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Lanfredi et al.(10) **Pub. No.: US 2006/0110265 A1**(43) **Pub. Date: May 25, 2006**(54) **PUMP AND CLEANING APPARATUS
COMPRISING SAID PUMP**(30) **Foreign Application Priority Data**

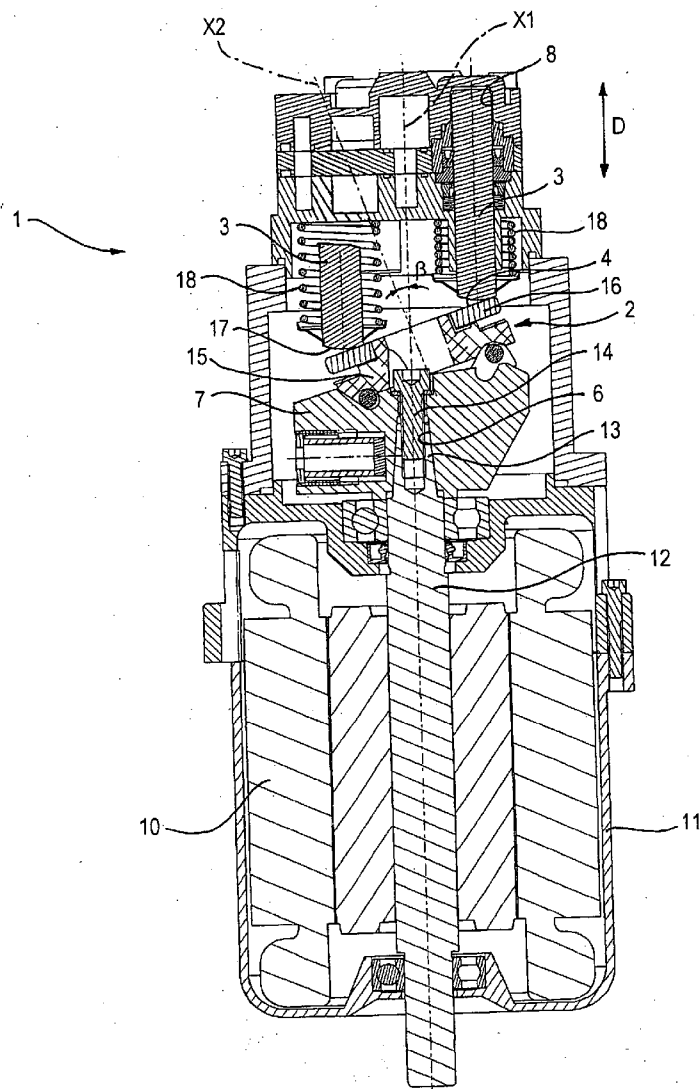
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Virgilio (IT)**Publication Classification**(51) **Int. Cl.**
F04B 27/08 (2006.01)(52) **U.S. Cl.** **417/269**

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ARLINGTON, VA 22203 (US)(57) **ABSTRACT**

A pump comprises a plurality of pistons movable in a direction, a swash plate arrangement forming an angle with said direction so as to reciprocate said plurality of pistons in said direction and an elastic element interacting with said swash plate arrangement to enable said angle to be modified. Between said elastic element and said swash plate arrangement a transmission device is interposed for receiving a force from said swash plate arrangement and transmitting a fraction of said force to said elastic element.

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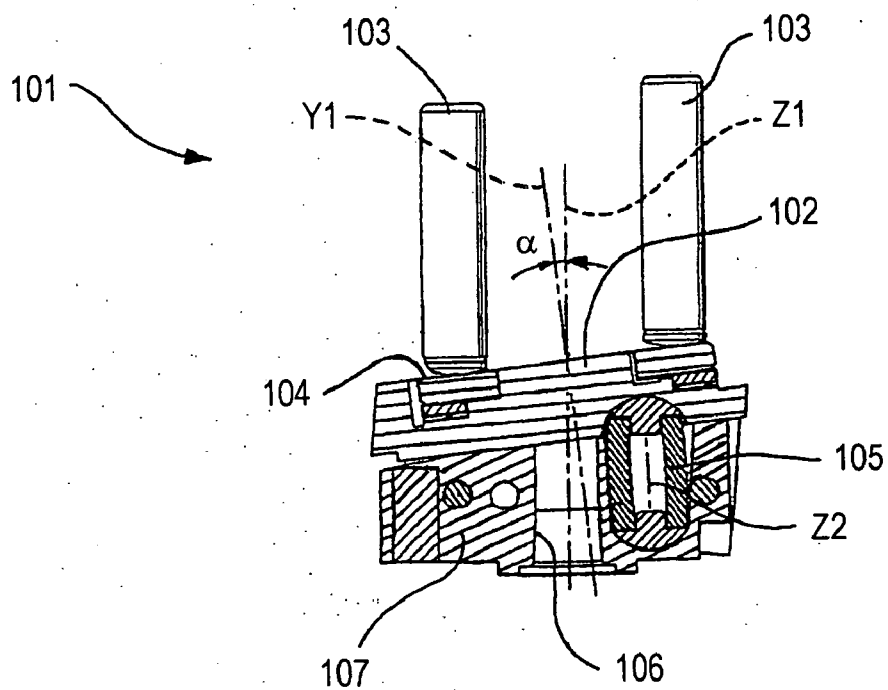


Fig. 1

PRIOR ART

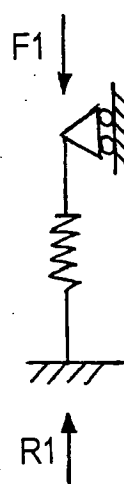


Fig. 2

PRIOR ART

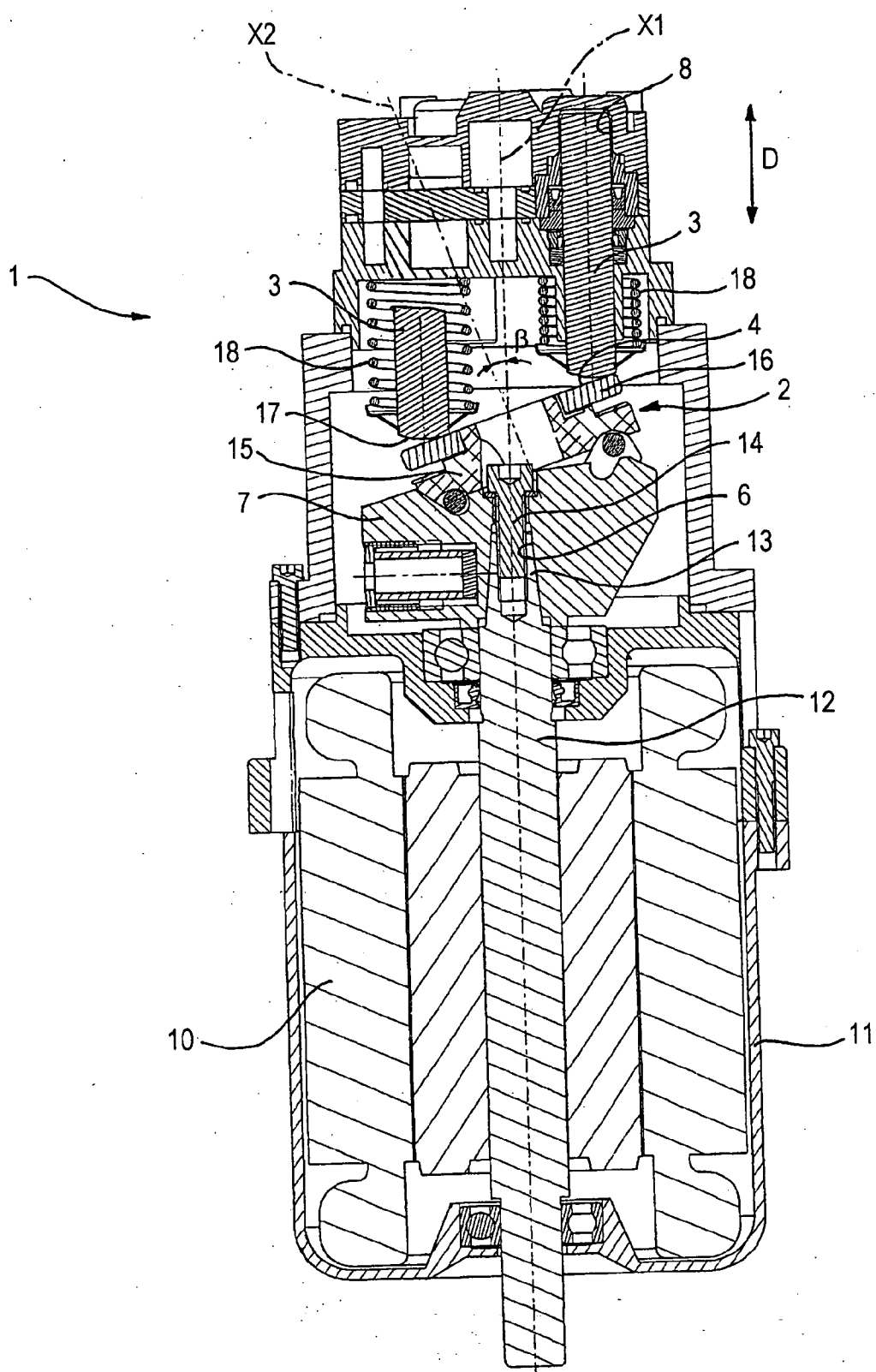


Fig. 3

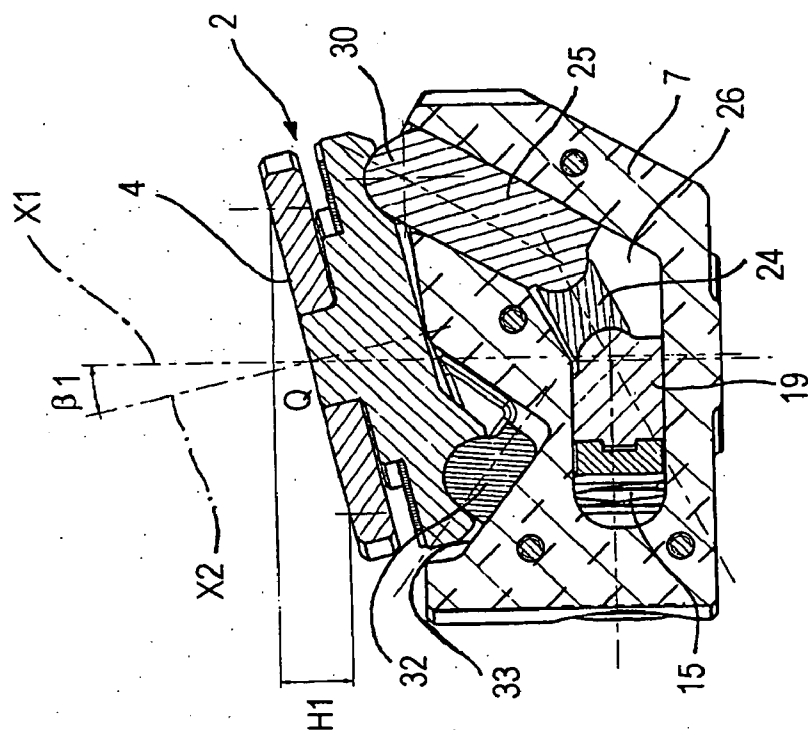


Fig. 5

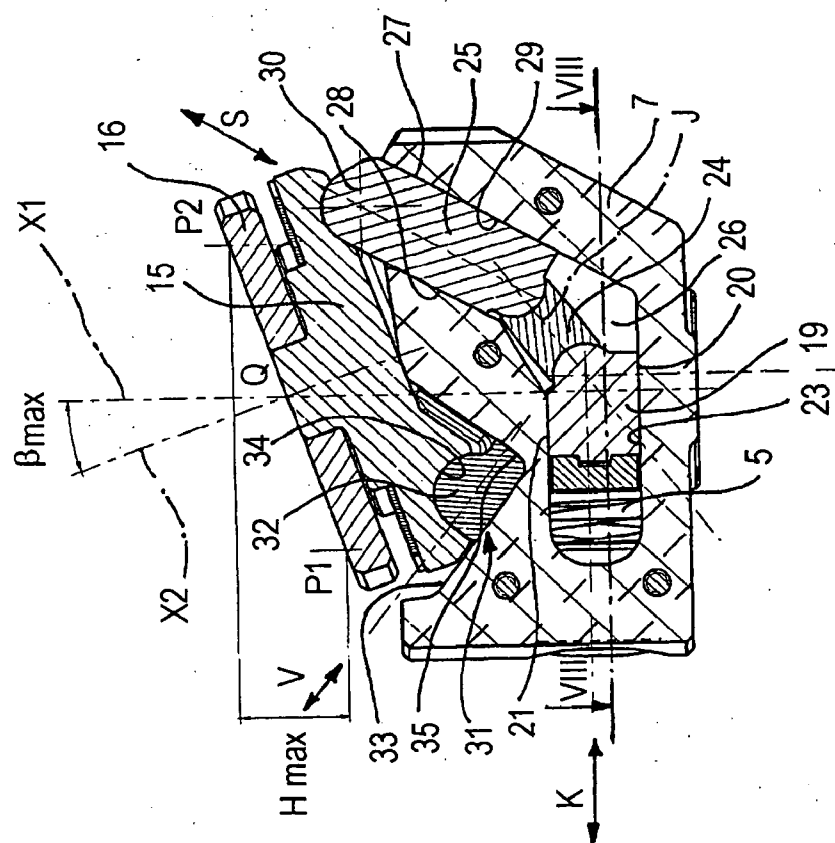


Fig. 4

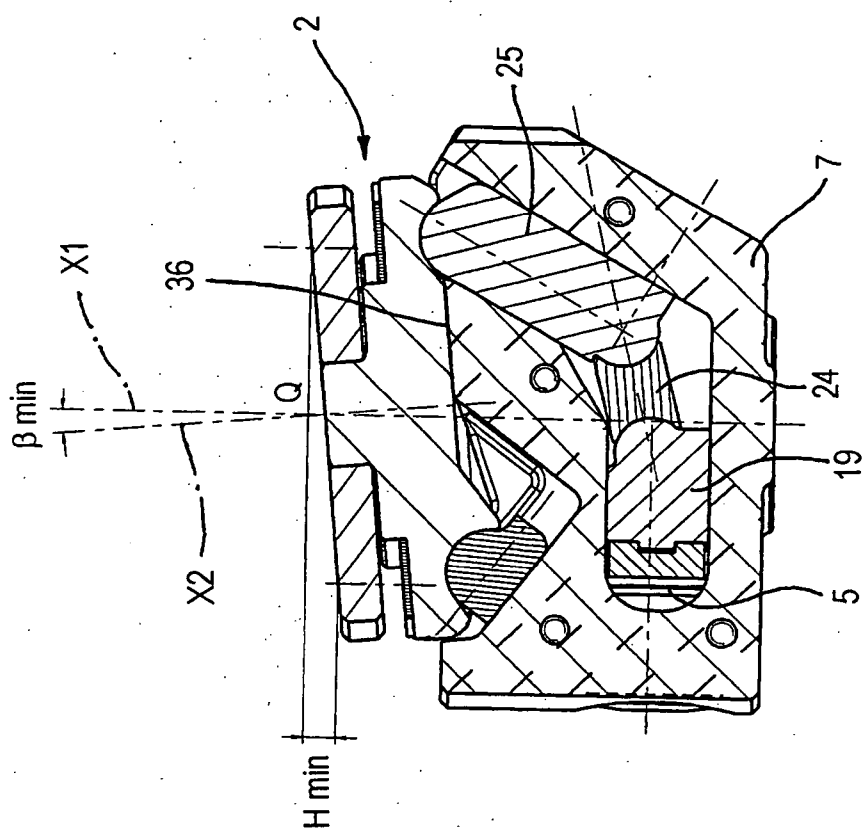


Fig. 6

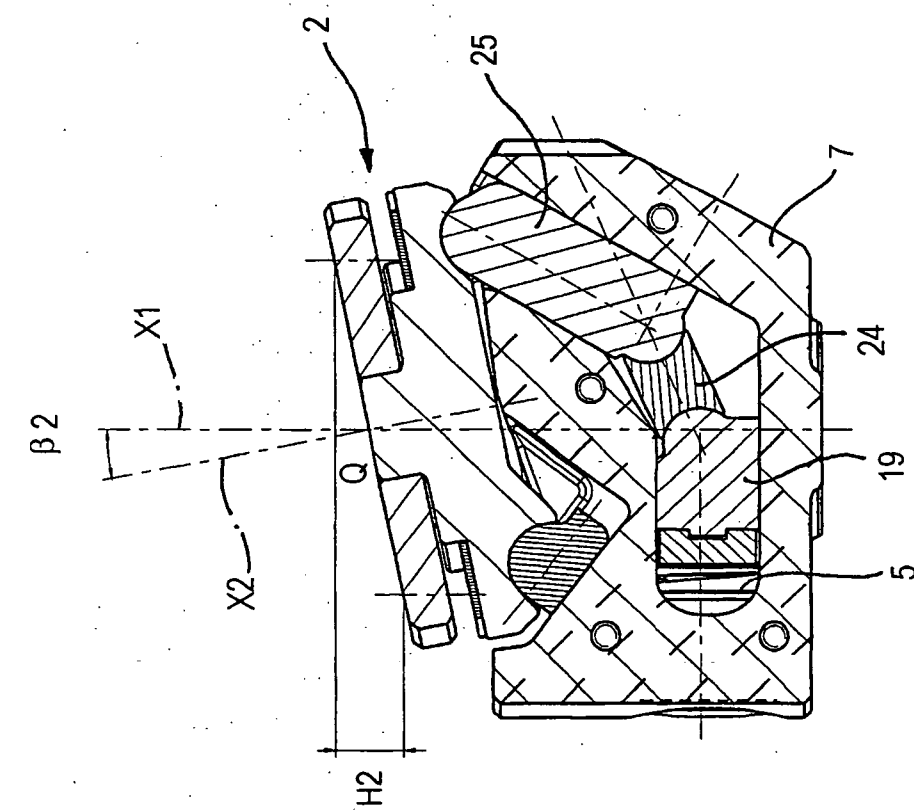


Fig. 7

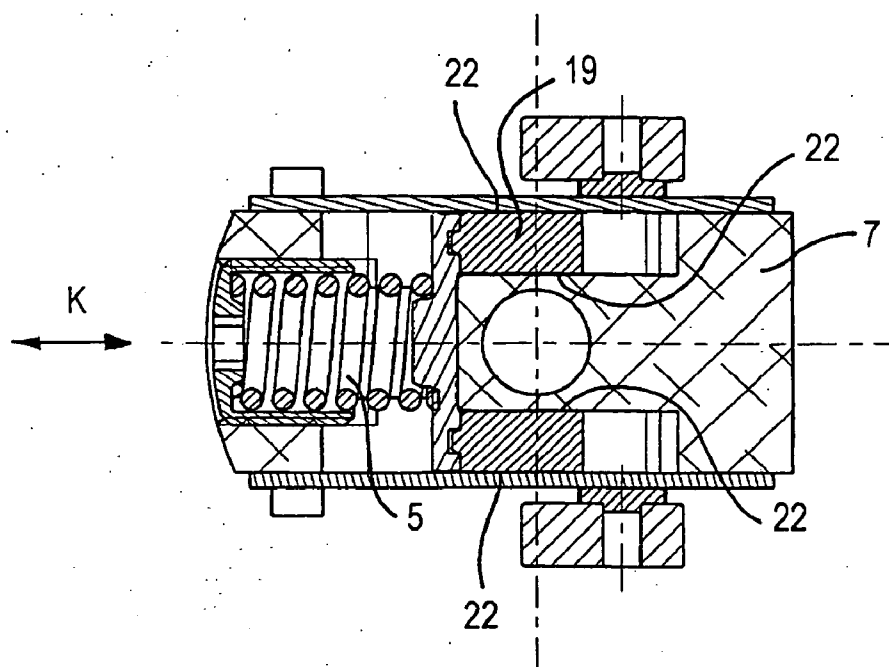


Fig. 8

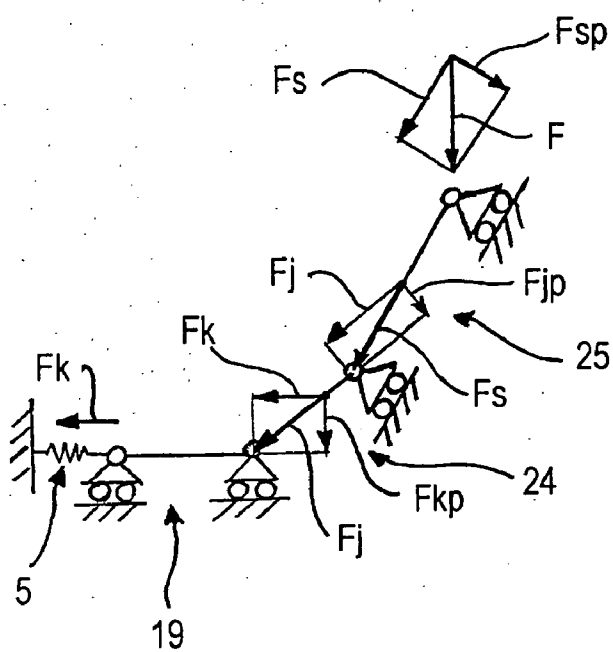


Fig. 9

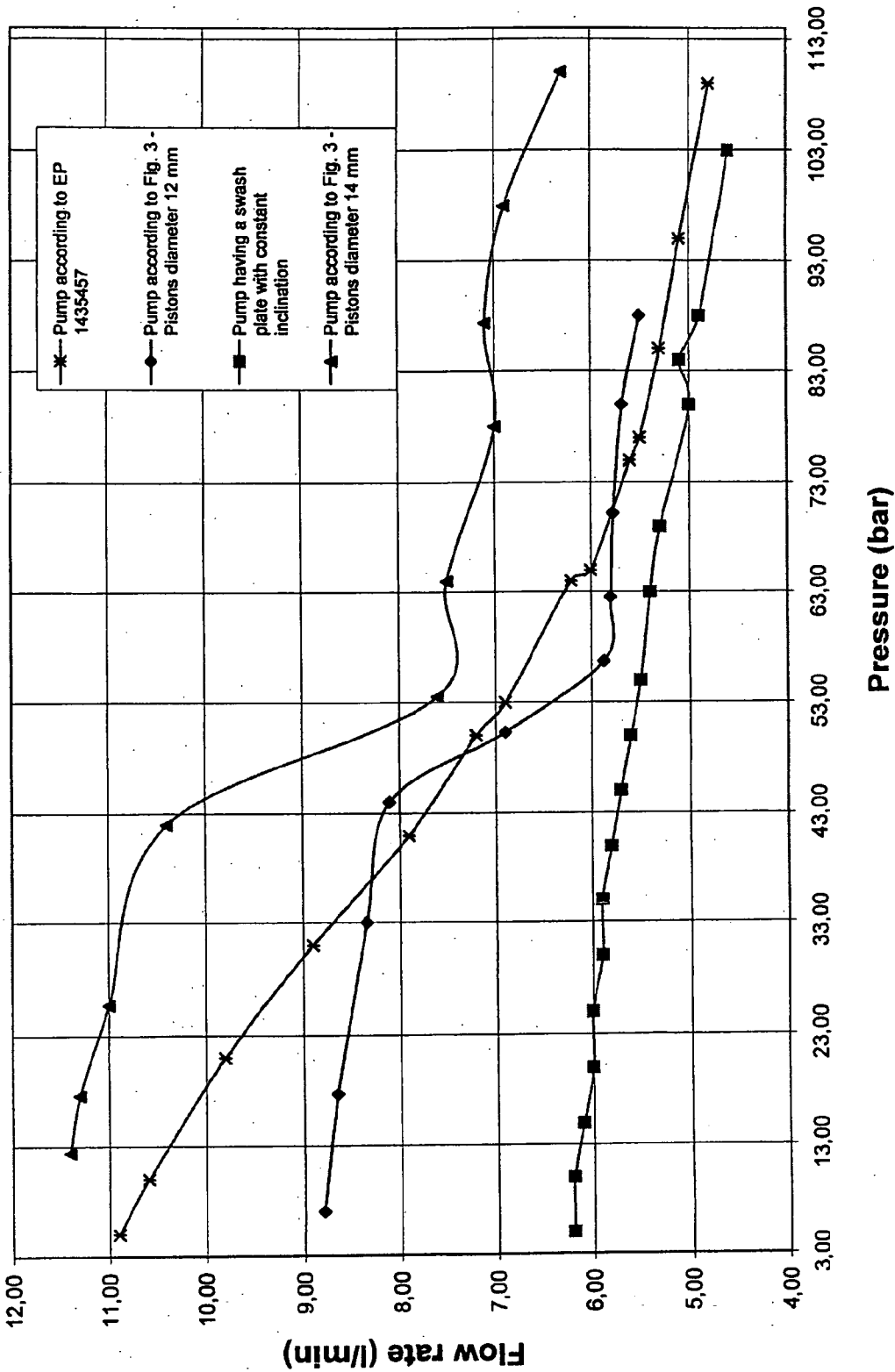
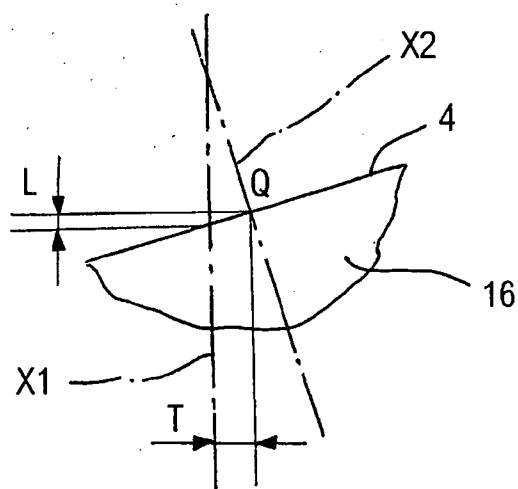
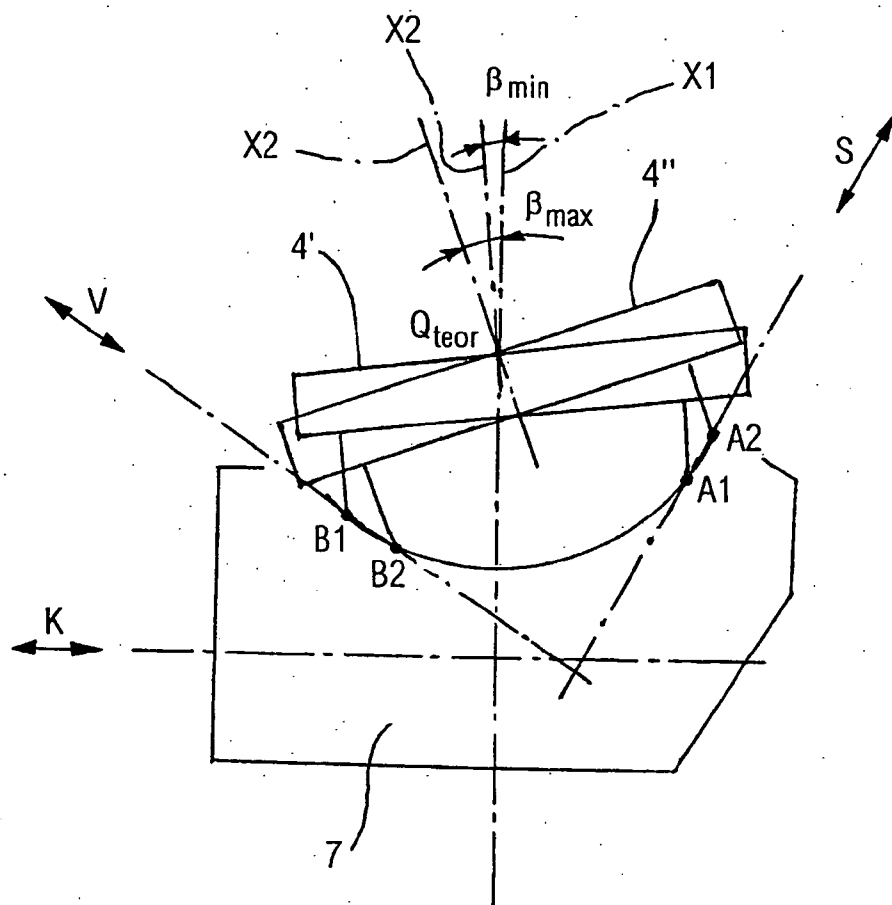
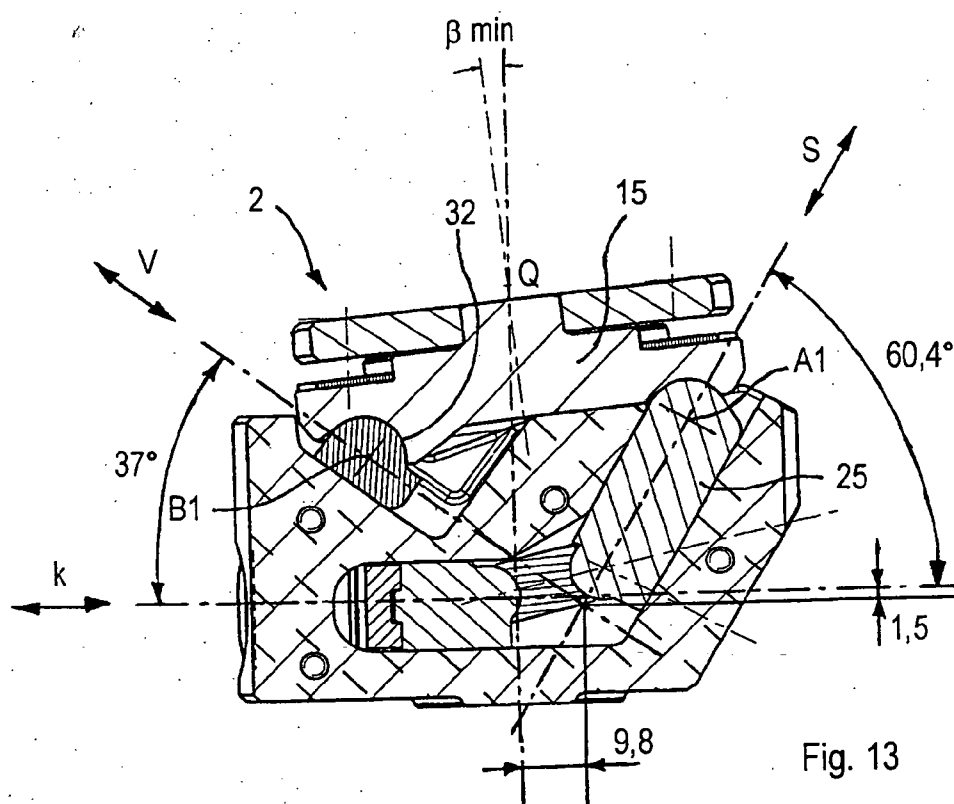
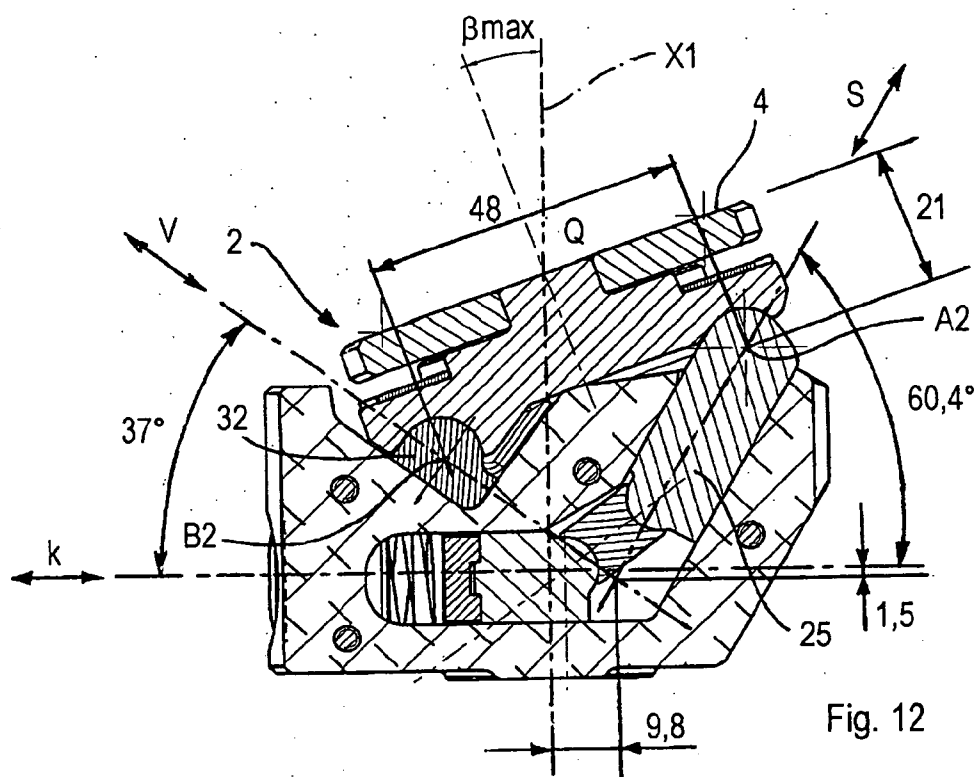


Fig. 10





PUMP AND CLEANING APPARATUS COMPRISING SAID PUMP

[0001] The invention relates to an axial piston pump with variable flow rate. This pump is particularly suitable for processing a cleaning fluid in a cleaning apparatus, for example a high-pressure cleaner. The cleaning fluid may be water to which detergent substances may have been added. The invention further relates to a cleaning apparatus provided with said pump.

[0002] In high-pressure cleaning machines axial piston pumps are usually used. Known axial piston pumps comprise a swash plate rotationally driven by a motor shaft which, during rotation, reciprocates a plurality of pistons inside respective cylinders. A pump of this type is for example disclosed in the European patent application EP 1435457, in which an elastic element is arranged below the swash plate. Owing to the elastic element, it is possible to vary the flow rate of the cleaning fluid depending on the dispensing pressure of said fluid, which is selectable by a user by means of a separate pressure-adjusting device. The elastic element in fact enables the angle between the swash plate and the motor shaft to be modified when the dispensing pressure varies. Thus, the stroke of the pistons is modified, i.e. the volume of cleaning fluid that the pistons are able to displace changes.

[0003] A drawback of the pump disclosed in EP 1435457 is that, as will be explained in greater detail below, the flow rate of the cleaning fluid decreases very rapidly when the dispensing pressure selected by the user increases. The elastic element, which is substantially parallel to the pistons, is in fact almost completely compressed when the dispensing pressure of the cleaning fluid exceeds a relatively low value. In this situation, the swash plate is almost perpendicular to the motor shaft, which implies that the stroke of the pistons is short and the volume of cleaning fluid displaced by the pump is low.

[0004] A rapid decrease in the flow rate as pressure increases is not desired, because in certain applications it is preferable to combine a high pressure with a high flow rate. A high pressure ensures an effective cleaning action, whereas a high flow rate enables the cleaning fluid to reach zones that are relatively far away from the dispensing point.

[0005] An object of the invention is to improve existing pumps and cleaning apparatuses.

[0006] A further object is to provide an axial piston pump in which the flow rate of the fluid processed by the pump is as constant as possible as the dispensing pressure increases.

[0007] In a first aspect of the invention, there is provided a pump comprising a plurality of pistons movable in a direction, a swash plate arrangement forming an angle with said direction so as to reciprocate said plurality of pistons in said direction, an elastic element interacting with said swash plate arrangement to enable said angle to be modified, wherein between said elastic element and said swash plate arrangement a transmission device is interposed for receiving a force from said swash plate arrangement and transmitting a fraction of said force to said elastic element.

[0008] Owing to this aspect of the invention, it is possible to obtain a pump in which, when pressure increases, the flow rate decreases only to a limited extent. The transmission

device in fact enables only a fraction of the force exerted by the swash plate arrangement to be transmitted to the elastic element. This force depends on the thrust exerted on the swash plate arrangement by the pistons, i.e. on the pressure of the processed fluid. At a preset dispensing pressure selected by the user, the elastic element is thus less stressed than the elastic element disclosed in EP 1435457 and is able to keep the swash plate arrangement in a more inclined position, in which the pistons perform relatively long strokes. Thus, relatively high flow rates of fluid can be processed.

[0009] In a second aspect of the invention, there is provided a pump comprising a plurality of pistons movable in a direction, a swash plate arrangement forming an angle with said direction so as to reciprocate said plurality of pistons in said direction, said swash plate arrangement being oscillatable substantially around a point to modify said angle, wherein said swash plate arrangement is supported by a sliding element and a further sliding element movable along respective substantially rectilinear paths, said paths approximating to circumference arcs centred on said point.

[0010] Owing to this aspect of the invention, it is possible to obtain a pump provided with a swash plate arrangement oscillating around a substantially stationary point, which can be constructed in a relatively simple and economical manner. It is not constructionally complicated to provide a sliding element and a further sliding element that are movable along respective substantially rectilinear paths.

[0011] The invention will be better understood and carried out with reference to the attached drawings, which show an exemplifying and not restrictive embodiment thereof, in which:

[0012] **FIG. 1** is a schematic section of a portion of a pump according to the prior art;

[0013] **FIG. 2** is a schematic representation of the distribution of forces on an elastic element of the pump of **FIG. 1**;

[0014] **FIG. 3** is a schematic section taken along the longitudinal axis of an axial piston pump;

[0015] **FIG. 4** is a schematic section of a swash plate of the pump of **FIG. 3** in a position of maximum inclination;

[0016] **FIG. 5** is a section like **FIG. 4**, showing the swash plate in a first intermediate position;

[0017] **FIG. 6** is a section like **FIG. 4**, showing the swash plate in a second intermediate position;

[0018] **FIG. 7** is a section like **FIG. 4**, showing the swash plate in position of minimum inclination;

[0019] **FIG. 8** is a section taken along the plane VIII-VIII of **FIG. 4**;

[0020] **FIG. 9** is a schematic representation of the forces applied to an elastic element of the pump of **FIG. 4**;

[0021] **FIG. 10** is a graph that shows how the flow rate varies depending on pressure for some pumps;

[0022] **FIG. 11** is a schematic representation showing the swash plate in the position of maximum inclination and in the position of minimum inclination;

[0023] FIG. 12 is a section like FIG. 4, showing some dimensions of the swash plate;

[0024] FIG. 13 is a section like FIG. 7, showing some dimensions of the swash plate;

[0025] FIG. 14 is an enlarged and fragmentary schematic section of a central portion of the swash plate.

[0026] With reference to FIG. 1, a portion of a pump 101 is shown that is particularly suitable for pumping a cleaning fluid in a high-pressure cleaner. The pump 101 comprises a motor shaft that is not shown, extending along a longitudinal axis Z1 and rotatable around this axis. The motor shaft engages in a hole 106 obtained on a support 107. A swash plate 102 is fixed to the support 107, the swash plate 102 having a flat surface 104 that is inclined in relation to the longitudinal axis Z1. Two or more pistons 103 interact with the inclined flat surface 104 of the swash plate 102, the pistons 103 being movable inside respective cylinders that are not shown. Respective valves are associated with the cylinders, said valves selectively connecting each cylinder with a delivery conduit or with an intake conduit for the cleaning fluid.

[0027] When the motor shaft rotates the plate 102, the pistons 103, by interacting with the inclined flat surface 104, which also rotates, reciprocate parallelly to the longitudinal axis Z1. Thus the pistons 103 alternately penetrate inside the respective cylinders and subsequently exit from the cylinders, thereby pressurising the cleaning fluid and sending it from the intake conduit to the delivery conduit. The pump 101 further comprises an elastic element 105 interposed between the swash plate 102 and the support 107 to enable the flow rate of cleaning fluid to be varied depending on the dispensing pressure. The elastic element 105 may be a coil spring or a sleeve made of elastomeric material, extending around an axis Z2 that is substantially parallel to the longitudinal axis Z1.

[0028] During operation of the high-pressure cleaner, the user may select a desired dispensing pressure with which the cleaning fluid is dispensed on a surface to be cleaned, by means of a pressure-adjusting device arranged downstream of the pump 101. Thus the user selects the delivery pressure of the pump 101.

[0029] The swash plate 102 exerts on the elastic element 105 a force F1 that depends on the thrust exerted by the pistons 103 on the swash plate 102 and therefore on the delivery pressure that the cleaning fluid has to reach before leaving the cylinders of the pump 101. The force F1, as shown diagrammatically in FIG. 2, is directed along a line of action parallel to the axis Z2 and is entirely applied to the elastic element 105, which reacts with an equal and contrary reaction R1. Simultaneously, the elastic element 105 is compressed by an amount proportional to the force F1. In this way it is possible to vary the angle α defined between the longitudinal axis Z1 and an inclined axis Y1 perpendicular to the flat inclined surface 104. By varying the angle α , it is possible to modify the stroke of the pistons 103 inside the respective cylinders and therefore the flow rate of the fluid processed by the pump 101.

[0030] Tests have shown that in the known pump 101 the flow rate decreases very rapidly as the dispensing pressure selected by the user increases. When the dispensing pressure increases, the force F1 exerted by the swash plate 102 very

rapidly compresses the elastic element 105 so that the swash plate 102 is positioned in its configuration of minimum inclination. In this configuration, the stroke of the pistons 103 is minimal and as a result the flow rate of processed fluid is rather limited.

[0031] In order to remedy the rapid decrease of flow rate that occurs in the pump according to EP 1435457 as the dispensing pressure increases, a pump 1 as shown in FIG. 3 is provided. The pump 1 is connected to a motor 10, for example an electric motor, provided with a housing 11 from which a shaft 12 protrudes. The shaft 12 can rotate around a longitudinal axis X1. The shaft 12 has a frustum conical end 13 that shapingly engages in a corresponding hole 6 obtained in a support 7 of the pump 1. The shaft 12 is fixed relative to the support 7 by means of a screw 14. On the support 7 a swash plate 2 is provided comprising a base 15 that supports an annular plate 16 acting as a thrust bearing. The swash plate 2 has an inclined axis X2. The annular plate 16 can be rotated around the inclined axis X2. The annular plate 16 interacts with a plurality of pistons 3 along a thrust plane 4 that intersects the inclined axis X2 at a point Q. The inclined axis X2 is substantially perpendicular to the thrust plane 4. As will be better explained below, the inclination of the thrust plane 4 in relation to the longitudinal axis X1 may vary and is defined by an angle of inclination β defined between the longitudinal axis X1 and a line perpendicular to the thrust plane 4.

[0032] Each piston 3 is bound at the bottom thereof by a rounded end 17 kept in contact with the annular plate 16 by a respective spring 18. In the embodiment of FIG. 3, three pistons 3 are provided, only two of which have been shown; nevertheless, it is also possible to use a number of pistons different from three, for example two. The pistons 3 are slidable in a direction D, parallel to the longitudinal axis X1, inside respective cylinders 8, each of which is connected, by means of valves that are not shown, to an intake conduit and to a delivery conduit. Thus a fluid can enter each cylinder 8 through the respective intake conduit and after being pressurised can exit towards the surface to be cleaned through the delivery conduit.

[0033] As shown in FIG. 4, inside the support 7 an elastic element 5 is housed, arranged in such a way as to exert a force along a line of action K transversely to the direction D in which the pistons 3 are movable. In other words, the elastic element 5 can be compressed along the line of action K. In the example of FIGS. 4 to 7, the line of action K is perpendicular to the direction D. The elastic element 5 may for example comprise a coil spring. Between the elastic element 5 and the swash plate 2 a transmission device is interposed for transmitting a portion of force from the swash plate 2 to the elastic element 5 while substantially modifying the line of action of this force. The transmission device may comprise a first slide 19, associated with the elastic element 5 and slidable parallelly to the line of action K owing to a lower guide surface 20, an upper guide surface 21 and lateral guide surfaces 22 shown in FIG. 8. The guide surfaces 20, 21 and 22 shapingly engage with corresponding surfaces bounding a seat 23 obtained inside the support 7 for receiving the first slide 19.

[0034] The transmission device further comprises a lever 24, having a first end pivoted on the first slide 19 and a second end pivoted on a second slide 25. The lever 24

extends along an inclined axis J that may oscillate inside a recess 26 obtained in the support 7.

[0035] The second slide 25 is slidable in a slide direction S owing to a guide surface 27 and to a further guide surface 28 that shapingly engage with corresponding surfaces obtained in a groove 29 of the support 7. The second slide 25 is provided, at an end opposite the lever 24, with an articulated joint 30 by means of which the second slide 25 is connected to the base 15 of the swash plate 2. The articulated joint 30 is associated with the swash plate 2 near the outer perimeter of the base 15.

[0036] A further articulated joint 31 is associated with the swash plate 2, the further articulated joint 31 being arranged in a position diametrically opposite the articulated joint 30. The further articulated joint 31 is obtained on a sliding block 32, slidable in a translation direction V along a track 33 obtained on the support 7, and shapingly engages with a cavity 34 obtained on the base 15.

[0037] When the pump 1 is mounted in a high-pressure cleaner, downstream of the pump 1 there is usually provided a pressure-adjusting mechanism of known type, by means of which a user can select the dispensing pressure with which a cleaning fluid processed by the pump 1 is dispensed onto a surface to be cleaned. The dispensing pressure selected by the user corresponds, apart from the pressure losses that occur in the connecting pipe between the pump 1 and the pressure-adjusting mechanism, to the delivery pressure of the pump 1, i.e. to the pressure of the cleaning fluid inside the cylinders 8 when the respective delivery valves are open.

[0038] FIG. 4 shows a configuration of the swash plate 2 in which the dispensing pressure selected by the user is relatively low. The force exerted by the pistons 3 on the swash plate 2 is not particularly high and the elastic element 5, which is only slightly stressed, keeps the swash plate 2 in a very inclined position in relation to the longitudinal axis X1. In particular, FIG. 4 shows the configuration of maximum inclination of the swash plate 2, in which the sliding block 32 abuts against a first abutment surface 35 of the support 7 and cannot get any nearer to the longitudinal axis X1. In this configuration, the angle of inclination has a value $\beta_{\max}$. The stroke of the pistons 3 in the configuration of FIG. 4 is equal to Hmax and corresponds to the distance, measured in the direction D, between a first point P1 and a second point P2 arranged in a diametrically opposite position on the thrust plane 4. The first point P1 is the point at which the longitudinal axis of a piston 3 interacts with the swash plate 2 at the end of the intake phase of the cleaning fluid in the corresponding cylinder 8; the second point P2 is the point at which the longitudinal axis of a piston 3 interacts with the swash plate 2 at the end of the delivery phase of the cleaning fluid in the corresponding cylinder 8. For example, the angle $\beta_{\max}$ may be equal to 19.331° , whereas the maximum stroke Hmax may be 16.8 mm.

[0039] If, starting from the configuration of FIG. 4, the user increases the dispensing pressure by means of the pressure-adjusting device, the force F exerted by the pistons 3 on the swash plate 2 increases, as shown schematically in FIG. 9. This Figure schematically shows the transmission device interposed between the elastic element 5 and the swash plate 2, each component of the transmission device being represented by a beam that extends between the pivot points of two adjacent components.

[0040] The force F applied by the swash plate 2 to the first slide 25 is directed parallelly to the direction D along which the pistons 3 are movable, i.e. vertically in the example of FIGS. 4 to 7. The force F can be resolved into a first component F_s , directed in the slide direction S along which the second slide 25 is slidable, and into a second component F_{SP} , perpendicular to the slide direction S. Whilst the first component F_s acts on the second slide 25, the second component F_{SP} acts on the support 7. The first component F_s is then transmitted from the second slide 25 to the lever 24, and may in turn be resolved into a third component F_J directed along the inclined axis J of the lever 24, and into a fourth component F_{JP} perpendicular to said axis. Only the third component F_J acts on the lever 24, which in turn transmits the third component F_J to the first slide 19. In particular, the third component F_J can be resolved, at the point in which the lever 24 is pivoted on the first slide 19, into a fifth component F_K parallel to the line of action K and into a sixth component F_{KP} perpendicular to said line of action. Whilst the sixth component F_{KP} acts on the support 7, the fifth component F_K is transmitted to the elastic element 5, which is compressed proportionally to the fifth component F_K . Due to compression of the elastic element 5, the first slide 19 moves parallelly to the line of action K and penetrates deeper inside the seat 23. Correspondingly, the lever 24 rotates around its fulcrum inside the recess 26, and the second slide 25 slides in the slide direction S inside the groove 29, thereby moving towards the recess 26, as shown in FIG. 5. The articulated joint 30 thus protrudes outside the support 7 to a lesser extent than is shown in FIG. 4. As a result, the sliding block 32 slides along the track 33 towards a peripheral region of the support 7. The swash plate 2 is therefore positioned in a configuration which is less inclined than the one shown in FIG. 4. In other words, the angle of inclination of the swash plate 2 has a value β_1 that is less than the value $\beta_{\max}$ corresponding to the configuration of maximum inclination. Also the stroke of the pistons 3 has a value H1 that is less than the value Hmax shown in FIG. 4. In the example of FIG. 5, the angle β_1 is 13.3° and the stroke H1 is 11.3 mm. As a result, the flow rate of cleaning fluid processed by the pistons 3 decreases.

[0041] It is noted that, at a constant dispensing pressure selected by the user, the flow rate decreases less than it did in known pumps of the type shown in FIG. 1. Owing to the transmission device, a significant part of the force F applied by the pistons 3 to the swash plate 2 acts on the support 7, and only a fraction of the force F is transmitted to the elastic element 5. In fact, only the fifth component F_K , which is significantly lower than the force F, is applied to the elastic element 5. At a constant dispensing pressure selected by the user, the elastic element 5 is therefore much less stressed than the elastic element 105 included in known pumps. As a result, the elastic element 5 is deformed more gradually than the elastic element 105 included in known pumps and the reduction of flow rate as the dispensing pressure increases is less significant.

[0042] If the user further increases the dispensing pressure, the elastic element 5 is compressed more and more, as shown in FIG. 6, in which the angle of inclination has a value β_2 of 11.1° and the stroke H2 of the pistons 3 is 9.4 mm.

[0043] The elastic element 5 may be further compressed until it reaches the configuration shown in FIG. 7, in which

the swash plate **2** is in its position of minimum inclination and rests on a second abutment surface **36** obtained on the support **7**. The angle of inclination of the swash plate **2** has a minimum value $\beta_{\min}$, and the pistons **3** perform a minimum stroke $H_{\min}$. In the example of **FIG. 7**, the angle $\beta_{\min}$ is 5.4° and the minimum stroke $H_{\min}$ is 4.5 mm. In this configuration, the flow rate of cleaning fluid processed by the pump **1** is equal to a minimum value.

[0044] If the user decreases the selected dispensing pressure, the force F exerted by the swash plate **2** on the second slide **25** decreases. As a result, the fifth component F_K that acts on the elastic element **5** also decreases. The elastic element **5** is less compressed and, through the first slide **19** and the lever **24**, pushes the second slide **25** towards the outside of the groove **29**. Thus, the swash plate **2** inclines more, i.e. the angle of inclination β increases. As a result, the stroke of the pistons **3** increases and thus the flow rate of cleaning fluid processed by the pump **1** increases.

[0045] Tests have shown that, by using the transmission device of **FIGS. 3** to **8**, relatively high flow rates may be obtained with dispensing pressures up to about 40 bar. This constitutes a significant improvement over the prior art, in which the flow rate decreased significantly when the dispensing pressure exceeded 15-20 bar. This is visible in the graph of **FIG. 10**, which shows how the flow rate of cleaning fluid varies as a function of the dispensing pressure selected by the user. The flow rate, which was measured during tests, is expressed in litres per minute whereas the pressure is expressed in bar. The curve drawn in the lower part of **FIG. 10**, the points of which are indicated by squares, refers to an axial piston pump in which the swash plate has a constant inclination. In this pump, the flow rate decreases very slowly as the pressure increases, passing from 6.2 l/min at a pressure of 5 bar to 4.6 l/min at a pressure of 113 bar. The flow rate decrease is due to the reduction in hydraulic efficiency that occurs in all pumps as the pressure increases, for example because there are hydraulic losses and because the rotation speed of the swash plate slightly decreases as the pressure increases.

[0046] The curve obtained by joining the points indicated by stars refers to a pump of the type disclosed in EP 1435457. This curve has a slope that is much greater than the slope of the curve relating to a pump having a swash plate of constant inclination. This means that the flow rate of fluid delivered by the pump of the type disclosed in EP 1435457 decreases very rapidly as the dispensing pressure increases, for the reasons that were set out previously. For example, at a dispensing pressure of 5 bar the pump dispenses a flow rate of 10.90 l/min, but at a pressure of 41 bar the flow rate has already decreased to 7.90 l/min, i.e. it has decreased by almost 30%.

[0047] The curve obtained by joining the triangles refers to a pump of the type disclosed with reference to **FIGS. 3** to **8**. This pump is so dimensioned that, at a relatively low dispensing pressure, the flow rate is almost the same as the initial flow rate of the pump disclosed in EP 1435457. In particular, a flow rate of 11.40 l/min corresponds to a dispensing pressure of 12.40 bar. It is noted that, in a wide range of dispensing pressure values, the curve has a very reduced slope, almost equal to the slope of the curve for pumps having a swash plate of constant inclination. Over this range the flow rate decreases very slowly as the dis-

pensing pressure increases. For example, at 42 bar the flow rate is still 10.40 l/min, i.e. it has decreased by only about 14% compared with the initial value. At around 50 bar, the flow rate drops suddenly, and then starts decreasing slowly with a slope that is approximately equal to the slope of the curve relating to a pump having a swash plate of constant inclination.

[0048] In a pump as disclosed with reference to **FIGS. 3** to **8** two distinct operating zones are thus identifiable. In a first zone, from 0 to about 40 bar, the pump is able to process high flow rates of fluid, that vary little as the dispensing pressure increases. A jet of cleaning fluid is thereby obtained that, owing to its high flow rate, has a good cleaning efficiency even far from the dispensing point. In a second zone, comprised between about 50 bar and the maximum dispensing pressure processed by the pump, the dispensing pressure of the cleaning fluid is very high, which means that it is possible to clean effectively the region in which the cleaning fluid is dispensed.

[0049] The curve identified by joining the rhombus refers to a pump of the kind disclosed in **FIGS. 3** to **8**, in which, however, certain geometrical parameters have been modified.

[0050] In particular, the pistons **3** have a diameter of 12 mm, whereas in the pump examined previously the pistons **3** had a diameter of 14 mm. By diminishing the diameter of the pistons and keeping other conditions unchanged, the flow rate of fluid processed by the pump obviously decreases. For example, the flow rate is equal to 8.80 l/min when the dispensing pressure is 7 bar. Nevertheless, the curve has the same shape as the curve relating to a pump with pistons diameter of 14 mm. In particular, when the dispensing pressure is equal to 44 bar, the flow rate is still equal to 8.10 l/min, i.e. it has decreased by less than 10% in relation to the initial value. This shows that the slow decrease in flow rate obtained by the pump of **FIGS. 3** to **8** does not depend on a particular value of a single constructional parameter of the pump, but is rather due to the transmission device.

[0051] The transmission device may also have different geometry from the one disclosed so far. It is for example possible to use a lever mechanism different from that shown in **FIGS. 4** to **8**, or to interpose between the first slide and the second slide more than one lever, or again to modify the angle formed between the line of action K and the slide direction S . By varying the geometry of the transmission device, the fraction of force that is transmitted to the elastic element changes. Accordingly, when choosing the configuration of the transmission device, the fraction of force that it is desired to transmit to the elastic element has to be taken into account.

[0052] During operation of a theoretical pump, the point Q , which was previously defined as the point of intersection between the inclined axis X_2 and the thrust plane **4**, lies on the longitudinal axis X_1 . Whatever the inclination of the thrust plane **4**, in a theoretical situation the point Q is in a stationary position along the longitudinal axis X_1 . To reproduce this theoretical situation in reality, it would be necessary to support the swash plate **2** so that it oscillates around a stationary point. The sliding block **32** and the second slide **25** should therefore be movable along respective circular paths, centred on a point lying on the longitudinal axis X_1

and coinciding with the intersection between the inclined axis X2 and the thrust plane 4. To this end, the sliding block 32 and the second slide 25 should be provided with circular guides that would make the support 7, the sliding block 32 and the second slide 25 difficult to manufacture and would thus increase costs of the pump 1.

[0053] It has therefore been thought to adopt the arrangement shown schematically in FIG. 11.

[0054] This Figure schematically shows the swash plate, the thrust plane of which has been indicated by 4', in the position of minimum inclination, in which the angle of inclination is equal to $\beta_{\min}$. In this position, the pivot at which the base 15 is pivoted on the second slide 25 is in a first position A1, whereas the further pivot at which the base 15 is pivoted on the sliding block 32 is in a further first position B1.

[0055] It is now supposed that the point of intersection between the thrust plane and the inclined axis X2 is kept in a stationary position Q_{teor} along the longitudinal axis X1 and that the swash plate is oscillated around this point of intersection until the swash plate reaches the position of maximum inclination, in which the thrust plane is indicated by 4'' and the angle of inclination is equal to $\beta_{\max}$.

[0056] When the swash plate moves from the position of minimum inclination to the position of maximum inclination, the pivot at which the base 15 is pivoted on the second slide 25 moves away from the longitudinal axis X1 until it reaches a second position A2, whereas the further pivot at which the base 15 is pivoted on the sliding block 32 moves closer to the longitudinal axis X1, until it reaches a further second position B2.

[0057] In a theoretical condition in which the point Q is perfectly stationary, the points A1, A2, B1 and B2 are on the same circumference centred on Q. To reproduce this condition with good accuracy, it was decided to move the second slide 25 and the sliding block 32 along respective rectilinear paths, which approximate to the circular path along which the second slide 25 and the sliding block 32 would move in the theoretical case. In other words, the circumference arc that joins the points A1 and A2 has been replaced by a rectilinear segment that is arranged in the slide direction S and approximates to said arc. The further circumference arc that joins the points B1 and B2 has been replaced by a further rectilinear segment arranged in the translation direction V and which approximates to said further arc. For example, the arc that joins the points A1 and A2 can be replaced by the segment A1-A2 or by a segment parallel to the chord A1-A2 but passing through the middle point of the corresponding arc. The further arc that joins the points B1 and B2 can be approximated according to similar methods.

[0058] By adopting these approximations, when the inclination of the swash plate 2 varies, the point Q of intersection between the thrust plane and the inclined axis X2 moves slightly away from the longitudinal axis X1. Nevertheless, tests have shown that by proceeding as described above, the point Q undergoes an insignificant displacement if compared with the dimensions of the swash plate 2. As shown in FIG. 14, the transverse displacement T and the longitudinal displacement L of the point Q respectively perpendicularly to, and along, the longitudinal axis X1, are of a few tenths of a millimetre, often less than 1 millimetre. It is thus

possible to say that the swash plate 2 oscillates around a substantially stationary point Q.

[0059] An example of swash plate and transmission device dimensioned according to the criterion explained above is shown in FIGS. 12 and 13. It has been seen experimentally that, by adopting the dimensions indicated in the Figures, the point Q undergoes a maximum displacement of 0.1 mm perpendicularly to the longitudinal axis X1 and of 0.4 mm parallel to said axis, when the swash plate 2 is moved from the position of maximum inclination, shown in FIG. 12, to the position of minimum inclination, shown in FIG. 13. The small transverse displacement T of the point Q minimizes friction between the rounded ends 17 of the pistons 3 and the swash plate 2, whilst the small longitudinal displacement L of the point Q enables the overall dimensions of the pump 1 to be kept limited. In particular, the pump 1 can be so dimensioned that in the position of maximum inclination the pistons 3 slide inside the respective cylinders 8 until they reach a position in which the top of each piston 3 is very close to the bottom of the respective cylinder 8, as shown in the top right-hand part of FIG. 3.

[0060] It has also been seen that when the dimensions shown in FIGS. 12 and 13 are chosen, and in particular the translation direction V is inclined of about 37° and the slide direction S is inclined of about 60° , it is possible to obtain a good transmission of the force from the swash plate 2 to the elastic element 5. In other words, it is possible to ensure that the elastic element 5 is not deformed too rapidly when the force transmitted by the swash plate 2 increases and that the swash plate 2 returns rapidly to a more inclined position when said force decreases.

[0061] The inclinations of the translation direction V and of the slide direction S indicated above are an example suitable for a pump having the dimensions shown in FIGS. 12 and 13, in which, for example, the distance between the inclined surface 4 and the pivot point at which the base 15 is pivoted on the second slide 25 is 21 mm. If the dimensions of the pump 1 vary, the inclination of the slide direction S and of the translation direction V have to be modified in such a way that the first slide 25 and the sliding block 32 move along rectilinear paths approximating to a circular path, as disclosed previously.

1. Pump comprising a plurality of pistons movable in a direction, a swash plate arrangement forming an angle with said direction so as to reciprocate said plurality of pistons in said direction, an elastic element interacting with said swash plate arrangement to enable said angle to be modified, wherein between said elastic element and said swash plate arrangement a transmission device is interposed for receiving a force from said swash plate arrangement and transmitting a fraction of said force to said elastic element.

2. Pump according to claim 1, wherein said transmission device is mounted on a support which supports said swash plate arrangement, so as to apply to said support substantially the difference between said force and said fraction.

3. Pump according to claim 2, wherein said difference is a significant part of said force.

4. Pump according to claim 1, wherein said elastic element can be compressed along a line of action that is transverse to said direction.

5. Pump according to claim 4, wherein said line of action is substantially perpendicular to said direction.

6. Pump according to claim 1, wherein said transmission device comprises a lever arrangement oscillatable around a fulcrum due to said force.

7. Pump according to claim 6, wherein said transmission device comprises a first slide connected to said lever arrangement, said first slide being slidable for activating said elastic element.

8. Pump according to claim 7, wherein said first slide is movable parallelly to a line of action along which said elastic element may be compressed.

9. Pump according to claim 7, wherein said transmission device comprises a second slide connected to said lever arrangement and slidable in a slide direction for driving said lever arrangement.

10. Pump according to claim 9, wherein said slide direction is inclined in relation to said direction.

11. Pump according to claim 9, wherein said second slide is connected to said swash plate arrangement by an articulated joint, so as to be driven by said swash plate arrangement in said slide direction.

12. Pump according to claim 11, wherein said articulated joint is associated with a peripheral region of said swash plate arrangement.

13. Pump according to claim 9, wherein said lever arrangement comprises a lever having a first end pivoted on said first slide and a second end pivoted on said second slide.

14. Pump according to claim 9, wherein said swash plate arrangement is connected to a sliding block that is movable in a translation direction so that, when said angle is changed, said sliding block moves in said translation direction and said second slide moves in said slide direction.

15. Pump according to claim 14, wherein said sliding block is arranged in a position diametrically opposite said second slide.

16. Pump according to claim 14, wherein said sliding block and said second slide are movable along substantially rectilinear paths, said paths approximating to circumference arcs centred on a point around which said swash plate arrangement is substantially oscillatable.

17. Pump according to claim 16, wherein said arcs lie on a single circumference.

18. Pump according to claim 16, wherein at said point an axis of said swash plate arrangement intersects a thrust plane on which said plurality of pistons interact with said swash plate arrangement.

19. Pump according to claim 16, wherein said point lies on a longitudinal axis around which a shaft of said pump is rotatable.

20. Pump according to claim 19, wherein said translation direction is inclined by an angle comprised between 35° and 40° in relation to a plane that is perpendicular to said longitudinal axis.

21. Pump according to claim 19, wherein said slide direction is inclined by an angle comprised between 55° and 65° in relation to a plane that is perpendicular to said longitudinal axis.

22. Pump comprising a plurality of pistons movable in a direction, a swash plate arrangement forming an angle with said direction so as to reciprocate said plurality of pistons in said direction, said swash plate arrangement being oscillatable substantially around a point to modify said angle, wherein said swash plate arrangement is supported by a sliding element and a further sliding element movable along respective substantially rectilinear paths, said paths approximating to circumference arcs centred on said point.

23. Pump according to claim 22, wherein said arcs lie on a single circumference.

24. Pump according to claim 22, wherein at said point an axis of said swash plate arrangement intersects a thrust plane on which said plurality of pistons interact with said swash plate arrangement.

25. Pump according to claim 22, wherein said point lies on a longitudinal axis around which a shaft of said pump is rotatable.

26. Pump according to claim 22, wherein said sliding element is associated with a region of said swash plate arrangement diametrically opposite a further region of said swash plate arrangement with which said further sliding element is associated.

27. Pump according to claim 25, wherein said sliding element comprises a slide movable in a slide direction along a guide.

28. Pump according to claim 27, wherein said slide direction is inclined by an angle comprised between 55° and 65° in relation to a plane perpendicular to said longitudinal axis.

29. Pump according to claim 28, wherein said further sliding element comprises a sliding block movable along a track in a translation direction.

30. Pump according to claim 29, wherein said translation direction is inclined by an angle comprised between 35° and 40° in relation to a plane perpendicular to said longitudinal axis.

31. Cleaning apparatus comprising a dispensing device for dispensing a cleaning fluid and a pump according to claim 1 for conveying said fluid to said dispensing device.

32. Apparatus according to claim 31, and further comprising a pressure adjusting device for selecting a dispensing pressure of said fluid achievable by said pump.

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