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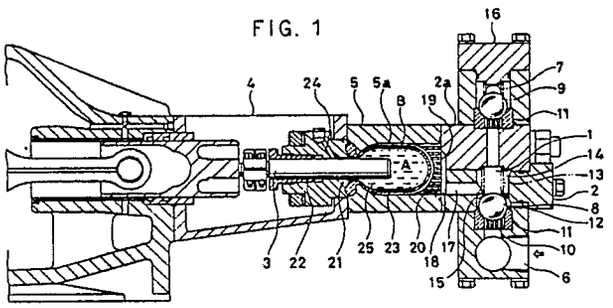
(54) Fluid pump apparatus and valve device.

(57) In a pump apparatus in which the action of a piston (3) draws fluid into and pumps fluid from a valve chamber (1), a partition is provided between the piston cylinder (21) and the valve chamber (1). The partition is able to transmit the force of the piston action, and for this purpose the cylinder (21) side (A) of the partition contains a suitable liquid medium that transmits the actuation of the piston (3). A screening (19) means is provided in a passage between the partition (18) and the valve chamber (1) to screen out particles in the fluid that exceed a prescribed size. The overall effect is to eliminate wear to working parts of the valve caused by entrained particles. In addition there is a valve device (8,9) which prevents bounce or vibration of valve-pieces during high pressure/high speed pumping operations.

FIG. 1



EP 0 343 773 A1

FLUID PUMP APPARATUS AND VALVE DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a fluid pump apparatus for ultrahigh pressure pumping of fluids and a valve device that prevents valve-piece vibration to thereby provide reliable valve operation.

Description of the Prior Art

Pumps include reciprocating pumps in which the reciprocating action of a piston is used to open and close valves to pump a fluid such as water, for example. In accordance with the configuration of the piston, reciprocating pumps are divided into the bucket type, the plunger type and the piston type.

Each type of reciprocating pump has its own uses, but in all such pumps the sliding parts are prone to wear. In the prior art there is known a technique whereby the fluid is prevented from coming into direct contact with the sliding parts of the reciprocating pump, consisting of providing a diaphragm in front of the piston and filling the space on the inner side of the diaphragm with fluid in order to transmit the force of the piston (Japanese Patent Publication No. 48-35405).

However, in the said conventional configuration the diaphragm is exposed to the fluid, and as a result the diaphragm wears quickly and has to be replaced each time. The diaphragm has to be replaced especially frequently when the pump is being used in cement mills, for example.

When plunger pumps, too, are used in cement mills, for example, the rapid wear of packings caused by cement particles has limited pumping pressures to 200 kgf/cm^2.

The flow of fluid is limited and controlled by various types of valves. Figures 14 and 15 show a valve device used on plunger pumps, a type of pump which is often used for high-pressure applications.

This valve device is constituted of a tubular seat 100, a valve-piece 102 provided with a surrounding flange 101, and a valve spring 103 which urges the valve-piece 102 against the seat 100.

Because plunger pumps are used to pump materials such as cement clinker, in the conventional valve device solid particles entrained in the fluid may be caught between the valve-piece 102 and the seat 100.

The tubular shape of the seat 100 used in the conventional valve device makes it easy for solid particles to pass through; in addition, because the seat 100 and the valve-piece 102 are made of metal the operation of the valve may be adversely affected by solid particles that are caught therebetween. The result is that it has sometimes been impossible to pump a constant amount of fluid at a constant rate, so that operation of the pump was accompanied by a decline in efficiency. Furthermore, solid particles caught between the seat 100 and the valve-piece 102 can damage the seat and valve-piece, leading to leakage of fluid. Conventionally, therefore, the valve device has to be replaced at this point, which interrupts operations.

This led to the invention of Japanese Patent Application 62-237996, a valve device that prevented the inflow of solid particles present in the fluid and increased the durability of the device.

The valve device of the said invention comprises a seat 107 having a valve seat 104 formed as a concave surface 105 corresponding to a part of a spherical surface, and a prescribed number of fluid passages 106 which are formed in the seat 107 and open into the concave surface 105. There are also a valve-piece 108 that has a surface corresponding to the shape of the concave surface 105 in the seat 107, and a valve cover 110 and spring retainer 111 that maintain the valve-piece 108 on the concave surface 105 of the seat 107 via a valve spring 109. In the valve device thus configured at least one of the seat 107 and the valve-piece 108 is either formed of, or covered with, a hard resilient material, or one is formed of a hard resilient material and the other is covered with a hard resilient material. In addition, wood may be used instead of the hard resilient material.

With the valve device thus configured, the fluid passages 106 formed in the seat 107 have a small diameter which makes it difficult for solid particles to pass therethrough. Even if solid particles should pass through the fluid passages 106 and get caught between the seat 107 and the valve-piece 108, the resilience of the valve seat and/or the valve-piece ensures that the functioning of the valves will be not obstructed.

However, the conventional device thus configured has been inadequate for pumping at higher pressures because increasing the amount being pumped causes the valve-piece 108 to vibrate during the inflow of fluid.

Summary of the Invention

An object of the present invention is to provide a fluid pump apparatus for ultrahigh pressure pumping of fluids and a valve device that prevents valve-piece vibration to thereby provide reliable valve operation.

To achieve this object, the present invention comprises a fluid pump apparatus in which the reciprocating action of a piston provided in a cylinder draws fluid into a valve chamber and pumps fluid from the valve chamber wherein: a partioning pressure action member is provided between the cylinder and the valve chamber and the cylinder side of the partioning pressure action member contains an operating medium that transmits the actuation of the piston; and a screening member is provided in a passage between the pressure action member and the valve chamber whereby only particles in the fluid that do not exceed a prescribed size are passed. It also comprises a fluid pump apparatus in which the reciprocating action of a piston provided in a cylinder draws fluid into a valve chamber and pumps fluid from the valve chamber wherein: a pressure-action chamber is provided between the cylinder and the valve chamber, the said pressure-action chamber being filled with a liquid that has a different specific gravity than that of the said fluid; and a passage that connects the pressure-action chamber and the valve chamber is provided at a position at which the height relative to the pressure-action chamber and the valve chamber is such that the liquid does not flow owing to the difference in specific gravity between the liquid and the fluid.

The invention further comprises a valve device comprising: a seat in the face of which are formed valve seats spaced at regular intervals around the edge, each shaped into a concave from that corresponds to part of a spherical surface; a multiplicity of fluid passages formed in the said valve seats as seat through passages; valve-pieces arranged in the valve seats, each valve-piece having a spherical surface that corresponds to the surface of the valve seats; and a valve housing provided with resilient means that resiliently presses the valve-pieces onto the valve seat surfaces.

The suction action of the piston causes the pressure action member to contract and an amount of fluid equal to the amount of change in the volume of the pressure action member is drawn into the valve chamber. Particles in the fluid that exceed a prescribed size are eliminated by the screening member and therefore do not come into contact with the pressure action member. Next, the expulsion action of the piston causes the pressure action member to expand, thereby expelling the fluid in the valve chamber. The suction action of the piston then causes fluid to flow into the valve chamber. The liquid contained in the pressure-action chamber is moved in the passage by an amount that corresponds to the change in the volume of the pressure action member, and there is a corresponding inflow of fluid. Then, the expulsion action of the piston produces a movement of liquid in the passage, in accordance with which fluid is expelled from the valve chamber. Thus, because the liquid in the pressure-action chamber has a specific gravity that is different to that of the fluid, the liquid moves between the pressure-action chamber and the passage but does not flow out at the valve chamber side. Also, fluid that enters the valve chamber is expelled from the valve chamber without coming into contact with the piston.

Furthermore, the valve operation takes the form of numerous actions that have a small amplitude of movement, which enables vibration accompanying the opening and closing action of the valve to be prevented.

The above and other features of the invention will become apparent from the description made below with reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a general cross-sectional view of a first embodiment of the fluid pump apparatus according to the present invention;

Figure 2 is an enlarged cross-sectional view of part of the device shown in Figure 1;

Figure 3 is a general cross-sectional view of a second embodiment of the fluid pump apparatus;

Figure 4 is a general cross-sectional view of a third embodiment of the fluid pump apparatus; is a perspective view of the valve device;

Figures 5 and 6 are general cross-sectional views of a fourth embodiment of the invention;

Figure 7 is cross-sectional view of a fifth embodiment of the invention applied to an ultrahigh pressure pump;

Figure 8 is a cross-sectional view of a valve device for the fifth embodiment;

Figure 9 is a perspective view of the valve device of Figure 8, shown disassembled;

Figure 10 is a plan view of the valve housing shown in Figure 9;

Figure 11 is a cross-sectional view taken along line A--A of Figure 10;

Figure 12 is a plan view of the seat shown in Figure 8;

Figure 13 is a cross-sectional view taken along line A--A of Figure 12;

Figures 14 and 16 are cross-sectional views of conventional valve devices; and

Figures 15 and 17 are perspective views of conventional valve devices.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the present invention will now be described with reference to Figure 1, which is a general cross-sectional view of the invention applied to a plunger pump used for pumping fluid containing a high level of particles, such as cement particles, for example.

In Figure 1 a fluid pump apparatus is comprised of a valve box 2 provided with a valve chamber 1, a plunger box 4 provided with a plunger 3, and a box 5 forming a pressure action chamber 5a disposed between the valve box 2 and the plunger box 4.

The valve box 2 has an inlet passage 6 and an outlet passage 7 that communicate with the valve chamber 1 and which are provided with an inlet valve 8 and an outlet valve 9, respectively. The inlet valve 8 and the outlet valve 9 each have a valve seat which is formed into a concave, semispherical shape; a seat 11 in which there are a multiplicity of small holes 10 that extend axially from the concave valve seats; a valve-piece 12 that has a spherical shape corresponding to the said concave valve seats; and a valve spring 13 that urges the valve-piece 12 against the seat 11. The holes 10 are for limiting the entry into the valve chamber 1 of particles in the fluid 14 that exceed a given size.

The valve-piece 12 of the inlet valve 8 can open in the direction of the valve chamber 1 and is therefore urged toward the seat 11 by the valve spring 13 via a valve retainer 15, one end of the valve spring 13 being engaged with the inner wall of the valve chamber 1. The valve-piece 12 of the outlet valve 9 opens away from the valve chamber 1 and is therefore urged against the seat 11 by a valve spring 13 provided between the valve box 2 and a valve cover 16.

Provided in the side wall 2a of the valve box 2 is a passage 17 that connects the pressure-action chamber 5a with the interior of the valve chamber 1, the said passage 17 opening into the lower part of a recess 18 formed in the side wall 2a of the valve box 2.

The valve box 5 that constitutes the pressure-action chamber 5a is provided with a screening member 19 disposed between the recess 18 and the pressure-action chamber 5a, as shown in the enlarged view of Figure 2. A mesh screen, for example, is used for the screening member 19, and formed therein are passages 20 to prevent the entry into the pressure-action chamber 5a of particles that exceed a given size. The passages 20 may be formed integrally in the side of the valve box 5, and are set at a prescribed inclination toward the passage 17 side.

The end of a plunger 3 maintained within a cylinder 21 in the plunger box 4 via a V-packing 22 projects into the pressure action chamber 5a and is reciprocated at high speed by a drive means (not illustrated).

A resilient membrane 23 is provided in the pressure-action chamber 5a to divide the pressure-action chamber 5a into a cylinder 21 side A and a valve chamber 1 side B. The cylinder 21 side A of the resilient membrane 23 is filled with an operating medium 25, such as oil, via an oil passage 24 of the plunger box 4.

With the above configuration, when suction operation of the plunger 3 causes the resilient membrane 23 to contract, reducing the volume on the cylinder 21 side A of the pressure-action chamber 5a, and a corresponding amount of fluid 14 flows into the valve chamber 1. At this time, particles in the fluid 14 that exceed a given size are eliminated by the seat 11 and are thus prevented from flowing into the valve chamber 1. Also, as particles in the fluid 14 that exceed a given size cannot pass the screening member 19, any such particles in fluid 14 that flows into the valve chamber 1 cannot enter the valve chamber 1 side B of the pressure-action chamber 5a.

The expulsion operation of the plunger 3 expands the resilient membrane 23, causing fluid 14 that has entered the valve chamber 1 to be expelled from the valve chamber 1.

Figure 3 shows a second embodiment of the present invention. In Figure 3, parts that are the same as parts shown in Figure 1 have been given the same reference numerals. In the second embodiment, a resilient membrane 26 directly covers the plunger 3 and the reciprocating action of the plunger 3 directly expands the resilient membrane 26. In this embodiment the passages 20 provided in a screening member 27 are not disposed facing the passages 17 but are instead located higher, which fully prevents the entry of any particles in the fluid 14. When pumping operations are being carried out where there are high levels of particles, such as in a cement mill, large particles contained in the fluid 14 can be fully prevented from entering the valve chamber 1 side B by filling the valve chamber 1 side B of the pressure-action chamber 5a with a liquid such as water that contains no particles, prior to the start of the pumping.

Figure 4 shows a third embodiment of the present invention. In Figure 4, parts that are the same as parts shown in Figure 1 have been given the same reference numerals. In this third embodi-

ment the side wall 2a of the valve box 2 is provided with a passage 17 that connects the pressure-action chamber 5a with the valve chamber 1. As explained below, the position of the passage 17 is determined according to the difference in specific gravity between a liquid and the fluid 14. When the liquid has a higher specific gravity than the fluid the passage 17 is located at a higher position in the pressure-action chamber 5a, and when the liquid has a lower specific gravity the passage 17 is positioned lower. In the illustrated example the position where the passage 17 opens into the pressure-action chamber 5a is higher than the inlet of the of the valve chamber 1. Thus, in this embodiment the position of the passage 17 is determined according to the relationship between the heights of the pressure-action chamber 5a and the valve chamber 1 and a consideration of the specific gravities of the liquid and the fluid 14.

The end of the plunger 3 maintained within the cylinder 21 in the plunger box 4 via V-packing 22 projects into the pressure action chamber 5a and is reciprocated at high speed by a drive means (not illustrated).

A resilient membrane 23 is provided in the pressure-action chamber 5a to divide the pressure-action chamber 5a into a cylinder 21 side A and a valve chamber 1 side B. The cylinder 21 side A of the resilient membrane 23 is filled with an operating medium 25, such as oil, via an oil passage 24 of the plunger box 4. In addition, the valve chamber 1 side of the pressure-action chamber 5a and part of the passage 17 are filled with a liquid 28, such as oil, which has a lower specific gravity than the fluid 14 used in a cement mill, for example, and does not mix with the fluid 14. The liquid 28 comes into contact with the fluid 14 part-way along the passage 17.

Provided between the pressure-action chamber 5a and the passage 17 is a screening member 29 that uses a mesh screen, for example, to prevent particles that exceed a given size from entering the pressure-action chamber 5a. The screening member 29 may be formed as an integral part of the valve box 5 which forms the pressure-action chamber 5a, and the passages 20 therein are set at a downward inclination toward the passage 17 side.

With the above configuration, suction operation of the plunger 3 causes the resilient membrane 23 to contract, reducing the volume on the cylinder 21 side A of the pressure-action chamber 5a and increasing the volume on the valve chamber 1 side B. The change in volume results in a rise in the level of the liquid 28 in the passage 17. Also, an amount of fluid 14 corresponding to the change in volume flows into the valve chamber 1 as the inlet valve 8 opens. The expulsion operation of the plunger 3 causes the resilient membrane 23 to expand via the operating medium 25, and with the reduction in the volume of the valve chamber 1 side B the liquid 28 in the valve chamber 1 side B of the pressure-action chamber 5a is expelled. Also, the level of the liquid 28 in the passage 18 decreases and a corresponding amount of fluid 14 is forced out as the outlet valve 9 opens. The liquid 28 is only forced part-way along the passage 17 and does not flow over to the valve chamber 1 side.

Figure 5 shows a fourth embodiment of the present invention. In Figure 5, parts that are the same as parts shown in Figure 1 have been given the same reference numerals. In this embodiment, a pre-chamber 30 filled with liquid 28 is also provided on the outside of the valve box 5. The pre-chamber 30 is communicated with the liquid 28 in the passage 17 by means of a branch pipe 31. With this embodiment the point of confluence of the liquid 28 and the fluid 14 does not move above the pre-chamber 30, and therefore the liquid 28 in the pressure-action chamber 5a can be kept fresh by changing the liquid 28 in the pre-chamber 30.

Figure 6 illustrates the insertion of a liquid 32 having a specific gravity that is midway between the specific gravities of the liquid 28 and the fluid 14 and which, in addition, does not mix with the fluid 14. With this arrangement, there is no direct contact between the liquid 28 and the fluid 14. A partitioning medium disposed between the liquid 28 and the fluid 14 may be used in place of the liquid 32.

In the above embodiments a liquid 28 is used having a lower specific gravity than the fluid 14, but a liquid having a higher specific gravity than the fluid 14 may also be used. In such a case the passage connecting the pressure-action chamber 5a with the valve chamber 1 should be provided toward the upper part of the pressure-action chamber 5a. A premise for such an arrangement is that the positional relationship between the height of the pressure-action chamber 5a and the valve chamber 1 will be adjusted.

Also, the above embodiments have been described with reference to the provision of a resilient membrane 23 in the pressure-action chamber 5a. However, the resilient membrane 23 may be dispensed with if the liquid 28 is one like oil that has lubricative properties and will not mix with the 14.

Figure 7 shows a fifth embodiment of the present invention applied to an ultrahigh pressure pump for use in cement mills, for example. In Figure 7, parts that are the same as parts shown in Figure 1 have been given the same reference numerals. In this embodiment the ultrahigh pressure pump consists of a valve box 2 that has a valve chamber 1; a plunger box 4 containing a plunger; and a valve box 5 forming a pressure-

action chamber 5a that is disposed between the valve box 2 and the plunger box 4.

The valve box 2 has an inlet passage 6 and an outlet passage 7 that communicate with the valve chamber 1 and which are provided with an inlet valve 80 and an outlet valve 81, respectively. As shown in Figures 8 to 13, the inlet valve 80 and the outlet valve 81 have a seat 84 in the face 82 which are formed a multiplicity of valve seats 83 (eight, in the illustrated example) spaced at regular intervals around the edge, each shaped into a concave form that corresponds to part of a spherical surface; spherical valve-pieces 85 arranged on the valve seats 83; and a valve housing 87 that presses the valve-pieces 85 onto the valve seats 83 by means of springs 86.

In each of the valve seats 83 in the seat 84 there are formed multiple fluid passages 88 (three in each case, in the illustrated example) that extend axially through the seat 84. Disposed around the edge of the valve housing 87 are fluid passages 89 corresponding to the valve seats 83 and into which the valve-pieces 85 fit. The exit end of each of the fluid passages 89 is formed into a smaller diameter portion by a lip 90. One end of each of the valve springs 86 are held in place at the said lip 90.

The valve housing 87 and seat 84 are each provided with respective central bolt through-holes 91 and 92 whereby they are bolted together by a bolt 93 and a nut 94.

In addition to metal, the valve-pieces 85 and/or the seat 84 may be made of, or covered with, a hard resilient material such as synthetic resin, for example.

In the side wall 2a of the valve box 2 is a passage 17 that connects the pressure-action chamber 5a with the interior of the valve chamber 1, and provided at the opening of the passage at the pressure-action chamber 5a end is a screening member 29 constituted of a mesh screen or the like that limits the entry of particles that exceed a given size.

The end of a plunger 3 maintained within a cylinder 21 in the plunger box 4 via a V-packing 22 projects into the pressure action chamber 5a and is reciprocated at high speed by a drive means (not illustrated).

A resilient membrane 23 is provided in the pressure-action chamber 5a to divide the pressure-action chamber 5a into a cylinder 21 side A and a valve chamber 1 side B. The cylinder 21 side A of the resilient membrane 23 is filled with an operating medium 25, such as oil. Also, the valve chamber 1 side B of the pressure-action chamber 5a is filled with a liquid such as oil having a specific gravity that differs from that of the fluid, so that the pumped fluid does not enter the pressure-action chamber 5a.

With the above configuration, when suction operation of the plunger 3 causes the resilient membrane 23 to contract, reducing the volume on the cylinder 21 side A of the pressure-action chamber 5a, the result is that the valve-pieces 85 on the inlet valve 80 side open against the resistance of the springs 86, and cement mill fluid 14 flows into the valve chamber 1. At this time, the valve-pieces 85 of the outlet valve 81 are drawn in the direction of their closed positions, and therefore remain closed. Before the fluid can flow into the valve chamber 1, entrained particles that exceed a given size are removed by the fluid passages 88 and then by the screening member 29.

The expulsion operation of the plunger 3 expands the resilient membrane 23, causing fluid 14 that has entered the valve chamber 1 to open the outlet valve 81 and be pumped out.

Because the operation of the valves 80 and 81 takes the form of small amplitude movements of the numerous valve-pieces 85, vibration accompanying the opening and closing action of the valves can be prevented.

As has been described in the foregoing, the fluid pump apparatus according to the present invention offers numerous features, advantages and effects, which will now be summarized with reference to the claims.

The provision of a screen member as described in claim 1 stops the entry of particles in the fluid that exceed a given size. Thus preventing large particles from coming into direct contact with the pressure action member eliminates a source of wear and damage to the pressure action member, and as such increases the durability. When applied to a pump, it allows pressures of around 500kgf/cm^2 to be achieved, and therefore can provide major improvements in efficiency if employed for pumping operations in civil engineering projects.

The provision of a resilient membrane as set out in claim 2 ensures reliable transmission of the piston action, while using a resilient membrane to cover a plunger (claim 3) has the same effect as the invention of claim 1.

Claim 4 uses a specific gravity differential between the fluid and the stated liquid to prevent the liquid flowing from the pressure-action chamber into the valve chamber. Consequently ther is no inflow of the fluid into the pressure-action chamber, and hence no wear and tear to the frictional parts of the piston. This results in a major boost in pump output levels, compared to the conventional apparatuses.

In accordance with claim 5, the freshness of liquid in the pressure-action chamber can be maintained by changing the liquid in the pre-chamber, while the partitioning medium arrangement of claim

6 is a reliable way to prevent mingling between liquid and fluid, and claim 7 enables all particles, dirt, etc., in the fluid that exceed a given size to be prevented from entering the pressure-action chamber.

In accordance with claim 8 the screen member can be dispensed with. With claim 9, piston lubricant or the like is provided on the cylinder side of the pressure-action chamber, which increases the durability of the piston frictional parts. The arrangement of Claim 10 provides sure response to the piston operation and is easy to implement. Claim 11 can provide the same effect as claims 8 and 9, while in accordance with claim 12 particles in the fluid that exceed a given size can be removed before reaching the valve chamber. Claims 13 and 14 enable valve-piece vibration to be prevented, and when applied to pumps can provide reliable valve function and increased durability, compared with conventional arrangements.

Claims

1. A fluid pump device in which the reciprocating action of a piston provided in a cylinder draws fluid into a valve chamber and pumps fluid from the valve chamber wherein:
a partioning pressure action member is provided between the cylinder and the valve chamber and the cylinder side of the partioning pressure action member contains an operating medium that transmits the actuation of the piston; and
a screening member is provided in a passage between the pressure action member and the valve chamber whereby only particles in the fluid that do not exceed a prescribed size are passed.

2. The fluid pump device according to claim 1 wherein the pressure action member is a resilient membrane.

3. A fluid pump device in which the reciprocating action of a plunger provided in a cylinder draws fluid into a valve chamber and pumps fluid from the valve chamber wherein:
a pressure-action chamber is provided between the cylinder and the valve chamber; a resilient membrane is provided in the pressure-action chamber that is pushed directly by the plunger; and a screening member is provided in a passage that connects the valve chamber and the pressure-action chamber whereby only particles in the fluid that do not exceed a prescribed size are passed.

4. A fluid pump device in which the reciprocating action of a piston provided in a cylinder draws fluid into a valve chamber and pumps fluid from the valve chamber wherein:
a pressure-action chamber is provided between the cylinder and the valve chamber, the said pressure-action chamber being filled with a liquid that has a different specific gravity than that of the said fluid; and a passage that connects the pressure-action chamber and the valve chamber is provided at a position at which the height relative to the pressure-action chamber and the valve chamber is such that the liquid does not flow owing to the difference in specific gravity between the liquid and the fluid.

5. The fluid pump device according to claim 4 wherein a pre-chamber is provided to contain the said liquid and the liquid in the said pre-chamber is communicated with the liquid in the said passage.

6. The fluid pump device according to claim 4 wherein a partioning medium is provided between the said liquid and fluid that conforms to changes in level.

7. The fluid pump device according to any one of claims 4 to 6 wherein a screening member is provided between the pressure-action chamber and the valve chamber that limits the inflow to particles in the fluid that do not exceed a fixed size.

8. The fluid pump device according to claim 7 wherein the screening member is formed integrally with the pressure-action chamber.

9. The fluid pump device according to any one of claims 4 to 8 wherein a pressure-action chamber is provided with a partioning pressure action member that divides the pressure-action chamber into a cylinder side and a valve chamber side, and contained on the cylinder side of the pressure-action chamber divided by the pressure action member is an operating medium that transmits the actuation of the piston, and the valve chamber side also contains fluid.

10. The fluid pump device according to claim 9 wherein the pressure action member is a resilient membrane.

11. The fluid pump device according to any one of claims 4 to 8 wherein a plunger is used for the piston and the plunger is covered directly by a resilient membrane that is attached to the pressure-action chamber.

12. The fluid pump device according to any one of claims 1 and 3 and 4 to 11 wherein the inlet and outlet of the valve chamber are each provided with a valve, and at least for the inlet side valve a valve device is used that limits the inflow to particles in the fluid that do not exceed a fixed size.

13. A valve device comprising:
a seat in the face of which are formed valve seats spaced at regular intervals around the edge, each shaped into a concave form that corresponds to part of a spherical surface;
a multiplicity of fluid passages formed in the said valve seats as seat through passages;
valve-pieces arranged in the valve seats, each valve-piece having a spherical surface that cor-

responds to the surface of the valve seats; and a valve housing provided with resilient means that resiliently presses the valve-pieces onto the valve seat surfaces.

14. The fluid pump device according to any one of claims 4 to 11 provided with the valve device of claim 3.

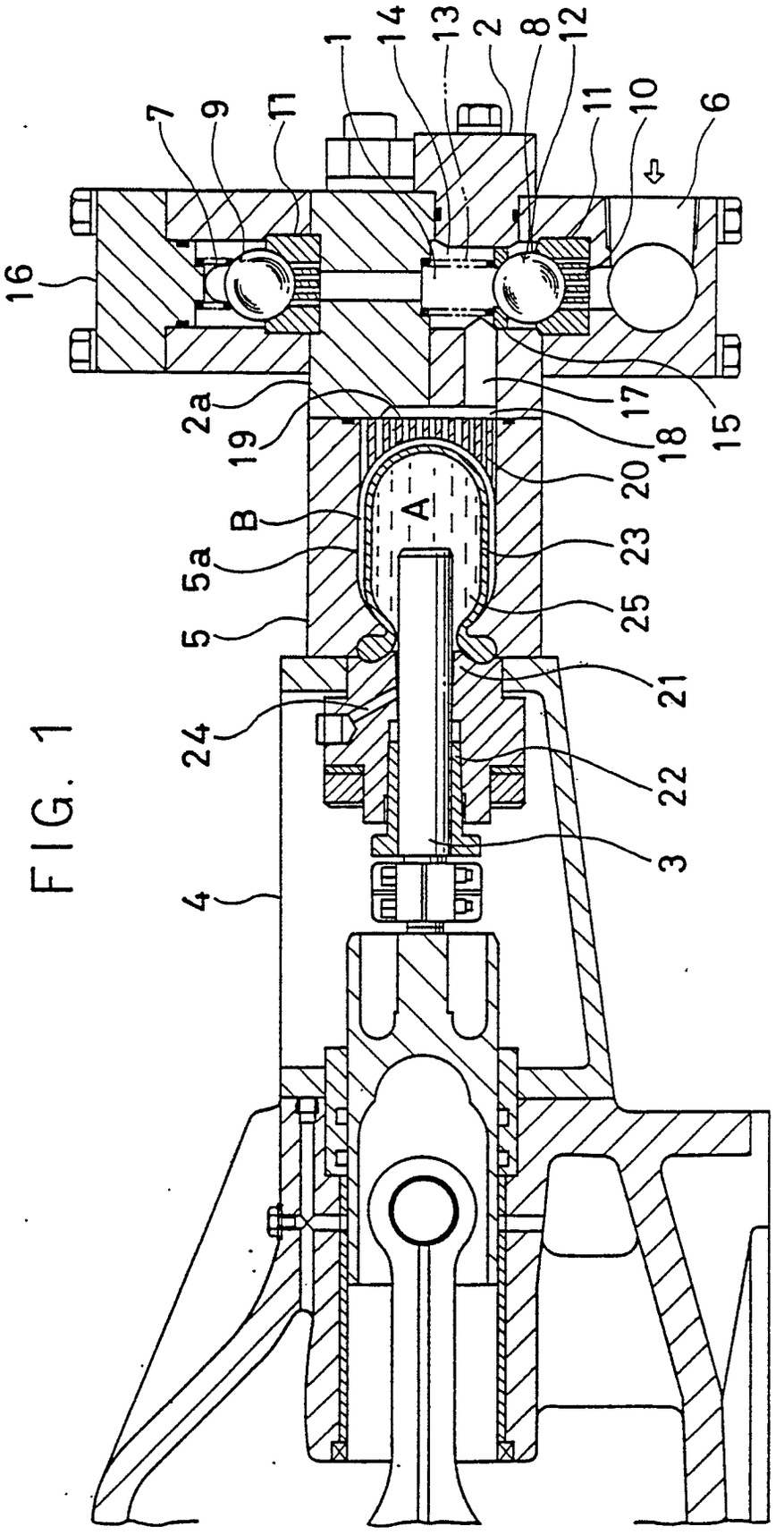


FIG. 1

FIG. 2

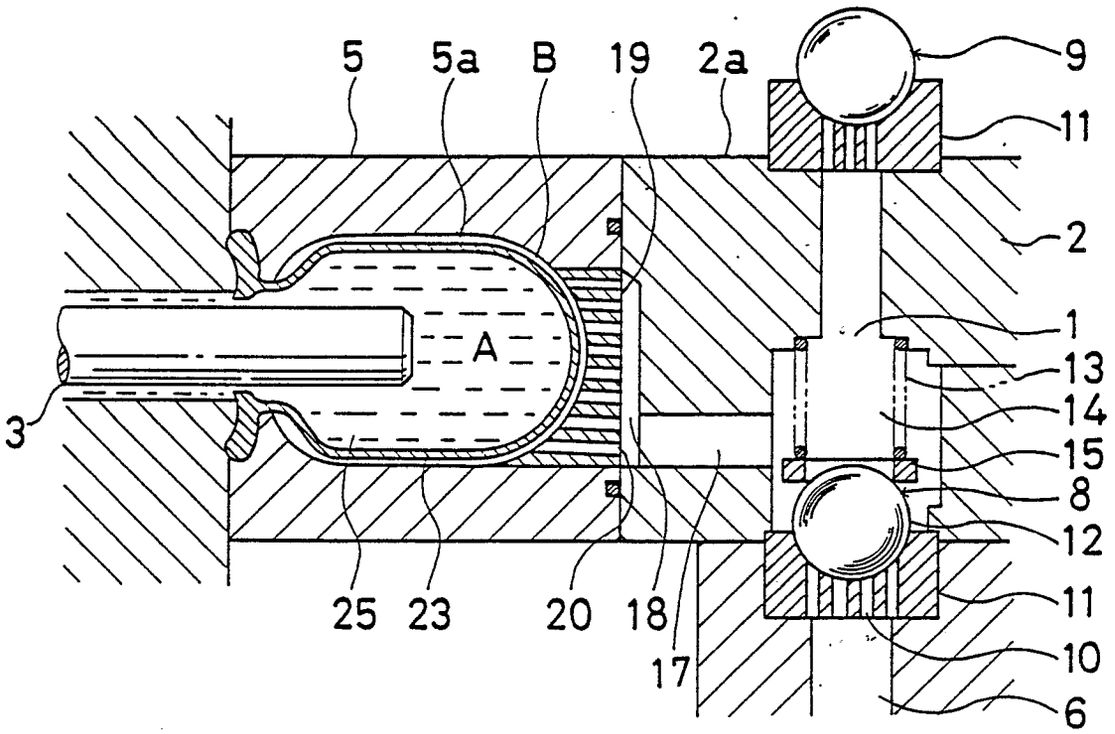

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FIG. 3

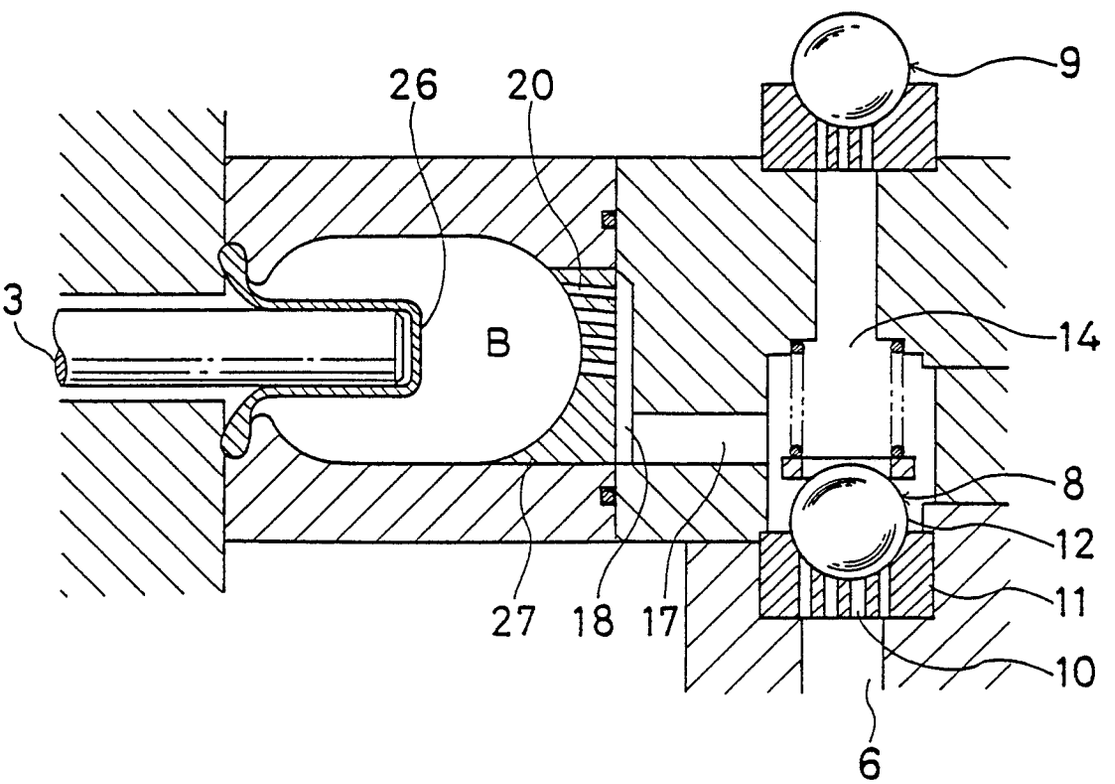
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FIG. 4

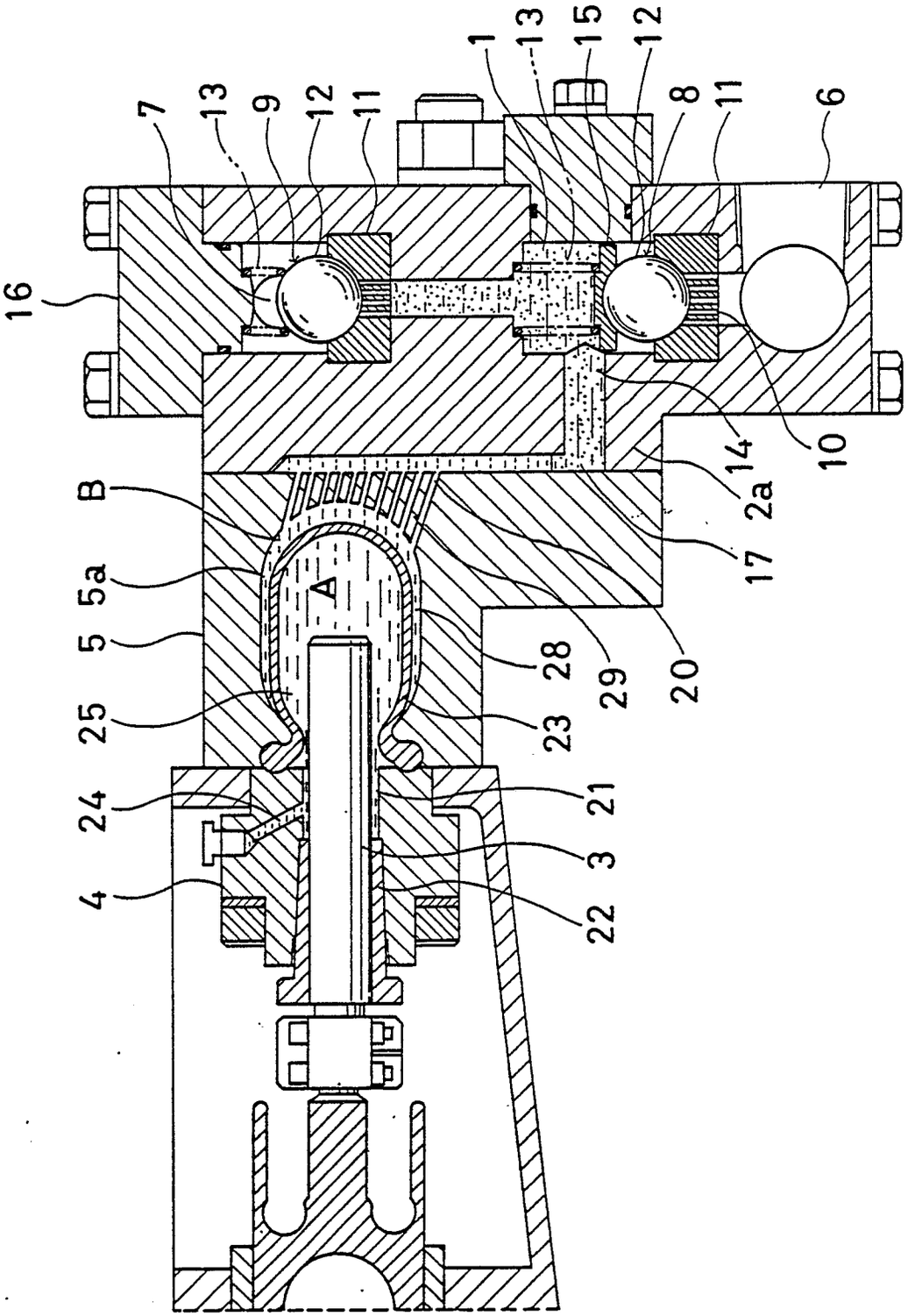
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FIG. 5

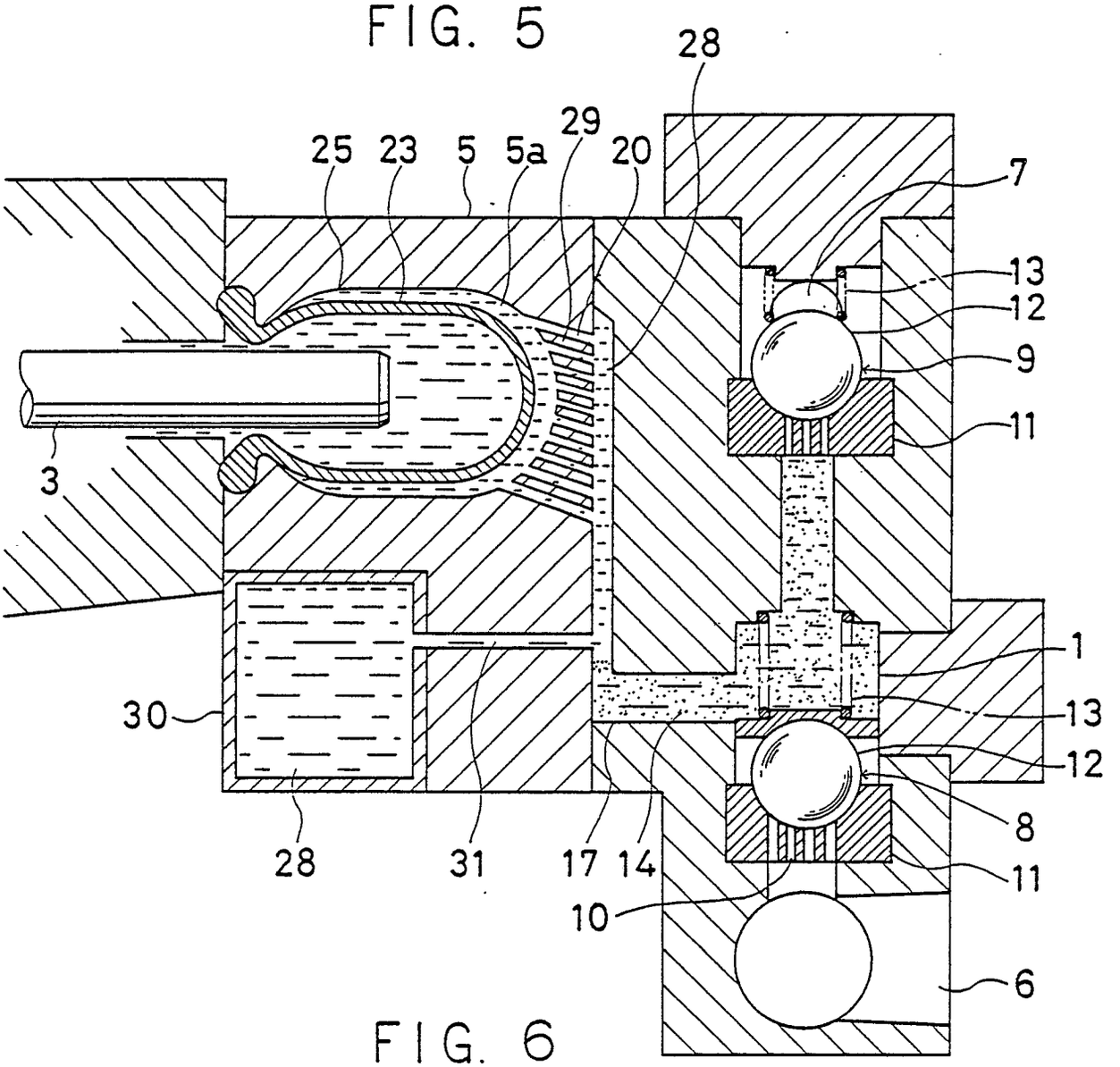


FIG. 6

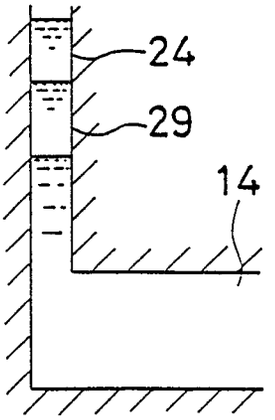


FIG. 7

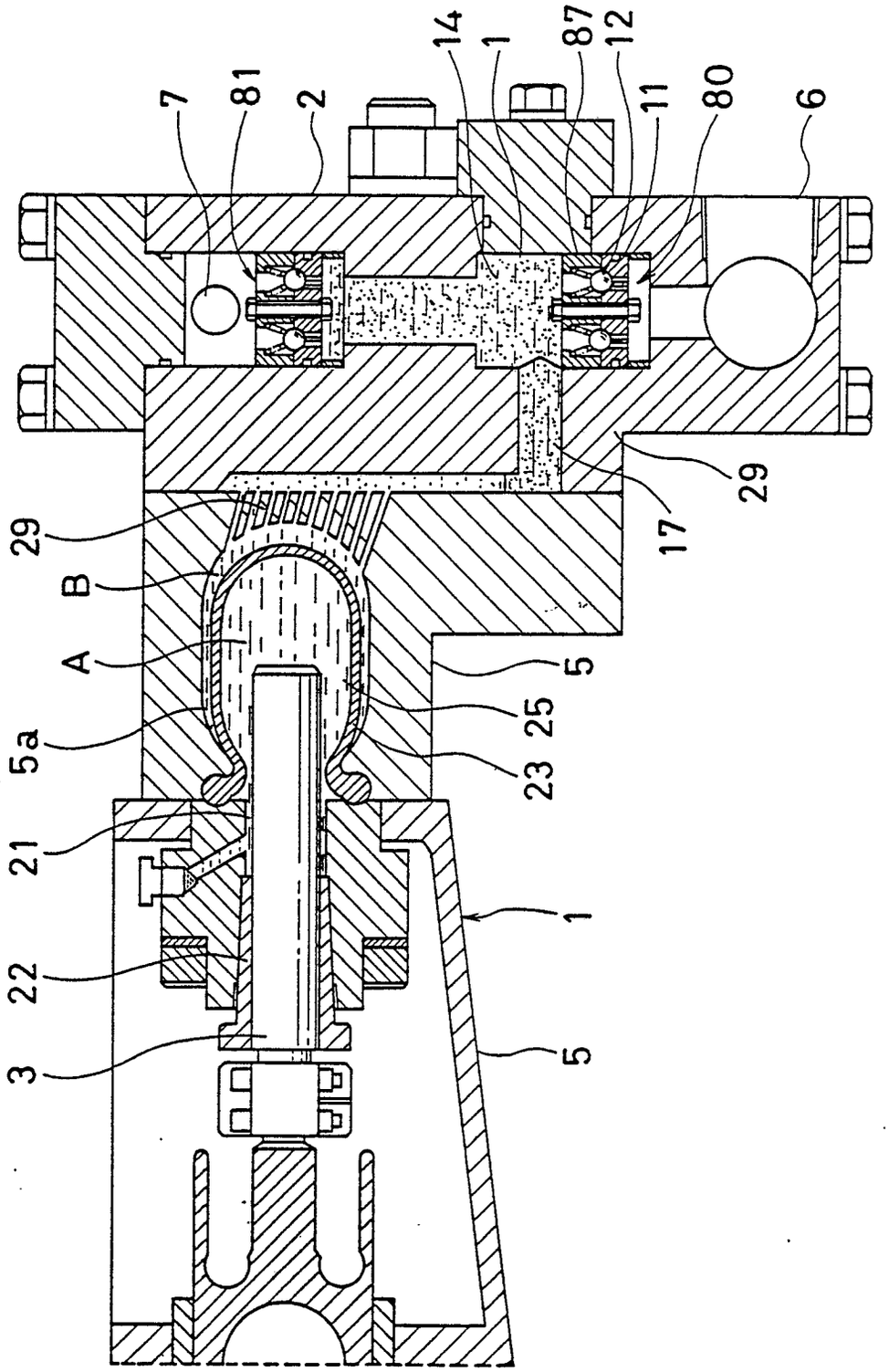


FIG. 8

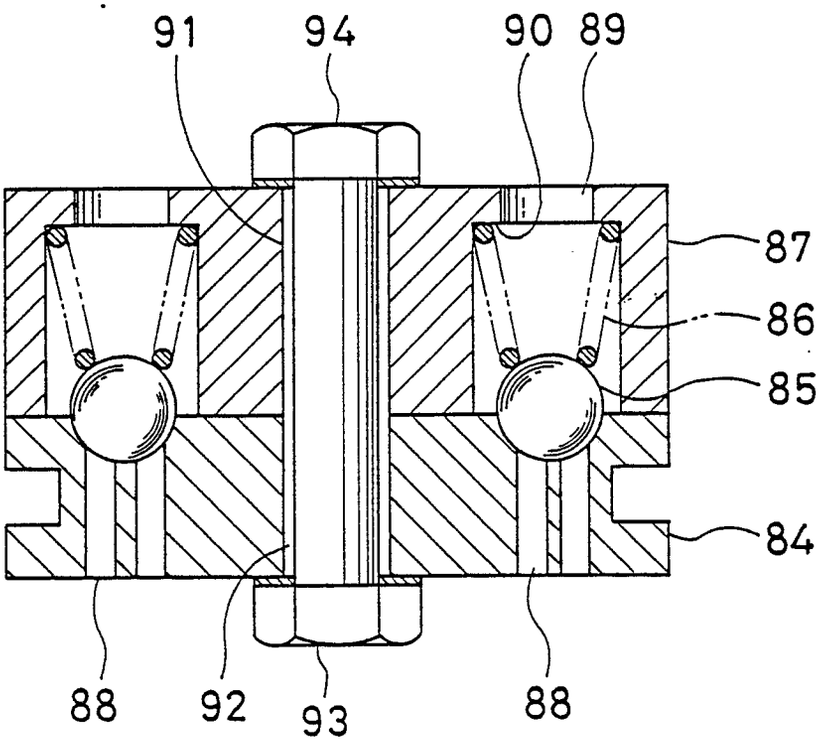


FIG. 9

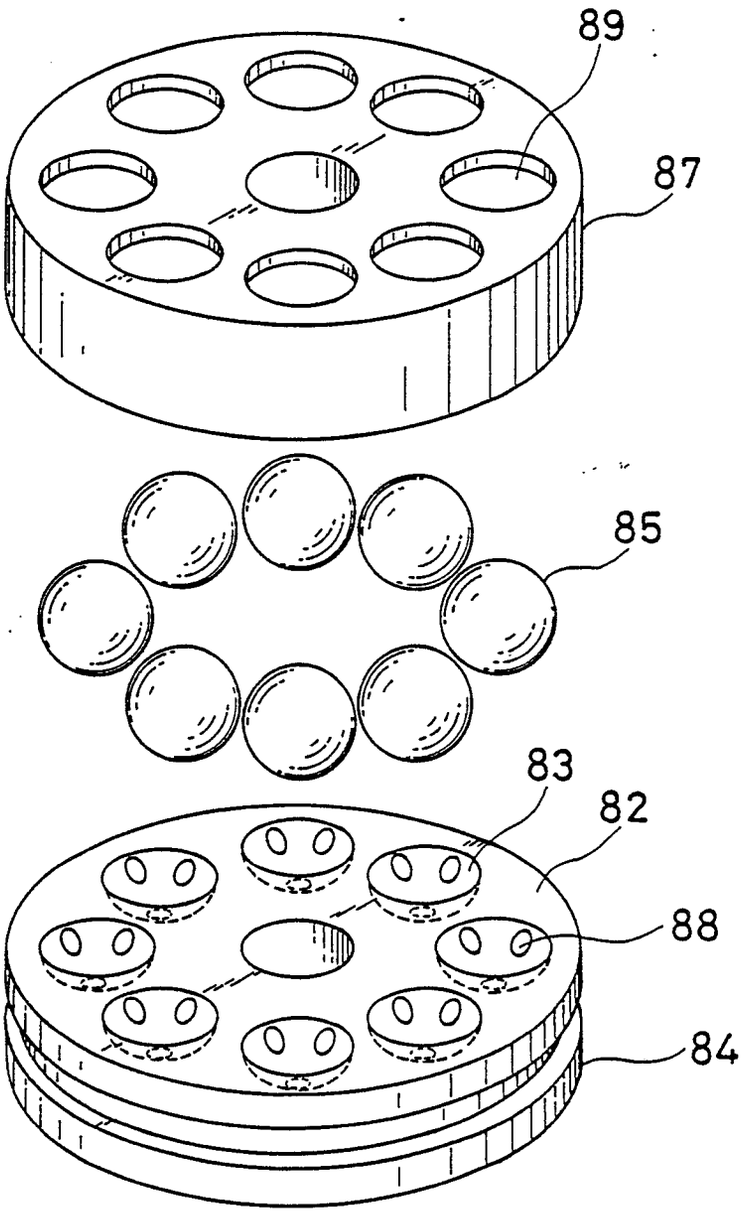


FIG. 10

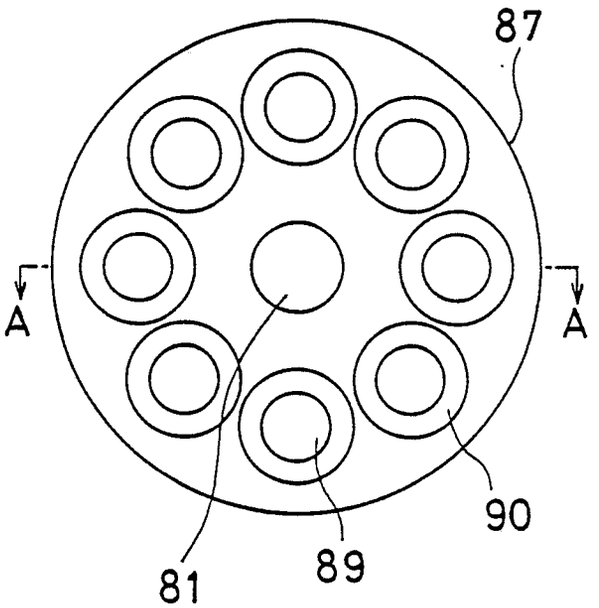


FIG. 11

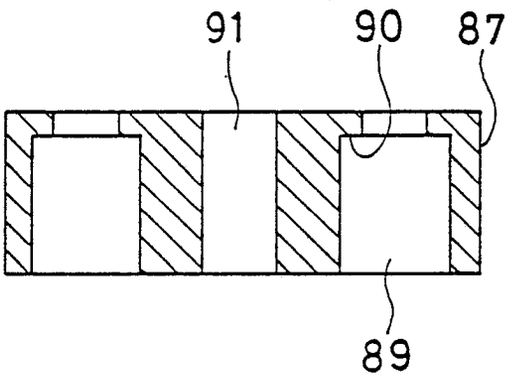


FIG. 12

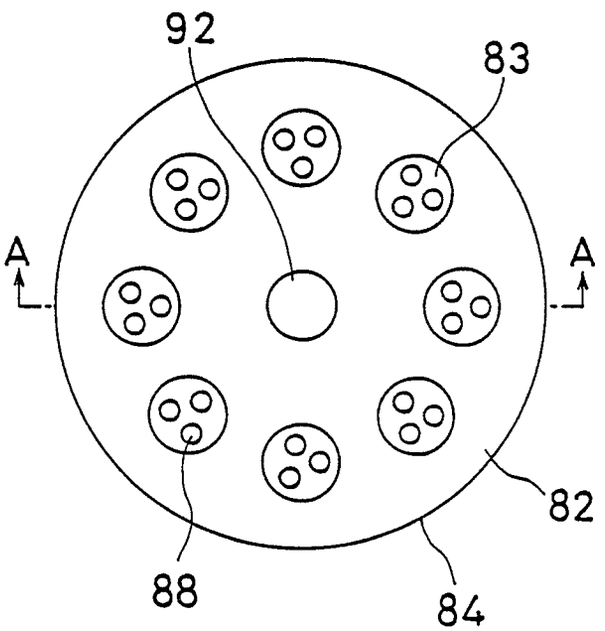


FIG. 13

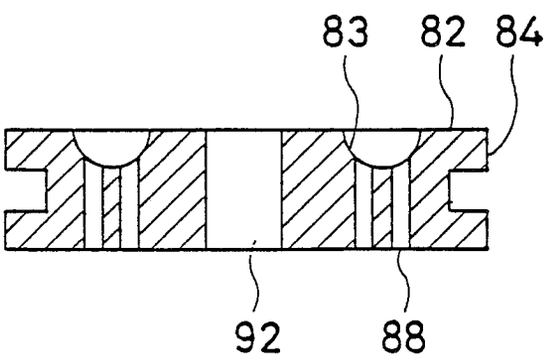


FIG. 14

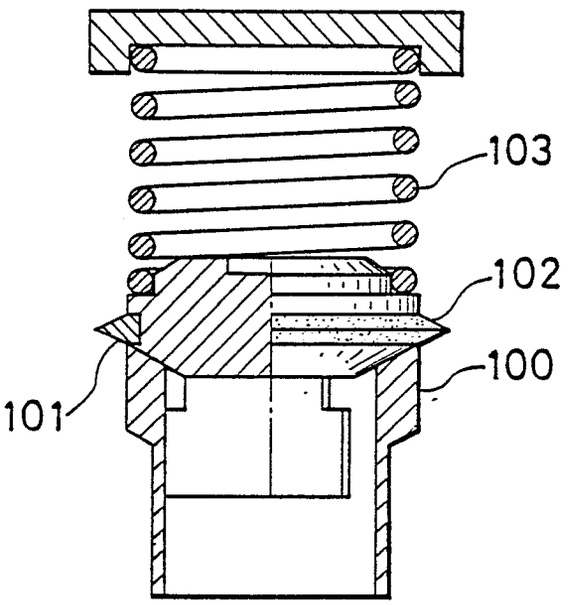


FIG. 15

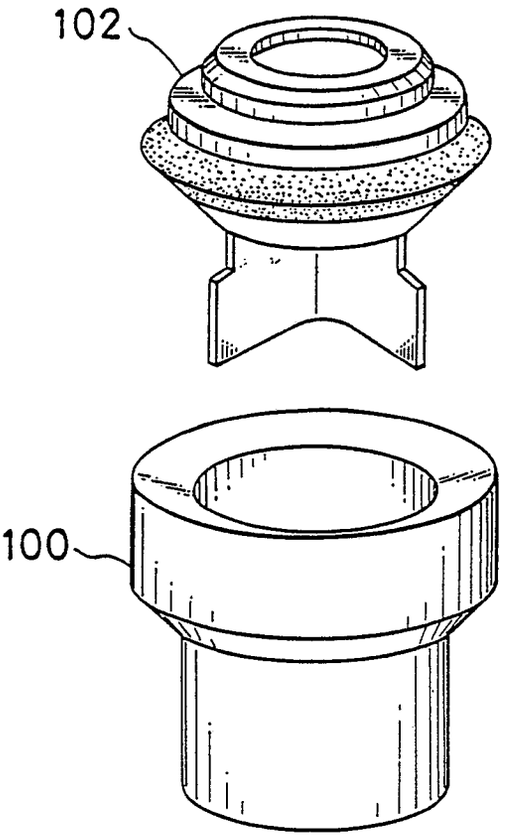


FIG. 16

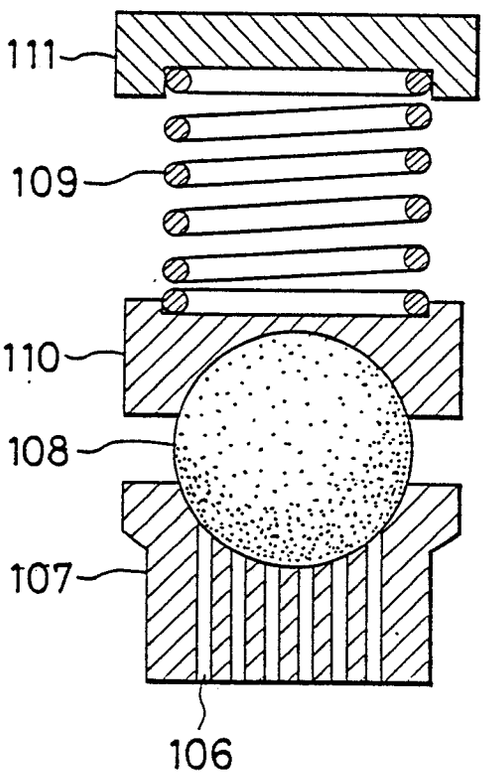
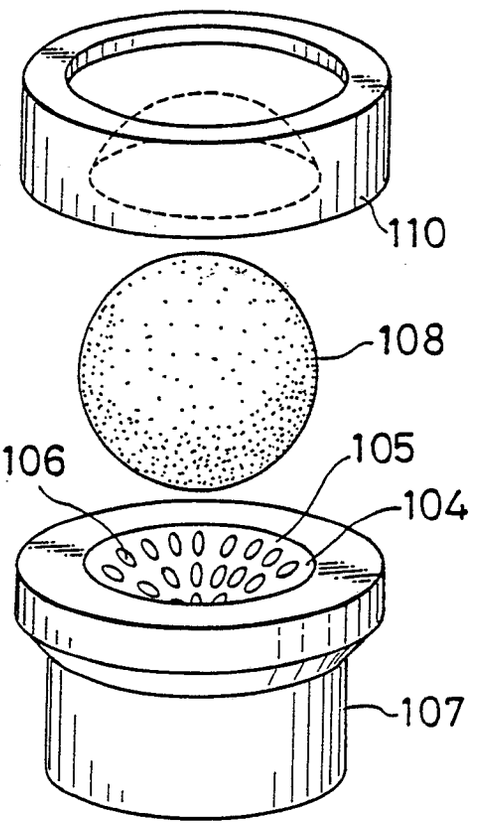


FIG. 17



European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 89 30 2606

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 4)
X	DE-C- 805 006 (KORTE) * Page 2, lines 1-18; figure 1 *	1-3	F 04 B 43/06 F 04 B 21/04 F 04 B 21/02 F 04 B 43/10
X	GB-A- 272 374 (N.S.A.P.) * Page 1, lines 31-50, line 77 - page 2, line 21; figure 1 *	1-3	
X	DE-A-2 218 781 (TAMAGAWA) * Page 2, line 1 - page 8, last line; figure 1 *	4,5	
X	US-A-3 802 807 (KILAYKO) * Column 1, line 59 - column 3, line 24; figures 1,2 *	4,5,11	
X	EP-A-0 074 321 (CAPITANI) * Page 1, line 31 - page 5, line 35; figure 1 *	4-10	TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 04 B
X	EP-A-0 048 535 (P. & M. C.M.C.) * Page 3, line 27 - page 12, line 8; figure 1 *	4,5,7	
X	FR-A- 959 521 (GRILLOT) * Page 2, lines 4-16; figure 5 *	12,14	
E	EP-A-0 309 240 (KOIWA YOSHINOBU) * Page 3, line 57 - page 4, line 3; figures 2,3 *	12,14	
A		13	

The present search report has been drawn up for all claims ./.

Place of search	Date of completion of the search	Examiner
THE HAGUE	20-09-1989	VON ARX

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid.

namely claims:

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

X LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions.

namely:

1. Claims 1-3: Membrane pump with a screening member between the pressure action member and the valve chamber

2. Claims 4-11: Liquid piston between a reciprocating piston and the valve chamber

3. Claims 12-14: Details of a valve device for a pump

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid.

namely claims:

☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims.

namely claims:

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EUROPEAN SEARCH REPORT

Application number

EP 89 30 2606

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 4)
A	US-A-3 664 770 (PALMER) * Column 2, lines 32-62; figures 1, 2 *	12-14	
A	EP-A-0 238 380 (CANAUD) * Column 6, line 46 - column 7, line 24; figure 1 *	12-14	
A	US-A-3 363 580 (LOGUE) * Column 3, line 74 - column 4, line 58; figures 2,3 *	13	

TECHNICAL FIELDS SEARCHED (Int. Cl 4)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner

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
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