March 24, 1970 W. L. MOORE 3,502,001

FLUID OPERATED CYLINDER

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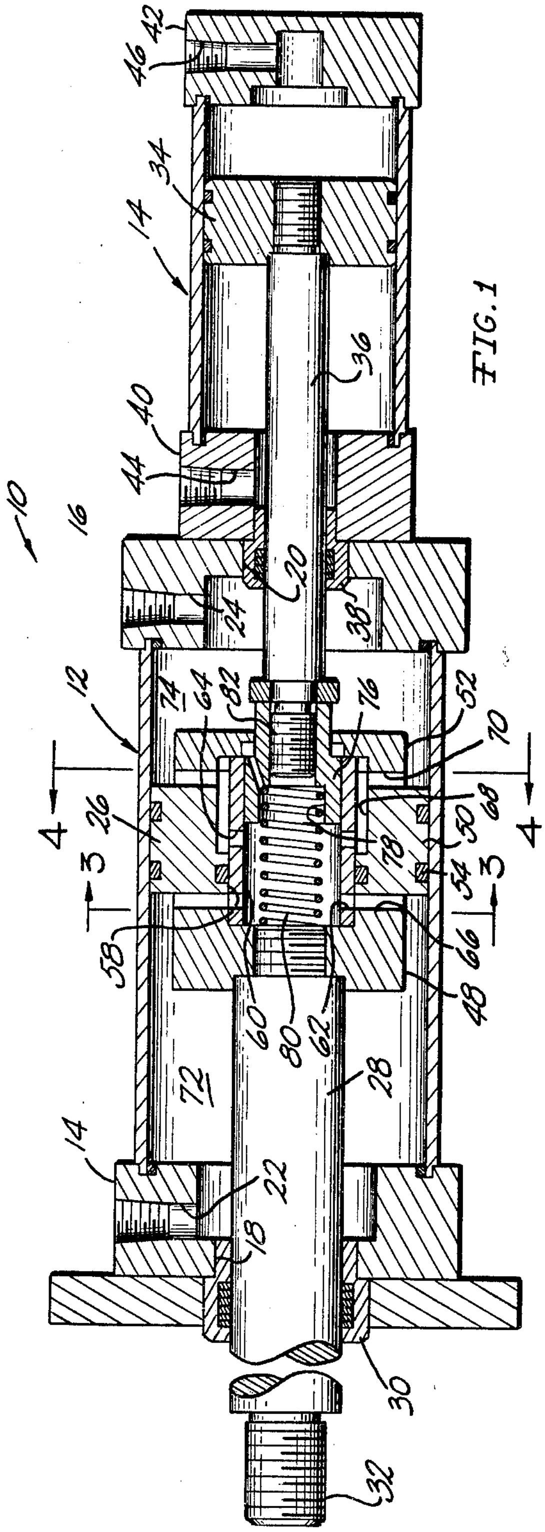

FIG. 1

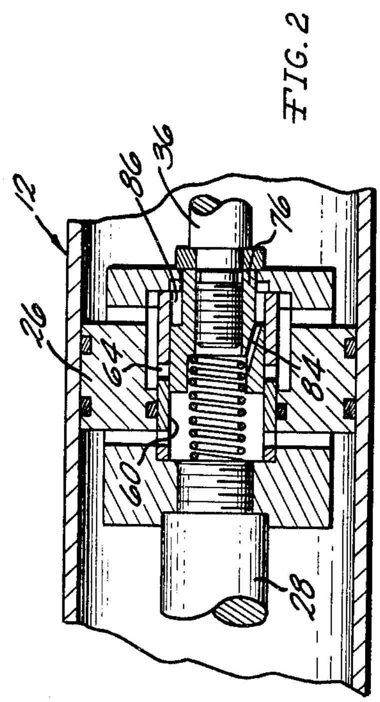

FIG. 2

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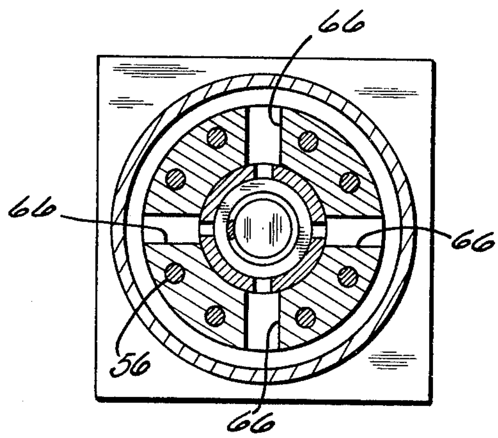

FIG. 3

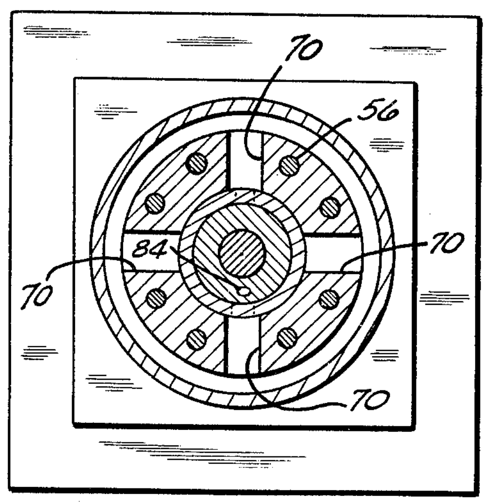

FIG. 4

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FLUID OPERATED CYLINDER

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ABSTRACT OF THE DISCLOSURE

A fluid-actuated cylinder for use in applying rectilinear power strokes wherein a minimum volume of fluid is utilized. The cylinder contains a piston which has a passageway therethrough for flow of fluid through the piston when the latter is moved under no load conditions so that no exhausting of fluid from the cylinder during such movement is necessary. A spool valve is positioned in the passageway for movement under predetermined load conditions to a position to close the passageway. A mechanism is connected to the spool for moving the piston in either direction with the passageway open under no load conditions, and for moving the spool to a closed position when the pre-established load condition is encountered. The cylinder is ported at opposite ends to permit ingress and egress of working fluid during the time periods when the spool valve is moved to the closed position.

BACKGROUND OF THE INVENTION

The present invention relates to fluid-actuated power cylinders and is directed particularly to an improved piston construction and associated pilot control means. The present invention can be used with either hydraulic power cylinders or pneumatic power cylinders.

It is conventional practice when employing hydraulic or pneumatic power cylinders to utilize the working fluid to displace the piston the full length of the stroke. During this operation the actual working stroke may be relatively short, and therefore, the amount of working fluid required to be displaced may be several times that which is necessary for the working portion of the stroke. Accordingly, the pumping and control apparatus that is required with a large bore cylinder is relatively large and expensive, and to a great extent limits the capacity of the work that can be performed by the power cylinder assembly.

SUMMARY OF THE INVENTION

The present invention has overcome the problems of the prior art, fluid-actuated power cylinder devices, which have been limited in their capacity of speed and operation by the restrictions that have been placed on controls, pumping equipment and in the fluid flow passages to the cylinder. The present invention provides an arrangement whereby the pumping equipment to the cylinder requires a capacity only sufficient to that for moving the piston through the work portion of the stroke. Thus, the fluid reservoir and the piping and capacity of the pump for pumping the fluid to the cylinder can be restricted to this volume.

According to one form of the present invention a fluid actuated piston and cylinder assembly is provided which comprises a main cylinder having ports at opposite ends for ingress and egress of a working fluid, a main piston mounted in said main cylinder for reciprocation therein and defining with said main cylinder, working fluid chambers on opposite sides of the main piston. A main piston rod extends into one end of the main cylinder, a pilot control mechanism is mounted on the other end of the cylinder and has a control rod extending into the other end of the cylinder. The main piston has a passageway therethrough providing communication between the op-

posite sides of the piston, and a valve means is mounted in the passageway for limited axial movement and is responsive to a predetermined axial load to move to a closed position to close the passageway. The main piston rod is connected to the piston, and the control rod is connected to the valve means, with the valve means being mounted in the piston so as to be operative when an axial load less than the pre-determined axial load is applied thereto, to move the main piston in the direction of the applied load. When the piston rod engages a workpiece or other obstruction which requires the work stroke of the piston to be carried out, the valve means will be closed by the control rod, and the high pressure fluid can then be introduced into the cylinder to effect the work stroke of the cylinder. Thus, during the no load movement of the piston, the passageway through the piston is open, and no working fluid is required to be introduced into the cylinder for the purpose of moving the piston. The fluid in the piston is merely transferred from one side of the piston to the other side during this no-load condition. However, as soon as the main piston rod encounters an opposing force, the passageway through the piston will be closed, and a suitable control may then be utilized for introducing high pressure fluid into the cylinder for completing the work stroke. Under these conditions, the body of work fluid that must be displaced is substantially less than that required when the work fluid not only must move the piston through the work portion of the stroke, but also must move the piston through the remainder of its entire stroke. When using the present invention the working fluid can be either a liquid or a gas.

Accordingly, it is the primary object of the present invention to provide an improved fluid-acuated power cylinder which will satisfy the above requirements.

More specifically, it is an object of the present invention to provide improved pneumatic or hydraulic power cylinders which can apply a desired power stroke within a system utilizing a minimum volume of fluid for effecting the power stroke.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 is a sectional view taken longitudinally through a fluid-actuated power cylinder embodying the present invention, and showing the piston thereof with its passageway in a normally open position;

FIGURE 2 is a fragmentary sectional view similar to FIG. 1, but showing the piston with its passageway in a closed position;

FIGURE 3 is a sectional view taken on the line **3—3** of FIG. 1; and

FIGURE 4 is a sectional view taken on the line **4—4** of FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring now to the drawings, the invention will be described in greater detail. As there shown, the fluid-actuated piston-and-cylinder assembly **10** comprises a main cylinder **12** and a pilot control cylinder **14**. The main cylinder **12** has heads **14** and **16** at opposite ends, with the heads having axial bores **18** and **20**, respectively, therein. The heads **14** and **16** are provided with ports **22** and **24** for ingress and egress of a working fluid which, by way of example, may be either a hydraulic liquid or compressed air.

Connected within the cylinder **12** for axial reciprocation is the piston **26**. A main piston rod **28** is threadedly connected to one end of the piston **26** and extends out of the forward end of the cylinder **12** through the axial bore **18**, and a suitable sealing member **30** is fitted around the rod **28** to prevent leakage of working fluid from the forward end of the cylinder **12**. The forward end of the rod **28** is threaded, as at **32** for connection to tooling (not shown) which is to be actuated by fluid-actuated piston-and-cylinder assembly **10**.

The pilot control cylinder **14** is mounted on the rear end of the main cylinder **12** and has a piston **34** axially movable therein, and to which is connected the control rod **36** which extends through the bore **20** into the interior of the main cylinder **12**. Suitable sealing means are provided at **38** to prevent leakage of working fluids around the rod **36**.

The pilot control cylinder **14** has heads **40** and **42** at its opposite ends which in turn have ports **44** and **46** for ingress and egress of a control fluid for controlling movement of the piston **34**. The control rod **36** is connected to main piston **36** in a manner which now will be described.

Th piston **26** includes three body sections **48**, **50** and **52**. The middle section **50** has conventional piston rings **54** to provide an effective seal around the periphery of the piston. The end sections **48** and **52** are secured to the middle section **50** by suitable screws **56**, which can be seen in FIGS. 3 and 4. An axial bore **58** is located in the piston **26**, extending through the middle section **50**, and terminating in the end sections **48** and **52**. A sleeve **60** is fitted in the bore **58** and has a first set of radially directed ports **62** adjacent to the forward end of the sleeve and a second set of ports **64** rearwardly thereof. The radial ports **62** are aligned with radial ducts **66** formed between the end section **48** and the middle section **50**, so as to provide fluid communication between the interior of the sleeve **60** and the annular space surrounding the forward end section **48**. The radial ducts **64** are in communication with the axial passageways **68** in the middle section **50** and with the radial ducts **70**, located between the middle section **50** and the end section **52**, so as to provide communication between the interior of the sleeve **60** and the annular space surrounding the end section **52**. By virture of this arrangement, the ducts **66**, **62**, the interior of sleeve **60**, ducts **64**, **68** and **70** provide a fluid passageway between the chamber **72** and the chamber **74**, located on opposite sides of the piston **26**. The ducts **66** and **70** define ports in the opposite sides of the piston **26** so that the passageway terminates at its opposite ends in direct communication with the chambers **72** and **74**. Thus, if the piston **26** is moved in either direction the fluid in chambers **72** and **74** can be displaced through the passageway, and thus, during such movement, no fluid need be exhausted from the main cylinder **12**. It will be recognized that in order for the piston **26** to be effective to move the rod **28** under load conditions, it will be necessary that the passageway through the piston **26** be closed so that high pressure working fluid can be introduced through the port **24** to advance the piston **26** under load conditions. The means for accomplishing these ends will now be described.

A spool valve element **76** is mounted in the sleeve **60** and it has a cavity **78** in which a compression spring **80** is seated, the latter being held in compression between spool element **76** and the end of rod **28** that is secured in piston **26**. The spool element **76** is threadedly connected at **82** to the end of the control piston rod **36**, so that under no-load conditions, the spring **80** will act against the spool element **76** to hold the latter in its normal position at the rear end of the piston **26**, as is shown in FIG. 1, and under such normal conditions, the control piston rod **36** can move the piston **26** in either direction in the cylinder **12** and fluid within the cylinder **12** can pass back and forth through the piston via the passageway therein, previously described.

When a control fluid enters the control cylinder **14** through the port **46**, to move the piston **34** to the left, as seen in FIG. 1, the control rod **36** will advance the piston **26** a corresponding distance to the left, until the tooling (not shown) on the end of rod **28** engages a workpiece or the like, so as to impose an opposing force against the rod **28**. Under which circumstances, the control rod **36** will then advance the spool **76** against the pressure of the compression spring **80** to a closed position in which the ports **64** are closed. This position of the spool **76** can be seen in FIG. 2. High pressure fluid can now be introduced into the chamber **74** of the main cylinder **12**, via the port **24**, for moving the piston **26** through the working portion of its stroke. A volume of fluid corresponding to the displacement of the piston **26** during the working portion of its stroke will then be discharged through the port **22** of cylinder **12**. As soon as the working portion of the stroke is completed, introduction of high pressure fluid through port **24** will be terminated, and fluid can now be introduced through port **44** of pilot control cylinder **14**, for reversing direction of movement of piston rod **36**. This will have the effect of returning the spool valve element **76** to its normally open position shown in FIG. 1. As soon as the valve element **76** is in its open position, the pilot control cylinder **14** will be effective to return the piston **26** in the direction of the head **16**, and during this return stroke, the fluid in chamber **74** that is displaced by movement of the piston **26**, can pass through the passageway in the piston **26** into the chamber **72**, thereby avoiding the necessity of exhausting fluid from the cylinder **12** during this return stroke.

In order to avoid the occurrence of an undesirable shock between the end of the spool valve element **76** and the section **52**, against which the spool element **76** is adapted to seat, a cushioning means is provided. This is accomplished by providing a duct **84** of limited capacity, through the spool valve element **76**. When the latter is moved to the position shown in FIG. 2, fluid in the sleeve **60** can pass through the duct **84** to the annular chamber located at **86**. When the spool valve element **76** is moved back to the position shown in FIG. 1, the trapped fluid in chamber **86** will dampen the return stroke because the passage or duct **84** will restrict the rate at which the trapped fluid can escape from the chamber **86**.

As previously indicated, the above-described invention can be used with either a pneumatic or hydraulic system. When used with a pneumatic system the invention has the particular advantage in that the only loss of high pressure air to the atmosphere during a cycle of operation is that amount which is equal to the displacement of the piston **26** during the working portion of the stroke, as distinguished from conventional pneumatic systems wherein during each cycle of operation the loss of high pressure air from the system corresponds to an amount equal to the displacement of the piston **26** during its entire stroke. Similarly, with respect to hydraulic systems, the connecting lines to the cylinder **12** as well as the controls and pumping equipment required can be much smaller when using the present invention. This desirable feature is realized because of the fact that the auxiliary equipment used with the cylinder **12** need only supply a volume of high pressure fluid corresponding to the work stroke portion of the piston **26**, as distinguished from having to supply a volume of pressure fluid corresponding to the displacement of the piston during its entire stroke, such as required by a conventional piston and cylinder assembly.

Thus, it will be understood that when the present invention is used with a hydraulic system, the large volume of hydraulic fluid normally required with large bore cylinders is eliminated, the need for large capacity control means is eliminated, and better results are realized when using smaller controls which will function more accurately. It is inherent in the conventional prior art devices where large bore cylinders are used, to have heat problems resulting from the large amount of friction involved in the large capacity equipment required, and these problems have been substantially reduced in the present system by virtue of the relatively small volume of fluid used to produce the working portion of the piston stroke. The large reservoirs, pumps and motors which were previously required, are no longer necessary when using the present invention. Also, another significant feature of the present invention is that the present arrangement allows relatively high velocity action to occur without the accompanying high velocity shock loads passing through the pumping and high pressure circuits, which occurs with respect to the large bore devices currently found in the prior art.

With respect to pneumatic equipment, it is found that the savings resulting from using the present invention are very significant. In view of the fact that the large bore cylinder piston can be moved, in effect, through the air in the cylinder, that air can be maintained under maximum desired pressure at all times. A suitable valve arrangement associated with the rod-end port would permit this to occur. Both the control piston and the main piston would advance in a forward direction, the same as in the hydraulic cycle. After the valve spool element is seated in the closed position, a two-way valve in the air system can be opened to allow air to be vented from the chamber **72** for the work portion of the stroke only, and the venting through a flow control element would permit speed control of the piston during the advancing stroke. When the working portion of the stroke is completed, the venting two-way valve would return to the closed position before the retraction stroke, the maximum pressure air on the chamber **74** side of the main piston would be released in the chamber **72** resulting in a minimum pressure drop within the cylinder without exhausing the air from the cylinder, which avoids replenishing the entire cylinder volume during each cycle of operation.

Having thus described my invention, I claim:

1. A fluid-actuated piston-and-cylinder assembly comprising a main cylinder having ports at opposite ends for ingress and egress of a working fluid, a main piston mounted in said main cylinder for reciprocation therein and defining with said main cylinder working fluid chambers on opposite sides of the main piston, a main piston rod extending into one end of said main cylinder, a pilot control mechanism mounted at the other end of said cylinder and having a control rod adapted to reciprocate extending into the other end of said cylinder, said main piston having a passageway therethrough providing communication between the opposite sides thereof, and valve means mounted in said passageway for limited axial movement and responsive to a predetermined axial load to move to a closed position to close said passageway, one of said rods being connected to said piston and the other of the rods being connected to said valve means, said valve means being mounted in said main piston so that when in

said closed position it is in a nonresponsive position to pressure conditions of said working fluid in the chamber adjacent to said other end and when in its open position so as to be operative when an axial load less than said predetermined axial load is applied thereto to move said main piston in the direction of the applied load, said valve means including a valve element movable relative to said main piston to close said passageway, a compression spring operatively disposed between said main piston and said valve element to a normally open position, and means are provided between said valve element and said main piston for cushioning said valve element when being returned to a normally open position.

2. In a fluid-actuated piston-and-cylinder assembly, a main piston adapted to be connected on one side to a piston rod and having a passageway therethrough providing fluid communication between opposite sides thereof, valve means mounted in said passageway for limited axial movement between a normally open position when fluid can pass in either direction through said passageway and a closed position preventing flow of fluid therethrough, said valve means being responsive to an axial load of a predetermined magnitude applied from the direction of the other side of said piston to move to its closed position, said valve means being mounted in said piston so as to be operative when an axial load less than said predetermined magnitude is applied to move said piston in the direction of the applied load while maintaining its normally open position and being mounted so that when in said closed position it is nonresponsive to the pressure of the fluid on said other side of said piston, said valve means including a valve element movable relative to said piston to close said passageway, and a compression spring operatively disposed between said piston and said valve element urging said valve element to the normally open position, said spring having characteristics for holding said element in the open position until an axial load at least equal to said predetermined load is applied to the element, and means are provided between said valve element and said piston for cushioning said valve element when being returned to a normal position.

3. In a fluid-actuated piston-and-cylinder assembly according to claim **2**, wherein said means comprises a cavity defined in said piston in which said valve element is adapted to seat when in its normally open positions, and restricted fluid passage means communicate between the cavity and said passageway.

4. In a fluid-actuated piston-and-cylinder assembly according to claim **3**, wherein said restricted fluid passage means comprises at least one duct extending through said valve element.

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U.S. Cl. X.R.

91—189, 378, 431; 92—152