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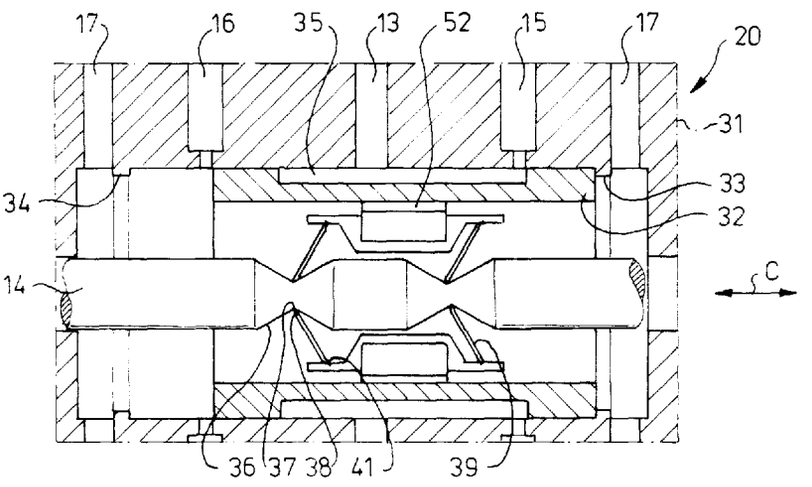
(54) Control valve and pump provided with control valve

(57) The invention relates to a control valve (20) for a pump provided with at least one pump element, which control valve (20) comprises a slide (32), which is movable between two positions, an operating rod (14) and a coupling between the slide (32) and the operating rod (14), wherein the slide (32) is slidable parallel to and a fixed distance away from the operating rod (14), and wherein the operating rod (14) is movable in the longitudinal direction thereof by means of the pumping movement of the pump element. The coupling comprises at least one arm (39) which at a first hinge point can be carried along by the operating rod and which at a second hinge point can be carried along by the slide (32). The coupling further comprises at least one element which on movement of the operating rod (14) relative to the slide (32) is compressible, with the storage of spring force, when the first and the second hinge points move towards one another, towards the dead point, in the longitudinal direction of the operating rod (14) and which releases the stored spring force on passing beyond the dead point, such that the slide (32) is moved in the direction opposite to the direction of movement of the rod. The first and second hinge points can comprise knife-edge hinges, the compressible, resilient element being pretensioned. The pump can be a diaphragm pump, bellows pump, plunger pump or piston pump.

Fig-2



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Description

The present invention relates to a control valve for a pump provided with at least one pump element capable of making a pumping movement, which control valve comprises a slide, which is movable between two switch positions, an operating rod and a coupling between the slide and the operating rod, wherein the slide is slidable parallel to the operating rod and at a fixed distance away from the operating rod and wherein the operating rod can be connected to the at least one pump element so as to be movable to and fro in the longitudinal direction during the pumping movement of the at least one pump element.

A control valve of this type for a double diaphragm pump is disclosed in German "Offenlegungsschrift" 3 310 131. In the case of this control valve for a double diaphragm pump, the operating rod is an axially slidable rod which extends through the control valve housing. Said operating rod operates in both axial directions of movement via an axially oriented compression spring which is compressible in the axial direction and has spring cups on the slide, which is held in its end positions by locking balls under spring force until the force of the spring applied coaxially to the operating rod is greater than the locking force. As soon as this is the case, the slide accelerates under the influence of the spring force of the coaxial spring in the direction counter to the axial direction of movement of the control rod, as a result of which reversal of the diaphragm movement takes place. In this way the slide is moved to and fro between two positions. With this construction the slide is provided with two hollow cavities, within which the cups movable along the operating rod are located, the axial spring being arranged between said cups. In order to be able to mount a slide of this type on the operating rod, the slide must consist of two parts, which can lead to sealing problems since the parts have to bc joined together so as to produce a seal. This construction has the further disadvantage that at very low pump capacities, at which the diaphragms move only slowly in tandem, the slide can easily remain stuck in a position located between the two end positions. At very high pump capacities, at which the diaphragms moving in tandem move rapidly to and fro, the spring mechanism can start to chatter, as a result of which the accuracy of the valve control is adversely affected. The spring mechanism is subjected to severe stresses and has a relatively short life, which, as a result of the relatively difficult assembly and the associated high assembly costs, leads to an increase in operating costs. Operation of the double diaphragm pump disclosed in said German "Offenlegungsschrift" 3 310 131 is generally not possible at drive fluid pressures of below about 2 bar, since the load on the control valve at lower pressures is insufficient to cause this to switch.

European Patent EP B1 0 480 192 also discloses a control valve for a double diaphragm pump, with which the coupling between the slide and the operating rod is effected by means of magnets. To this end a magnet is arranged both in the slide and in the operating rod. Said magnets exert attractive and repellent forces on one another, depending on the distance between them. When said magnets pass by one another, the slide will, as a consequence of the repellent effect between said magnets, accelerate away in a direction opposite to the direction of movement of the operating rod. A control valve of this type which operates with the aid of magnets has the major disadvantage that it cannot be used under all operating conditions. The magnetism of the required relatively strong magnets exerts an interfering effect on electronics arranged in the vicinity of the diaphragm pump. Furthermore, it can arise that the medium to be pumped contains magnetisable material which is magnetised under the influence of the magnetic fields generated in the control valve by the magnets. This can again lead to problems, such as blockage problems, during subsequent use of the medium to be pumped.

The aim of the present invention is to provide a mechanically acting control valve for a pump, which is preferably driven by a fluid and which is provided with at least one pump element capable of pumping movement, which control valve is able to function in a reliable manner under very diverse operating conditions, the slide not remaining stuck between the two end positions or switch positions.

A further aim of the invention is to overcome the disadvantages inherent to known pumps, such as double-acting diaphragm pumps.

This aim is achieved according to the invention in that the coupling comprises at least one arm which at a first hinge point can be carried along by the operating rod and which at a second hinge point can be carried along by the slide, and in that the coupling further comprises at least one resilient element which stores spring force on movement of the operating rod relative to the slide when the first and second hinge points move towards one another, towards the dead point, in the longitudinal direction of the operating rod and releases the stored spring force on passing beyond the dead point, such that the slide is moved in the direction opposite to the direction of movement of the operating rod. In this context the dead point is understood to be the point in time at which the first and the second hinge point are located on a straight line perpendicular to the longitudinal direction of the operating rod. The advantage of a construction of this type is that no additional spring elements are needed in order to hold the slide in one of the two outermost positions. The slide is held in the desired position by the resilient element just until the dead point is passed. As the dead point is passed, the force which the resilient clement exerts on the slide changes direction, as a result of which the slide moves. An advantage in positioning the arms such that a direct coupling between operating rod and the slide is provided is that the slide will be moved over a relatively large distance by a small movement of the shaft. This means that the chan-

nels used in the slide can be relatively large, so that the resistance forces to which fluids are subjected in the channels will be relatively low.

As a consequence of the arm being hingeable at a first hinge point with respect to the operating rod and at a second hinge point with respect to the slide, a construction is achievable with which the dead point forms a very brief instant of unstable balance. Said labile balance can be destroyed by a very small force, acting in the longitudinal direction, on the operating rod or the slide. Once the unstable/labile balance has been disturbed, the energy stored in the resilient element ensures that the second hinge point is forcibly driven away from the dead point.

A spring can be used as the resilient element, but it is equally possible, and more preferable, to use a body made of a resilient, compressible material such as natural or synthetic rubber, elastomer or plastic, it being possible for said materials to be of either massive (optionally with one or more recesses) or of foamed construction. Such a resilient, compressible body made of rubber or plastic generally has a relatively high fatigue limit, which benefits the operational reliability, especially at relatively high switching frequencies. Should a metal resilient element be used, the risk of fatigue problems at high switching frequencies is then much higher.

The theoretical arm, which is formed by the straight connecting line between the first and the second hinge, will, although the range is theoretically 90°, preferably move within the range of about 45°, for example 25° to about 35°, about the so-called dead point or labile balance point during switching from the one position to the other position of the slide. In this way it can be ensured that the force of reaction in the arm at all times has a component in the longitudinal direction of the operating rod which is smaller than the component in the direction perpendicular to the operating rod. In this context it must be borne in mind that a low operating or actuating force for the operating shaft is desired in order easily to effect switching. A small range of the theoretical arm(s) results in a relatively small switching force at a relatively high actuating force. However, a certain minimum range (or certain minimum angle) is needed to store sufficient spring force in the resilient element. To guarantee good switching of the valve, a certain minimum acceleration for the slide will be required when designing the valve.

The, preferably compressible, resilient element can be accommodated either in the arm (that is to say between the first and the second hinge point) or can be accommodated between the first hinge point and the operating rod and/or between the second hinge point and the slide.

According to the invention, the coupling can be made with small dimensions if the first and/or the second hinge point comprise (comprises) a knife-edge hinge. In this context the knife-edge hinge is understood to be a hinge which comprises a sharp knife edge and is positioned such that it is rotatable about the sharp knife edge in a groove. A knife-edge hinge of this type can be made with very small dimensions. A knife-edge hinge of this type furthermore has a hinge axis of very small width formed by the contact line between the knife edge and the groove, which increases the instability about the dead point. In order to guarantee the contact between the knife edge and the groove with a knife-edge hinge of this type, it is advantageous, with this arrangement, according to the invention if the compressible, resilient element is pretensioned. Preferably, both the first and the second hinge point will be a knife-edge hinge.

The dimensions of the coupling in the direction perpendicular to the longitudinal direction of the operating rod, and thus the distance between the slide and the operating rod, can advantageously be minimised according to the invention if the coupling comprises at least two parallel arms each having a first and a second hinge and if a yoke is arranged between the first or second hinge points, which yoke comprises a recess extending between the arms in which the at least one compressible, resilient element is accommodated such that said element, on compression, exerts, on the one hand, a force of reaction on the yoke and, on the other hand, a force of reaction on, respectively, the slide or the operating rod. The compressible, resilient element can in this way be partially arranged between the arms, with the effect that the dimensions of the coupling in the direction pcrpendicular to the longitudinal direction of the operating rod can be minimised.

With a view to balanced loading, in particular balanced lateral loading, of the operating rod, it is advantageous according to the invention if the coupling is symmetrical with respect to the operating rod. The coupling will then therefore comprise at least one arm having a first and a second hinge point and at least one compressible, resilient element, on either side of the operating rod. The reason for this is that embodiments which are of asymmetrical construction have the disadvantage that large frictional forces are produced on movement of the slide, which forces increase the risk of jamming around the dead point and also increase the minimum pressure at which the pump is able to operate.

In order to facilitate assembly of the control valve, it is advantageous according to the invention if the slide has a passage in which the operating rod extends and is movable and in which the coupling is housed, and if an auxiliary frame is provided which encloses the operating rod and coupling in the circumferential direction of the operating rod in order to position the coupling relative to the operating rod in such a way that the operating rod and coupling can be introduced as a whole into the passage. The coupling and operating rod can then be assembled separately from the slide in order then to be introduced as a whole into the slide.

In order further to facilitate assembly of the control valve with this arrangement, it is advantageous according to the invention if the passage has an essentially rectangular cross-section and if the auxiliary frame can

be divided, for example into a U-shaped part and a plate-shaped part or into two identical U-shaped parts. A U-shaped part can then be placed with its body section joining the legs on a substrate, aftcr which the operating rod and the coupling parts can be assembled inside the legs of the U-shaped part in order then to close the auxiliary frame by fitting the plate-shaped part or second U-shaped part over the free ends of the legs of the one U-shaped part. The use of two identical U-shaped parts offers the advantage from the production engineering standpoint that a single mould can suffice.

In order to fix the frame, and thus the coupling, to the slide, it is advantageous, with this arrangement, if the frame is provided with stop ridges which are able to engage with the slide. Such stop ridges can engage with cavities formed in the passage in the slide. However, the stop ridges will equally well, and with a view to disassembly more advantageously, engage with the front outer edges of the passage in the slide. With this arrangement, the stop ridges can optionally be arranged on bearers which extend from the frame in the longitudinal direction of the operating rod.

The invention further relates to a pump provided with a control valve according to the invention. A pump of this type preferably comprises at least one drive chamber, which can be actuated by a pressurised fluid, such as compressed air, and at least one pump chamber, the pump chamber and drive chamber being separated from one another by a pump element. A pump of this type can be a so-called single-acting pump, but also a so-called double-acting pump. Both types of pump can advantageously be equipped with a control valve according to the invention. However, the control valve according to the invention can highly advantageously be used in a double-acting pump which comprises two cavities which are each divided by a pump element into a pump chamber and a drive chamber and wherein the pump elements are joined to one another so as to be movable in tandem with a pumping action.

Both with single-acting pumps and with double-acting pumps, the control valve according to the invention can be used with so-called plunger pumps, so-called diaphragm pumps, so-called piston pumps and so-called bellows pumps. With pumps of this type the pump element is formed by, respectively, a plunger, a diaphragm, a piston or a bellows.

Pumps according to the invention equipped with a control valve according to the invention can be used as pumps which have to operate highly accurately, such as, for example, metering pumps, but also as pumps which have to be able to pump large volumes, such as tank pumps with which a tank has to be emptied.

In the case of a double-acting pump, the control valve according to the invention can highly advantageously be accommodated in the connection between the pump elements for tandem movement thereof, in which case the connection for the tandem movement of the pump elements then comprises the connecting rod for the control valve. A control valve according to the invention can also be fitted in other ways such as are known per se in practice. The control valve can thus, for example, also be arrangcd eccentrically with respect to the connecting rod.

The present invention will be explained in more detail below with reference to illustrative embodiments shown in the drawing. In the drawing:

Fig. 1 shows, highly diagrammatically, a double-acting diaphragm pump which, if fitted with the control valve according to the invention, can be a diaphragm pump according to the invention;
Fig. 2 shows, diagrammatically, a longitudinal section of a control valve according to the invention for a pump according to the invention;
Fig. 3 shows, diagrammatically, a perspective view with dismantled components, of the control valve from Fig. 2; and
Figs 4a-4c show, diagrammatically, the operating principle of the control valve on the basis of a highly simplified illustrative embodiment of another construction variant; and
Fig. 5 shows, diagrammatically, an operating principle of a double, double-acting plunger pump fitted with a control valve according to the invention;
Fig. 6 shows, diagrammatically, an operating principle of a single-acting plunger pump which is fitted with a control valve according to the invention; and
Fig. 7 shows, diagrammatically, an operating principle of a piston pump which is fitted with a control valve according to the invention.

Fig. 1 shows, highly diagrammatically, a double diaphragm pump having two cavities 1 and 2, each of which is subdivided by a diaphragm into a pump chamber and a drive chamber. Cavity 1 is subdivided by diaphragm 7 into a pump chamber 3 and a drive chamber 4, and cavity 2 is subdivided by diaphragm 8 into a pump chamber 6 and a drive chamber 5. Thus, in this case the diaphragms 7 and 8 form the so-called pump elements. Fluid or medium to be pumped is drawn towards the pump chambers via lines 9 and 10 in order then to be discharged from the pump chambers via lines 11 and 12. Drive fluid, such as compressed air or a liquid, is fed to the control valve 20 via line 13. The control valve 20 is connected, via line 15, with the drive chamber 4 and, via line 16, with the drive chamber 5. The control valve 20 is further provided with a return line 17 for drive fluid. The diaphragms 7 and 8 are connected to one another by means of a rod 14 to enable them to move in tandem. By moving the rod 14 alternately to the right and to the left it is possible to achieve alternate pumping of fluid from the one cavity 1 whilst fluid is drawn into the other cavity 2. Figure 1 shows the diaphragms in the position where they have been moved fully to the right. In this position the pump chamber 3 has been emptied as far as possible by driving off the fluid contained therein, via

line 12, whilst the pump chamber 6 is completely filled by drawing in fluid to be pumped, via line 9. When the rod 14 is now moved to the left by filling the drive chamber 5 with drive fluid via line 16, the fluid contained in the pump chamber 6 is pumped via line 11, whilst the drive fluid present in the drive chamber 4 is able to escape via line 15 and line 17 and fluid to be pumped is drawn into the pump chamber 3 via line 10. When the rod 14 is moved to the right again, fluid will be pumped via line 12 and the drive chamber 4 will be filled with drive fluid via line 15, drive fluid will escape from the drive chamber 5 via lines 16 and 17 and fluid to be pumped will be drawn into the pump chamber 6 via line 9. The switching valve 20 used with this arrangement can be a switching valve as disclosed in German "Offenlegungsschrift" DE 3 310 131 or EP B1 0 480 192. Switching valves of this type are provided with a slide which, via a coupling with the rod 14, is movable to and fro between two end positions such that when the rod 14 is moved to the right line 13 is connected to line 15 and line 16 is connected to line 17 until, on reaching the right-hand end position, the slide is automatically switched over, after which line 13 is connected to line 16 and line 15 is connected to line 17. As a consequence of this switching, the movement of the rod 14 will now be reversed and take place to the left until the rod 14 approaches the left-hand end position, the slide again being automatically switched over such that line 13 is connected to line 15 and line 16 is connected to line 17. In principle, this is a wholly mechanical, automatic switching process. However, the known switching valves display a number of disadvantages. They are not usable under diverse operating conditions from very low to very high switching frequencies and/or they are not usable in every environment.

As a result of the use of a control valve according to the invention in a double diaphragm pump, the double diaphragm pump according to the invention which is thus obtained is usable in a reliable manner at both low and high switching frequencies and in very diverse environments.

It will be clear with reference to Fig. 1 that a control valve according to the invention can also be used highly advantageously in a so-called double-acting piston pump and in a so-called double-acting bellows pump. In the case of a piston pump the pump elements 7, 8 (which in the case of Fig. 1 are formed by diaphragms in a diaphragm pump) must be replaced by pistons, which are movable to and fro in the cavities 1 and 2. The cavities 1 and 2 in this case form the cylinders of double-acting piston pumps. A so-called bellows pump is obtained by replacing the pump elements 7 and 8 in diaphragm form in Fig. 1 by bellows.

In the case of the switching valve according to the invention, use is made of a coupling between the operating rod 14 and the slide, which coupling consists of at least one, preferably rigid, arm and at least one resiliently compressible element. The arm has a first hinge point which can be carried along by the operating rod 14 and a second hinge point which can be carried along by the slide. The distance between the operating rod and the slide, viewed perpendicular to the longitudinal direction of the operating rod, remains unchanged. With this arrangement, tilting of the arm extending between the first and the second hinge point is rendered possible by the compressible, resilient element. This principle can be illustrated highly diagrammatically with reference to Figures 4a to 4c.

In Figures 4a-4c, 14 is the operating rod, 21 the first hinge, 22 the second hinge, which in this example is fixed relative to the slide, which is not shown, 23 is the arm and 24 is a compressible, resilient element. In this example the compressible, resilient element 24 is accommodated in the arm between the first and the second hinge, which arm 23 is preferably rigid in its transverse direction. As will become clear later with reference to Figs 2 and 3, said resilient element 24 can also be arranged between the first hinge point 21 and the operating rod 14 and/or between the second hinge point 22 and the slide. Instead of using a compressible element 24, it is also certainly conceivable to construct the arm such that it is itself deformable, for example compressible or bendable.

Starting from the situation in Fig. 4a, the slide, which is not shown, is in the right-hand end position and the operating rod 14 is moved to the right in accordance with arrow A. In this situation the second hinge point 22 remains in place and the first hinge point 21 is moved to the right until said first hinge point 21 is lying below the second hinge point 22. This situation is shown in Fig. 4b. Figure 4b shows the point in time at which the so-called dead point is reached, at which dead point the first hinge point 21 and the second hinge point 22 are on one line, which is perpendicular to the longitudinal direction or direction of movement of the operating rod 14. As can be seen from Figs. 4a and 4b, the vertical distance between the first and the second hinge point, that is to say the distance viewed perpendicularly to the direction of movement of the operating rod 14, is unchanged. This is possible because in this illustrative embodiment the arm 23 becomes shorter as a consequence of the compression of the compressible, resilient element 24. However, it will be clear that the same effect with regard to the distance between the slide and the operating rod can be achieved if the resilient, compressible element 24 were to be arranged between the first hinge point 21 and the operating rod 14. When the operating rod 14 moves even a little further towards the right, the unstable balance position shown in Fig. 4b is disturbed and the compressed, resilient element 24 is able to relax. As a consequence of this, the second hinge point 22 is moved to the left with respect to the first hinge point 21, in the direction of arrow B. From that point in time further movement of operating rod 14 to the right (arrow A) will be blocked. As a consequence of the relaxation of the compressed, resilient element, the

slide will rapidly be moved in the direction of arrow B, which renders rapid, reliable switching possible.

The above description of the switching mechanism according to the invention with reference to Figures 4a-4c has been given with, throughout, reference to one arm and one resilient, compressible element. However, as is indicated in Figures 4a-4c, it will be clear that use can equally well be made of a coupling which is symmetrical with respect to the operating rod 14 and has at least one arm and at least one compressible, resilient element on either side of the switching rod. This offers the additional advantage that the energy stored in the elements 24 has no resultant force in the transverse direction on the operating rod 14.

An advantageous embodiment of a switching valve according to the invention is shown diagrammatically in Figures 2 and 3. With a view to clarity, the lines 13, 15, 16, 17 and the operating rod 14 have been given the same reference numerals in these figures as in Fig. 1. The switching valve 20 consists of a casing 31 with a slide 32 therein which is slidable to and fro between two end positions. The right-hand end position is delimited by a stop 33 and the left-hand end position is delimited by a stop 34. In the right-hand position of the slide 32, which is shown, line 13 is connected via the cavity 35, delimited by the slide 32 and the casing 31, to line 15. In this position, line 16 is connected via the casing to line 17. It will be clear that when the slide 32 is in its left-hand position delimited by the stop 34, line 13 is connected to line 16 and line 15 is connected to line 17.

The operating rod 14 is provided with grooved notches 36 at two points on either side. The bases of each groove 37 act as a support point for a knife edge 38 on an arm 39, which is preferably essentially rigid. The groove base 37 and knife edge 38 together form the first hinge point of the arm 39. The second hinge point of the arm 39 is formed by a knife edge 40 and groove 41, which is formed in a yoke 42. The yoke 42 is provided with a recess 43, which extends between two parallel arms 39. A compressible, resilient element 44 is accommodated in said recess 43. Each yoke 42 and compressible, resilient element 44 is fixed in the axial direction C with respect to the slide 32.

Referring back to the description of the principle with reference to Figures 4a-4c, it will be clear that when the operating rod 14 is moved to the right the first hinge point 37, 38 is brought to below the second hinge point 40, 41, this being the so-called dead point, that the dead point is then passed by on very slight further movement of the operating rod 14 to the right, after which the slide is driven, under the influence of the spring force stored in the compressed element, to the left into the left-hand end position delimited by the stop 34. The effect of this is that instead of the one drive chamber the other drive chamber is now actuated by drive fluid. In the embodiment shown, the arms can hinge over a range of 30°.

As can be seen in particular from Fig. 3, assembly of the operating rod 14 and the coupling (which consists of the arms 39, the yokes 42 and the compressible, resilient elements 44) in the slide 32 is appreciably facilitated by means of an auxiliary frame which consists of a U-shaped frame section 50 and a plate-shaped frame section 51. After the operating rod 14 and the components of the coupling have been placed in the U-shaped frame section 50, the plate-shaped frame section 51 can be fixed on top of the free ends of the legs of the U-shaped frame section 50. With this assembly the compressible, resilient elements 44 come to lie against the inside of the legs of the U-shaped section 50, the yoke components come to lie with a recess around the element 44 and the operating shaft 14 comes to lie between the yoke components. The arms 39 can then be slid into the grooves 37 and 41, after which the coupling is complete.

The cover section 51 of the frame is then placed over the U-shaped frame section. The shape of the outer periphery of the assembled frame 50, 51 corresponds to the shape of the inner periphery of the recess 53 in the slide 32. The assembled whole comprising operating shaft, coupling and frame can be slid into the recess 53 until the stop ridges 54 and 55 on the frame 50, 51 engage behind the edges 56 on the front ends of the passage 53. In order to prevent unintentional detaching of the frame from the slide 32, it can be advantageous to construct the stop ridge at one end only, that is to say the stop ridge 54 or the stop ridge 55, as a snap-fit ridge, for example by constructing the bearers 60 or bearers 51 such that they give.

When a frame made up of two identical U-shaped parts is used for the auxiliary frame, the leading ends of the legs of each part will be placed against one another.

Fig. 5 shows, highly diagrammatically, an operating principle of a so-called double, double-acting plunger pump. Since the functioning of said double, double-acting plunger pump corresponds in broad terms to that of the double-acting diaphragm pump according to Fig. 1, the same numbers have been used for corresponding reference numerals, with the suffix a. Thus, with respect to the functioning reference can be made essentially to Fig. 1. Only a brief explanation of the differences will be given here. In the case of Fig. 5, the pump elements 7a and 8a are formed by plungers, which are movable to and fro in accordance with arrow C in respective cylinders 2a and 1a. The plungers 7a and 8a are rigidly coupled to one another by a connecting rod 70a, with the operating rod 14a for the control valve 20a fixed thereto. The operating rod 14a will in this case be movable to and fro together with the pumping movement of the plungers. Since the plungers are rigidly coupled, they will move in the same direction in this case. This means that when the drive chamber of the one cylinder is actuated in order to pump empty the pump chamber of said cylinder, the drive chamber of the other cylinder is not actuated, so that the drive fluid can be driven therefrom and the pump chamber belonging to the other cylinder can, as a result of the suction action, be filled with fluid

to be pumped.

Fig. 6 shows, highly diagrammatically, an operating principle of a single plunger pump, provided with a control valve according to the invention. Since in this case as well the functioning in broad terms corresponds to that of the double diaphragm pump according to Fig. 1, here again the same reference numerals are used with the suffix b. In the case of the embodiments according to Fig. 5 and Fig. 1, the one pump element is always brought back to its initial position in accordance with pumping by actuation of the drive chamber for the other pump element. In the case of Fig. 6, and also in the case of Fig. 7, which is still to be discussed, however, the second drive chamber is lacking. In order nevertheless to be able to drive the pump element back, a spring 71b (or 71c in the case of Fig. 7) is provided in these cases. It will also be clear that the control valve 20b in this case does not have to switch between two drive chambers, but has alternately to actuate and to relieve only one drive chamber. Therefore a line equivalent to line 16 in Fig. 1 can be dispensed with. The plunger 7b is connected, via a rod 70b rigidly attached thereto, to the operating rod 14b for the control valve 20b. When the plunger 7b moves to and fro in accordance with arrow C, the operating rod 14b for the control valve 20b will also move to and fro in accordance with arrow C. The operation in Fig. 6 can be summarised very briefly as follows: control valve 20b actuates drive chamber 4b (line 13b and line 15b are then connected to one another), the plunger 7b is driven to the right and pumps the pump chamber 3b empty via line 12b. When plunger 7b has moved a certain, adjustable distance to the right, the switching valve 20b will shut line 13b and connect line 15b to line 17b. The drive chamber 4b is then relieved and the spring 71b will drive back the plunger 7b, during which operation, in the meantime, the pump chamber 3b is filled with fluid to be pumped by suction via line 10b. As soon as plunger 7b has moved a specific, adjustable distance to the left, the control valve 20b will be switched over again. Line 13b will then be connected to line 15b again, after which the cycle just described can repeat.

Fig. 7 shows a single-acting piston pump provided with a control valve according to the invention. The functioning of said single-acting piston pump is completely identical to that of the plunger pump according to Fig. 6. The reference numerals are therefore identical, except that the letter b has been replaced by letter c for differentiation. The operating rod 14c is in this case integrated with the piston rod for the piston 7c, which in this case forms the pump element. It will also be clear with reference to Fig. 7 that the piston 7c can very readily be replaced by a diaphragm or a bellows. A diaphragm pump or a bellows pump will then be obtained.

It will be clear that numerous variants of the control valve and diaphragm pump according to the invention are conceivable within the scope of the invention. For instance, instead of two parallel arms it is also possible to provide three or more parallel arms. Reference has always been made above to one arm 39 with a knife edge 40 which engages in a groove base 37. It is also possible to provide the yoke with a protrusion which engages in a groove on the end of the arm. It is also conceivable to fix the element 44 with respect to the operating rod instead of with respect to the slide. It is also conceivable to construct the yokes 42 such that they are resiliently bendable, in which case the elements 44 can then be dispensed with. Furthermore, it is conceivable to replace the yokes 42 by, for example, flat strips, to dispense with the elements 44 and to use as resilient elements one or more draw springs, which extend through a slot made in the operating rod 14 and join two strips, which are located opposite one another and are preferably under pretension, to one another.

Claims

1. Control valve for a pump provided with at least one pump element capable of pumping movement, which control valve comprises a slide, which is movable between two switch positions, an operating rod and a coupling between the slide and the operating rod, wherein the slide is slidable parallel to the operating rod and at a fixed distance away from the operating rod and wherein the operating rod can be connected to the at least one pump element so as to be movable to and fro in the longitudinal direction during the pumping movement of the at least one pump element, **characterised in that** the coupling comprises at least one arm which at a first hinge point can be carried along by the operating rod and which at a second hinge point can be carried along by the slide, and in that the coupling further comprises at least one resilient element which stores spring force on movement of the operating rod relative to the slide when the first and second hinge points move towards one another, towards the dead point, in the longitudinal direction of the operating rod and releases the stored spring force on passing beyond the dead point, such that the slide is moved in the direction opposite to the direction of movement of the operating rod.

2. Control valve according to Claim 1, **characterised in that** the first and/or the second hinge point comprise/comprises a knife-edge hinge and in that the resilient element is preferably pretensioned.

3. Control valve according to one of the preceding claims, **characterised in that** the at least one resilient element is a resilient compressible element.

4. Control valve according to one of the preceding claims, **characterised in that** the coupling comprises at least two parallel arms, each with a first

and a second hinge, and in that a yoke is arranged between the first or second hinge points, which yoke comprises a recess which extends between the arms and in which the at least one compressible, resilient element is accommodated such that said element, on compression, exerts, on the one hand, a force of reaction on the yoke and, on the other hand, a force of reaction on the slide or the operating rod, respectively.

5. Control valve according to one of the preceding claims, **characterised in that** the coupling comprises, on either side of the operating rod, at least one arm with first and second hinge points and at least one compressible, resilient element.

6. Control valve according to Claim 5, **characterised in that** the slide has a passage in which the operating rod extends and is movable and in which the coupling is housed, and in that an auxiliary frame is provided which encloses the operating rod and the coupling in the circumferential direction of the operating rod in order to position the coupling relative to the operating rod in such a way that the operating rod and coupling can be introduced as a whole into the passage.

7. Control valve according to Claim 6, **characterised in that** the passage has an essentially rectangular cross-section and in that the auxiliary frame can be divided into a U-shaped part and a plate-shaped part or into two, preferably identical, U-shaped parts.

8. Control valve according to Claim 6 or 7, **characterised in that** the frame is provided with stop ridges, wherein the stop ridges are able to engage with the slide in such a way that the unit comprising frame, coupling means and operating rod can be fixed to the slide.

9. Control valve according to one of the preceding claims, **characterised in that** the connecting line between the first and second hinge points of an arm is movable within a range of about 45° about the dead point on moving from the one end position to the other end position.

10. Pump provided with a control valve according to one of the preceding claims.

11. Pump according to Claim 10, comprising at least one drive chamber, which can be actuated by a pressurised fluid, such as compressed air, and at least one pump chamber, wherein the pump chamber and drive chamber are separated from one another by a pump element.

12. Pump according to Claim 10 or 11, wherein the pump is a double-acting pump which comprises two cavities, each of which is subdivided by a pump element into a pump chamber and a drive chamber, and wherein the pump elements are connected to one another in order to be movable in tandem with a pumping action.

13. Pump according to Claim 12, wherein the connection for movement of the pump elements in tandem comprises the connecting rod of the control valve.

14. Pump according to one of Claims 10-13, wherein the pump is a plunger pump and wherein the pump element comprises the plunger.

15. Pump according to one of Claims 10-13, wherein the pump is a diaphragm pump and wherein the pump element comprises the diaphragm.

16. Pump according to one of Claims 10-13, wherein the pump is a piston pump and wherein the pump element comprises the piston.

17. Pump according to one of Claims 10-13, wherein the pump is a bellows pump and wherein the pump element comprises the bellows.

Fig-1

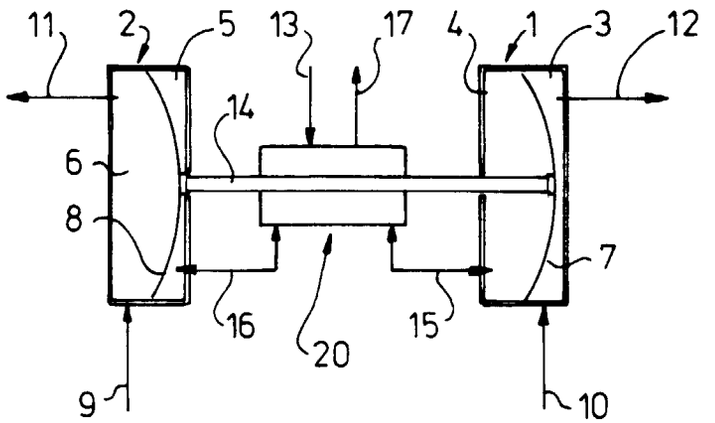
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Fig-2

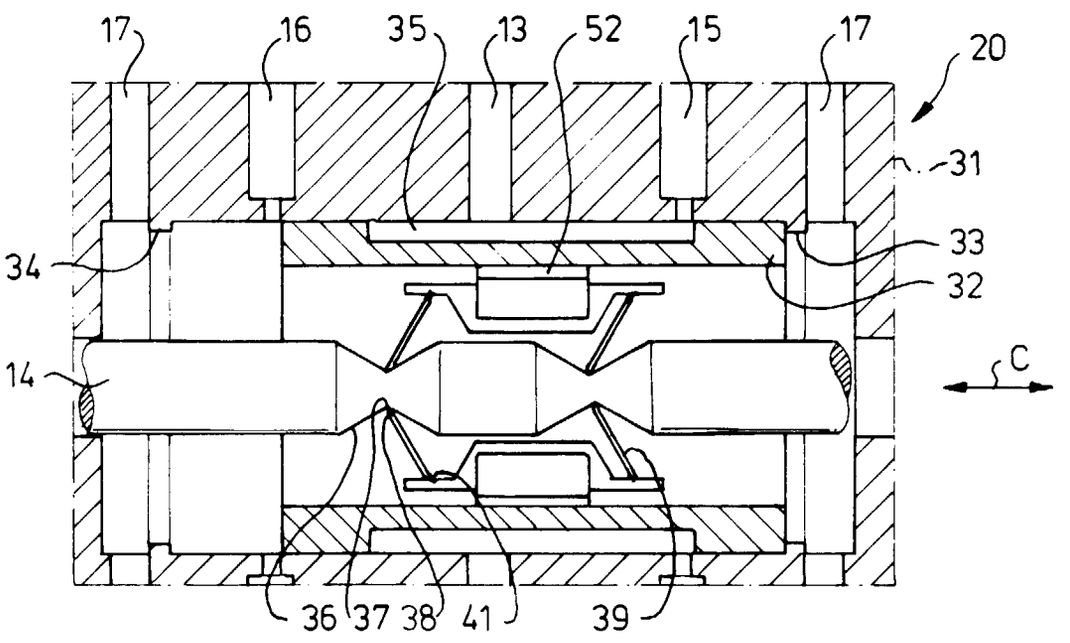
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Fig-3

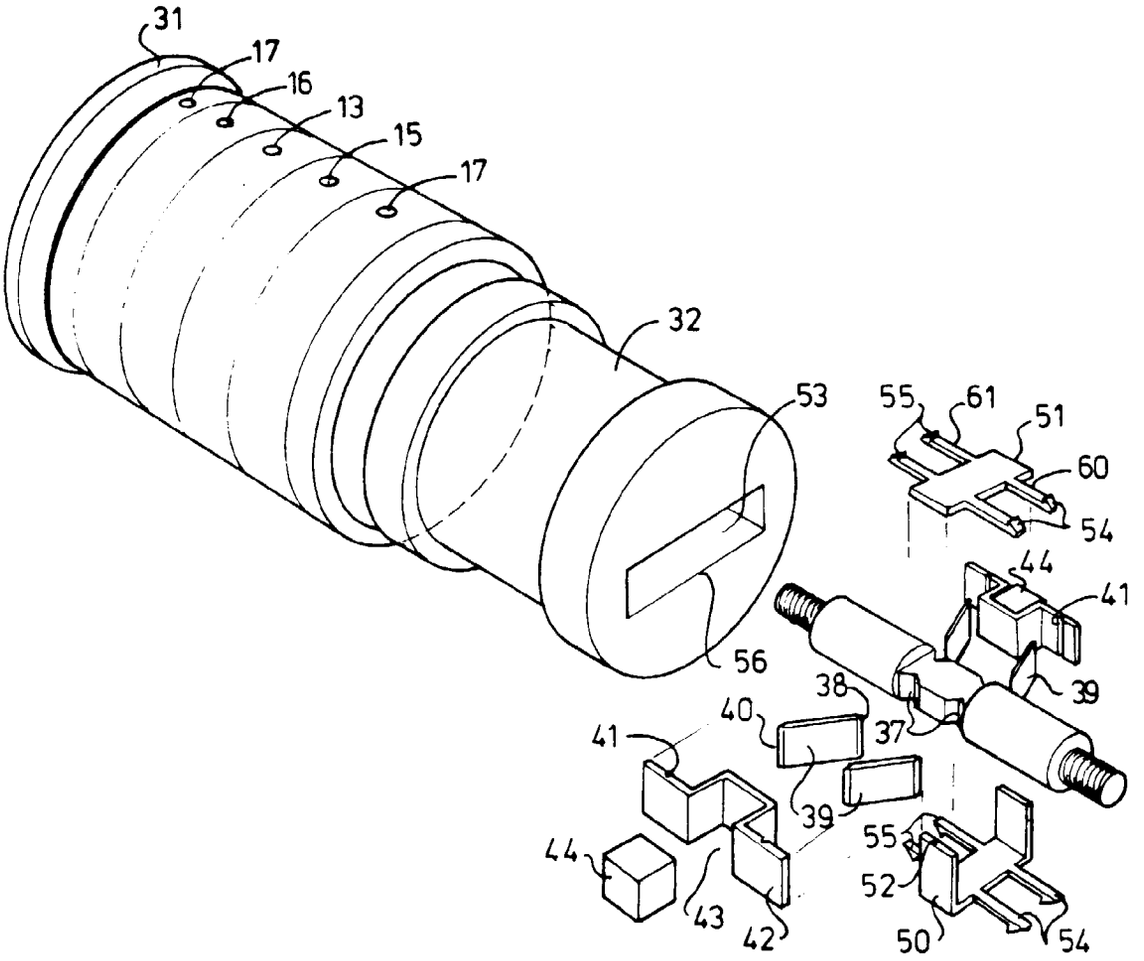


Fig-4a

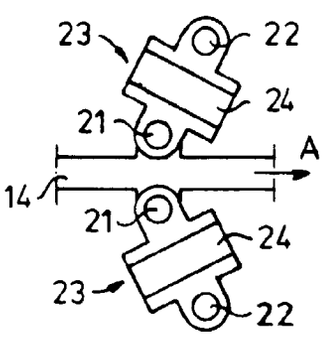


Fig-4b

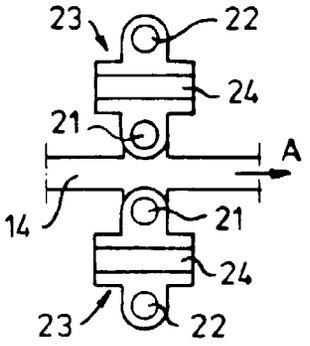


Fig-4c

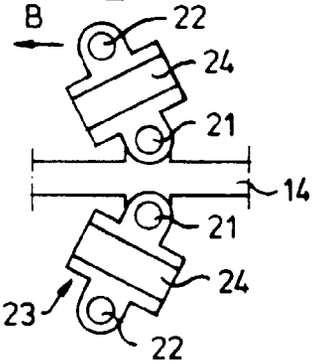


Fig - 5

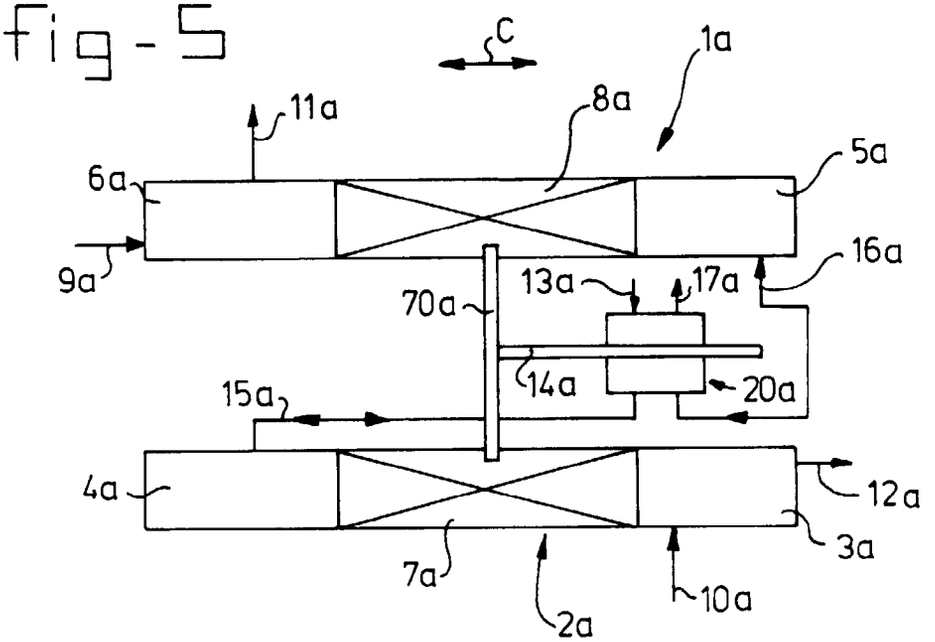


Fig - 6

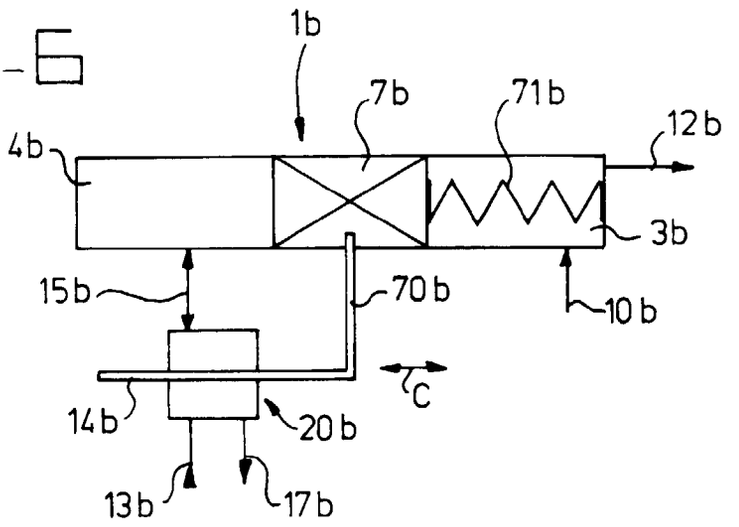
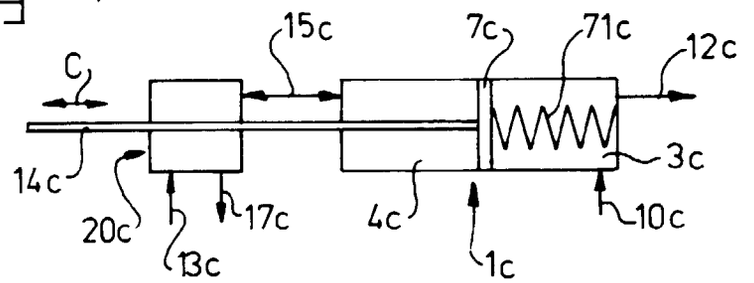


Fig - 7



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EUROPEAN SEARCH REPORT

Application Number
EP 96 20 3655

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.6)
X Y	DE 27 26 674 B (DRÄGERWERK AG) 18 May 1978 * the whole document * ---	1,2, 9-13,15 14,16,17	F04B43/073
Y A	EP 0 508 555 A (MURATA ET AL.) 14 February 1992 * the whole document * ---	14,16 1-3,5,6	
Y	US 5 308 230 A (MOORE) 3 May 1994 * the whole document * ---	17	
A	BE 489 001 A (DE MIRIBEL) 31 May 1949 * the whole document * ---	1,3, 9-13,15	
A	US 4 354 806 A (MCMILLIN JOHN R ET AL) 19 October 1982 * the whole document * ---	1	
D,A	DE 33 10 131 A (DEPA GES FUER VERFAHRENSTECHNI) 27 September 1984 ---		TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	EP 0 321 573 A (MURATA ET AL.) 28 June 1989 * page 2, paragraph 3 - page 4, paragraph 3; figure 16 * -----	1,4	F04B F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 March 1997	Von Arx, H

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