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(54) **Hydraulic booster device for linear actuator.**

(57) A linear actuator 1 comprising : a housing 2 having a primary piston chamber 3 and a booster piston chamber 4 ; a piston rod 5 disposed within the housing 2 ; a primary piston 6 secured to one end of the piston rod 5 and disposed within the primary piston chamber 3, the primary piston chamber 3 having a first primary compartment 7 and a second primary compartment 8 disposed on opposite sides of the primary piston 6 ; a booster piston 9 movably disposed about the piston rod 5 and within the booster piston chamber 4, the booster piston chamber 4 having a first booster compartment 10 and a second booster compartment 11 disposed on opposite sides of the booster piston 9 ; a thrust column 12 attached to the booster piston 9 and disposed between the booster piston 9 and the piston rod 5 so as to define a fluid channel 16 ; a first port 13 capable of supplying or draining fluid or air to or from the first primary compartment 7 and the first booster compartment 10 concurrently, wherein the first primary compartment 7 and the first booster compartment 10 are in fluid contact via said fluid channel 16 disposed between the thrust column 12 and the piston rod 5 ; a second port 14 capable of supplying and draining fluid or air to or from the second primary compartment 8 ; and a third port 15 capable of supplying and draining fluid or air to or from the second booster 11 compartment.

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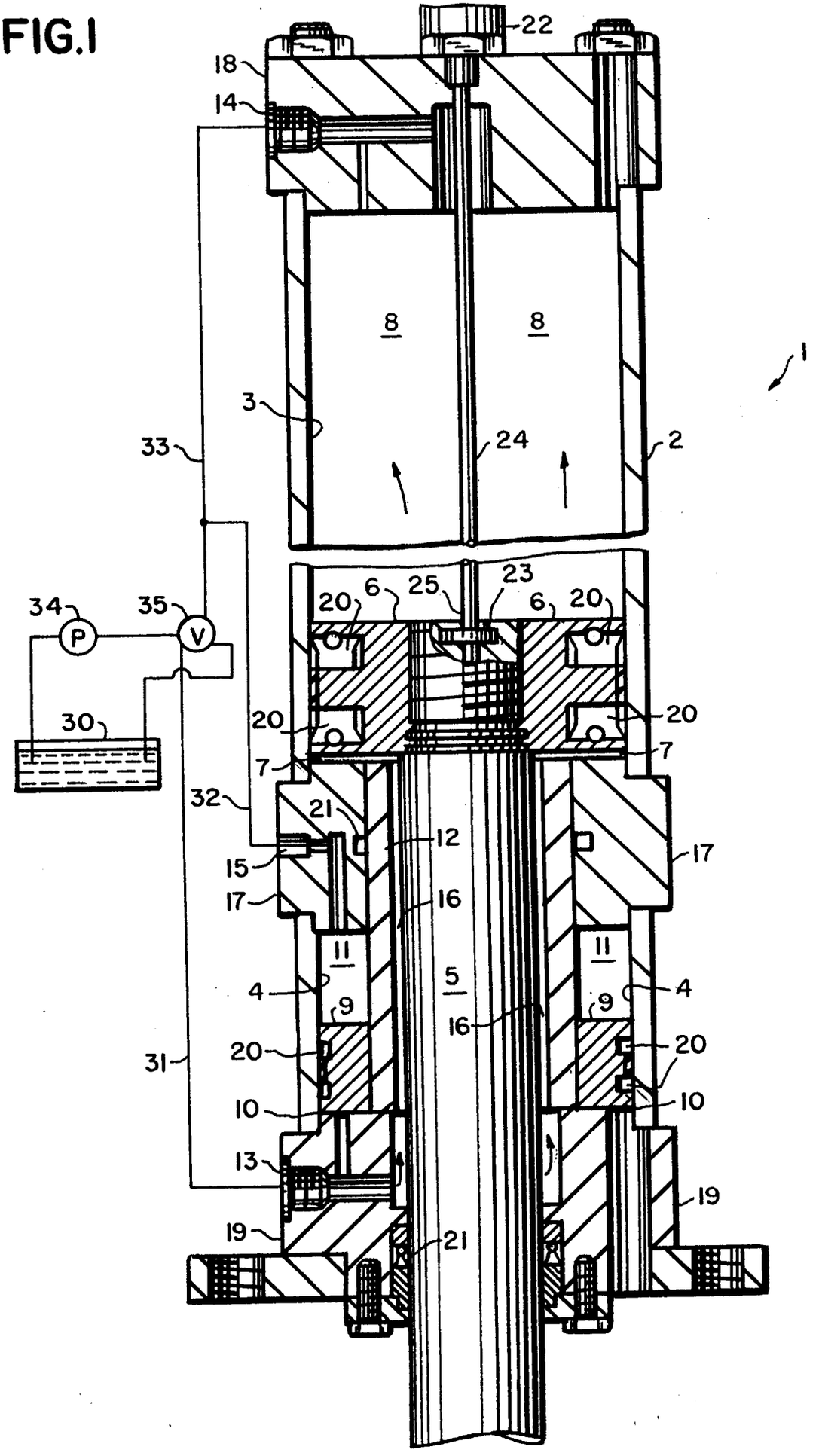
FIG.1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The present invention relates generally to a linear actuator used in moving, for example, gate valves and sluice gates, where an increased thrust is required during the initial movement of the valve. More particularly, the present invention is a novel booster piston movably disposed about a piston rod of a linear actuator which is capable of providing additional thrust to a piston.

BACKGROUND OF THE INVENTION

Linear actuators comprising piston means displaced by fluid or air pressure are typically used to control the opening and closing of valves, e.g., gate valves and sluice gates. One of the principal problems encountered in providing actuators of this type to control valves results from the fact that the force required to break the seal upon opening the valve is generally considerably greater than that necessary at any other portion of the opening or closing cycle. This relatively large force is commonly referred to as the "break-away" force and is caused by friction of the valve disk against the valve seat on opening.

Another problem results from the fact that when the final closing force is too large, the valve may slam shut causing distortion of the parts and damage to the seals.

Various actuators have been designed with the purpose of overcoming the "break-away" force by supplying an initial larger force. U.S. patent Nos. 2,896,413 (Hussey), which issued July 28, 1959, and 3,208,354 (Topinka), which issued September 28, 1965, both disclose fluid actuators having means for providing a large initial force capable of overcoming the friction forces involved in breaking a valve seal or moving an object. Furthermore, both the Hussey and Topinka patents use auxiliary pistons to generate the large initial force.

The Hussey patent provides a working piston which provides the principal opening and closing force and an auxiliary piston which provides a supplemental force during the initial part of the opening cycle and which also acts as a buffer during the final portion of the closing cycle. An operating fluid enters an annular chamber and flows into a compartment adjacent to the primary piston. The fluid adjacent to the primary piston then flows from that compartment into another compartment adjacent the auxiliary piston by means of a conduit within the auxiliary piston. The force of the fluid pressure in the compartments acting against the pistons urges them both to the right.

The Topinka patent discloses a dual motor having both a large diameter piston and a small diameter piston for actuation of a single piston rod. The Topinka patent differs from the Hussey patent in that its fluid receiving chambers for the large and small pistons are isolated from each other so as to adapt the motor for various modes of operation. That is, fluid is pumped into separate isolated chambers associated with each piston in order to actuate the piston rod. With the pistons being isolated from each other within the motor housing, an on-off valve may be install within the conduit line supplying fluid to the auxiliary piston and when closed will prevent fluid from being delivered to that piston.

Conventional dual piston designs can cause the primary piston to move before it receives the benefit of the thrust generated from the auxiliary piston. That is, the Hussey patent supplies fluid to the compartment associated with the primary piston and then from that compartment to the compartment associated with the auxiliary piston. The Topinka patent includes isolated chambers wherein it may also supply fluid to the primary piston prior to the auxiliary piston depending upon the efficiency of its fluid delivery system.

The present invention also provides many additional advantages which shall become apparent as described below.

SUMMARY OF THE INVENTION

The present invention provides a unique integrated booster piston design which does not require additional lengthening of the housing or separate isolated fluid compartments necessitating additional ports and a sophisticated fluid delivery system. That is, the novel booster piston of the present invention is disposed about the piston rod to permit the rod to travel through the booster piston and thrust column in both directions, while providing a compact dual piston design.

Furthermore, the present invention is designed such that the fluid or air pressure acts upon the booster piston prior to the primary piston so that the initial thrust on the piston rod is, in fact, the combined thrust of both pistons.

A primary feature of the present invention is a linear actuator comprising: a housing having a primary piston chamber and a booster piston chamber; a piston rod disposed within the housing; a primary piston secured to one end of the piston rod and disposed within the primary piston chamber, the primary piston chamber having a first primary compartment and a second primary compartment disposed on opposite sides of the primary piston; a booster piston movably disposed about the piston rod and within the booster piston chamber, the booster piston chamber having a first booster compartment and a second booster compartment disposed on opposite sides of the booster piston; a thrust column attached to the booster piston and disposed between the booster piston and the piston rod; a first port capable of simultaneously supplying or draining fluid or air to or from the first primary compartment and the first booster compartment, wherein the first primary compartment and the first booster compartment are in contact via a fluid or air channel

disposed between the thrust column and the piston rod; a second port capable of supplying and draining fluid or air to or from the second primary compartment; and a third port capable of supplying and draining fluid or air to or from the second booster compartment.

Another feature is a method for increasing the initial thrust on a piston rod of a linear actuator comprising the steps of: supplying a fluid or air from a reservoir simultaneously into the first booster compartment and the first primary compartment by means of the first port and the channel; displacing the booster piston by supplying the fluid or air into the first booster compartment, while draining through the third port a proportionate quantity of the fluid or air from the second booster compartment; contacting the primary piston with an end of the thrust column due to the displacement of the booster piston; displacing the primary piston by applying the force generated from the contacting of the primary piston with the thrust column and supplying the fluid or air into the first primary compartment, while draining through the second port a proportionate quantity of the fluid or air from the second primary compartment.

Other and further objects, advantages and features of the present invention will be understood by reference to the following specification in conjunction with the annexed drawings, wherein like parts have been given like numbers.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a schematic cross-sectional view of a linear actuator of the present invention with the piston rod in the fully extended position; and

Fig. 2 is a schematic cross-sectional view of a linear actuator of the present invention with the piston rod in the fully retracted position.

DESCRIPTION OF PREFERRED EMBODIMENTS

The design of the present invention insures that a booster piston associated with a linear actuator is actuated such that its thrust is always applied to a primary piston during retraction of an associated piston rod. The present inventor has developed a novel linear actuator which includes a booster piston which, although independent from the primary piston, is displaced by fluid or air which simultaneously acts on the primary piston. The simultaneous thrusts either directly exerted upon the primary piston by the thrust column affixed to the booster piston or by the fluid or air transmitted to the primary piston increases the total thrust upon the associated piston rod by approximately 50-60% over conventional single piston devices.

This novel linear actuator increases the thrust during the initial movement of the piston rod within the first inch or so when the highest thrust, i.e., "breakout", is required in many linear applications, such as gate valves and sluice gates. The increase of thrust is accomplished by putting a booster or auxiliary piston about the piston rod or, if desired, at the piston end. Additional thrust is obtained by supplying high pressure air or oil to the booster piston and primary piston simultaneously. Typically, the booster piston has a thrust of 20 psi and the primary piston has a thrust of 30 psi, which generate a combined initial thrust of 50 psi.

The booster piston is independent of the primary piston and disposed about the piston rod. A center thrust column affixed to the booster piston and disposed between the booster piston and the piston rod pushes against the bottom of the primary piston during the initial retraction of the piston rod. The piston rod travels through the thrust column affixed to the booster piston in both directions and is separate from the booster piston.

During initial retraction of the piston rod, fluid or air is supplied to both the booster piston and the primary piston via the same port. The fluid displaces the booster piston which causes the thrust column to push against the bottom of the primary piston. Therefore, an initial combined thrust caused by the pushing of the fluid and thrust column against the bottom of the primary piston acting in concert produce an increased initial thrust upon the piston rod. The booster piston only operates for approximately 1-2 inches, although it may be designed to operate for any desired distance depending upon the particular requirements of the actuator.

The present invention can further be described while referring to the attached drawings, wherein Fig. 1 depicts a linear actuator 1 comprising: a housing 2 having a primary piston chamber 3 and a booster piston chamber 4. A piston rod 5 is disposed within housing 2, wherein a primary piston 6 is secured to one end of piston rod 5 and disposed within primary piston chamber 3. As shown in Fig. 1, piston 5 is in a fully extended position within housing 2. Primary piston chamber 3 includes a first primary compartment 7 and a second primary compartment 8 disposed on opposite sides of primary piston 6.

A booster piston 9 is movably disposed about piston rod 5 and within booster piston chamber 4. Booster piston chamber 4 includes a first booster compartment 10 and a second booster compartment 11 disposed on opposite sides of booster piston 9. A thrust column 12 is attached to booster piston 9 and disposed between booster piston 9 and piston rod 5.

Linear actuator 1 also includes means for supplying and draining fluid or air to primary piston chamber 3 and booster piston chamber 4. Such means include first port 13, second port 14 and third port 15. First port 13 is capable of supplying or draining fluid to or from first primary compartment 7 and first booster compartment 10 concurrently, inasmuch as first primary com-

partment 7 and first booster compartment 10 are in fluid contact via an annular Channel 16 disposed between thrust column 12 and piston rod 5. A second port 14 is capable of supplying and draining fluid to or from second primary compartment 8 and a third port 15 is capable of supplying and draining fluid to or from second booster compartment 11.

Intermediate plate or head 17 is disposed between primary piston chamber 3 and booster piston chamber 4, whereby intermediate plate 17 restricts both the vertical movement of primary piston 6 during extension of piston rod 5 and the vertical movement of booster piston 9 during retraction of piston rod 5. Blind end plate or head 18 is disposed within housing 2 such that it restricts the vertical movement of primary piston 6 during retraction of piston rod 5. Rod end plate or head 19 is disposed within housing 2 such that it restricts the vertical movement of booster piston 9 during extension of piston rod 5.

Third port 15 is disposed within intermediate plate 17, second port 14 within blind end plate 18 and first port 13 within rod end plate 19.

To provide a fluid seal between housing 3, primary piston 6 and booster piston 9, each piston includes piston seals 20. Furthermore, rod seals 21 are disposed on intermediate plate 17 and rod end plate 19 to provide a fluid seal within actuator 1.

It will be seen that a linear transducer 22 is provided to indicate the extent to which the main piston has moved upwardly (Fig. 2). An LED (not seen) forms part of transducer 22 which also comprises a magnet 23, within primary piston 6, whose movement relative to a conduit 24, which is held within a bore 25, formed in rod 5, causes generation of appropriate signals representative of distance traveled by piston 6. Such signals are applied to the LED to display the distance that piston 6, and therefore the gate valve, has moved. Such arrangement of a transducer is advantageous in that it obviates the need for limit switches and the like, which are totally inadequate in that they will not stand up in use.

The operation of actuator 1 can best be described while referring to both Figs. 1 and 2, wherein Fig. 1 depicts piston 5 in a fully extended position (downward) and Fig. 2 depicts piston 5 in a fully retracted position. In order to increase the initial thrust on piston rod 5 of linear actuator 1 fluid or air must be supplied from a reservoir 30 concurrently into first booster compartment 10 and first primary compartment 7 by means of pipe 31, first port 13, and channel 16.

Booster piston 9 is displaced by supplying the fluid or air into first booster compartment 10, while draining through third port 15 a proportionate quantity of fluid or air from second booster compartment 11. The drained fluid is returned to reservoir 30 via pipes 32 and 33. As booster piston 9 is displaced under fluid or air pressure it contacts the bottom of primary piston 6 with an end of thrust column 12.

Primary piston 6 is thereafter displaced by the application of the combined force generated from the contacting of primary piston 6 with thrust column 12 and the fluid or air pressure exerted by the supply of fluid or air into first primary compartment 7. A proportionate quantity of fluid or air as that introduced into first primary compartment 7 is drained through second port 14 from second primary compartment 8. The fluid drained from fluid second port 14 is returned to reservoir 30 via pipe 33. The supply and drainage of the fluid or air is controlled by means of a pump 34 and a bidirectional valve 35.

Conversely, when piston rod 5 is to be extended, as shown in Fig. 1, fluid or air is supplied from reservoir 30 to second primary compartment 8 via second port 14 and pipe 33. As the fluid enters second primary compartment 8, causing piston 6 to move downward, a proportionate quantity of fluid is drained and returned to reservoir 30 from first primary compartment 7 and first booster compartment 10 via first port 13 and pipe 31. Fluid or air is also supplied to second booster compartment 11 via third port 15 in an amount proportionate to that drained from first booster compartment 10. Optionally, first booster compartment 10 may also be drained by means of primary piston 6 pushing against thrust column 12 which in turn forces fluid from first booster compartment 10. In this instance, fluid would be supplied to second booster compartment 11 by means of the suction caused by the retraction of booster piston 9 within booster piston chamber 4.

While I have shown and described several embodiments in accordance with my invention, it is to be clearly understood that the same are susceptible to numerous changes apparent to one skilled in the art. Therefore, I do not wish to be limited to the details shown and described by intend to show all changes and modifications which come within the scope of the appended claims.

Claims

1. A linear actuator comprising:

a fluid supply;

a housing having a primary piston chamber and a booster piston chamber;

a piston rod disposed within said housing;

a primary piston secured to one end of said piston rod and disposed within said primary piston chamber, said primary piston chamber having a first primary compartment and a second primary compartment disposed on opposite sides of said primary piston;

a booster piston movably disposed about said piston rod and within said booster piston chamber, said booster piston chamber having a first booster compartment and a second booster

compartment disposed on opposite sides of said booster piston;

a thrust column for pushing directly against said primary piston so as to provide an initial thrust component to said piston rod, said column being affixed to said booster piston and disposed between said booster piston and said piston rod so as to define an annular fluid channel extending between said first booster compartment and said first primary compartment for enabling said fluid to contribute substantial thrust to move said primary piston;

a first port capable of supplying or draining said fluid to or from said first primary compartment and said first booster compartment concurrently, said first primary compartment and said first booster compartment being in fluid contact via said annular fluid channel disposed between said thrust column and said piston rod whereby said fluid contributes said substantial thrust;

a second port capable of supplying and draining fluid or air to or from said second primary compartment; and

a third port capable of supplying and draining fluid or air to or from said second booster compartment.

2. The linear actuator according to claim 1, wherein a first plate is disposed between said primary piston chamber and said booster piston chamber, whereby said plate restricts both the vertical movement of said primary piston during extension of said piston rod and the vertical movement of said booster piston during retraction of said piston rod.

3. The linear actuator according to claim 1, wherein a second plate is disposed within said housing such that it restricts the movement of said primary piston during retraction of said piston rod.

4. The linear actuator according to claim 1, wherein a third plate is disposed within said housing such that it restricts the movement of said booster piston during extension of said piston rod.

5. The linear actuator according to claim 2, wherein said third port is disposed within said first plate.

6. The linear actuator according to claim 3, wherein said second port is disposed within said second plate.

7. The linear actuator according to claim 4, wherein said first port is disposed within said third plate.

8. The linear actuator according to claim 1, wherein a linear transducer attached to one end of said housing measures the movement of said piston rod.

9. The linear actuator according to claim 8, wherein said linear transducer incudes a magnet disposed within said primary piston and a conduit extending within a bore formed in said piston rod.

FIG.1

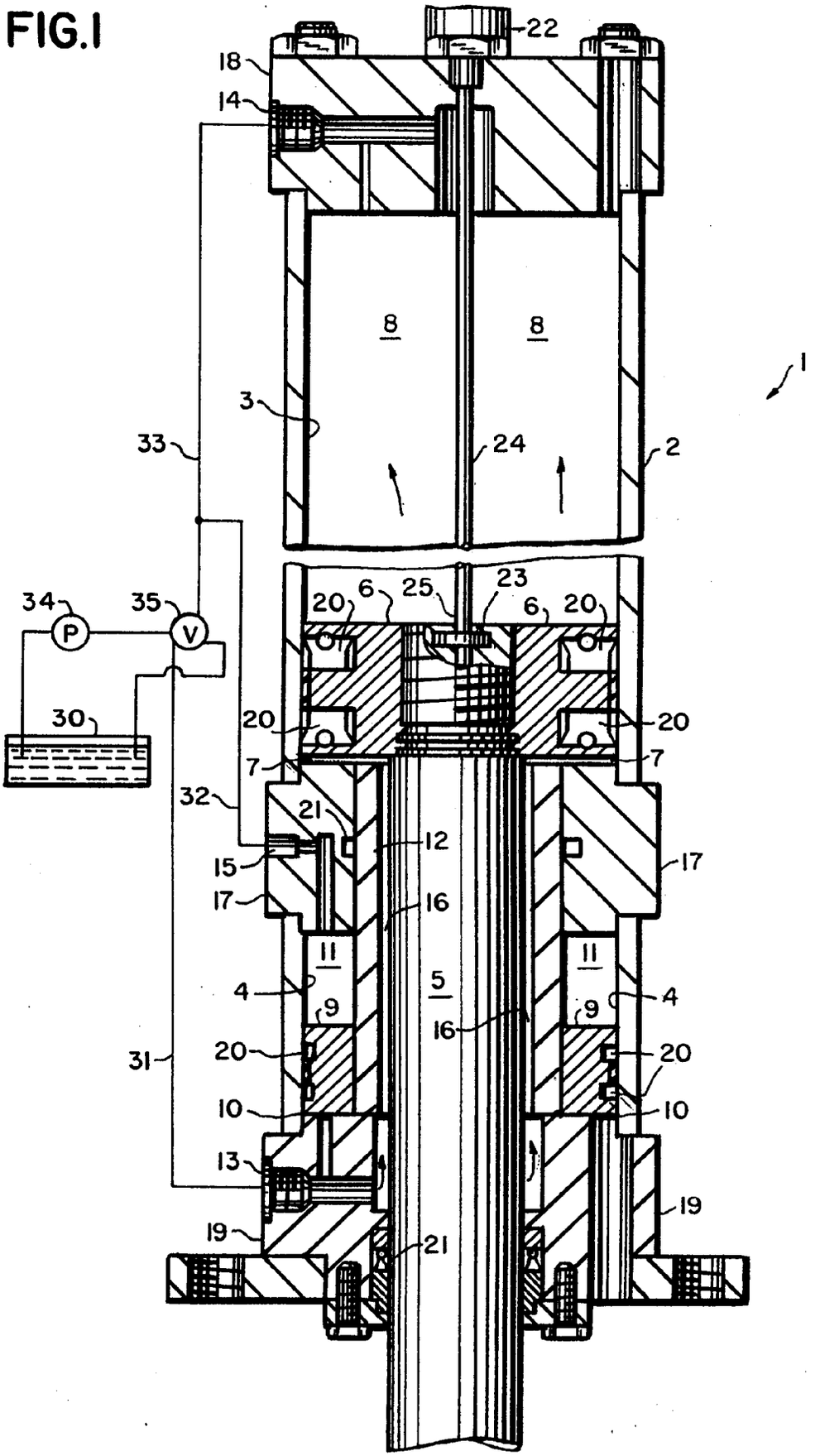
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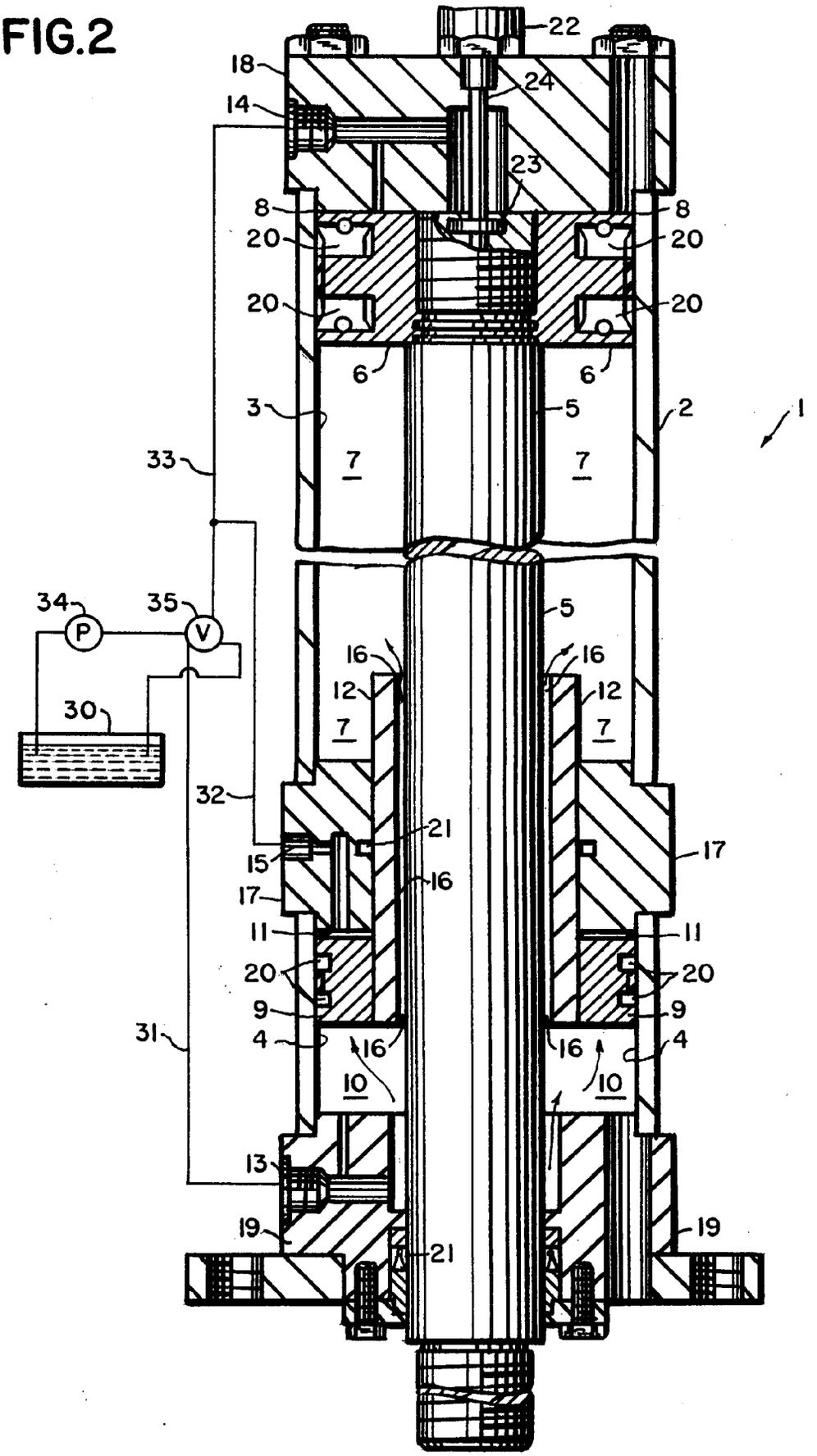
FIG.2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European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 30 6788

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-B-2 127 181 (UNION) * the whole document *	1-7	F15B15/14 F16K31/122
X	US-A-3 018 762 (KORB) * the whole document *	1-7	
X	GB-A-911 709 (AUTOMOTIVE) * the whole document *	1-7	
A	GB-A-1 432 226 (SUPERFOS)		
A	FR-A-1 155 231 (AUTOMATIC VALVE)		
A	NL-A-6 701 438 (DOUWE)		
A	NL-C-108 724 (VAN WIJK)		
A	DE-A-3 306 846 (NIEPENBERG)		
A	DE-A-1 905 577 (ALBRECHT-AUTOMATIK)		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F15B F16K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 OCTOBER 1991	KNOPS J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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