 10 having piston 11 reciprocally mounted therein. Secured to the left end of the cylinder 10 is the head or end member 12 which together with the piston 11 and the cylinder 10 forms an actuation chamber 13. Similarly, the other head or member 14 together with the cylinder 10 and the piston 11 define an actuation

chamber 15 on the right side of the piston. The hollow piston rod 16 which is secured to piston 11 in a particular manner, to be described in detail hereinafter, projects through the aperture in the end 14. To obviate leakage between the piston rod 16 and the head 14, spaced parallel ring grooves 17 and 18 have O-rings 19 mounted therein to engage the outer surface of the rod or output member 16.

The device 20 which is being reciprocated or positioned by the cylinder 10 is, as shown in FIG. 1, threadedly attached to rod or output member 16, and it should be understood that such apparatus may be connected to the rod 16 in any of the various expedients known to those skilled in the art.

Fluid pressure is supplied to the chambers 13 and 15 via the ports 21 and 22, respectively. Each of these ports 21 and 22 has connected thereto a source of pressurized gas, not shown, supplied thereto through conduits 24, and one or more electrically ignited explosive squibs 25 which, when ignited, will generate sufficient pressure to move piston 11 from one end of the cylinder to the other.

Inserted in and rigidly secured to the hollow piston rod 16 is a fitting or member 28 which, together with the disk 29 which is secured to the member 28 by nut 30, define, in the hollow rod 16, separate exhaust chambers 31 and 32 (see FIG. 3), and the outlet or exhaust passage 33. When the rod extends a short distance the port 34 will vent the passage 33 to the atmosphere. As shown in FIG. 3, chamber 31 is in continuous communication with the actuator chamber 13 through the port 35 while the chamber 32 is normally in communication with the actuator chamber 15 via the port 36.

The piston 11 will move with respect to rod 16 a distance x, as shown in FIG. 3, between engagement with disk 29 and the shoulder or stop 37 on rod 16. In one position (FIG. 1) the valving groove 40 of the piston piston 11 connects the ports 41 and 42, thereby connecting the chamber 31 with the exhaust passage 33 and blocking port 43. When shifted to the right, as shown in FIG. 2, the valving groove 40 connects the ports 42 and 43, thereby interconnecting the chamber 32 with the exhaust passage 33 while blocking fluid flow through the port 41.

In operation, when it is desired to move the piston 11 from the position as shown in FIG. 1 to the extended position as shown in FIG. 2, one of the explosive squibs 25 which communicates with the actuation chamber 13 is ignited by a suitable electrical signal, thereby producing highly pressurized gas in the chamber 13 to force the piston 11 the distance x into engagement with the shoulder 37 thereby interconnecting the actuation chamber 15 and the exhaust passage 33 via the port 36, exhaust chamber 32, port 43, valving groove 40 and port 42. This chamber is not yet in communication with the atmosphere as the port 34 in the right end of the piston rod is blocked by the end 14 and, consequently, the gas in the actuation chamber 15 tends to resist movement of the piston. However, the pressure generated by the explosive squib is initially very high and sufficient to overcome the resistance of the gas in chamber 15 and force the piston rod 16 outwardly from the end 14 until the port 34 is uncovered and resistance to piston 11 movement is overcome. As the piston 11 moves to the right, pressure in chamber 13 decays or gradually decreases due to the increased volume of this chamber and the cooling of the gases.

As the piston 14 approaches the terminal portion of its rightward stroke, the port 36 becomes blocked by the end 14 as the rod extends therethrough. Consequently, the chamber 15 is again sealed from the atmosphere and a predetermined volume of fluid is trapped therein. This

trapped fluid cushions the final movement of the piston 11 and prevents it from slamming against the end 14 thereby preventing damage to actuator components, as well as eliminating undesirable noise. When the piston reaches its rightwardmost position it will be held there by the pressure in the chamber 13 which is sealed against outward passage of such fluid. It should be emphasized that the inlet ports 24 will not permit fluid to flow outwardly from the cylinder 10 and the only escape of fluid, other than negligible leakage, from the cylinder is through port 34.

When it is desired to move the piston to the leftward position, one of the squibs 25 in communication with the chamber 15 is exploded thereby pressurizing chamber 15. Again, since the initial pressure from the squib will be relatively high, the pressure in the left actuation chamber 13 is overcome and the piston moves with respect to the rod 16 the distance x to a position wherein it engages the disk 29. In this position, the chamber 13 is vented to the atmosphere via the port 35, exhaust chamber 31, port 41, valving groove 40, port 42, exhaust passage 33 and port 34. As the piston approaches its leftward position, the port 34 is covered by the end 14 as the piston rod is retracted into the cylinder 10 and, hence, chamber 13 is no longer vented to the atmosphere and the trapped portion of fluid again forms a cushion which prevents the piston 11 from slamming into the end 12. The piston 11 is then maintained in the leftward position by the pressure which is trapped in the actuator chamber 14. The aforesaid operation can be repeated as often as desired by merely replacing the explosive squibs 25 or, if desired, by mounting a plurality of squibs on a manifold, not shown, connected to ports 21 and 22 and firing them at alternate ends of the actuator successively as required.

The inlet ports 24 are provided for test purposes so that proper operation of the actuator assembly may be verified prior to the actual use thereof without removing squibs 25. This is particularly important when the cylinder is used in devices, such as ballistic missiles or satellite boosters, wherein prior to actual use, the cylinder must be tested and retested to insure that, when ultimately used, it will function properly. Such tests are carried out when the cylinder has been idle for some time and the pressure which normally resists initial movement of the piston 11 is not present. However, should the testing require the actuator assembly be put quickly through one complete cycle, it is only necessary that a sufficiently large pressure be utilized in the testing procedure in order to overcome the aforesaid initial resistance of the piston 11 so that the appropriate actuator chamber 13 or 14 may be connected to the atmosphere.

FIGS. 4–7 illustrate another embodiment of the invention wherein many of the components thereof are identical to those of the FIG. 1 embodiment and hence are designated with like reference characters. As shown in FIGS. 4–5 the piston 50 is rigidly secured to the piston rod 51 which extends outwardly from the housing 10 in the same manner as the FIG. 1 embodiment. Extending through the piston 50 is a cylindrical bore 53 having a poppet valve 55 reciprocally mounted therein and operable to connect and disconnect the passage 57 formed in the piston 50 with the motor chambers 13 and 15. The passage 57 connects with the longitudinal passage 58 in the piston rod 51; the latter passage being connected by the passageway 59 to the atmosphere so that at all times the passage 57 and bore 53 are vented to the atmosphere.

As shown in FIG. 6 the central portion 60 of the poppet valve 55 is triangular shaped so that it reciprocates easily in the bore 53 while permitting fluid flow therearound. Conversely, the cylindrical portion 62 on each end of the valve, as shown in FIG. 7, has a diameter slightly smaller than the bore 53 so that the valve will fit snugly therein. Angular seals 64 surround the cylindrical portions 62 adjacent the head members 65 and seal off the bore 53 from chambers 13 and 15 when the valve is shifted to the right or left, respectively. While the central portion 60 is shown with a triangularly shaped cross-section it is within the contemplation of the invention to use other configurations which permit the valve 55 to reciprocate in the bore 53 while permitting flow from chambers 13 and 15 to the passage 57, for example, a square cross-section.

In operation, when the piston 50 is positioned as shown in FIG. 4 and it is desired to move the same to the opposite end of the cylinder 10, the chamber 13 is pressurized via passage 21 either by exploding an explosive squib 25 or by communicating high pressure fluid thereto through the conduit 24, thereby moving the valve 55 to the right to block flow from this chamber 13 to the conduit 57. In this right-hand position the chamber 15 is vented to the atmosphere through space formed between the bore 53 and the triangular central portion 60 of the valve 55, passages 57, 58, and 59 to eliminate resistance caused by fluid in chamber 15 as the piston 50 moves to the right. As the piston 50 nears the terminal portion of its rightward movement the valve head 65 strikes the end 14 and is shifted to the left thereby sealing chamber 15 from the atmosphere and trapping air therein which cushions the terminal movement of the piston 50.

When it is desired to shift the piston to the other end of the cylinder the chamber 15 is pressurized in the same manner as chamber 13 and pressure acting on the valve 55 shifts it to the left, if it is not already there, thereby sealing chamber 15 from the atmosphere and driving the piston 50 to the left. The valve in this left-hand position connects the chamber 13 to the atmosphere via the space between the triangular central portion 60 and the bore 53, passages 57, 58, and 59. It should be apparent that the piston can be shifted from one position to the other without the necessity of a complicated and complex valving arrangement for controlling the ingress and egress of fluids to and from the cylinder by merely communicating pressurized fluid to either of chambers 13 or 15.

While the invention has been described as having cylinder 10 held stationary and the output member 16 being extended and retracted therefrom, it is within the scope and contemplation of the invention that the output member will be held stationary and the cylinder be moved or that neither the cylinder nor output member be held stationary so that during operation both the cylinder and the output member move with respect to apparatus with which the actuator is associated. This in effect would make the cylinder 10 an output member.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A fluid actuated motor comprising a cylinder having first and second ends; a piston reciprocally mounted in said cylinder; a first actuation chamber formed between said first end and said piston; a second actuation chamber formed between said second end and said piston; a hollow piston rod connected to said piston and extending through said second end; means dividing the interior of said rod into a first exhaust chamber connected with said first actuation chember, a second exhaust chamber, and an exhaust passage; valve means associated with said piston to interconnect said first exhaust chamber and said exhaust passage when said second actuation chamber is being increased in volume and to interconnect said second exhaust chamber with said exhaust passage when said first actuation chamber is being increased in volume; a first port in said rod operatively connecting said exhaust passage with the atmosphere and positioned to be closed by said second end when said first end approaches

said piston; and a second port in said rod connecting said second actuation chamber and said second exhaust chamber and positioned to be closed as said second end approaches said piston.

2. A fluid actuated motor comprising a cylinder having first and second ends; a piston reciprocally mounted in said cylinder; a first actuation chamber formed between said first end and said piston; a second actuation chamber formed between said second end and said piston; a piston rod secured to said piston and extending through said second end of said cylinder; an exhaust passage in said rod normally connected to the atmosphere; valve means associated with said piston to interconnect said first chamber and said exhaust passage when said piston is being driven toward said first end and to interconnect said second chamber with said exhaust passage when said piston is being driven toward said second end; a first port in said hollow rod connecting said exhaust passage with the atmosphere and positioned to be closed by said second end when said piston approaches said first end, and a second port in said rod connecting said second chamber and said exhaust passage and positioned to be closed as said piston approaches said second end to block flow of fluid from said second end.

3. A fluid actuated motor comprising a cylinder having first and second ends; a piston reciprocally mounted in said cylinder; a first actuation chamber formed between said first end and said piston; a second actuation chamber formed between said second end and said piston; a piston rod projecting through said second end and having said piston mounted thereon; spaced shoulder means projecting radially from said rod and having said piston mounted therebetween for movement between a first position when pressure in said first chamber exceeds pressure in said second chamber and a second position when the pressure in said second chamber exceeds pressure in said first chamber; an exhaust passage in said rod normally connected to the atmosphere; three longitudinal spaced ports in said rod between said shoulders, a first of said ports in fluid communication with said first chamber, the middle port being in fluid communication with said passage, and the third port being in fluid communication with said second chamber; and valve means formed in said piston operable to interconnect said first and middle ports when in said second position and to interconnect said third and middle ports when in said first position.

4. A fluid actuated motor comprising a cylinder having first and second ends; a piston reciprocally mounted in said cylinder; a first actuation chamber formed between said first end and said piston; a second actuation chamber formed between said second end and said piston; a piston rod projecting through said second end and having said piston operably mounted thereon; an exhaust passage in said rod; three longitudinal spaced radially extending ports in said rod, a first of said ports in fluid communication with said first chamber, the middle port being in fluid communication with said passage, and the third port being in fluid communication with said second chamber; a valve formed in the piston operable to interconnect said first and middle port when pressure in said first chamber exceeds pressure in said second chamber and to interconnect said third and middle ports when said pressure in said second chamber exceeds pressure in said first chamber; a fourth port in said rod normally connecting said exhaust passage with the atmosphere and positioned to be closed by said second end when said piston approaches said first end; and a fifth port in said rod connecting said second chamber and said exhaust passage and positioned to be closed by said second end as said piston approaches said second end.

5. A fluid actuated motor comprising a cylinder having first and second ends; a piston reciprocally mounted in said cylinder; a first actuation chamber formed between said first end and said piston; a second actuation chamber formed between said second end and said piston; a piston rod projecting through said second end and having said piston mounted thereon for limited relative movement to a first position when pressure in said first chamber exceeds pressure in said second chamber and to a second position when pressure in said second chamber exceeds pressure in said first chamber; an exhaust passage in said rod; three longitudinally spaced ports in said rod, the first of said ports being in fluid communication with said first chamber, a middle of said ports being in fluid communication with said passage, and the third port being in fluid communication with said second chamber; valve means formed in the piston adjacent said rod for interconnecting said first and middle ports when said piston is in said second position and for interconnecting said third and middle ports when said piston is in said first position; a fourth port in said rod normally connecting said exhaust passage with the atmosphere and positioned to be closed by said second end when said piston approaches said first end; and a fifth port in said rod connecting said second chamber and said exhaust passage and positioned to be closed by said second end as said piston approaches said second end.

6. A fluid actuated motor comprising a cylinder having first and second ends; a piston reciprocally mounted in said cylinder; a first actuation chamber formed between said first end and said piston; a second actuation chamber formed between said second end and said piston; a piston rod projecting through said second end and having said piston mounted for limited relative movement thereon to a first position when pressure in said first chamber exceeds pressure in said second chamber and to a second position when pressure in said second chamber exceeds pressure in said first chamber; an exhaust passage in said rod; three longitudinally spaced ports in said rod, the first of said ports being in fluid communication with said first chamber, the middle of said ports being in fluid communication with said passage, and the third port being in fluid communication with said second chamber; and valve means formed in the piston adjacent said rod for interconnecting said first and middle ports when said piston is in said second position and for interconnecting said third and middle ports when said piston is in said first position.

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