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(54) **Diaphragm pump system**

(57) A pumping system incorporating a diaphragm pump and in association therewith a pressure intensifier receiving pressurised driving fluid from a supply, said intensifier boosting the pressure of the drive fluid be-

yond its supply pressure and supplying the drive fluid, at said increased pressure, to said diaphragm pump, to generate pumping strokes of the pump producing a pump output pressure in excess of the drive fluid supply pressure.

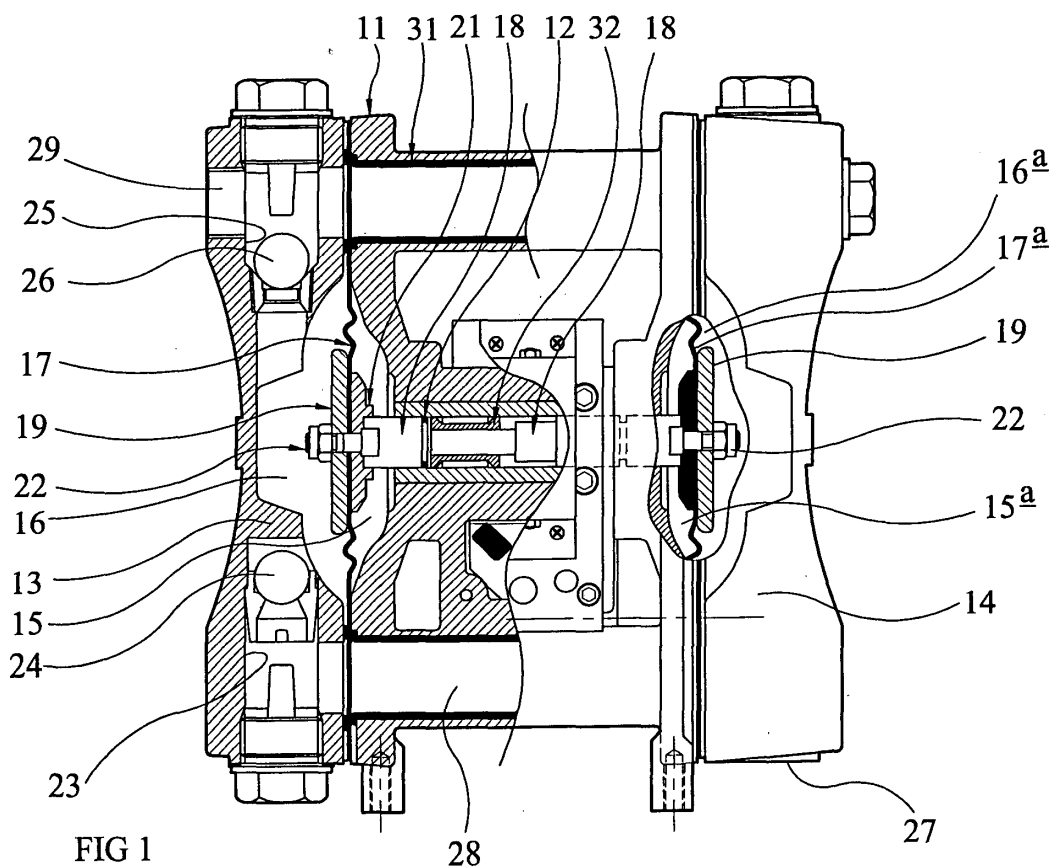
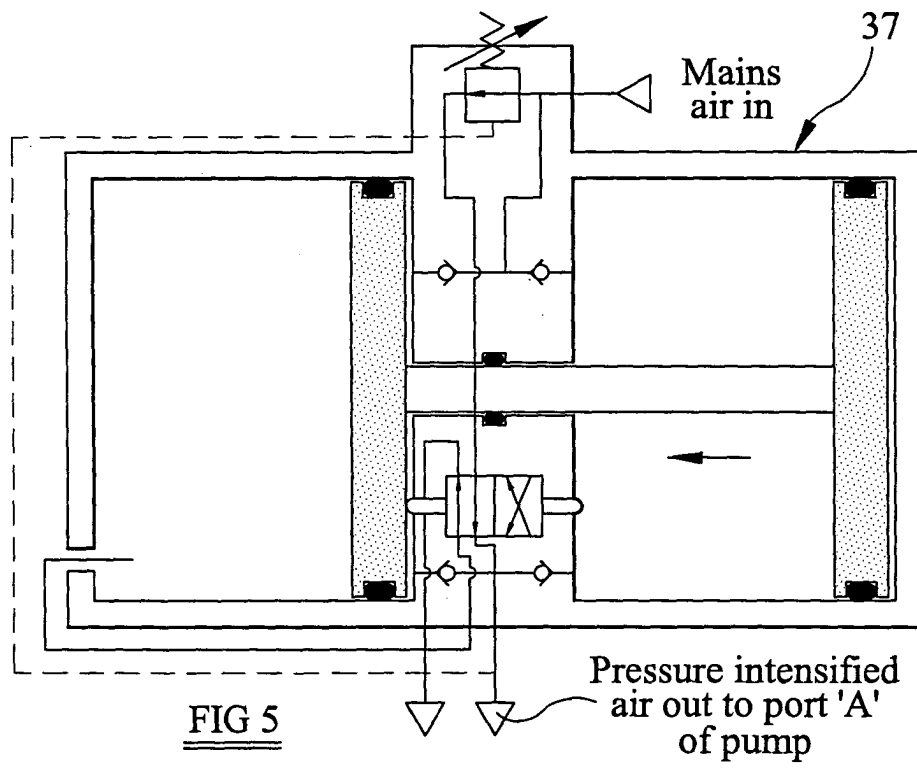


FIG 1

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Description

Technical Field

[0001] This invention relates to a pumping system incorporating a diaphragm pump, particularly but not exclusively for supplying liquid paint to a paint spraying system.

Background Art

[0002] Diaphragm pumps are well known and generally comprise a pumping chamber bounded in part by a moveable diaphragm, the diaphragm being moveable by the application of fluid under pressure to reduce the volume of the pumping chamber and so expel fluid, usually liquid, from the pumping chamber. Generally diaphragm pumps are constructed as double-acting pumps in that there are two pumping chambers each having an associated diaphragm, the two diaphragms being physically interconnected so that when one is moving to reduce the size of its pumping chamber to expel fluid from the pumping chamber the opposite diaphragm is moving in a direction to increase the volume of the pumping chamber and so draw fluid from a fluid supply into the pumping chamber. It is to be understood however that in its simplest aspect the present invention could be applied to a single acting (single diaphragm) pump although in practice it is much more likely to be applied with double-acting diaphragm pumps and so throughout the remainder of this application reference will be made to double-acting pumps rather than single acting pumps.

[0003] Conventionally the fluid being pumped by a diaphragm pump is a liquid, and also, conventionally, the pressurised fluid applied to the diaphragms to cause them to perform their pumping strokes is compressed air. Usually diaphragm pumps exhibit a 1:1 pressure ratio in that air at 1 bar pressure is applied to the pump to drive the pump, producing a liquid pressure in the output line of the pump which is also 1 bar. It is known to provide diaphragm pumps with an increased pressure ratio in that, for example, a 1 bar air pressure driving the pump produces a 3 bar output pressure in the liquid output line of the pump. However, although such diaphragm pumps are significantly larger and more expensive to produce than are pumps which have a 1:1 ratio, their use in systems in accordance with the present invention is not excluded. For convenience hereinafter in this specification it is assumed that the pump has a 1:1 ratio.

[0004] In the paint spraying industry it is conventional to provide a paint spray shop with an air pressure supply rated nominally at 5 bar. In practice the air pressure is unlikely to be less than 5 bar, but may be as high as 6 bar. Additionally, it is recognised that in many applications it would be desirable to supply liquid, for example paint from the diaphragm pump to a paint spraying system at a nominal minimum pressure of 10 bar, and it is an object of the present invention to provide a pumping

system incorporating a diaphragm pump in which this objective can be achieved in a simple and convenient manner, it being understood that the invention has a broader application than simply to achieve a nominal 10 bar paint pressure in a paint spraying system supplied with air at nominally 5 bar.

Disclosure of the Invention

[0005] In accordance with the present invention there is provided a pumping system incorporating a diaphragm pump and in association therewith a pressure intensifier receiving pressurised driving fluid from a supply, the intensifier boosting the pressure of the drive fluid beyond its supply pressure and supplying the drive fluid, at said increased pressure, to said diaphragm pump, to generate pumping strokes of the pump producing a pump output pressure in excess of the drive fluid supply pressure.

[0006] Conveniently said pressure intensifier is at least a two times intensifier (preferably a 2.5 times intensifier) and conveniently the pump has a 1:1 input to output pressure ratio whereby the pressure in the output line of the pump is two times (preferably 2.5 times) the supply pressure of the drive fluid to the pressure intensifier.

[0007] Desirably the pressure intensifier is incorporated into the diaphragm pump.

[0008] Conveniently the diaphragm pump is a double-acting diaphragm pump and the pressure intensifier is incorporated in a spool valve controlling the supply of drive fluid to the diaphragms of the double-acting diaphragm pump.

[0009] Preferably the diaphragm pump has a 1:1 input to output pressure ratio.

Brief Description of the Drawings

[0010] One example of the invention will now be described with reference to the accompanying drawings wherein:

Figure 1 is a diagrammatic cross-sectional view of a double-acting diaphragm pump;

Figures 2 and 3 are diagrammatic representations of part of the pump of Figure 1 showing how the pump operates; and

Figures 4 and 5 are diagrammatic cross-sectional views of alternative constructions of pressure intensifier for use in combination with the diaphragm pump of Figures 1, 2 and 3.

Preferred Mode of Carrying Out the Invention

[0011] Referring to the drawings, Figures 1, 2 and 3 illustrate a known form of diaphragm pump in which a

generally cylindrical central metal body 11 has an axial through bore 12 and is fitted, at its opposite ends respectively, with first and second end plates 13, 14. The face of the body 11 presented to the end plate 13 is concave, and the face of the end plate 13 presented towards the body 11 is also concave. The concavities of the end plate 13 and body 11 define an internal chamber which is divided into a drive chamber 15 and a pumping chamber 16 by a flexible metal diaphragm 17 having its periphery trapped between peripheral regions of the end plate 13 and the body 11. The arrangement at the opposite axial end of the body 11 is similar in that an internal chamber is divided into a drive chamber 15a and a pumping chamber 16a by means of a diaphragm 17a. A link rod 18 is slidably received in the bore 12 of the body and is connected at its opposite axial ends respectively to the diaphragms 17, 17a. At each end the rod 18 passes through the respective diaphragm and diaphragm control washers 19, 21 of different diameter are clamped against opposite faces of the diaphragm by a nut 22 engaged on a screw threaded end region of the rod 18. The diaphragm pump illustrated in Figure 1 is designed to be driven by compressed air, and to pump a liquid paint. The references to drive air, and pumped liquid will be retained throughout the remainder of this application, but it is to be understood that there may be applications in which fluids other than liquid paint are pumped, and fluids other than compressed air are used to power the pump.

[0012] Each end plate 13, 14 includes a liquid inlet passage 23 which communicates with its respective pumping chamber 16, 16a through a non-return valve 24 conveniently in the form of a ball check valve. Similarly, each end plate 13, 14 includes a liquid outlet passage 25 communicating with the respective chamber 16, 16a through a non-return valve 26 also conveniently in the form of a ball check valve. The liquid inlet passage of the end plate 14 has an open union 27 whereby the inlet passage can be connected to a supply of liquid to be pumped in use. The inlet passage of the end plate 14, upstream of the respective non-return valve, is coupled to the inlet passage 23 of the end plate 13 upstream of the non-return valve 24 by a transverse passage 28 extending axially within the body 11.

[0013] The liquid outlet passage 25 of the end plate 23 has an open union 29 for connection to the arrangement to be supplied with pumped liquid, for example a paint spraying system. The union 29 is downstream of the non-return valve 26 of the end plate 13 and a transverse passage 31 parallel to the passage 28, extends within the body 11 axially to interconnect the liquid outlet passage of the end plate 14, downstream of its non-return valve, with the passage 25 of the end plate 13 downstream of the non-return valve 26. Thus liquid enters the double-acting diaphragm pump through the union 27 to be pumped either from the chamber 16, or the chamber 16a, and irrespective of which chamber is performing a pumping stroke, the pumped liquid issues from the

pump by way of the union 29.

[0014] Intermediate its ends the rod 18 forms part of a spool valve 32 controlling the admission of compressed air to the drive chambers 15, 15a of the pump.

[0015] The spool valve 32 forms part of a change-over valve arrangement of the pump and operates in combination with a change-over valve 33 the housing of which forms part of, or is secured to, the body 11. The change-over valve 33 has a first operative position (as shown in Figure 2) to which it is urged by the application of compressed air to one end of the valve, and a second operative position (as shown in Figure 3) to which it is urged by a return spring 34 of the valve. A compressed air inlet port 35 of the spool valve 32 is supplied with compressed air from a standardised mains supply (indicated at "B" in Figures 2 and 3) associated with the liquid pumping system. For the purposes of this example it can be assumed that the pressure at the standardised supply line B is 5 bar. An air pressure inlet port 36 of the valve 33 is supplied with compressed air from the standard mains supply through the intermediary of a pressure intensifier 37 (Figure 4). The pressure intensifier 37 is a 2.5 times intensifier, and so the pressure in a supply line "A" from the intensifier 37 to the inlet port 36 is 12.5 bar.

[0016] Figure 2 illustrates the double-acting diaphragm pump at the right-hand end of its travel, in which the diaphragm 17a has moved towards the end plate 14 so that the chamber 16a has undergone a pumping stroke. As this point in the travel of the rod 18 relative to the body 11 is reached the spool valve 32 places the port 35 in communication with an outlet port 38 coupled to the pressure sensing port of the valve 33. Mains supply air pressure applied to the valve 33 from the port 38 of the body 11 drives the valve 33 against the spring 34 to a position in which the intensified supply "A" is connected through a line 39 to the chamber 15 of the pump and at the same time the chamber 15a is connected through a line 41 and the valve 33 to atmosphere so that pressure in the chamber 15a can be exhausted. Thus compressed air at 12.5 bar is supplied through the valve 33 to the chamber 15 driving the piston 17 to the left carrying with it the rod 18 and the piston 17a. Liquid within the chamber 16 is expelled by this movement of the diaphragm 17 and flows from the chamber 16 through the non-return valve 26 and the pressure supply port 29 of the pump. The non-return valve 24 on the inlet side of the chamber 16 remains firmly closed and thus the left-hand end of the pump (as drawn in Figure 1) performs a pumping stroke. Simultaneously the chamber 16a at the right hand end of the pump is undergoing reduced pressure as the volume of the chamber 16a is increased and so the non-return valve at the outlet side of the chamber 16a remains firmly closed, but the non-return valve at the inlet side of the chamber 16a opens to permit fresh liquid to be drawn into the chamber 16a from the liquid supply port 27.

[0017] As the diaphragm 17 achieves its maximum displacement to the left, that is to say at the end of the

pumping stroke of the chamber 16, the spool valve 32, moving with the rod 18, achieves a position in which the pressure sensing port of the valve 33 is connected to an exhaust port 44 of the body 11 and the position of the change-over valve 33 switches, under the influence of the spring 34, to place the line 39 in communication with atmosphere through the valve 33 and to place the line 41 in communication with the intensified air pressure at "A". Thus the chamber 15a is now supplied with pressure and so the diaphragm 17a performs a pumping stroke while the diaphragm 17 is retracted, increasing the volume of the chamber 16, and allowing liquid to be drawn from the inlet union 27 through the passage 28 and the valve 24 into the chamber 16. The liquid pumped from the chamber 16a by movement of the diaphragm 17a flows through the non-return valve at the outlet of the chamber 16a and through the passage 31 to the outlet union 29 of the pump.

[0018] The pump continues to reciprocate in the above manner under the control of the spool valve 32 and change-over valve 33 as long as there is compressed air at "A" and "B". As the pump is a 1:1 pump and the air pressure applied to the diaphragms 17, 17a is 12.5 bar, then liquid is pumped from the union 29 nominally (ignoring usual operating losses) at 12.5 bar.

[0019] The 2.5 times pressure intensifier 37 illustrated in Figure 4 is of known, commercially available form, and will be connected between the standard mains air pressure supply of the system and the port 36 of the change-over valve 33. It is anticipated however that a pressure intensifier fulfilling the same function as the intensifier 37 can be mechanically incorporated into the change-over system consisting of the spool valve 32 and the change-over valve 33 thereby minimising the component count of the system, and ensuring that the pump incorporates the pressure intensifier, and so can simply be coupled to an existing compressed air and liquid supply arrangement.

[0020] The intensifier shown in Figure 4 utilizes pistons of different diameter appropriately dimensioned to effect pressure intensification at 2.5:1. It is to be understood that while pressure intensification of about 2:1 is desired for the above described paint spraying system, other applications may require other pressure intensification ratios. The skilled man will recognise that other ratios can be achieved using intensifiers based upon the Figure 4 design with their relative dimensions adjusted according to the required ratio.

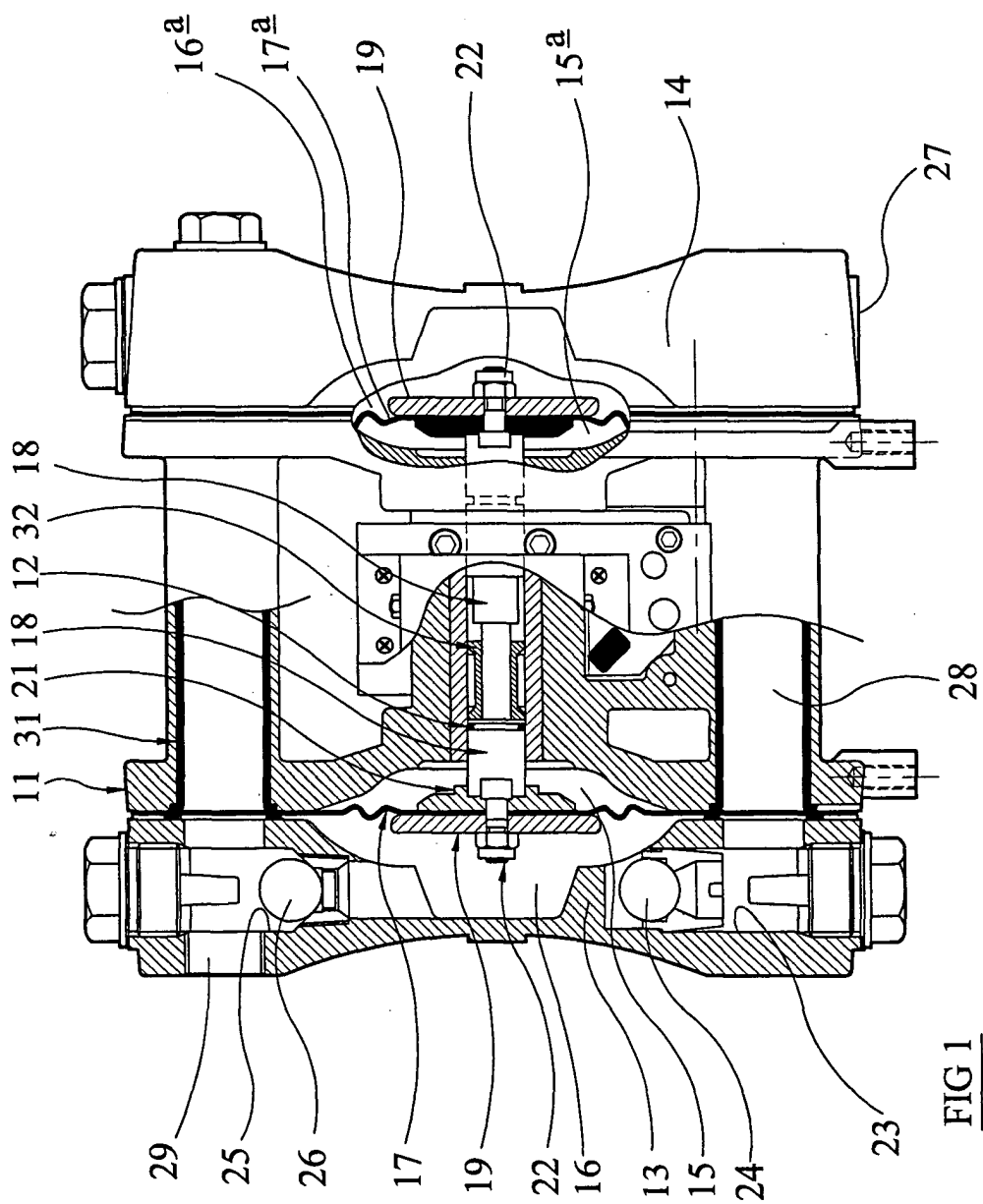
[0021] Figure 5 shows an alternative intensifier design arranged using pistons of equal diameter to achieve a 2:1 pressure intensification ratio, which could be substituted for the Figure 4 design in an appropriate application. The construction and operation of the intensifiers of Figures 4 and 5 will be well understood by the skilled man.

[0022] Although the pump described above has a 1:1 pressure ratio between the input air and the output liquid it is to be understood that the invention can utilize pumps

having other input to output ratios if desired

Claims

1. A pumping system **characterised by** a diaphragm pump (11, 13, 14, 17) and in association therewith a pressure intensifier (37) receiving pressurised driving fluid from a supply, the intensifier boosting the pressure of the drive fluid beyond its supply pressure and supplying the drive fluid, at said increased pressure, to said diaphragm pump, to generate pumping strokes of the pump producing a pump output pressure in excess of the drive fluid supply pressure.
2. A pumping system as claimed in claim 1 **characterised in that** said pressure intensifier is at least a two times intensifier and conveniently the pump has a 1:1 input to output pressure ratio whereby the pressure in the output line of the pump is two times the supply pressure of the drive fluid to the pressure intensifier.
3. A pumping system as claimed in claim 1 **characterised in that** said pressure intensifier is at least a 2.5 times intensifier and conveniently the pump has a 1:1 input to output pressure ratio whereby the pressure in the output line of the pump is 2.5 times the supply pressure of the drive fluid to the pressure intensifier.
4. A pumping system as claimed in any one of claims 1 to 3 **characterised in that** the pressure intensifier is incorporated into the diaphragm pump.
5. A pumping system as claimed in any one of the preceding claims **characterised in that** said intensifier (37) is incorporated in a control valve (32) forming part of the assembly of the pump.
6. A pumping system as claimed in any of claims 1 to 5 **characterised in that** the diaphragm pump is a double-acting diaphragm pump and the pressure intensifier is incorporated in a spool valve (32) controlling the supply of drive fluid to the diaphragms (17, 17a) of the double-acting diaphragm pump.
7. A pumping system as claimed in claim 1 **characterised in that** the diaphragm pump has a 1:1 input to output pressure ratio.



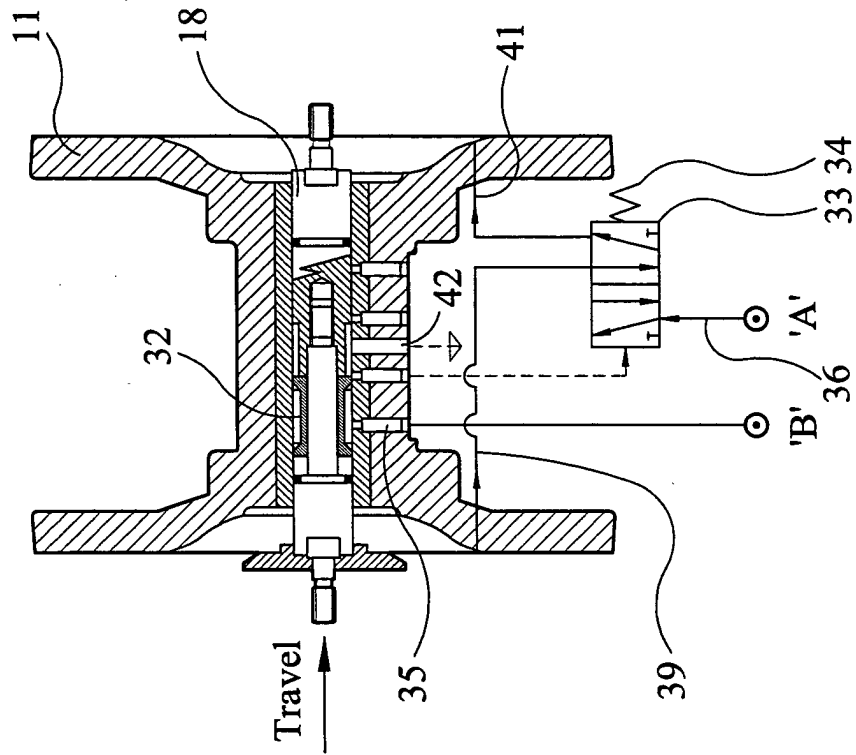


FIG 3

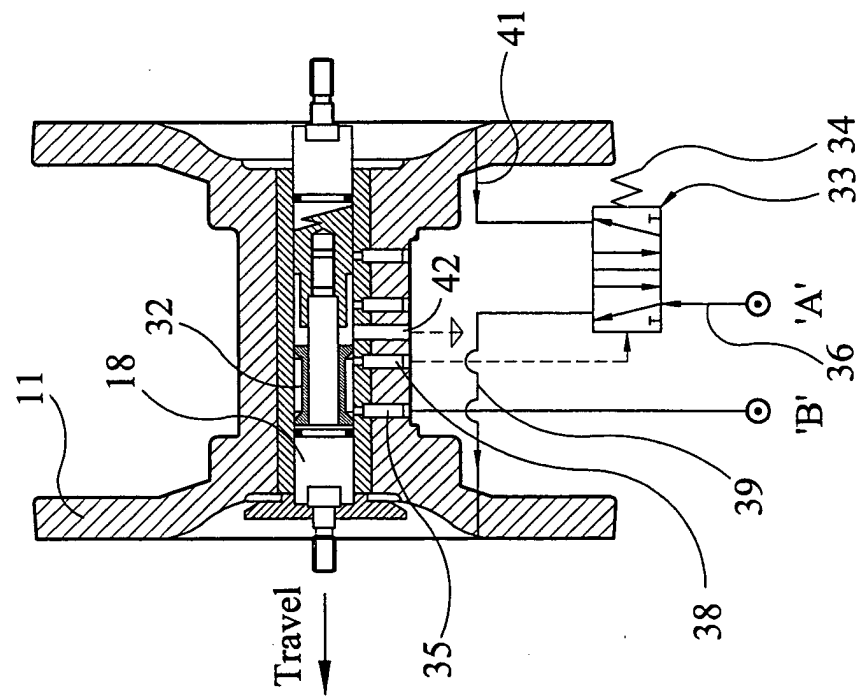
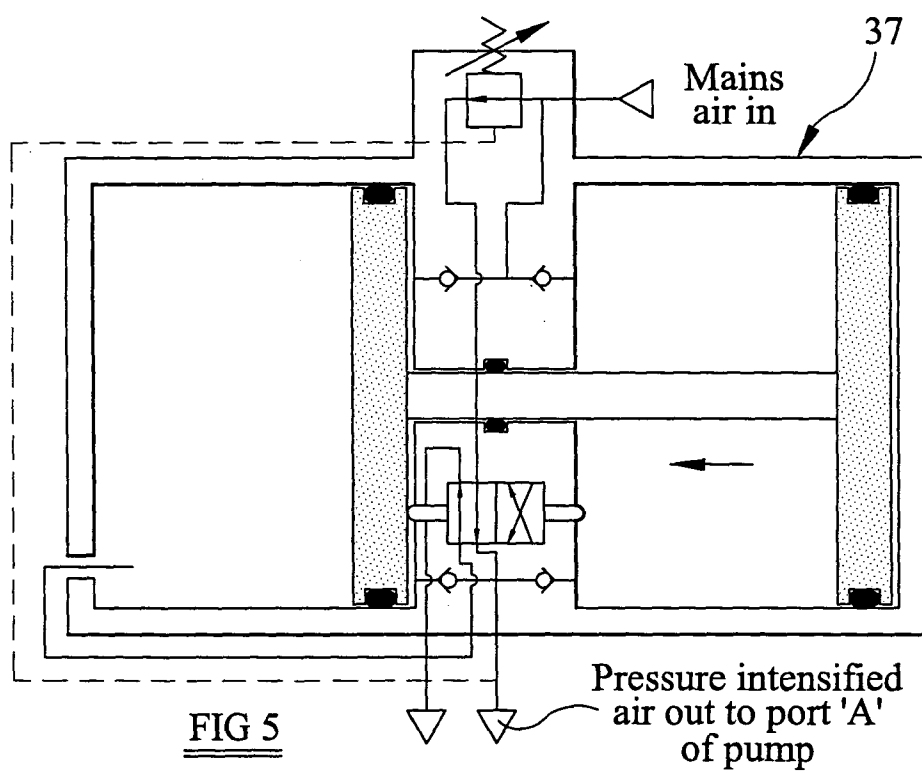
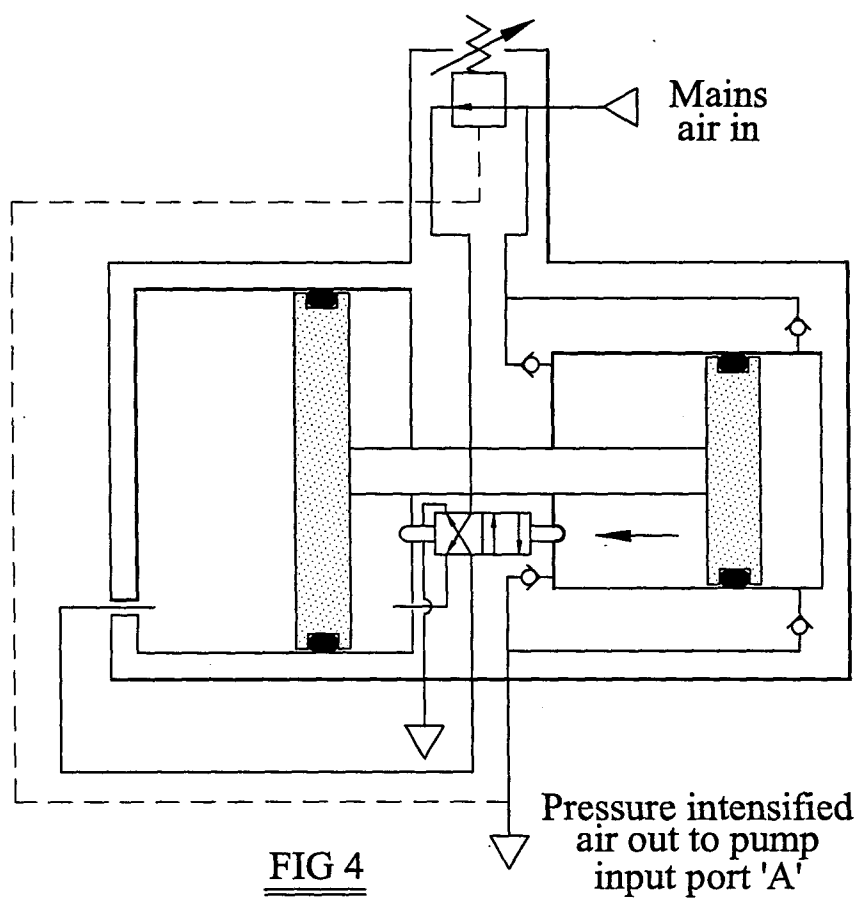


FIG 2





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EUROPEAN SEARCH REPORT

Application Number
EP 04 25 2713

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The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 2 September 2004	Examiner Pinna, S
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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