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Description

[0001] The invention relates to an apparatus for pumping a fluid from a fluid reservoir as defined in the preamble of claim 1. Such an apparatus is known from US-A-4026661. The invention further relates to a method of pumping a fluid from a fluid reservoir as defined in claim 15.

[0002] Sucker rod pumps are used throughout the entire industry and are adapted for pumping various kinds of fluids such as liquids. These pumps are very popular in oil well production also. In such sucker rod pumps, a pump is actuated in a defined depth by a sucker rod string which is hence reciprocated by a beam pumping unit at the surface. The pump is basically composed of a piston that is movably supported in the bore hole and that may comprise a travelling valve. At the bottom of the bore hole a pump barrel may be installed that may include a standing valve.

[0003] During an upstroke of the pump, the piston is lifted together with the entire column of liquid that is gathered in the bore hole above the piston. The travelling valve at the lower end of the piston is therefore closed and hinders the liquid column to a flow back at the bottom of the bore hole. At the same time the standing valve is open and allows fluid to fill the pump. During a downstroke the standing valve of the pump is closed while at the same time the travelling valve opens in order to make all the fluid in the pump flowing through the piston above into a tubing string.

[0004] WO 2002/46613 discloses a rodless pump which is connected to a pressure source via a conduit. In a common oilfield application the pump would be connected to the bottom of a tubing string within the reservoir fluid to be produced. A pressure source such as a hydraulic pump would be connected at the surface to the tubing string so as to selectively apply pressure via fluid in the conduit to the pump, raising the plunger assembly in the pump drawing reservoir fluid into the pump. When pressure via the surface pressure source is released, a gas source in the pump urges the plunger assembly downward in the pump urging the reservoir fluid in the pump into the tubing and to the surface. Preferably, the pump includes dampening mechanisms at both the top and bottom of the plungers stroke so as to reduce metal to metal impact within the pump. This dampening mechanism may include elastomer barriers, springs, and other dampening mechanisms.

[0005] WO 2006/032145 discloses an intermittent lift plunger for intermittently lifting fluids from a well and includes at least one seal mandrel with a plurality of openings, a bottom sub and an upper valve assembly. The valve assembly is closed by a well bottom stop which inserts into the lift plunger and opened by a lubricator stop at the top of the well. The seal mandrel includes a sleeve seal formed from an elastomeric rubber or plastic and covers the seal mandrel openings. The sleeve seal inflates to engage the well bore surface when the valve

assembly is closed and a pressure differential exists.

[0006] Conventional pumps may still not allow for a sufficiently efficient pumping of a fluid from a fluid reservoir.

5 **[0007]** It is an object of the invention to provide a pump system allowing for an efficient pumping of a fluid from a fluid reservoir.

[0008] In order to achieve the object defined above, an apparatus for and a method of pumping a fluid from a fluid reservoir according to the independent claims are provided as defined in claims 1 and 15, respectively.

10 **[0009]** According to an exemplary embodiment of the invention, an apparatus for pumping a fluid (such as a liquid, for instance water or oil) from a fluid reservoir (such as a water resource or an oil well) is provided. The apparatus comprises a piston (which may also be denoted as a plunger) adapted for reciprocating (for instance under control of a control unit and powered by a drive unit) upwardly and downwardly for pumping the fluid (for instance from the reservoir to a container above ground). Furthermore, the apparatus comprises a first annular fluid chamber (for instance having an annular space or volume for accommodating fluid) partially delimited by the piston, a second annular fluid chamber (for instance having another annular space or volume for accommodating fluid) laterally surrounding the first fluid chamber (for instance circumferentially enclosing an outer perimeter of the first fluid chamber), and a fluid communication recess (such as a fluidic path fluidly connecting the fluid chambers) adapted for providing a fluid communication between the first fluid chamber and the second fluid chamber. A movable valve (which may be movable by a control unit, for instance coordinated to the reciprocation of the piston) of the apparatus is adapted so that when the flow of fluid originating from the fluid reservoir to the first annular fluid chamber is disabled by the movable valve, the piston moves upwardly and fluid flows from the second fluid chamber into the first fluid chamber. The movable valve may be further adapted so that when the flow of fluid originating from the fluid reservoir to the first annular fluid chamber is enabled by the movable valve, the piston moves downwardly and fluid flows from the first fluid chamber into the second fluid chamber.

30 **[0010]** According to another exemplary embodiment of the invention, a method of pumping a fluid from a fluid reservoir is provided. The method comprises reciprocating a piston upwardly and downwardly for pumping the fluid via a first annular fluid chamber partially delimited by the piston and via a second annular fluid chamber laterally surrounding the first fluid chamber. The method further comprises providing a fluid communication between the first fluid chamber and the second fluid chamber. The method furthermore comprises moving a valve so that when the flow of fluid originating from the fluid reservoir to the first annular fluid chamber is disabled by the valve, the piston moves upwardly and fluid flows from the second fluid chamber into the first fluid chamber. When the flow of fluid originating from the fluid reservoir

to the first annular fluid chamber is enabled by the valve, the piston moves downwardly and fluid flows from the first fluid chamber into the second fluid chamber.

[0011] In the context of this application, positional terms such as "upwardly", "downwardly", "laterally", "above", "below" are particularly used in accordance with a geometry during a normal use of the apparatus, i.e. may relate to an operation state of the apparatus in which the apparatus is installed in a vertical or a bevelled bore hole or the like.

[0012] According to an exemplary embodiment of the invention, a concentric pumping system for the production of fluids, for instance oil or water, is provided. Hence, a for instance hydraulic pump for deep holes is provided which may be anchored in a concentric arrangement of fluid chambers for pumping a fluidic medium. The concentric arrangement of the first and the second annular fluid chambers may allow to make use of a sort of U-tube effect to thereby allow to operate the pump with a very small consumption of energy. This results from the fact that, due to the U-tube effect, fluid accommodated in one of the annular fluid chambers may flow back to the other annular fluid chamber to thereby contribute to the lifting of the piston during an upstroke. The pump may for instance be hydraulically actuated from above ground, i.e. from outside of a bore hole, and is also appropriate for use in strongly inclined bore holes and also in very deep bores.

[0013] At least a part of the first annular fluid chamber may be delimited by a piston which may have a dual configuration with different diameter sections in an upper and a lower portion as compared to a middle portion for defining the inner one of the annular fluid chambers. During an upstroke, the fluid may be sucked from the reservoir into an intermediate chamber and, independently from this, fluid may flow back from an outer annular fluid chamber to the inner annular fluid chamber to cause the U-tube effect. During this upstroke, the valve is in a position to basically prevent a fluid communication between the intermediate chamber and the inner annular fluid chamber. During a downstroke, the fluid can be displaced from the intermediate chamber into the inner annular fluid chamber. The fluid can therefore be moved upwardly or raised above the bore hole.

[0014] Next, further exemplary embodiments of the apparatus will be explained. However, these embodiments also apply to the method.

[0015] For instance, the pump can be driven using a wire/rope or can be circulated in the bore hole. An additional foot valve or standing valve can be constructed to be pullable so that when circulating out the pump, the circulation fluid does not get into contact with the reservoir. However, this valve can be pulled at the wire/rope without the need to use a work-over apparatus or the like. For the operation, no further external wires are required so that the implementation can be performed in a short time without the need of a work-over arrangement.

[0016] The hydraulic pump may be installed in a con-

centric completion making use of the dual plunger geometry. Because of the extra standing valve it is possible to exchange the pump basically without any impact on the formation. The U-tube effect allows to operate the pump with minimized energy consumption.

[0017] Due to the small energy consumption, the pump system is advantageous from the point of view of environmental protection. No work-over arrangements are required for exchanging pumps which allows to operate the system with a high degree of safety. The formation or reservoir can be treated gently which allows to obtain a high production rate and a high rate of yield. The U-tube effect can be achieved by two concentrically arranged tubes which are in fluid communications via a perforation, a conduit or the like. Thus, the hydrostatic fluid pressure from the outer of the two concentrically arranged volumes can be used, i.e. the potential energy of the fluid buffered therein may be used, for supporting an upwards stroke of the piston. In other words, a back flow of fluid, temporarily stored in the outer annular volume, during the upstroke can provide a lifting force for supporting the raising of the piston during the upwards stroke.

[0018] Hence, an arrangement with a piston and a check valve may be provided which may be operated by a hydraulic cylinder which may be arranged directly above the piston. The hydraulic cylinder may be connected via a separate tube to a hydraulic pump which may be arranged at or above ground. The moved fluid serves as operating medium of the pumping procedure.

[0019] The movable valve, which may be a check valve, may be adapted so that when the flow of fluid originating from the fluid reservoir to the first annular fluid chamber is disabled by the movable valve, flow of fluid originating from the fluid reservoir to an intermediate chamber arranged below the movable valve is enabled by the movable valve. Thus, the intermediate chamber may buffer fluid which can, during a subsequent downstroke, be conducted further upwardly into the annular fluid chambers. The intermediate chamber may be a single chamber openable or closable by a valve portion. The intermediate chamber may also comprise two or more separate but adjacent chamber portions openable or closable by different separate valve portions.

[0020] Still referring to the described embodiment, the movable valve may be further adapted so that when the flow of fluid originating from the fluid reservoir to the first annular fluid chamber is enabled by the movable valve, flow of fluid originating from the fluid reservoir to the intermediate chamber arranged below the movable valve is disabled by the movable valve. Thus, no further fluid will flow to the intermediate chamber from below when the intermediate chamber is at least partially emptied by enabling a fluid flow through the piston towards the annular fluid chambers. This allows for a continuous pumping of the fluid in an upwards direction.

[0021] The movable valve may comprise a first valve section and a second valve section. The first valve sec-

tion and the second valve section may both serve as a check valve. The movable valve may be selectively operable for disabling fluid flow through the first valve section and simultaneously enabling fluid flow through the second valve section. Alternatively, fluid flow through the first valve section may be enabled and simultaneously fluid flow through the second valve section may be disabled. By such a smart valve configuration it is possible with a single actuation of the movable valve to control the fluid flow at two (or more) different positions or ports at the same time.

[0022] The first valve section and the second valve section may be mutually movable relative to the piston and/or relative to a casing of the apparatus which may be arranged stationary in the bore hole. Therefore, a simple actuation action may be sufficient to simultaneously control (i.e. enable or disable) fluid flow in multiple different fluidic channels.

[0023] The movable valve may comprise one or more valve sections, for instance altogether three check valve sections. Each section may have a ball valve element or a tapering cone valve element. For instance, the different ball valve elements may be rigidly coupled to one another so that they can be operated simultaneously. For instance, a diameter of the valves may be different for the various valve sections. Also in the case of a tapering cone valve element, the different tapering cone valve elements may have a different size, for instance the size may be the larger the lower the corresponding tapering cone valve element is arranged within the bore hole.

[0024] In an embodiment, the piston may have a central bore (or an internal channel) having a basically T-shaped cross-section. In other words, a bifurcated fluid conduit may be formed within the piston body. The central bore (or internal channel) may provide for a fluid communication between fluid originating from the fluid reservoir (and being for instance accommodated temporarily in the intermediate chamber) and the first fluid chamber. However, this basically T-shaped bore in the piston may be selectively opened or closed by the movable valve. Therefore, a first operation state may allow to pump fluid originating from the bore hole to the annular chambers, and a second operation mode may allow to pump fluid directly from the reservoir to the intermediate chamber below the T-shaped bore hole.

[0025] The piston may have an upper part and a lower part. An abutting portion (or intermediate portion) between the upper part and the lower part may have a lateral contraction (or a recess) forming a locally reduced lateral extension delimiting the first annular fluid chamber. In other words, a dual piston geometry may allow for the formation of the inner annular volume thanks to the geometric configuration of the piston. For example, the upper part and the lower part of the piston may have identical or different lateral extensions which may however be larger than a lateral extension of the intermediate part in between.

[0026] The fluid communication recess may be formed

by a perforated wall. Therefore, a tubular wall may have one or more perforation openings for allowing for a fluid communication of the two adjacent annular volumes. This is a simple space-saving and efficient way of fluidly coupling the two annular (for instance hollow cylindrical) fluid chambers.

[0027] The second annular fluid chamber may extend up to a vertical position (i.e. in a direction towards a position above ground) which is located above a vertical position up to which the first annular fluid chamber extends. Due to the gravitation, such an arrangement enables a downward flow of fluid from the second annular chamber to the first annular chamber to promote the upwards motion of the piston. The back-flow of fluid from the outer fluid chamber to the inner fluid chamber during an upstroke may allow to use a U-tube effect in a concentric arrangement for reducing the energy required for reciprocating the piston.

[0028] The first annular fluid chamber and the second annular fluid chamber may be arranged concentrically. In other words, the hollow tubular fluid chambers may share the same symmetry axis. Such a highly symmetric concentric geometry allow for an efficient and circumferentially symmetric U-tube effect.

[0029] The first annular fluid chamber and the second annular fluid chamber may both be shaped as hollow cylindrical volumes. A hollow circular cylinder is defined by an inner radius, an outer radius, and a height. In an embodiment, the radii of the inner annular fluid chamber may be smaller than the radii of the outer annular fluid chamber, and the height of the inner annular fluid chamber may be smaller than the height of the outer annular fluid chamber.

[0030] The apparatus may comprise an annular (for instance circular) wall which includes the fluid communication recess and delimits the first fluid chamber together with the piston. Therefore, the annular first fluid chamber is formed by cooperation of the perforation comprising annular wall and the dual piston.

[0031] The piston may be mounted to sealingly reciprocate along (or relative) to the annular wall. Therefore, an undesired fluid flow along the annular wall, which would deteriorate the piston performance, can be safely prevented.

[0032] The valve may comprise multiple separate but jointly or cooperatively movable valve sections. Each of these valve sections may be adapted for enabling or disabling a fluid flow through a corresponding fluid port depending on a present position of the respective valve section. By cooperatively moving the various valve sections it is at the same time possible to close one fluid path and open another one. Therefore, a simple operation of the apparatus can be achieved. Different valve sections may have different cross-sectional areas. For instance, the cross-sectional area of a corresponding valve section may be the larger, the further away this valve section is spaced from the piston. In other words, the deeper a valve section is arranged in a bore hole, the larger is the diam-

eter of the corresponding valve section.

[0033] In an embodiment, the apparatus may be configured as a sucker rod pump. Such a sucker rod pump is particularly improved by an embodiment of the invention by the provision of two annular volumes one surrounding the other one. This may result in a U-tube effect contributing to the lifting of the piston during an upwards stroke. Also the geometric arrangement of the piston with a laterally constricted middle part and the internal fluid channel, in conjunction with the cooperatively operating valve contribute to a significant improvement of the sucker rod pump according to an embodiment of the invention as compared to conventional sucker rod pumps.

[0034] The aspects defined above and further aspects of the invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to these examples of embodiment.

[0035] The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Fig. 1 illustrates an apparatus for pumping a fluid from a fluid reservoir during a downwards stroke according to an exemplary embodiment of the invention.

Fig. 2 illustrates the apparatus of Fig. 1 during an upwards stroke.

[0036] The illustration in the drawing is schematically. In different drawings, similar or identical elements are provided with the same reference signs.

[0037] In the following, referring to Fig. 1 and Fig. 2, an apparatus 50 according to an exemplary embodiment of the invention for pumping a fluid such as oil or water from a fluid reservoir 30 such as a formation above ground will be explained. The apparatus 50 may comprise further elements, for instance above ground or closer to the ground than the shown elements. However, the person skilled in the art of fluid pumps will easily recognize that key features of exemplary embodiments of the invention can be clearly understood based on Fig. 1 and Fig. 2.

[0038] **Fig. 1** shows the apparatus 50 during a downwards stroke (i.e. during a motion of a piston 13, 14 in a direction pointing from earth's surface towards the fluid reservoir 30, or parallel to gravitation), as indicated by an arrow 60. An arrow 62 illustrates that **Fig. 2** shows the apparatus 50 in an operation mode in which an upwards stroke is performed, i.e. during a motion of the piston 13, 14 in a direction pointing from the fluid reservoir 30 towards the ground or earth's surface, or antiparallel to gravitation.

[0039] The piston 13, 14 sealingly reciprocates along annular wall 42. Hence, at a position denoted with reference numeral 44, the piston 13, 14 moves sealedly with respect to the surrounding wall 42. Although a small leakage may occur in this region, it can be considered as basically sealed. The piston 13, 14 is formed of a piston

bottom portion 14 and a piston top portion 13. This for instance integrally formed dual piston 13, 14 is adapted for reciprocating upwardly and downwardly for pumping the fluid. The reciprocable piston 13, 14 is accommodated within a hollow stationary casing 8 ("Fanghals") having an outlet port 9 through which fluid may flow upwardly, as shown in Fig. 2. A first annular fluid chamber 32 is partially delimited by a surface of a laterally constricted middle portion of the piston 13, 14, and is delimited partially by an opposing portion of side wall 42.

[0040] A second annular fluid chamber 34 laterally surrounds the first annular fluid chamber 32. Therefore, the annular fluid chambers 32 and 34 are arranged concentrically to one another and with respect to a vertical symmetry axis of the apparatus 50 (see dot and dash line 72). A second annular fluid chamber 34 laterally surrounds the first annular fluid chamber 32.

[0041] Furthermore, a fluid communication recess 6 in the form of a perforation of side wall 42 provides for a fluid communication between the first fluid chamber 32 and the second fluid chamber 34 so that fluid such as oil or water can flow from the first fluid chamber 32 to the second fluid chamber 34, or vice versa, depending on the actual pressure conditions.

[0042] A movable valve 5, 15, 19 is provided which is adapted to be operated so that when the flow of fluid originating from the fluid reservoir 30 to the first annular fluid chamber 32 via a bore 40 in the piston 13, 14 is disabled by an uppermost valve section 15, the piston 13, 14 moves upwardly and fluid flows from the second fluid chamber 34 into the first fluid chamber 32, as shown in Fig. 2 and indicated by arrow 46. The movable valve 5, 15, 19 is further adapted to be operable so that when the flow of fluid originating from the fluid reservoir 30 to the first annular fluid chamber 32 via the bore 40 in the piston 13, 14 is enabled by uppermost valve section 15, the piston 13, 14 moves downwardly and fluid flows from the first fluid chamber 32 into the second fluid chamber 34. This scenario is shown in Fig. 1 and is indicated by an arrow 49.

[0043] As further shown in Fig. 2, when the flow of fluid originating from the fluid reservoir 30 to the first annular fluid chamber 32 is disabled by the uppermost valve section 15, flow of fluid originating from the fluid reservoir 30 (i.e. from below of the apparatus 50) to an intermediate double-chamber 36, 38 arranged below the movable valve 5, 15 is enabled by a middle valve section 19 and a lowermost valve section 5 of the movable valve 5, 15 (see arrows 12).

[0044] In contrast to this, as shown in Fig. 1, when the flow of fluid originating from the fluid reservoir 30 to the first annular fluid chamber 32 is enabled by the uppermost valve section 15 (see arrow 74), flow of fluid originating from the fluid reservoir 30 to the intermediate double-chamber 36, 38 is disabled by valve sections 5, 19.

[0045] Fig. 1 and Fig. 2 show that the movable valve comprises altogether three sealing portions or valve portions 15, 5 and 19. In Fig. 1, valve section 15 is in an

open position, whereas valve sections 5, 19 are both in a closed position. In contrast to this, as a result of a mutual motion of the valve sections 15, 5, 19, the valve section 15 is closed and the valve sections 19, 5 are open in Fig. 2. In the shown embodiment, all valve sections 15, 5, 19 are arranged as ball valve elements cooperating with circular holes (not shown in the figure) in the various bottom walls or in a central bore (or an internal channel) 40 of the piston 13, 14. As mentioned above, the piston 13, 14 has a central bore (or internal channel) 40 having a T-shaped cross-section for providing a fluid communication between fluid originating from the fluid reservoir 30 and the fluid chamber 32. Depending on the present state of the valve section 15, this fluid communication is disabled (see Fig. 2) or enabled (see Fig. 1).

[0046] In another embodiment, each of the valve sections 15, 5, 19 may move separately (instead of the mutual motion).

[0047] As can be taken from Fig. 1 and Fig. 2, the second annular fluid chamber 34 extends up to a vertical position which is located above a vertical end position up to which the first annular fluid chamber 32 extends (in either operation mode of Fig. 1 and Fig. 2) so as to enable a downward back-flow of fluid from the second annular fluid chamber 34 to the first annular fluid chamber 32 to promote the upwards motion of the piston 13, 14, as can be taken from Fig. 2. Thus, the U-tube effect resulting from the spatial arrangement of the first annular fluid chamber 32 and the second annular fluid chamber 34 redirects fluid from the second annular fluid chamber 34 to the first annular fluid chamber 32 for promoting an upwards motion of the piston 13, 14 during the upwards stroke shown in Fig. 2. This allows for a low energy consumption when operating the apparatus 50.

[0048] Reference numeral 1 denotes a casing tube, i. e. an outer tube within the bore hole. Casing tube 1 also has perforations 6. An outer tube delimiting the second annular fluid chamber 34 is denoted with reference numeral 2. An inner tube delimiting the second annular fluid chamber 34 is denoted with reference numeral 3 and also comprises perforations 6. Reference numeral 4 denoted a bottom sealing. Pump is denoted with reference numeral 7. An upper sealing section is denoted with reference numeral 10. A further sealing section is denoted with reference numeral 11.

[0049] As denoted with the arrow 46 shown in Fig. 2, fluid from the second chamber 34 flows back to the chamber 32 due to a U-tube effect of communicating tubes 34, 32 to thereby exert a lifting force directed to an upper side to the piston 13, 14 for supporting the upstroke 62. The sucking effect exerted on the fluid in the reservoir 30 by the upwards stroke 62 in Fig. 2 is denoted with reference numeral 48.

[0050] It should be noted that the term "comprising" does not exclude other elements or features and the "a" or "an" does not exclude a plurality.

[0051] It should also be noted that reference signs in the claims shall not be construed as limiting the scope

of the claims.

Claims

1. An apparatus (50) for pumping a fluid from a fluid reservoir (30), the apparatus (50) comprising:

a piston (13, 14) adapted for reciprocating upwardly and downwardly for pumping the fluid;
a first annular fluid chamber (32) partially delimited by the piston (13, 14);
a second annular fluid chamber (34) laterally surrounding the first fluid chamber (32);
a fluid communication recess (6) adapted for providing a fluid communication between the first fluid chamber (32) and the second fluid chamber (34);
a movable valve (5, 15, 19);

characterized in that

the movable valve (5, 15, 19) is adapted so that when the flow of fluid originating from the fluid reservoir (30) to the first annular fluid chamber (32) is disabled by the movable valve (5, 15, 19) and the piston (13, 14) moves upwardly, fluid flows from the second fluid chamber (34) into the first fluid chamber (32) to cause a U-Tube effect,

wherein, due to the U-tube effect, fluid accommodated in the second fluid chamber (34) flows back to the first annular fluid chamber (32) to thereby contribute to the lifting of the piston during an upstroke;

and

when the flow of fluid originating from the fluid reservoir (30) to the first annular fluid chamber (32) is enabled by the movable valve (5, 15, 19) and the piston (13, 14) moves downwardly, fluid flows from the first fluid chamber (32) into the second fluid chamber (34).

2. The apparatus of claim 1, wherein the movable valve (5, 15, 19) is adapted so that when the flow of fluid originating from the fluid reservoir (30) to the first annular fluid chamber (32) is disabled by the movable valve (5, 15, 19), flow of fluid originating from the fluid reservoir (30) to an intermediate chamber (36, 38) arranged below the movable valve (5, 15, 19) is enabled by the movable valve (5, 15, 19).
3. The apparatus of claim 1 or 2, wherein the movable valve (5, 15, 19) is adapted so that when the flow of fluid originating from the fluid reservoir (30) to the first annular fluid chamber (32) is enabled by the movable valve (5, 15, 19), flow of fluid originating from the fluid reservoir (30) to an intermediate chamber (36, 38) arranged below the movable valve (5, 15, 19) is disabled by the movable valve (5, 15, 19).

4. The apparatus of any one of claims 1 to 3, wherein the movable valve (5, 15, 19) comprises a first valve section (15) and a second valve section (5, 19) and is selectively operable for disabling fluid flow through the first valve section (15) and simultaneously enabling fluid flow through the second valve section (5, 19), or for enabling fluid flow through the first valve section (15) and simultaneously disabling fluid flow through the second valve section (5, 19) wherein in particular the first valve section (15) and the second valve section (5, 19) are mutually movable relative to the piston (13, 14).
5. The apparatus of any one of claims 1 to 4, wherein the movable valve (5, 15, 19) comprises at least one or more valve sections (5, 15, 19) each of which having one of the group consisting of a ball valve element (5, 15, 19) and a tapering cone valve element, and/or wherein the piston (13, 14) has an internal channel (40) having a T-shaped cross-section, the internal channel (40) providing for a fluid communication between fluid originating from the fluid reservoir (30) and the first fluid chamber (32), wherein in particular at least a part of the movable valve (5, 15, 19) is adapted for selectively enabling or disabling fluid flow through the internal channel (40).
6. The apparatus of any one of claims 1 to 5, wherein the piston (13, 14) has an upper part (13) and a lower part (14), wherein an intermediate portion between the upper part (13) and the lower part (14) has a lateral contraction forming a locally reduced lateral extension delimiting the first annular fluid chamber (32), and/or wherein the fluid communication recess (6) is formed by a perforated wall between the first fluid chamber (32) and the second fluid chamber (34).
7. The apparatus of any one of claims 1 to 6, wherein the second annular fluid chamber (34) extends up to a vertical position which is located above a vertical position up to which the first annular fluid chamber (32) extends so as to enable a downward back-flow of fluid from the second annular fluid chamber (34) to the first annular fluid chamber (32) to promote the upwards motion of the piston (13, 14).
8. The apparatus of any one of claims 1 to 7, wherein the first annular fluid chamber (32) and the second annular fluid chamber (34) are arranged concentrically.
9. The apparatus of any one of claims 1 to 8, comprising an annular wall (42) which includes the fluid communication recess (6) and delimits, together with the piston (13, 14), the first fluid chamber (32), wherein in particular the piston (13, 14) is adapted for sealingly reciprocating along to the annular wall (42).
10. The apparatus of any one of claims 1 to 9, wherein the valve (5, 15, 19) comprises a plurality of, particularly three, separate but jointly movable valve sections (5, 15, 19) each of which being adapted for enabling or disabling a fluid flow through a corresponding fluid port depending on a current position of the respective valve section (5, 15, 19).
11. The apparatus of claim 10, wherein different valve sections (5, 15, 19) have different cross-sectional areas.
12. The apparatus of claim 11, wherein the cross-sectional area of a respective valve section (5, 15, 19) is the larger the further away this valve section (5, 15, 19) is spaced from the piston (13, 14).
13. The apparatus of any one of claims 1 to 12, wherein the reciprocating piston (13, 14) is accommodated within a hollow stationary casing (8).
14. The apparatus of any one of claims 1 to 13, configured as a sucker rod pump.
15. A method of pumping a fluid from a fluid reservoir (30), the method comprising:
 - reciprocating a piston (13, 14) upwardly and downwardly for pumping the fluid via a first annular fluid chamber (32) partially delimited by the piston (13, 14) and via a second annular fluid chamber (34) laterally surrounding the first fluid chamber (32);
 - providing a fluid communication between the first fluid chamber (32) and the second fluid chamber (34);
 - moving a valve (5, 15, 19) so that
 - when the flow of fluid originating from the fluid reservoir (30) to the first annular fluid chamber (32) is disabled by the valve (5, 15, 19) and the piston (13, 14) moves upwardly, fluid flows from the second fluid chamber (34) into the first fluid chamber (32) to cause a U-Tube effect, wherein due to the U-tube effect, fluid accommodated in the second fluid chamber (34) flows back to the first annular fluid chamber (32) to thereby contribute to the lifting of the piston during an up-stroke; and
 - when the flow of fluid originating from the fluid reservoir (30) to the first annular fluid chamber (32) is enabled by the valve (5, 15, 19) and the piston (13, 14) moves downwardly, fluid flows from the first fluid chamber (32) into the second fluid chamber (34).

Patentansprüche

1. Eine Vorrichtung (50) zum Pumpen eines Fluides von einem Fluidreservoir (30), die Vorrichtung (50) aufweisend:

einen Kolben (13, 14) geeignet zum aufwärts und abwärts Hin- und Herbewegen zum Pumpen des Fluides;
eine erste ringförmige Fluidkammer (32), welche teilweise mittels des Kolbens (13, 14) begrenzt ist;
eine zweite ringförmige Fluidkammer (34), welche die erste Fluidkammer (32) lateral umgibt;
eine Fluid Kommunikation Ausnehmung (6) geeignet zum Bereitstellen einer Fluidkommunikation zwischen der ersten Fluidkammer (32) und der zweiten Fluidkammer (34);
ein bewegliches Ventil (5, 15, 19);

dadurch gekennzeichnet, dass
das bewegliche Ventil (5, 15 19) geeignet ist, so dass,

wenn der Fluss des Fluides, welches von dem Fluidreservoir (30) her stammt, zu der ersten ringförmigen Fluidkammer (32), mittels des beweglichen Ventils (5, 15, 19) gesperrt wird und sich der Kolben (13, 14) aufwärts bewegt, Fluid von der zweiten Fluidkammer (34) in die erste Fluidkammer (32) fließt, um einen U-Rohr Effekt zu verursachen,

wobei, aufgrund des U-Rohr Effektes, Fluid, welches in der zweiten Fluidkammer (34) untergebracht ist, zurück zu der ersten ringförmigen Fluidkammer (32) fließt, um dadurch zu dem Heben des Kolbens während eines Hubes beizutragen; und

wenn der Fluss des Fluides, welches von dem Fluidreservoir (30) her stammt, zu der ersten ringförmigen Fluidkammer (32), mittels des beweglichen Ventils (5, 15, 19) ermöglicht wird und sich der Kolben (13, 14) abwärts bewegt, Fluid von der ersten Fluidkammer (32) in die zweite Fluidkammer (34) fließt.

2. Die Vorrichtung gemäß Anspruch 1, wobei das bewegliche Ventil (5, 15, 19) geeignet ist, so dass, wenn der Fluss des Fluides, welches von dem Fluidreservoir (30) her stammt, zu der ersten ringförmigen Fluidkammer (32), mittels des beweglichen Ventils (5, 15, 19) gesperrt wird, Fluss des Fluides, welches von dem Fluidreservoir (30) her stammt, zu einer Zwischenkammer (36, 38), welche unterhalb des beweglichen Ventils (5, 15, 19) angeordnet ist, mittels des beweglichen Ventils (5, 15, 19) ermöglicht wird.
3. Die Vorrichtung gemäß Anspruch 1 oder 2, wobei das bewegliche Ventil (5, 15, 19) geeignet ist,

so dass, wenn der Fluss des Fluides, welches von dem Fluidreservoir (30) her stammt, zu der ersten ringförmigen Fluidkammer (32), mittels des beweglichen Ventils (5, 15, 19) ermöglicht wird, Fluss des Fluides, welches von dem Fluidreservoir (30) her stammt, zu einer Zwischenkammer (36, 38), welche unterhalb des beweglichen Ventils (5, 15, 19) angeordnet ist, mittels des beweglichen Ventils (5, 15, 19) gesperrt wird.

4. Die Vorrichtung gemäß einem der Ansprüche 1 bis 3, wobei das bewegliche Ventil (5, 15, 19) aufweist einen ersten Ventilabschnitt (15) und einen zweiten Ventilabschnitt (5, 19) und selektiv betriebsbereit ist zum Sperren des Fluidflusses durch den ersten Ventilabschnitt (15) und gleichzeitig zum Ermöglichen des Fluidflusses durch den zweiten Ventilabschnitt (5, 19), oder zum Ermöglichen des Fluidflusses durch den ersten Ventilabschnitt (15) und gleichzeitig zum Sperren des Fluidflusses durch den zweiten Ventilabschnitt (5, 19), wobei insbesondere der erste Ventilabschnitt (15) und der zweite Ventilabschnitt (5, 19) gemeinsam beweglich relativ zu dem Kolben (13, 14) sind.

5. Die Vorrichtung gemäß einem der Ansprüche 1 bis 4, wobei das bewegliche Ventil (5, 15, 19) aufweist zumindest einen oder mehrere Ventilabschnitte (5, 15, 19), wobei von denen jeder eines der Gruppe hat, bestehend aus einem Ball Ventilelement (5, 15, 19) und einem verjüngendem Kegel Ventilelement, und /oder wobei der Kolben (13, 14) einen internen Kanal (40) hat, welcher einen T-förmigen Querschnitt hat, wobei der interne Kanal (40) eine Fluidkommunikation zwischen dem Fluid, welches von dem Fluidreservoir (30) her stammt, und der ersten Fluidkammer (32), bereitstellt, wobei insbesondere zumindest ein Teil des beweglichen Ventils (5, 15, 19) zum selektiven Ermöglichen oder Sperren des Fluidflusses durch den internen Kanal (40) geeignet ist.

6. Die Vorrichtung gemäß einem der Ansprüche 1 bis 5, wobei der Kolben (13, 14) einen oberen Teil (13) und einen unteren Teil (14) hat, wobei ein Zwischenteil zwischen dem oberen Teil (13) und dem unteren Teil (14) eine laterale Verengung hat, welche eine lokal reduzierte laterale Erstreckung formt, welche die erste ringförmige Fluidkammer (32) begrenzt, und /oder wobei die Fluid Kommunikation Ausnehmung (6) mittels einer perforierten Wand zwischen der ersten Fluidkammer (32) und der zweiten Fluidkammer (34) geformt ist.

7. Die Vorrichtung gemäß einem der Ansprüche 1 bis 6,

wobei sich die zweite ringförmige Fluidkammer (34) bis zu einer vertikalen Position erstreckt, welche oberhalb einer vertikalen Position lokalisiert ist, bis zu welcher sich die erste ringförmige Fluidkammer (32) erstreckt, um so einen absteigenden Rückfluss des Fluides von der zweiten ringförmigen Fluidkammer (34) zu der ersten ringförmigen Fluidkammer (32) zu ermöglichen, um die Aufwärtsbewegung des Kolbens (13, 14) zu fördern.

8. Die Vorrichtung gemäß einem der Ansprüche 1 bis 7, wobei die erste ringförmige Fluidkammer (32) und die zweite ringförmige Fluidkammer (34) konzentrisch angeordnet sind.

9. Die Vorrichtung gemäß einem der Ansprüche 1 bis 8, aufweisend eine ringförmige Wand (42), welche die Fluid Kommunikation Ausnehmung (6) enthält, und zusammen mit dem Kolben (13, 14) die erste Fluidkammer (32) begrenzt, wobei insbesondere der Kolben (13, 14) zum abdichtenden Hin und Herbewegen entlang der ringförmigen Wand (42) geeignet ist.

10. Die Vorrichtung gemäß einem der Ansprüche 1 bis 9, wobei das Ventil (5, 15, 19) aufweist eine Mehrzahl von, insbesondere drei, separaten aber gemeinsam beweglichen Ventilabschnitten (5, 15, 19), wobei von denen jeder zum Ermöglichen oder Sperren eines Fluidflusses durch einen korrespondierenden Fluid Port geeignet ist in Abhängigkeit von einer aktuellen Position des jeweiligen Ventilabschnitts (5, 15, 19).

11. Die Vorrichtung gemäß Anspruch 10, wobei verschiedene Ventilabschnitte (5, 15, 19) verschiedene Querschnittsbereiche haben.

12. Die Vorrichtung gemäß Anspruch 11, wobei die Querschnittsbereiche eines entsprechenden Ventilabschnitts (5, 15, 19) umso größer sind umso weiter weg dieser Ventilabschnitt (5, 15, 19) von dem Kolben (13, 14) beabstandet ist.

13. Die Vorrichtung gemäß einem der Ansprüche 1 bis 12, wobei der hin und herbewegende Kolben (13, 14) innerhalb eines hohlen stationären Gehäuses (8) untergebracht ist.

14. Die Vorrichtung gemäß einem der Ansprüche 1 bis 13, welche als eine Pferdekopfpumpe konfiguriert ist.

15. Ein Verfahren zum Pumpen eines Fluides von einem Fluidreservoir (30), das Verfahren aufweisend:

Hin- und Herbewegen eines Kolbens (13, 14) aufwärts und abwärts zum Pumpen des Fluides

via einer ersten ringförmigen Fluidkammer (32), welche teilweise mittels des Kolbens (13, 14) begrenzt wird und via einer zweiten ringförmigen Fluidkammer (34), welche die erste Fluidkammer (32) lateral umgibt;

Bereitstellen einer Fluidkommunikation zwischen der ersten Fluidkammer (32) und der zweiten Fluidkammer (34);

Bewegen eines Ventils (5, 15, 19), so dass, wenn der Fluss des Fluides, welches von dem Fluidreservoir (30) her stammt, zu der ersten ringförmigen Fluidkammer (32), mittels des Ventils (5, 15, 19) begrenzt wird und sich der Kolben (13, 14) abwärts bewegt, Fluid von der zweiten Fluidkammer (34) in die erste Fluidkammer (32) fließt, um einen U-Rohr Effekt zu verursachen,

wobei, aufgrund des U-Rohr Effektes, Fluid, welches in der zweiten Fluidkammer (34) untergebracht ist, zurück zu der ersten ringförmigen Fluidkammer (32) fließt, um dadurch zu dem Heben des Kolbens während eines Hubes beizutragen, und

wenn der Fluss des Fluides, welches von dem Fluidreservoir (30) her stammt, zu der ersten ringförmigen Fluidkammer (32), mittels des Ventils (5, 15, 19) ermöglicht wird und sich der Kolben (13, 14) abwärts bewegt, Fluid von der ersten Fluidkammer (32) in die zweite Fluidkammer (34) fließt.

Revendications

1. Appareil (50) pour pomper un fluide à partir d'un réservoir de fluide (30), l'appareil (50) comprenant :

un piston (13, 14) adapté pour se déplacer en va-et-vient vers le haut et vers le bas pour pomper le fluide ;

une première chambre de fluide annulaire (32) partiellement délimitée par le piston (13, 14) ;

une seconde chambre de fluide annulaire (34) entourant latéralement la première chambre de fluide (32) ;

un évidement de communication fluidique (6) adapté pour fournir une communication fluidique entre la première chambre de fluide (32) et la seconde chambre de fluide (34) ;

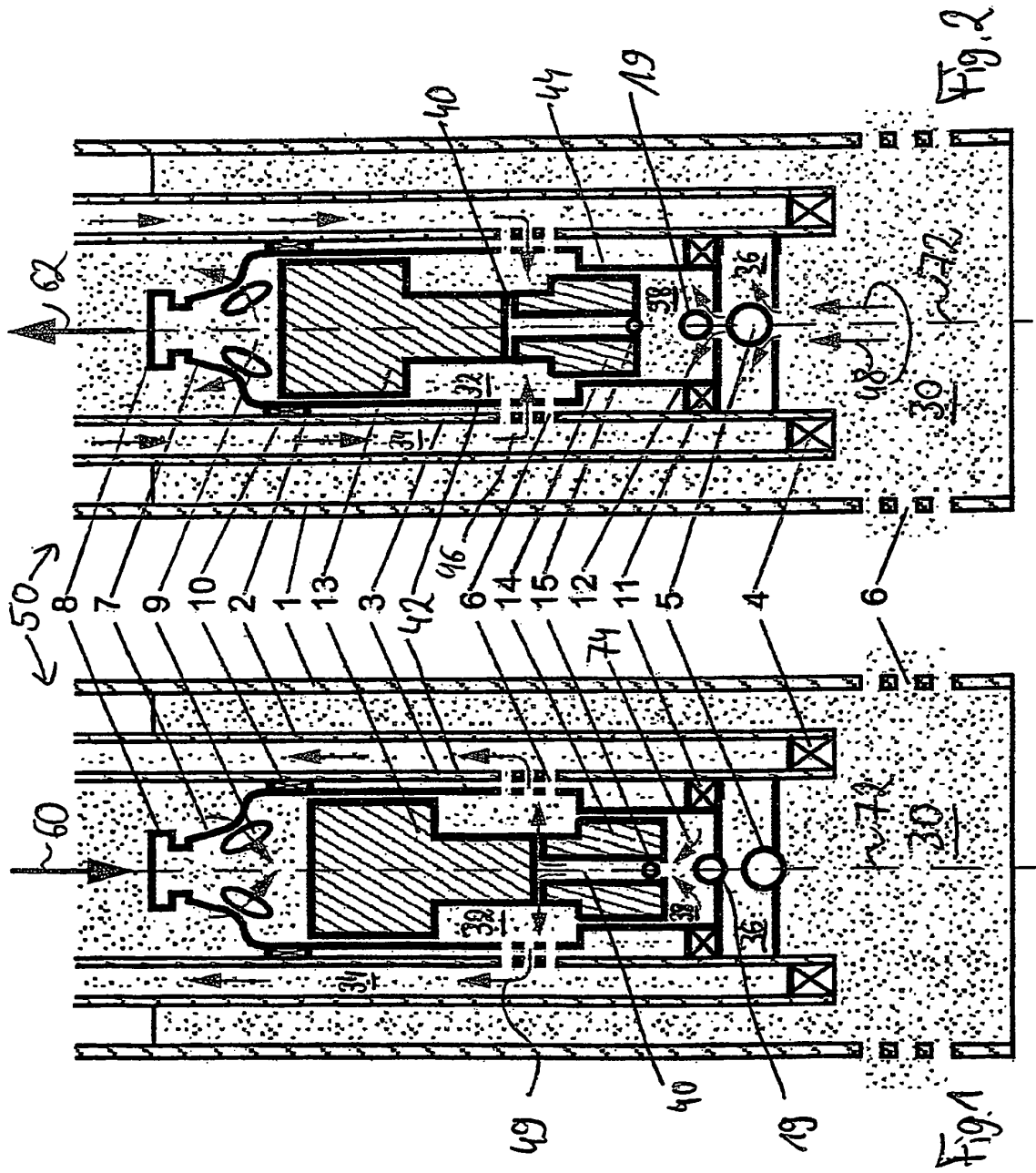
une valve mobile (5, 15, 19) ;

caractérisé en ce que

la valve mobile (5, 15, 19) est adaptée pour que, lorsque l'écoulement de fluide, provenant du réservoir de fluide (30), vers la première chambre de fluide annulaire (32) est empêché par la valve mobile (5, 15, 19) et le piston (13, 14) se déplace vers le haut, le fluide s'écoule à partir de la seconde chambre de fluide (34) dans la première

- chambre de fluide (32) pour entraîner un effet de tube en U,
 dans lequel, en raison de l'effet de tube en U, le fluide logé dans la seconde chambre de fluide (34) s'écoule en retour vers la première chambre de fluide annulaire (32) pour ainsi contribuer au levage du piston durant une course ascendante ; et
 lorsque l'écoulement de fluide provenant du réservoir de fluide (30) vers la première chambre de fluide annulaire (32) est permis par la valve mobile (5, 15, 19) et le piston (13, 14) se déplace vers le bas, le fluide s'écoule à partir de la première chambre de fluide (32) dans la seconde chambre de fluide (34).
2. Appareil de la revendication 1, dans lequel la valve mobile (5, 15, 19) est adaptée pour que, lorsque l'écoulement de fluide provenant du réservoir de fluide (30) vers la première chambre de fluide annulaire (32) est empêché par la valve mobile (5, 15, 19), un écoulement de fluide provenant du réservoir de fluide (30) vers une chambre intermédiaire (36, 38) agencée en dessous de la valve mobile (5, 15, 19) soit permis par la valve mobile (5, 15, 19).
 3. Appareil de la revendication 1 ou 2, dans lequel la valve mobile (5, 15, 19) est adaptée pour que, lorsque l'écoulement de fluide provenant du réservoir de fluide (30) vers la première chambre de fluide annulaire (32) est permis par la valve mobile (5, 15, 19), un écoulement de fluide provenant du réservoir de fluide (30) vers une chambre intermédiaire (36, 38) agencée en dessous de la valve mobile (5, 15, 19) soit empêché par la valve mobile (5, 15, 19).
 4. Appareil selon l'une quelconque des revendications 1 à 3, dans lequel la valve mobile (5, 15, 19) comprend une première section de valve (15) et une seconde section de valve (5, 19) et est sélectivement utilisable pour empêcher un écoulement de fluide à travers la première section de valve (15) et simultanément permettre un écoulement de fluide à travers la seconde section de valve (5, 19), ou pour permettre un écoulement de fluide à travers la première section de valve (15) et simultanément empêcher un écoulement de fluide à travers la seconde section de valve (5, 19) dans lequel en particulier la première section de valve (15) et la seconde section de valve (5, 19) sont mutuellement mobiles par rapport au piston (13, 14).
 5. Appareil selon l'une quelconque des revendications 1 à 4, dans lequel la valve mobile (5, 15, 19) comprend au moins une ou plusieurs sections de soupape (5, 15, 19) dont chacune comporte un parmi le groupe constitué d'un élément de valve à bille (5, 15, 19) et d'un élément de valve tronconique, et/ou dans lequel le piston (13, 14) comporte un canal interne (40) présentant une section transversale en forme de T, le canal interne (40) permettant une communication fluidique entre le fluide provenant du réservoir de fluide (30) et la première chambre de fluide (32), dans lequel en particulier au moins une partie de la valve mobile (5, 15, 19) est adaptée pour sélectivement permettre ou empêcher un écoulement de fluide à travers le canal interne (40).
 6. Appareil selon l'une quelconque des revendications 1 à 5, dans lequel le piston (13, 14) comporte une partie supérieure (13) et une partie inférieure (14), dans lequel une partie intermédiaire entre la partie supérieure (13) et la partie inférieure (14) comporte une contraction latérale formant une extension latérale localement réduite délimitant la première chambre de fluide annulaire (32), et/ou dans lequel l'évidement de communication fluidique (6) est formé par une paroi perforée entre la première chambre de fluide (32) et la seconde chambre de fluide (34).
 7. Appareil selon l'une quelconque des revendications 1 à 6, dans lequel la seconde chambre de fluide annulaire (34) s'étend jusqu'à une position verticale qui est située au-dessus d'une position verticale jusqu'à laquelle la première chambre de fluide annulaire (32) s'étend afin de permettre un écoulement de retour descendant de fluide de la seconde chambre de fluide annulaire (34) à la première chambre de fluide annulaire (32) pour favoriser le mouvement ascendant du piston (13, 14).
 8. Appareil selon l'une quelconque des revendications 1 à 7, dans lequel la première chambre de fluide annulaire (32) et la seconde chambre de fluide annulaire (34) sont agencées de façon concentrique.
 9. Appareil selon l'une quelconque des revendications 1 à 8, comprenant une paroi annulaire (42) qui comprend l'évidement de communication fluidique (6) et délimite, conjointement avec le piston (13, 14), la première chambre de fluide (32), dans lequel, en particulier, le piston (13, 14) est adapté pour se déplacer en va-et-vient de façon étanche le long de la paroi annulaire (42).
 10. Appareil selon l'une quelconque des revendications 1 à 9, dans lequel la valve (5, 15, 19) comprend une pluralité de, particulièrement trois, sections de valve mobile séparées mais conjointes (5, 15, 19) dont chacune est adaptée pour permettre ou empêcher un écoulement de fluide à travers un orifice de fluide correspondant en fonction d'une position actuelle de la section de valve respective (5, 15, 19).

11. Appareil de la revendication 10, dans lequel différentes sections de soupape (5, 15, 19) possèdent des surfaces de section transversale différentes.
12. Appareil de la revendication 11, dans lequel plus la surface de section transversale d'une section de valve respective (5, 15, 19) est grande, plus cette section de valve (5, 15, 19) est espacée du piston (13, 14). 5
13. Appareil selon l'une quelconque des revendications 1 à 12, dans lequel le piston se déplaçant en va-et-vient (13, 14) est logé à l'intérieur d'une cage stationnaire creuse (8). 10
14. Appareil selon l'une quelconque des revendications 1 à 13, configuré sous forme de pompe de fond à tige. 15
15. Procédé de pompage d'un fluide à partir d'un réservoir de fluide (30), le procédé comprenant : 20
- le déplacement en va-et-vient d'un piston (13, 14) vers le haut et vers le bas pour pomper le fluide par l'intermédiaire d'une première chambre de fluide annulaire (32) partiellement délimitée par le piston (13, 14) et par l'intermédiaire d'une seconde chambre de fluide annulaire (34) entourant latéralement la première chambre de fluide (32) ; 25
- la fourniture d'une communication fluidique entre la première chambre de fluide (32) et la seconde chambre de fluide (34) ; 30
- le déplacement d'une valve (5, 15, 19) pour que, lorsque l'écoulement de fluide provenant du réservoir de fluide (30) vers la première chambre de fluide annulaire (32) est empêché par la valve (5, 15, 19) et le piston (13, 14) se déplace vers le haut, le fluide s'écoule à partir de la seconde chambre de fluide (34) dans la première chambre de fluide (32) pour entraîner un effet de tube en U, dans lequel, en raison de l'effet de tube en U, le fluide logé dans la seconde chambre de fluide (34) s'écoule en retour vers la première chambre de fluide annulaire (32) pour ainsi contribuer au levage du piston durant une course ascendante ; et 35
- lorsque l'écoulement de fluide provenant du réservoir de fluide (30) vers la première chambre de fluide annulaire (32) est permis par la valve (5, 15, 19) et le piston (13, 14) se déplace vers le bas, le fluide s'écoule à partir de la première chambre de fluide (32) dans la seconde chambre de fluide (34). 40
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REFERENCES CITED IN THE DESCRIPTION

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