March 18, 1969 G. VETTER 3,433,161

DIAPHRAGM PUMP

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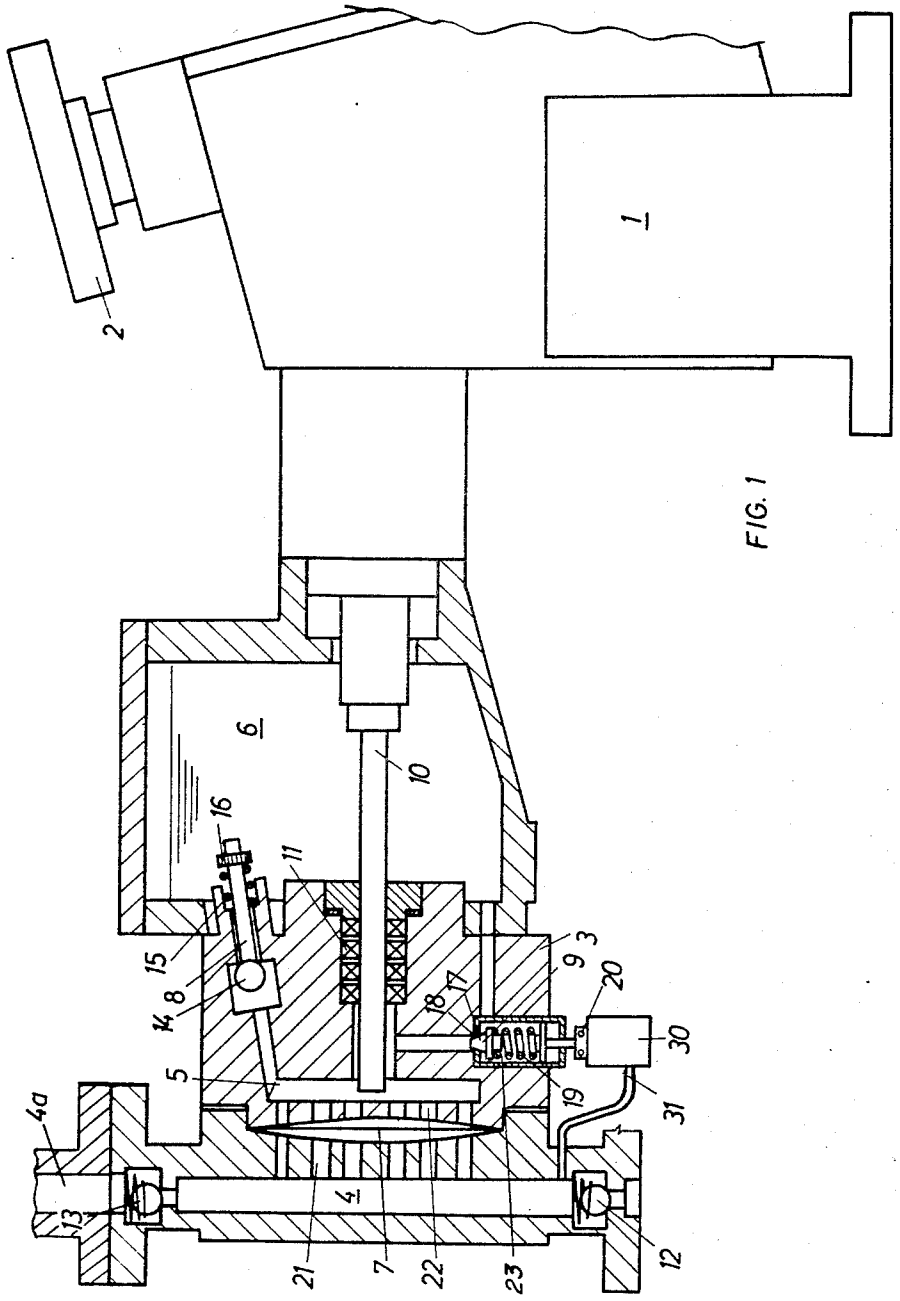


FIG. 1

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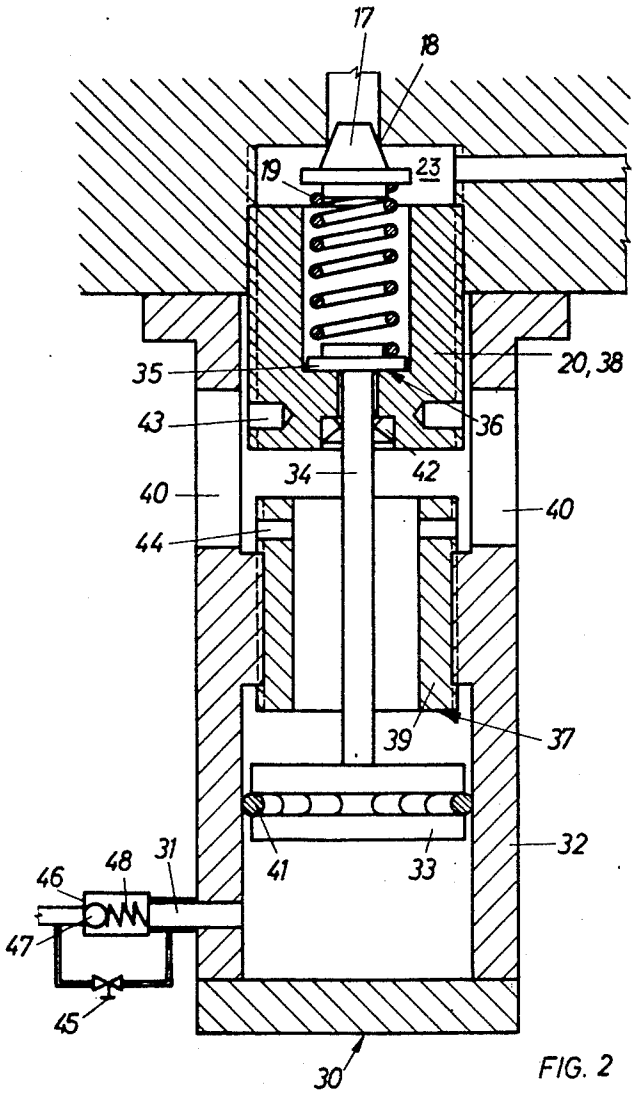


FIG. 2

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DIAPHRAGM PUMP

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ABSTRACT OF THE DISCLOSURE

A diaphragm pump having a diaphragm separating a pump chamber and a pressure fluid chamber, the latter chamber communicating with a pressure fluid reservoir by both an inlet valve and an overflow valve in order to limit the fluid pressure created within the pressure fluid chamber in dependence on the pressure developed in the pump chamber.

The present invention relates to a diaphragm pump in which the diaphragm separates a pump chamber and/or a pressure fluid pipe from a pressure fluid chamber, the pressure fluid chamber communicating with a pressure fluid reservoir both by an inlet valve to supplement the fluid and by an overflow valve to limit the fluid pressure generated by a displacement piston.

In such known pumps the diaphragm is usually arranged in a chamber, the walls of which are cup shaped and contain holes, the cup-shaped surfaces determining the end positions of the diaphragm. If, for example, the pressure in the pump chamber drops below a given value, or if too much pressure fluid passes into the fluid chamber by way of the inlet valve, the diaphragm will abut the cup-shaped surface adjacent the pump chamber. In order to prevent the diaphragm from being overstrained in the process, the holes in the cup-shaped walls are made small. However, this creates difficulties in production. Small holes are also disadvantageous, particularly when conveying viscous fluids, since many fluids cannot pass through the holes rapidly enough.

Another way of avoiding overstraining the diaphragm, generally used in addition to using small holes, is to set the opening pressure of the overflow valve low although this reduces the pumping head.

The present invention is directed towards providing a diaphragm valve in which overstraining of the diaphragm is avoided without incurring the above disadvantages. This is achieved by varying the closing force of the overflow valve in dependence on the pressure in the pump chamber, in the conveying pipe or in both.

In one embodiment of the invention, the closing force of the overflow valve is generated by a hydraulic means controlled by the pressure of the pump chamber, of the conveying pressure pipe or of both, the means urging a valve head onto a seat with a valve spring being interposed therebetween so as to control the overflow valve. Such a hydraulic device provides a convenient means for transferring the controlling pressure to the valve spring, the latter allowing the overflow valve to be opened without displacing the pressure fluid column of the hydraulic means. The valve head is accordingly not subject to the forces of inertia of the latter.

The means for accomplishing the foregoing objects and other advantages, which will be apparent to those skilled in the art, are set forth in the following specification and claims and are illustrated in the accompanying drawings dealing with a basic embodiment of the present invention. Reference is made now to the drawings in which:

FIG. 1 is a view, part diagrammatic and part in section, of an entire diaphragm pump according to the invention, and

FIG. 2 shows a detail of the pump shown in FIG. 1.

The diaphragm pump has a driving mechanism **1**, a stroke adjusting mechanism **2**, and a pump head **3**. The head **3** contains a pump chamber **4** for the fluid to be conveyed, a pressure fluid chamber **5** and a pressure fluid reservoir **6**. A diaphragm **7** separates the chamber **4** and its conveying pipe **4a** from the chamber **5**. Between the chamber **5** and reservoir **6** are an inlet valve **8** and an overflow valve **9**. A displacement piston **10**, operatively connected to the mechanism **1**, passes through the reservoir **6** and extends into the pressure fluid chamber **5**. Sealing means **11** is provided about the piston **10** to seal off the pressure fluid chamber **5** from the reservoir **6**. During the reciprocating movement of the piston **10**, the pressure in the chamber **5** is alternately raised and lowered. The diaphragm **7** follows the pressure changes and transmits them to the fluid to be conveyed. One-way valves **12** and **13** provide for the conversion of the pressure fluctuations into a pumping movement for the fluid.

The inlet valve **8** comprises a tappet with a valve head **14**, a spring **15**, and a set screw **16**. If the pressure in the chamber **5** drops a given value below the pressure in reservoir **6**, fluid will flow out of the reservoir **6** and into the chamber **5** through the valve **8**. This flow adds to any leakage of fluid which may occur from the reservoir **6** into the chamber **5** through the seal **11**. The overflow valve **9** contains a chamber **23**, a head **17**, a seat **18**, a spring **19**, and a set screw **20** to adjust the force of the spring **19**.

If the lift height is great or if the suction pipe or the fluid to be conveyed is strongly throttled, the pressure in the pump chamber **4** will be very low. On the suction stroke of the piston **10**, the pressure in the chamber **5** will fall correspondingly and the valve **8** will respond in such a way that too much pressure fluid will flow into the chamber **5** from the reservoir **6**. There is then a danger that the diaphragm **7** would be strained during the compression stroke of the piston **10**.

A known method for meeting this danger is to limit the movement of the diaphragm **7** with two opposingly mounted cup-shaped walls. These walls contain holes **21** and **22** so that the diaphragm **7** communicates with the chambers **4** and **5**, respectively. The force of the valve spring **19** is adjusted so that, when a given pressure is exceeded, the overflow valve **9** will respond and allow the surplus pressure fluid to flow back from the chamber **5** into the reservoir **6**.

By thus restricting the pressure in the chamber **5**, one also undesirably limits the pumping head.

The present invention is based on the principle that the closing force of the overflow valve **9** should be controlled in dependence on the pressure in the pump chamber **4** or in the pipe **4a** or in both. In this way the diaphragm **7**, when it covers the holes **21**, **22** at either end of its movement, is subjected to a constant pressure resulting from the difference between the pressures in the chambers **4** and **5**. Thus, when the pressure in the chamber **4** is low, the strain on the diaphragm **7** is not increased, and when it is high, the pumping head is not cut down.

In one embodiment of the invention, the closing force of the overflow valve **9** is controlled by a hydraulic actuator **30** which is subjected to the pressure in the pump chamber **4** and which presses the valve head **17** onto the seat **18** through the intermediary of the spring **19**. If the pressure differential between the chambers **4** and **5** exceeds a given value, the valve spring **19** will be further compressed beyond the degree of compression determined by the hydraulic actuator **30** or set screw **20**; the fluid column of the hydraulic actautor need not therefore move when the overflow valve **9** is being released, and the response time of the valve **9** is short.

The hydraulic actuator 30, only diagrammatically indicated in FIG. 1, is shown in detail in FIG. 2 and comprises a pressure pipe 31, a cylinder 32 having a piston 33 mounted therein, a thrust rod 34 fixed on one end to the piston and provided with a spring seat 35 at the opposite end, and two stops 36 and 37 arranged between the spring seat 35 and piston 33 to limit the movement of the piston 33. The stop 36, in the region of the spring seat 35, is formed by a sleeve-shaped spring housing 38 which in turn is a portion of the set screw 20. A given selected minimum tension can be set for the spring 19 by appropriately adjusting the spring housing-set screw 38, 20. The valve head 17 is accordingly pressed against the seat 18 with the desired amount of tension. The stop 37, in the region of the piston 33, is in the form of a tubular screw 39 so that a given selected maximum tension can be set for the valve spring 19 by allowing the piston 33 to compress the spring 19 only to a certain degree. Apertures 40 are provided in the cylinder 32 to give access to a suitable means such as a bar for turning the housing 38 and the tubular screw 39. The pressure chamber of the cylinder 32 and the valve chamber 23 are respectively sealed off from these apertures by means of a sealing ring 41 mounted on the piston 33 and by a seal 42 mounted in housing 38 encompassing thrust rod 34. The housing 38 and tubular screw 39 contain holes 43 and 44, respectively, for receiving therein the turning means. The apertures 40 in the housing of the hydraulic means 30 can be closed by detachable covers, if so desired.

A throttle 45 is arranged in parallel with a nonreturn valve 46 in the pressure pipe 31 of the hydraulic actuator 30. The valve 46 is connected to open when fluid flows into the hydraulic cylinder 32 and closes when the fluid flows back towards the pump chamber.

The action of the throttle 45 is adjustable. If such adjustability is not required, the throttle 45 can be dispensed with as a separate component and instead a nonreturn valve 46, with a slight leakage, can be used. The nonreturn valve comprises a ball 47 and a valve spring 28. The pressure fluid acting on the hydraulic cylinder 32 can come directly from the pump chamber 4; it is also possible for the hydraulic actuator 30 to be separated from the chamber 4 of the pipe 4*a* by a diaphragm or bellows.

The nonreturn valve 46 provides for the pressure loading of the cylinder 32 while the throttle 45 equalizes the pressure in the cylinder 32 with that in the chamber 4, in pipe 4*a* or in both. If the pressure pipe 31 does not open into the chamber 4, as illustrated, but instead leads into the pipe 4*a* or a pressure tank associated therewith, the throttle 45 and nonreturn valve 46 can be omitted as their functions are fulfilled by the one-way valve 13.

Owing to the action of the valve 46 or the valve 13, should the pressure pipe 31 be connected to the pipe 4*a*, the pressure established in the cylinder 32 will fluctuate only slightly; with the pump in normal operation, it will be near the maximum conveying pressure while, if the pressure drops sharply, e.g., as a result of cavitation, it will adapt itself to the reduced pressure.

Throughout this specification, the words "conveying pressure pipe 4*a*" are intended to include any pressure tank associated with the pipe 4*a*.

The force for controlling the valve spring 19 may equally be drawn from a source which, although controlled by the pressure in the pump chamber 4, in pipe 4*a* or in both, does not take the energy for changing

the position of the spring 19 from the chamber 4 or the pipe 4*a*.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore to be embraced therein.

What is claimed is:

1. A diaphragm pump comprising a pump head containing a pump chamber and a pressure fluid chamber with a diaphragm mounted therebetween, means to vary the pressure in said pressure fluid chamber to develop a pumping movement by said diaphragm, a pressure fluid reservoir, an inlet valve and an overflow valve connecting said pressure fluid chamber and said reservoir, said overflow valve comprising a chamber connected to both said pressure fluid chamber and said reservoir, a valve seat in said chamber, a valve head, spring means biasing said valve head into engagement with said valve seat to interrupt fluid flow through said chamber between said pressure fluid chamber and said reservoir, and means for controlling said overflow valve in dependence on the pressure developed in said pump chamber comprising hydraulic actuator means operatively connected to said valve head and responsive to the pressure developed in said pump chamber, said hydraulic actuator means comprising a cylinder having a piston therein forming a pressure chamber, pressure pipe means connecting said cylinder pressure chamber to said pump chamber, a thrust rod one end of which is fixed to said piston, the other end of said rod forming a seat for said spring, and stop means for limiting the stroke of said piston.

2. A diaphragm pump according to claim 1 in which said stop means are adjustable to provide maximum and minimum tension on said spring.

3. A diaphragm pump according to claim 2 in which said stop means are mounted interiorly of said cylinder and access aperture means are provided in the walls of said cylinder.

4. A diaphragm pump according to claim 3 in which sealing means are provided to seal off said pressure chamber and said valve chamber from said access aperture means.

5. A diaphragm pump according to claim 1 further comprising a nonreturn valve mounted in said pressure pipe, said nonreturn valve opening when pressure fluid flows into said hydraulic actuator and closing when said fluid flows out therefrom.

6. A diaphragm pump according to claim 5 further comprising adjustable throttle means connected to said pressure pipe in parallel to said nonreturn valve.

7. A diaphragm pump according to claim 1 further comprising means to adjust the biasing force of said spring.

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