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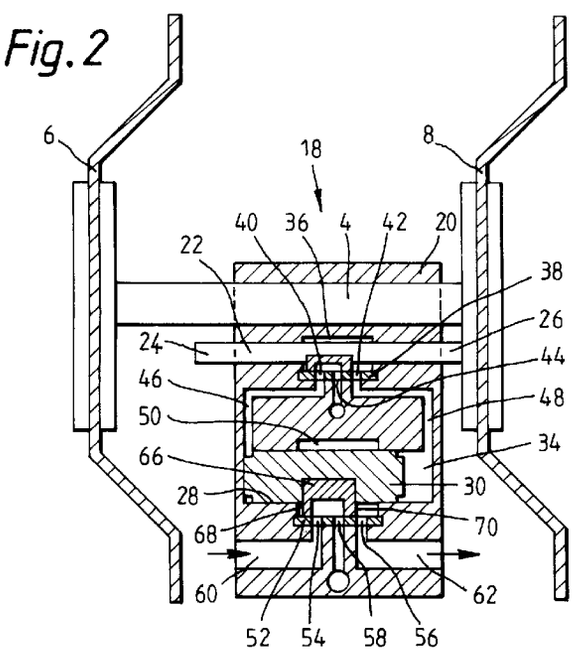
(54) Pumps.

(57) A gas-operated double diaphragm pump comprises first and second diaphragms (6,8) movable with a primary shaft (4), and a gas control valve (18) operable under gas pressure to effect a pumping action by the diaphragms (6,8), the control valve (18) including a housing (20) provided with first and second inlets (40,42) for the supply of gas under pressure into said housing (20), first and second outlets (54,56) for the supply of gas under pressure to the diaphragms (6,8), and an exhaust outlet. A control member (30) is movable axially within the housing (20) to interconnect the first and second inlets alternately with the first and second outlets, a first bearing member (64) being movable with the control member (30) to seal the outlet (54,56) being supplied with gas under pressure from the other outlet (56,54) and from the exhaust outlet, and a second bearing member (72) being movable with the diaphragms (6,8) to seal the inlet (40,42) being supplied with gas under pressure from the other inlet (42,40) and from the exhaust outlet.

Fig. 2



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This invention relates to pumps and more particularly to gas-operated double diaphragm pumps.

Conventional air-operated double diaphragm pumps comprise an axially movable shaft to which are attached a pair of elastomeric diaphragms each having a rear surface forming part of the defining walls of an air chamber to receive air under pressure and a front surface forming part of the defining walls of a liquid chamber containing liquid to be pumped. Compressed air is supplied alternately to the rear surfaces of the two diaphragms whereby, with one air chamber pressurised, fluid is pumped by the associated diaphragm out of the associated liquid chamber while, at the same time, the other diaphragm is pulled in by the shaft to draw liquid into the other liquid chamber. When the pressurised diaphragm reaches the limit of its stroke, an air control valve shifts the supply of compressed air to the air chamber of the other diaphragm and liquid is then pumped out of the other liquid chamber.

It is well-established practice for such air-operated double diaphragm pumps to incorporate one-piece moving valves as the control means for the compressed air supply to the diaphragms. Such valves have the advantage of comprising a minimum number of parts, being simple to understand and maintain and being cheap to manufacture.

However, a major disadvantage of such valves is that efficient operation thereof is very dependent upon close tolerances, while the known valves are prone to stalling at low cycle rates and to leak air slightly on stall.

More particularly, these valves comprise a spool valve member of generally cylindrical shape movable backwards and forwards in a cylindrical chamber in a valve block under the influence of compressed air applied alternately to the opposed ends of the spool valve member. The valve block has a series of apertures therein communicating with the two air chambers of the pump and with the atmosphere, while the spool valve member itself is recessed in such a manner that, on said backwards and forwards movement thereof, the various apertures in the valve block are interconnected with and disconnected from the source of compressed air and the atmosphere as required.

In such an arrangement, the backwards and forwards movement of the spool valve member, which may be up to 700 cycles per minute, of necessity results in wear between the spool valve member and the valve block whereby a small gap is formed therebetween. Thus, when the compressed air flows into the recessed spool valve member during passage of the air to one or other of the air chambers, there is a leakage path to atmosphere available to said air between the spool valve member and the block whereby air can escape and reduce the efficiency of the pump.

It has been proposed, for example in European application no. 86.308888.6, to provide a gas-operated double diaphragm pump incorporating an improved gas-control valve less prone to wear, and therefore to leakage, than the aforementioned arrangement.

More particularly this improved valve includes a wear-resistant bearing member or slide member movable with the main control member and permanently urged into sealing engagement with an associated plate, this bearing member being so arranged that, of the two valve outlets, one for each diaphragm, the outlet being supplied with gas under pressure is sealed from the exhaust outlet and from the other gas outlet.

However, sliding movement of the bearing member between its operative positions is determined by movement of the main valve control member, which is itself under pneumatic control by means of the source of compressed air feeding the pump.

Such pneumatic control can result in certain problems arising, particularly in the case of leakage between the opposed end chambers to each side of the main control member which can result in centring of the control member within the valve and a consequential shut-down of the pump. Such problems are particularly prevalent in larger pumps with fluid outlets of typically 25mm diameter or greater.

It would be desirable to be able to provide a gas-operated double diaphragm pump incorporating a gas-control valve less prone to centring of the main valve control member than heretofore.

According to the present invention there is provided a gas-operated double diaphragm pump comprising first and second diaphragms, preferably of an elastomeric material, secured to, for movement with, a primary shaft, and a control valve for supplying gas under pressure alternately to said diaphragms such that said diaphragms are extended and retracted alternately and a consequential pumping action is provided thereby, said control valve including a housing defining therein a substantially cylindrical chamber, a control member within said chamber, first and second inlets to said chamber for supplying gas under pressure to each end of said control member, first and second outlets from said chamber for supplying gas under pressure to the first and second diaphragms respectively and an exhaust outlet from said chamber, the control member being movable axially within the chamber such that the first and second inlets are interconnected alternately with the first and second outlets respectively, the control valve further including a first bearing member mounted in, to be movable with, the control member and urged into sealing contact with the inner wall of the chamber such as to seal the outlet being supplied with gas under pressure from the exhaust outlet and from the other gas outlet, and a second bearing member urged into sealing contact with the outer wall of the chamber and movable in accordance with movement of the diaphragms be-

tween first and second operative positions in which the inlet being supplied with gas under pressure is sealed from the exhaust outlet and from the other inlet.

In a preferred embodiment of the invention the second bearing member is carried by a secondary shaft mounted for axial sliding movement in the housing, opposed ends of said shaft being located for engagement by the first and second diaphragms respectively as said diaphragms approach their fully retracted positions, said engagement resulting in movement of the second bearing member from one operative position to the other operative position.

Conveniently a first input of gas under pressure is supplied to said first or second inlet dependent upon the position of the second bearing member to effect axial movement of the control member within the chamber, and a second input of gas under pressure is supplied to said first or second outlet dependent upon the position of the first bearing member to effect displacement of the first or second diaphragm. The first and second inputs of gas under pressure preferably originate from a common source.

Preferably the control valve includes a first exhaust port adapted for interconnection with the first or second outlet in dependence upon the position of the first bearing member, and a second exhaust port adapted for interconnection with the first or second inlet in dependence upon the position of the second bearing member, the first and second exhaust ports feeding into a common exhaust outlet.

In a preferred pump, the first bearing member is recessed to define a hollow interior therein bounded by free edges, said free edges of the bearing member making sealing contact with the inner wall of the hollow chamber, the arrangement being such that, with the control member and the first bearing member in a first operative position, the first gas outlet and the exhaust outlet are interconnected with one another by way of said hollow interior with gas under pressure being supplied to the second gas outlet, and, with the control member and the first bearing member in a second operative position, the second gas outlet and the exhaust outlet are interconnected with one another by way of said hollow interior with gas under pressure being supplied to the first gas outlet.

Similarly, it is preferred that the second bearing member is also recessed to define a hollow interior therein bounded by free edges, said free edges of the second bearing member making sealing contact with the outer wall of the chamber, the arrangement being such that, with the second bearing member in a first operative position, the first gas inlet and the exhaust outlet are interconnected with one another by way of said hollow interior with gas under pressure being supplied to the second gas inlet, and, with the second bearing member in a second operative position, the second gas inlet and the exhaust outlet are interconnected with one another by way of said hollow interior with gas under pressure being supplied to the first gas inlet.

The first and second bearing members may each be of a hard-wearing, self-lubricating material such as carbon-filled ptfe.

By way of example only, an embodiment of the invention will now be described in greater detail with reference to the accompanying drawings of which:

Figs. 1a and 1b show the principle of operation of a pump according to the invention, and

Figs. 2 to 4 show part of a pump according to the invention, and in particular the control valve thereof, in three different operating conditions.

Referring to the drawings and in particular to Figs. 1a and 1b, the illustrated pump includes a housing 2 in which is mounted an axially-movable primary shaft 4 to each end of which is secured the central regions of a flexible diaphragm 6,8 of an elastomer material, the rear surface of each diaphragm 6,8 forming part of the defining walls of an associated air chamber 10,12 and the front surface of each diaphragm 6,8 forming part of the defining walls of an associated liquid chamber 14,16 containing liquid to be pumped.

The pump according to the invention operates in conventional manner in that a source of compressed air is fed alternately to the two air chambers 10,12 whereby the diaphragms 6,8 are alternately extended to pump liquid from the associated liquid chambers 14,16. As with established air operated double diaphragm pumps, the two diaphragms 6,8 and the shaft 4 move in unison such that, as one diaphragm is extended to draw the shaft 4 with it and to pump liquid from the liquid chamber, the other diaphragm is pulled in by the shaft 4 to create a suction effect in the other liquid chamber whereby liquid is drawn into that chamber for subsequent pumping therefrom.

The invention resides in the means for controlling the flow of compressed air to the two air chambers 10,12 such that the leakage inherent in the known arrangements is eliminated, and in particular such that centring of the valve control member due to leakage between the chambers to opposed ends thereof is eliminated.

Referring in particular to Figs. 2 to 4, the air control valve of the illustrated pump is indicated generally at 18 and comprises a valve block 20, for example of die cast aluminium, provided with a first transverse bore in which is slidably mounted the primary shaft 4.

The valve block includes a further transverse bore parallel with said first-mentioned bore and in which is slidably mounted a secondary shaft 22 the ends 24,26 of which project one from each side of the block 20 for reasons which will become apparent.

Formed substantially centrally within the block 20 is a substantially cylindrical chamber 28 mounted in which is a valve carrier member 30 preferably of anodised aluminium of generally cylindrical shape to be a

close sliding fit in the chamber 28 and being axially movable between first and second extreme positions shown in Figs. 2 and 4 respectively in which cylindrical volumes 32,34 are defined within the chamber 28 between the ends of the carrier member 30 and the end walls of the valve block 20.

An annular chamber 36 is formed within the valve block 20 centrally around the further transverse bore housing the secondary shaft 22, a valve plate 38 secured within the block 20 defining a bounding wall of said chamber 36 and being provided with first and second inlets 40,42 and an exhaust port 44 connected to atmosphere.

The first inlet 40 is connected to the end volume 32 within the chamber 28 by means of a passageway 46, while the second inlet 42 is connected to the end volume 34 within the chamber 28 by means of a passageway 48.

A source of compressed air under pressure (not shown) is connected to the annular chamber 36.

A further annular chamber 50 is formed within the valve block 20 to surround the carrier member 30, a bounding wall of said chamber comprising a further valve plate 52 provided with first and second outlets 54,56 and an exhaust port 58 connected to atmosphere.

The first outlet 54 is connected to the air chamber 10 by a passageway 60, while the second outlet 56 is connected to the air chamber 12 by a passageway 62.

The aforementioned source of compressed air under pressure (not shown) is also connected to the annular chamber 50, while the exhaust ports 44 and 58 communicate with a common exhaust outlet.

The control valve 18 includes a first bearing member 64 in the form of a hollow slide-valve having a body portion 66 and surrounding sidewalls opposed parts of which are shown at 68,70, said body portion and sidewalls defining a hollow, open-faced interior to the slide-valve. The carrier member 30 is recessed to receive therein, as a close fit therein, the body portion 66 of the slide-valve, the free edges of the sidewalls of the slide-valve making sealing contact with the inner surface of the plate 52. The bearing member 64 is preferably of a hard-wearing, self lubricating material such as carbon-filled ptfe, and may be resiliently urged into engagement with the plate 52 by means of a coil spring (not shown) reacting between the carrier member 30 and the base portion 66 of the slide-valve to supplement the effect of the compressed air to the chamber 50 which serves to urge the member 64 into sealing contact with the plate 52.

The bearing member 64 is axially movable with the carrier member 30 and, in the first extreme position of the carrier member 30 shown in Fig. 2, the hollow interior of the slide-valve interconnects the outlets 54 and 58, but seals the outlet 56 from said outlets 54 and 58, while, in the second extreme position of the carrier member 30 shown in Fig. 4, the hollow interior of the slide-valve interconnects the outlets 56 and 58, but seals the outlet 54 from said outlets 56 and 58.

The control valve 18 further includes a second bearing member 72 also in the form of a hollow slide-valve having a body portion 74 and surrounding sidewalls opposed parts of which are shown at 76,78, the body portion and sidewalls defining a hollow, open-faced interior to the slide valve 72.

The secondary shaft 22 is recessed to receive therein, as a close fit therein, the body portion 74 of the bearing member 72, the free edges of the sidewalls of the bearing member 72 making sealing contact with the outer surface of the valve plate 38. The bearing member 72 is preferably of a hard-wearing, self-lubricating material such as carbon-filled ptfe.

The bearing member 72 is axially movable with the secondary shaft between a first operative position shown in Fig. 2, in which the hollow interior of the bearing member 72 interconnects the first inlet 40 and the exhaust outlet 44, but seals said first inlet 40 and outlet 44 from the second outlet 42, and a second operative position shown in Fig. 4 in which the hollow interior of the bearing member 72 interconnects the second inlet 42 and the exhaust outlet 44, but seals said inlet 42 and outlet 44 from the first inlet 40.

The described valve operates as follows. Referring to Fig. 2, compressed air is being supplied to the chambers 36 and 50 and the diaphragms 6,8 are in their left-most positions with diaphragm 6 fully extended to pump liquid from chamber 14 and diaphragm 8 fully retracted to draw liquid into chamber 16 as shown in Fig. 1b.

The back plate of diaphragm 8 has just engaged the end 26 of shaft 22 to urge said shaft and the bearing member 72 to their left-most positions thus exposing inlet 42 to the source of compressed air.

Compressed air flows through inlet 42, along passageway 48 and into volume 34 of the chamber 50 whereby the carrier member 30 is moved to the left as viewed in Fig. 2. On said movement, the bearing member 64 is moved to its left-most position whereby exposing outlet 56 to the source of compressed air being supplied to the chamber 50.

As the carrier member moves to the left, air in the volume 32 is exhausted via passageway 46, inlet 40 and exhaust port 44 to atmosphere.

Compressed air from the outlet 56 flows via passageway 62 to the air chamber 12 to extend the diaphragm 8 which moves through the position shown in Fig. 3 to that shown in Fig. 4.

As this movement of the diaphragm 8 occurs, the shaft 4 and attached diaphragm 6 also move to the right, air from the chamber 10 being vented to atmosphere via passageway 60, outlet 54 and exhaust port 58.

When chamber 12 is almost full, and the shaft 4 and attached diaphragms 6 and 8 are nearing the end

of their cycle, the backplate of diaphragm 6 engages the end 24 of the shaft 22 and moves said shaft 22 and the bearing member 72 carried thereby to the right to the position shown in Fig. 4.

This exposes inlet 40 to the source of compressed air being supplied to chamber 36, whereby said compressed air flows along passageway 46 and into the volume 32 of the chamber 28 to move the carrier member 30 and the bearing member 64 carried thereby to the right as viewed in the drawings.

Thus, outlet 54 is exposed to the source of compressed air being supplied to chamber 50, and compressed air flows along passageway 60 to air chamber 10 whereby diaphragm 6 is extended.

At the same time air from volume 34 of the chamber 28 is exhausted to atmosphere by way of passageway 48, inlet 42 and exhaust port 44, while air from air chamber 12 is exhausted to atmosphere by way of passageway 62, outlet 56 and exhaust port 58.

When chamber 10 is almost full, and the shaft 4 and attached diaphragms are nearing the end of their cycle, the backplate of diaphragm 8 will contact the end 26 of shaft 22 to move the shaft 22 and the bearing member 72 to the left to complete the cycle.

Thus there is provided a pump in which actuation of the control valve to determine air flow to the pump is under purely mechanical control by way of the secondary shaft 22 whereby any leakage from volume 32 to volume 34 within the chamber 28 will not result in centring of the carrier member 30 as was prone to occurring in prior arrangements.

Furthermore, the provision of the bearing members 64 and 72 in continual sealing engagement with the plates 52 and 38 ensures that there is no leakage of air to atmosphere from the inlet and outlet being supplied with air under pressure. The mounting of these bearing members such that the compressed air supplied to the chambers 36 and 50 urges the associated bearing member into sealing engagement with the associated valve plate ensures that the more the valve is used the more the bearing member wears into the associated plate and the better isthe seal therebetween.

Claims

1. A gas-operated double-diaphragm pump comprising first and second diaphragms (6,8) secured to, for movement with, a primary shaft (4), and a control valve (18) for supplying gas under pressure alternately to said diaphragms (6,8) such that said diaphragms (6,8) are extended and retracted alternately and a consequential pumping action is provided thereby, said control valve (18) including a housing (20) defining therein a substantially cylindrical chamber (28), a control member (30) within said chamber (28), first and second inlets (40,42) to said chamber (28) for supplying gas under pressure to each end of said control member (30), first and second outlets (54,56) from said chamber (28) for supplying gas under pressure to the first and second diaphragms (6,8) respectively, the control member (30) being movable axially within the chamber (28) such that the first and second inlets (40,42) are interconnected alternately with the first and second outlets (54,56) respectively, an exhaust outlet from the chamber (28), and a first bearing member (64) mounted in, to be movable with, the control member (30) and urged into sealing contact with the inner wall of the chamber (28) such as to seal the outlet (54,56) being supplied with gas under pressure from the exhaust outlet and from the other gas outlet (56,54), characterised by a second bearing member (72) urged into sealing contact with the outer wall of the chamber (28) and movable in accordance with movement of the diaphragms (6,8) between first and second operative positions in which the inlet (40,42) being supplied with gas under pressure is sealed from the exhaust outlet and from the other inlet (42,40).

2. A pump as claimed in claim 1 in which the second bearing member (72) is carried by a secondary shaft (22) mounted for axial sliding movement in the housing (20), opposed ends (24,26) of said shaft (22) being located for engagement by the first and second diaphragms (6,8) respectively as said diaphrams (6,8) approach their fully retracted positions, said engagement resulting in movement of the second bearing member (72) from one operative position to the other operative position.

3. A pump as claimed in claim 1 or claim 2 in which a first input of gas under pressure is supplied to said first or second inlet (40,42) dependent upon the position of the second bearing member (72) to effect axial movement of the control member (30) within the chamber (28), and a second input of gas under pressure is supplied to said first or second outlet (54,56) dependent upon the position of the first bearing member (64) to effect displacement of the first or second diaphragm (6,8).

4. A pump as claimed in claim 3 in which the first and second inputs of gas under pressure originate from a common source.

5. A pump as claimed in any one of claims 1 to 4 in which the control valve includes a first exhaust port (58) adapted for interconnection with the first or second outlet (52,54) in dependence upon the position of the first bearing member (64),and a second exhaust port (44) adapted for intercon-

nection with the first or second inlet (40,42) in dependence upon the position of the second bearing member (72), the first and second exhaust ports (58,44) feeding into a common exhaust outlet.

6. A pump as claimed in any one of claims 1 to 5 in which the first bearing member (64) is recessed to define a hollow interior therein bounded by free edges, said free edges of the bearing member (64) making sealing contact with the inner wall (52) of the hollow chamber (28), the arrangement being such that, with the control member (30) and the first bearing member (64) in a first operative position, the first gas outlet (52) and the exhaust outlet are interconnected with one another by way of said hollow interior with gas under pressure being supplied to the second gas outlet (54), and, with the control member (30) and the first bearing member (64) in a second operative position, the second gas outlet (54) and the exhaust outlet are interconnected with one another by way of said hollow interior with gas under pressure being supplied to the first gas outlet (52).

7. A pump as claimed in any one of claims 1 to 6 in which the second bearing member (72) is recessed to define a hollow interior therein bounded by free edges, said free edges of the second bearing member (72) making sealing contact with the outer wall (38) of the chamber (28), the arrangement being such that, with the second bearing member (72) in a first operative position, the first gas inlet (40) and the exhaust outlet are interconnected with one another by way of said hollow interior with gas under pressure being supplied to the second gas inlet (42), and, with the second bearing member (72) in a second operative position, the second gas inlet (42) and the exhaust outlet are interconnected with one another by way of said hollow interior with gas under pressure being supplied to the first gas inlet (40).

8. A pump as claimed in any one of claims 1 to 7 in which the first and second bearing members (64,72) are each of a hard-wearing, self-lubricating material such as carbon filled ptfe.

Fig.1a

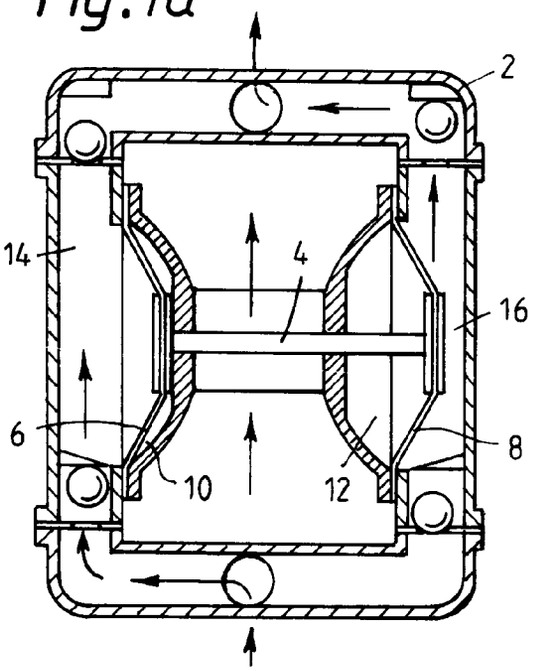

Fig.1b

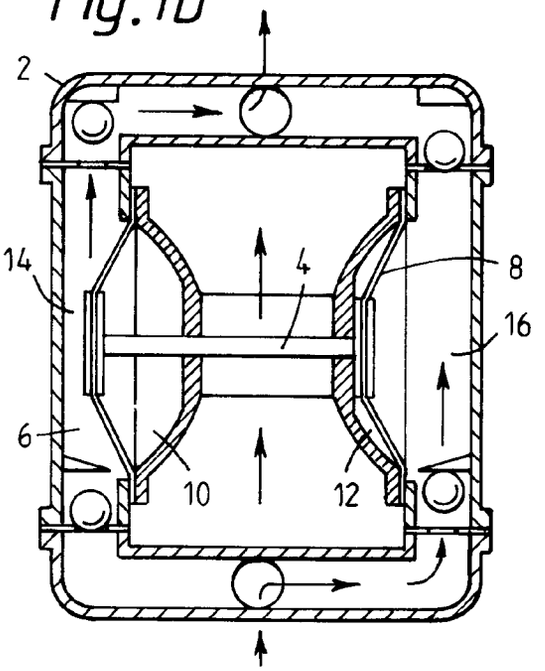

Fig.2

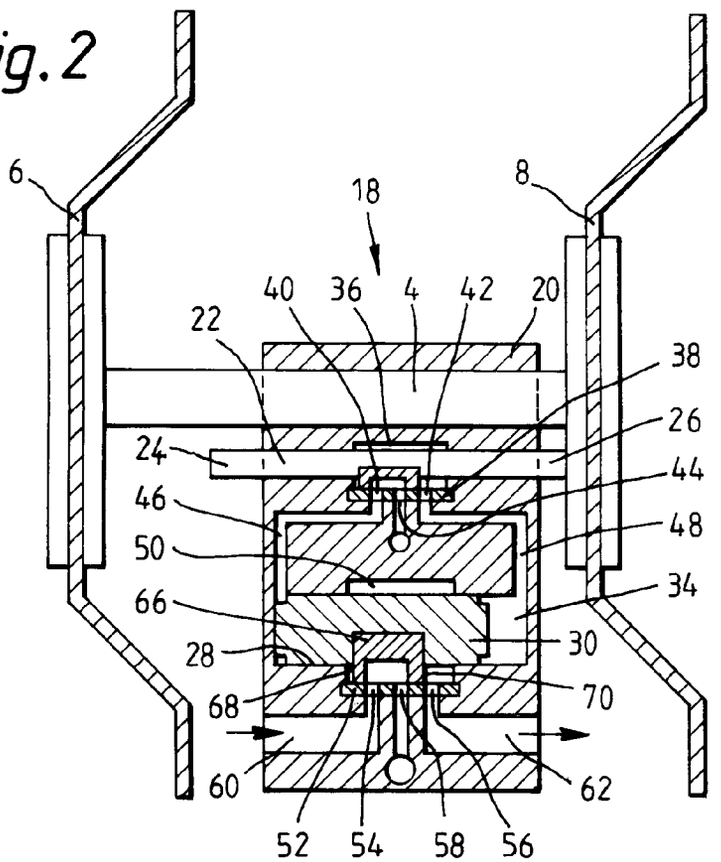

Fig.4

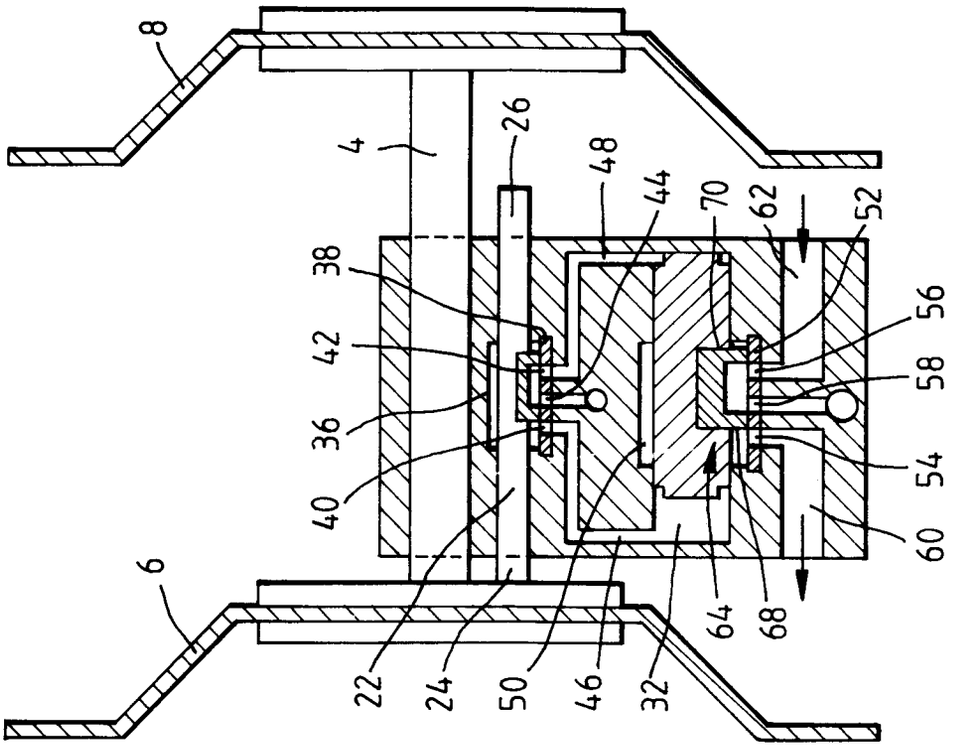
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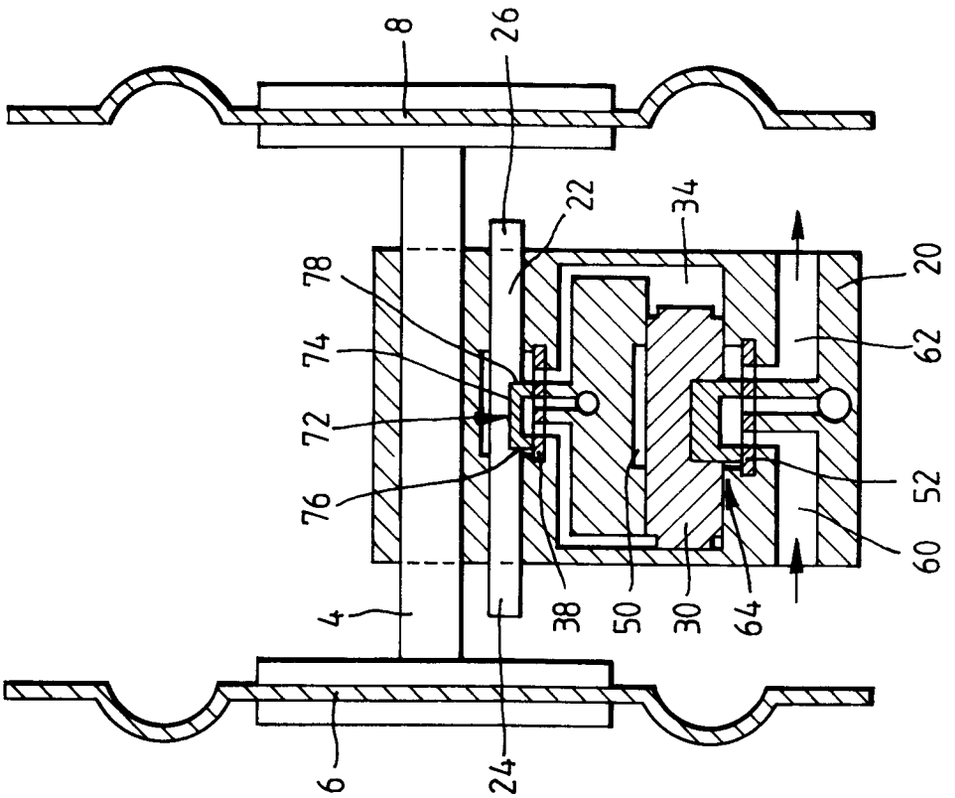
Fig 3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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 0764

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)
Y	FR-A-2 146 020 (DORR-OLIVER INCORP.) * page 4, line 10 - page 9, line 15; figures 1-2 * ---	1-8	F04B43/06 F01L25/06
Y	DE-A-3 720 674 (SCHLINKHEIDER) * the whole document * ---	1-8	
A	EP-A-0 061 706 (BUDDE) * page 19, paragraph 2 - page 25, paragraph 3; figures 19-30 * ---	1-8	
A	GB-A- 26302AD1910 (SHORE) -----		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F04B
F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	01 JUNE 1992	VON ARX H.P.

CATEGORY OF CITED DOCUMENTS

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