

[54] **RECIPROCATING FLUID OPERATED ACTUATOR**

[72] Inventor: **Hanns-Dieter Paschke**, Olgaweg 6,
Neckarsulm, Germany

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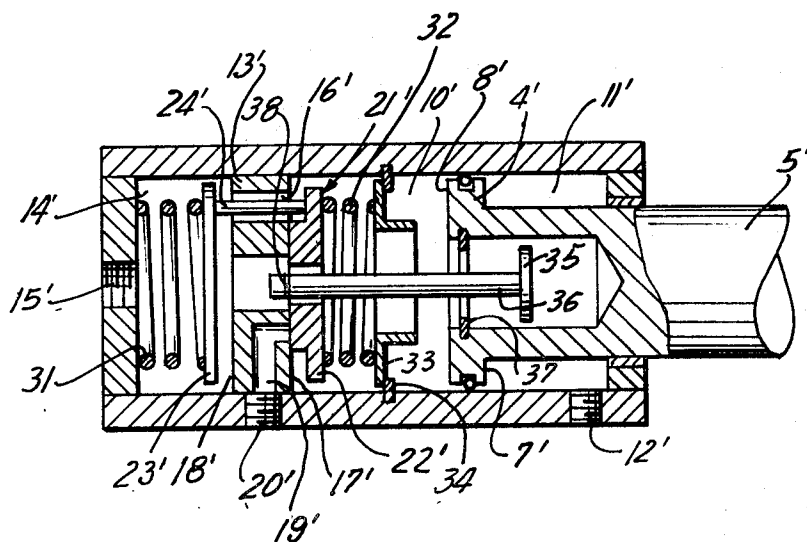
Primary Examiner—Paul E. Maslousky

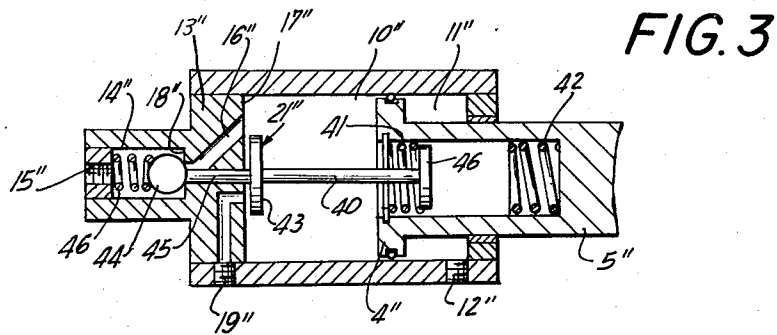
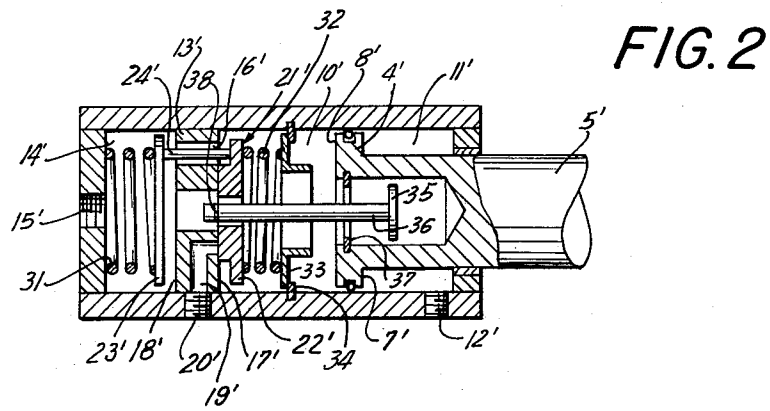
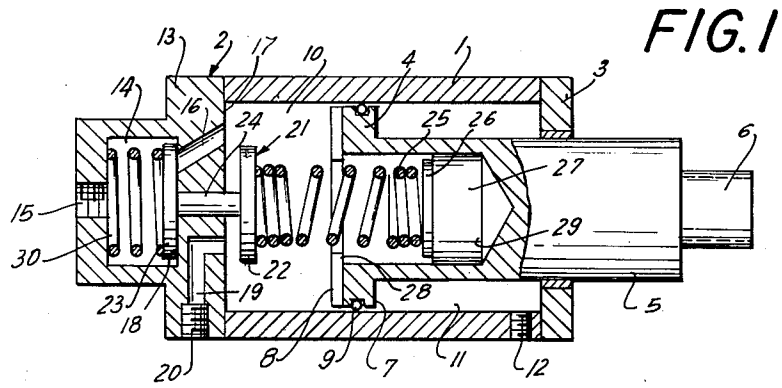
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[57] **ABSTRACT**

A reciprocating fluid operated actuator comprising a cylinder containing a differential piston and means for admitting fluid under pressure to the opposite ends of the cylinder and a reversing valve in the closed end wall of the cylinder for selectively opening and closing an inlet and outlet port at that end. The reversing valve is arranged to be actuated automatically by the piston through a spring and a lost motion mechanism at the opposite ends of the piston stroke. On the remote side of this end wall is a further pressure chamber, to which pressure fluid is admitted, and the reversing valve includes a valve element in this chamber controlling the flow through an inlet passage from the chamber into the adjacent end of the main cylinder, and a second valve element within the main cylinder controlling the outlet. The pressure inlets and outlets are all connected to the main cylinder.

6 Claims, 4 Drawing Figures





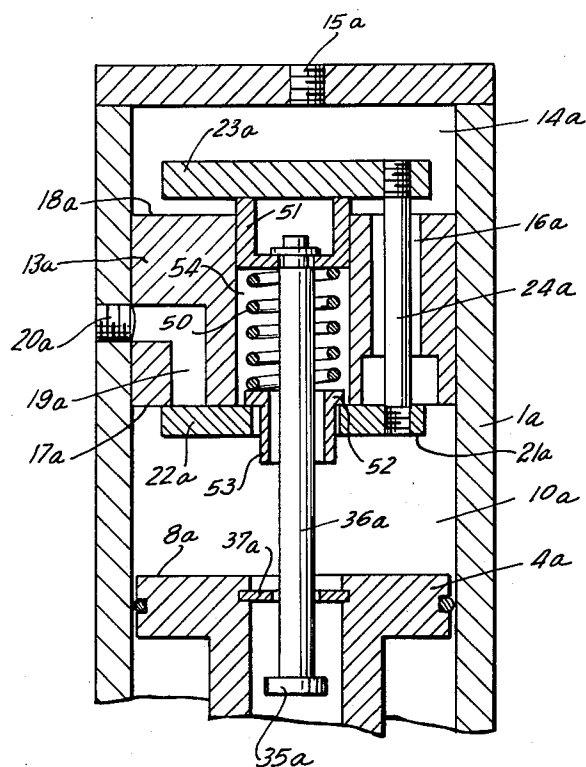


FIG. 4

RECIPROCATING FLUID OPERATED ACTUATOR

This invention relates to a fluid pressure operated actuator for generating a reciprocating movement, consisting of a cylinder containing a displaceable differential piston which separates two cylinder spaces from each other.

In such actuators it is known to provide a pressure supply connection leading into the first cylinder space which is associated with the smaller piston face, while in the second cylinder space associated with the larger piston face passages are provided for the supply and exhaust of pressure fluid to and from this space, being controlled by a valve which is reversible automatically by the piston in or near its extreme positions.

Hitherto the two latter passages and the reversing valve have been disposed in the piston, the switch-over of the longitudinally movable reversing valve taking place at the extreme positions of the piston by engagement with the end walls of the cylinder, the return line from the cylinder space associated with the larger piston face being located in the hollow piston rod.

Such arrangements have various disadvantages. For example the piston diameter must exceed a certain minimum size as otherwise the reversing valve cannot be accommodated, but in many applications, where only a limited output force is required a piston diameter of a few centimeters or less is sufficient, although this does not allow a reversing valve to be located in the piston. A further disadvantage lies in the fact that the piston rod must always be extended out of the cylinder, since the piston rod itself contains the return flow line. Often however it is not necessary for the piston rod to project externally, for example when the device is used as an oscillation generator for riddling devices, in which, by virtue of the reciprocating mass of the piston, the cylinder is itself caused to oscillate, these oscillations being transferred to the riddling plates, screens or the like. Another disadvantage is than if the supply and/or return lines are connected to the oscillating piston rod it is necessary to provide flexible connections.

It is an object of the invention accordingly to provide an improved reciprocating fluid operated actuator which will at least partly meet some or all of the disadvantages of existing designs.

The invention consists broadly in a reciprocating fluid pressure operated actuator, comprising a cylinder containing a displaceable differential piston having opposing faces of different effective areas the said piston and cylinder defining a first volume associated with the smaller area side of said piston, and a second volume associated with the larger area side of said piston, a fluid pressure inlet communicating with said first volume, a second fluid pressure inlet and a fluid outlet communicating with said second volume, and a reversing valve mounted in or on a wall of said cylinder and arranged selectively to open and close said second fluid pressure inlet and said fluid outlet, in opposition, said reversing valve being controlled, through springs means, by said piston at or adjacent the extreme operative positions of said piston, and so arranged that said valve is held in one or other operative position by the pressure of the operating fluid until so reversed.

Preferably, the end wall of the second cylinder volume bounds on the opposite side a chamber in to which a fluid pressure supply line leads, there being

provided in the end wall a first passage which connects together the two end faces and a second passage connecting the end face which lies towards or within the cylinder space to a return flow line, the reversing valve having one valve element on each side of the end wall, these valve elements alternately covering or exposing the end of the first passage on one side of the end wall and exposing or covering the end of the second passage on the other side of the end wall. In one position of the reversing valve, therefore, this second cylinder space is linked with the return flow line, so that the pressure fluid acting on the smaller piston face, pushes the piston towards the aforesaid end wall. When the piston has reached its relative extreme position, the reversing valve is rapidly switched over and the connection of this second cylinder space with the return flow line is closed and a connection made between this cylinder space and the supply line, so that the pressure acting on the larger piston face displaces the piston in the other direction.

It is important to the perfect functioning of the device that the reversing valve should always be moved abruptly from one position into the other, in order to avoid a midway position in which both passages in the end wall are temporarily open, since this would allow the pressure fluid to escape directly into the return flow line. This abrupt change-over is achieved by means of toggle-action springs which are stressed by the movement of the piston into its extreme positions, and then abruptly shift the reversing valve to the other position. In one such arrangement the reversing valve is operated by the piston through a combined tension and compression spring, the spring being compression-stressed upon reversal into one position and tension-stressed upon reversal into the other position. The reversing valve can also be operated by the piston through two tension or compression springs acting in opposite directions, or by a single compression spring.

The combined tension and compression spring can be arranged to bear directly at one end against the piston and at the other on the reversing valve. However it is also possible to provide in the piston a longitudinally displaceable rod which is connected to the piston against withdrawal, and which cooperates with the reversing valve and is in turn connected to the piston in one of the two directions of displacement through a spring which is not biased until the rod actuates the reversing valve. Alternatively, the piston itself can through a spring, switch the reversing valve into one position while only reversal into the other position is performed by the rod, and in fact likewise through the same spring.

The moment of switchover of the reversing valve depends on the one hand on the spring tension and on the other on the pressure of the fluid supplied. In order to be able to keep the piston stroke constant regardless of the pressure level, it is advantageous for the reversing valve to be connected to the piston through a stop which admits of a clearance between the reversing valve and the piston in keeping with the piston stroke desired. This stop can for example be constituted by the spring disposed between the piston and the reversing valve or between the piston and the aforesaid rod, when this spring is fully compressed, in other words, when its spiral turns abut against each other.

In order to ensure that the device will start up when the pressure fluid is supplied, the reversing valve should be spring-loaded, or subject to gravity or other force such that, in its inoperative state, it blocks one or other passage in the end wall, to avoid the reversing valve being in an intermediate position when the device is started, in which case the pressure fluid could flow through the passages in the end wall directly into the return flow line. This spring may be constituted by a spring which at the same time forms the spring abutment for the reversing valve.

The invention may be performed in various ways and four specific embodiments will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a longitudinal section through a reciprocating fluid-operated actuator according to the invention, including a reversing valve operated directly by the piston through a combined tension and compression spring,

FIG. 2 is a longitudinal section through a second example which includes a reversing valve switched over in one direction directly by the piston through a compression spring and in the other direction by a rod guided in the piston,

FIG. 3 is a longitudinal section through the third example, in which the reversing valve is switched over in both directions by a rod guided in the piston, and

FIG. 4 illustrates a modified form of the embodiment of FIG. 2.

Referring first to the embodiment of FIG. 1, the device consists of a cylinder 1 whose ends are closed by covers 2 and 3, and which contains a movable differential piston 4. Extending from the piston 4 is a piston rod 5 which passes through the end cover 3 and has on its free end a threaded portion 6 for attachment to a machine part which is to be moved. As a result of the piston rod 5, the end face 7 of the piston is smaller in area than the end face 8 of the piston. The piston 4 is sealed with respect to the interior cylinder wall by an O-ring 9, and thus separates from each other two cylinder spaces 10 and 11. A fluid pressure supply connection 12 extends through the cylinder wall into the cylinder space 11 associated with the smaller piston face 7. Another fluid pressure supply connection 15 leads into a chamber 14 lying on the opposite side of a wall 13 which forms the end wall of the other cylinder space 10. Provided in the end wall 13 is a first passage 16 which connects the two end faces 17 and 18 of the end wall 13, and a second passage 19 which connects the end face 17 which is within the cylinder space 10 to a return or exhaust flow connection 20. Longitudinally displaceable in the end wall 13 is a reversing valve generally designated 21, which has valve elements 22 and 23 mounted one on each side of the end wall 13. In this embodiment, the valve elements are in the form of valve plates or discs which are connected to each other by a pin 24 and separated by a fixed distance which is greater than the thickness of the end wall 13 in this region. The valve plate 22 is so constructed that it can selectively mask or expose the end of the passage 19, and the valve plate 23 can likewise mask or expose the end of the passage 16 which leads into the chamber 14.

The reversing valve is switched over at or adjacent the extreme positions of the piston 4 by means of a

combined tension and compression spring 25, which is attached at one end to the reversing valve 21 and at the other end to a spring plate 26 which is displaceable in the piston 4. The spring plate 26 can move between stops 28 and 29 in a recess 27 in the piston 4 or in the piston rod 5, and thus acts as a lost motion mechanism. Also acting on the reversing valve 21 is a spring 30 which urges the reversing valve 21 into the position shown in FIG. 1 when the device is not operating. This prevents both passages 16 and 19 being open when the device is started by the supply of pressure fluid to the connections 12 and 15, and so prevents fluid flowing from the passage 16 through the cylinder space 10 and directly into the return flow line 20.

This device operates in the following manner:

The supply of pressure fluid through the connection 12 applies pressure to the smaller piston face 7, while in the position of the reversing valve 21 as illustrated the return flow line 19 is open. The piston 4 therefore moves to the left (in the drawing). When the piston 4 nears its extreme left-hand position, the spring plate 26 engages the stop 29, and upon further leftwards displacement of the piston 4, the spring 25 is compressed. At a definite position, which depends on the pressure of the fluid fed through the connections 12 and 15, the force of the spring 25 can overcome the combined force of the spring 30 and the pressure acting on the valve plate 23, so that the reversing valve is abruptly shifted into its other operative position, in which it seals off the return flow passage 19 and opens the passage 16. In this position the pressure fluid supplied through the connection 15 can pass into the cylinder space 10, so that the reversing valve 21 is held in this position by the pressure acting on the valve plate 22. Since the end face 8 of the piston is larger than the piston face 7, the piston 4 is therefore displaced to the right in the drawing. When the piston 4 nears its extreme right-hand position, the spring plate 26 is engaged by the stop 28, and upon further movement of the piston 4 to the right, the spring 25 is extended until the tensile spring force thereby generated is sufficient to pull the reversing valve 21 back into the position shown in FIG. 1. The process is then repeated, i.e. the piston 4 performs a continual reciprocating movement as long as pressure fluid continues to be supplied to the pressure inlets 12 and 15.

In the example illustrated in FIG. 2 like parts are indicated by the same reference numerals, with added suffixes. The end wall 13' of the cylinder space 10' is formed by a component inserted into the cylinder 1', and which again has a passage 16' providing communication between the two end faces 17' and 18', and a passage 19' which connects the end face 17' which lies within the cylinder space 10' to a return or exhaust connection 20'. As in the previous example, the passages 16' and 19' are controlled by a reversing valve 21' which has two valve plates 22' and 23', one on each side of the end wall 13', which are held apart at a fixed distance from each other by one or more spacer pins 24', the distance being greater than the thickness of the end wall 13'. As in the preceding example, the end wall 13' also separates off a chamber 14' into which leads a pressure fluid supply connection 15'.

In this example the reversing valve 21' is switched over in a somewhat different manner from the embodi-

ment shown in FIG. 1. In this case, two counteracting compression springs 31 and 32 are arranged to act on the reversing valve 21' in opposite directions, the spring 31 being stronger than the spring 32, so as to hold the reversing valve 21' normally in an inoperative position. The spring 31 therefore simultaneously performs the function of spring 30 in FIG. 1. The spring 32 abuts at one end on the valve plate 22' and at the other end on a displaceable spring abutment plate 33, the movement of which in one direction is restricted by a snap ring 34. In the position of the reversing valve 21' as illustrated, the piston 4' is moved rightwardly in the drawing, since the passage 16' is open so that the pressure fluid fed through the connection 15' can pass into the cylinder space 10' and act on the larger piston face 8'. The reversing valve is held in the position illustrated by the pressure of the spring 32 and by the pressure of the fluid acting on the valve plate 22'. When the piston 4' nears its extreme right-hand position, a flange 35 on the end of a rod 36 which is movable relative to the piston 4', comes in contact with a stop 37 attached to the piston 4' and at the same time a stop 38 on the other end of the rod 36 engages the valve plate 22' so that the reversing valve 21', assisted by the force of the spring 31, snaps into the other extreme position in which the passage 16' is blocked and the passage 19' is opened. The pressure fluid fed through the connection 12' can now displace the piston 4' leftwardly again. As it nears its extreme left-hand position, the piston 4' engages the spring plate 33 and upon further movement of the piston 4' to the left, the spring 32 is compressed until the spring force is sufficient to overcome the force of the spring 31 and the pressure acting on the spring plate 23'. The reversing valve 21' then snaps back into the position illustrated.

In the embodiment illustrated in FIG. 3 the parts are again indicated by the same reference numerals, each with an added double suffix. This example differs from that shown in FIG. 1 essentially in that the reversing valve 21'' is switched over in both directions by means of a rod 40 which is longitudinally displaceable in the piston 4'', or in the piston rod 5'', between two compression springs 41 and 42. In this case, the reversing valve 21'' comprises a valve plate 43 connected rigidly to the rod 40, and a ball valve 44, which are held apart from each other by a pin 45, the distance being greater than the thickness of the end wall 13''. In the position of the reversing valve 21'' as illustrated, the passage 16'' is closed and the passage 19'' is open, so that the pressure fluid supplied through the connection 12'' can push the piston 4'' to the left in the drawing. The ball valve 44 is pressed onto its seating by the force of the spring 46 and by the pressure obtaining in the space 14''. When the piston 4'' approaches its extreme left-hand position, an end flange 48 on the rod 40 engages the compression spring 42 so that this is compressed. When the spring compression is sufficient to overcome force of the spring 46 and the fluid pressure acting on the ball valve 44, the reversing valve 21'' is abruptly switched over, the valve plate 43 then abutting against the end face 17'' and blocking the passage 19'', simultaneously the pin 45 lifts the ball valve 44 from its seating, so that the pressure fluid can flow from the connection 15'' through the passage 16'' into the cylinder space 10''. The spring 46 serves also like the spring 30

in FIG. 1, to keep the reversing valve 21'' in a defined inoperative position when no pressure fluid is admitted.

In FIG. 4, identical or identically-acting parts are designated by the same reference numerals as in FIG. 2, but with the index *a*. The main difference from the embodiment shown in FIG. 2 is that the reversing valve 21a is operated in both directions by the same compression spring 50. For this purpose, the spring 50 is disposed with a slight pre-tension between two spring abutments 51 and 52, of which the spring abutment 51 cooperates with the valve plate 23a while the spring abutment 52 cooperates with the valve plate 22a. The spring abutment 51 is connected rigidly to the rod 36a and the spring abutment 52 has a tubular extension 53 which extends loosely through the valve plate 22a. The spring 50 with its spring abutments 51 and 52 is housed in a bore 54 in the end wall 13a, so that the length of the cylinder space 10a may be kept to a minimum for any selected piston stroke.

In the position of the reversing valve 21a as illustrated, the pressure fluid fed through the connection 15a flows through the passage 16a into the cylinder space 10a and acts on the larger piston face 8a so that the piston 4a moves downwardly. When the piston 4a approaches its lower extreme position, a stop 37a attached to the piston engages a flange 35a on the lower end of the rod 36a so that the spring 50 is compressed by the spring abutment 51 and, through the spring abutment 52, shifts the valve plate 22a downwards off its seat 17a. At the same time, the spacer 24a, which is rigidly fixed to the two valve plates 22a and 23a pulls the valve plate 23a down onto its seat 18a. Now the passage 19a is open and the passage 16a covered, so that the piston 4a moves upwardly. When the piston 4a approaches its upper extreme position, it compresses the spring 50 through the spring abutment 52 until the reversing valve 21a snaps back into its position as shown in the drawing.

The inoperative position of the reversing valve 21a, which is achieved by spring force in the other examples, can be achieved by force of gravity in the vertical arrangement illustrated.

It will be apparent that various alternative embodiments of the examples illustrated are possible without departing from the scope of the invention. For example it is not necessary for the piston rod 5 to be extended out of the cylinder if the reciprocating movement of the piston is intended only to cause the cylinder to perform oscillations which are transmitted by the cylinder to an appliance for example a riddling plate. This means that the movable piston rod need not be sealed with respect to the surroundings or atmosphere.

I claim:

1. A reciprocating fluid pressure operated actuator comprising a cylinder having an end wall and containing a displaceable differential piston having opposing faces of different effective areas, the said piston and cylinder defining a first cylinder space associated with the smaller area side of said piston, and a second cylinder space associated with the larger area side of said piston, a fluid pressure supply connection communicating with said first cylinder space, said end wall having a fluid pressure supply passage and a fluid return passage adapted to communicate with said second cylinder space, a reversing valve mounted on

said end wall of said cylinder and arranged selectively to open and close said fluid pressure passage and said fluid return passage, spring means coupled with said reversing valve and said piston, said reversing valve being controlled through said spring means by said piston adjacent the extreme operative positions of said piston, the valve being held in each of its operative positions by the fluid pressure and by the force of the spring means, such spring force being independent of the position of the piston during its travel between the extreme positions, said end wall having a side defining the end of said second cylinder space, means forming a pressure chamber on the side of said end wall opposite said first cylindrical space and a further pressure supply connection into said chamber, said fluid pressure supply passage having an entrance on the chamber side of the end wall and is adapted to communicate with the chamber, said fluid pressure supply passage extending through said end wall between said chamber and said second cylinder space, said fluid return passage having an entrance opening into the side of said end wall defining the end of said second cylinder space, and said reversing valve having valve elements disposed one on each side of said cylinder end wall, selectively to open and close the entrance to the fluid pressure supply

passage on one side of said end wall, and simultaneously to close and open respectively the entrance to the fluid return passage on the opposite side of said end wall.

2. An actuator according to claim 1, wherein said reversing valve is operated by said piston through a combined tension and compression spring.

3. An actuator according to claim 1, wherein said reversing valve is operated by said piston through two springs acting in opposite directions.

4. An actuator according to claim 1, wherein said piston is operatively connected to said reversing valve through lost motion means permitting relative longitudinal movement in accordance with the stroke of said piston.

5. An actuator according to claim 4, including a longitudinally movable element connected to said piston and operatively connected to said valve, and means for preventing withdrawal of said movable element from said piston.

6. An actuator according to claim 1, wherein said reversing valve is spring-loaded towards a position in which it closes one of said fluid pressure passages and said fluid return passage.

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