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(71) Applicant(s)
Weir Minerals Netherlands B.V.

(72) Inventor(s)
Wilmsen, Arnoldus Gertrudis Hendrikus; Keijers, Ronald Godefridus Anna

(74) Agent / Attorney
Adams Pluck, PO Box 905, HORNSBY, NSW, 2077, AU

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- (71) **Applicant:** WEIR MINERALS NETHERLANDS B.V.
[NL/NL]; Egtenrayseweg 9, 5928 PH Venlo (NL).
- (72) **Inventors:** WILMSEN, Arnoldus Gertrudis Hendrikus;
c/o Weir Minerals Netherlands B.V., Egtenrayseweg 9,
5928 PH Venlo (NL). KEIJERS, Ronald Godefridus
Anna; c/o Weir Minerals Netherlands B.V., Egten-
rayseweg 9, 5928 PH Venlo (NL).
- (74) **Agent:** ALGEMEEN OCTROOI- EN MERKENBUR-
EAU B.V.; P.O. Box 645, 5600 AP Eindhoven (NL).
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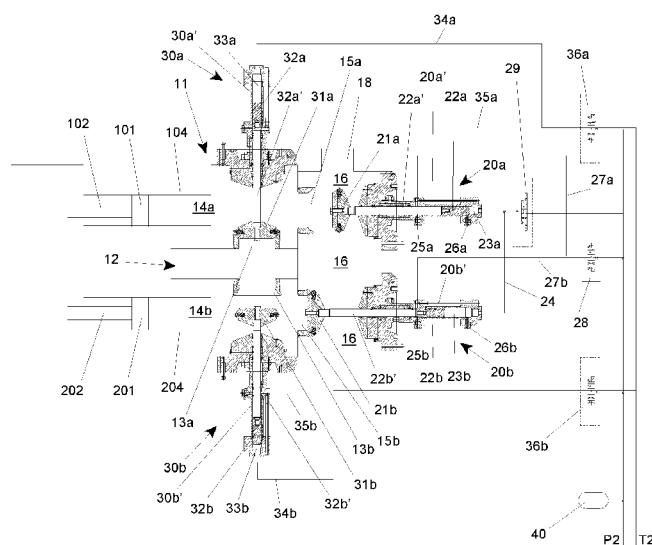
(54) **Title:** HYDRAULIC PUMP SYSTEM FOR HANDLING A SLURRY MEDIUM

Fig. 2a

(57) **Abstract:** This disclosure relates to a hydraulic pump system for handling a slurry medium at least comprising at least two reciprocating positive displacement pumps, both pumps being arranged for alternating intake of slurry medium via a suction inlet and discharge of slurry medium via a discharge outlet, and piston/cylinder discharge valves for alternating closing and opening each discharge outlet. In a first aspect, embodiments are disclosed of a hydraulic pump system for handling a slurry medium, comprising at least two reciprocating positive displacement pumps, both pumps being arranged for alternating intake of slurry medium via a suction inlet and discharge of slurry medium via a discharge outlet, and piston/cylinder discharge valves for alternating closing and opening each discharge outlet, as well as control means for controlling the alternate closing and opening of both piston/cylinder discharge valves, such that during operation no volume difference occurs in the discharge of slurry medium. In another aspect of the hydraulic pump system said control means comprise a lever assembly interconnecting the pistons of both piston/cylinder driven valves.

HYDRAULIC PUMP SYSTEM FOR HANDLING A SLURRY MEDIUM

BACKGROUND ART

5 This disclosure relates to an hydraulic pump system for handling a slurry medium at least comprising at least two reciprocating positive displacement pumps, both pumps being arranged for alternating intake of slurry medium via a suction inlet and discharge of slurry medium via a discharge outlet, and piston/cylinder discharge valves for alternating closing and opening each discharge outlet.

10 In reciprocating positive displacement pumps, a displacement element, such as a piston or plunger, undergoes a reciprocating motion inside a cylinder housing enabling the positive displacement the slurry medium to be handled (displaced or pumped). In a particular embodiment of the reciprocating pump, the reciprocating motion of the displacement element is generated by a mechanism which transfers the rotating
15 motion of the pump drive mechanism into a reciprocating motion of the displacement element. Particular embodiments of this mechanism may include crankshaft, excentric shaft, camshaft or cam disc mechanisms, for example as disclosed in Figure 1 of WO2011/126367.

20 Such reciprocating positive displacement pumps are used for pumping slurry media against relatively high pressure, when compared to single stage centrifugal pumps, for example. Further characteristics of such positive displacement pumps include high efficiency and an accurate flow output, but a relatively low flow capacity when compared to centrifugal pumps. When the flow requirements of a typical application cannot be met with a single pump, multiple positive displacement pumps can be arranged
25 in parallel in a manner so that their suction inlets and/or discharge outlets are connected and combined into a single suction and/or discharge line. This means that the sum flow of the individual pumps can meet the total flow requirements of the application. The combination of the individual displacement pumps and the interconnecting suction and discharge lines forms a pumping system.

30 In the aforementioned prior art publication WO2011/126367, a phase shift control system is disclosed for a pump system comprised of multiple reciprocating positive displacement pumps, wherein the speed of the individual pumps is controlled such that a desired phase shift between the pump cycles of the individual pumps is obtained and maintained. Each discharge outlet of the individual pumps is provided with a discharge
35 valve, which is to be opened and closed at the right time during the individual pump

cycles of the individual pumps. To create a nearly pulsation-free flow in the discharge outlet, apart from a proper phase shift control of the displacement pumps, the discharge valves also are closed and opened in a controlled manner, preferably such that the pressure across the discharge valve is zero.

To make sure that the pressure across the discharge valve is zero, a pre-compression stroke is performed prior to the opening of the respective discharge valve. Pressure fluctuations in the discharge flow of the displaced slurry medium results in variable consistency during further processing and hence adversely affects the product quality of the slurry medium.

Furthermore, the displacement of the valve rods of the respective discharge valves, which are operated independently of each other, create a small change in the flow and therewith a fluctuation in the pressure in the outlet.

SUMMARY OF THE DISCLOSURE

In a first aspect, embodiments are disclosed of an hydraulic pump system for handling a slurry medium, the pump system comprising:

at least two reciprocating positive displacement pumps, both pumps being arranged for alternating intake of slurry medium via a central suction inlet and discharge of slurry medium via a central discharge outlet; and the at least two reciprocating positive displacement pumps providing individual discharge outlets and

the pump system further comprising

discharge valves for alternating closing and opening each individual discharge outlet, wherein the individual discharge outlets communicate in a combined discharge chamber and further with the central discharge outlet, and wherein each discharge valve is driven by a piston and cylinder, with each discharge valve being mounted to a piston rod and a piston element respectively which are moveably accommodated within a cylinder chamber of a valve housing respectively,

characterised in that the hydraulic pump system comprises control means for controlling the alternate closing and opening of the discharge valves, wherein the control means are configured to interconnect the discharge valves, such that during operation of the hydraulic pump system, the control means are arranged for simultaneous closing and opening of the discharge valves, such that no volume difference occurs in the discharge of slurry medium. In another aspect of the hydraulic pump system said control means comprise a lever assembly interconnecting the pistons of the discharge valves.

In particular said lever assembly comprises a lever having two ends, each end being hingedly connected with the piston of one of the discharge valves.

In another aspect said discharge valves are hydraulic driven discharge valves and wherein said control means comprise a hydraulic line interconnecting both
5 cylinders of said hydraulic discharge valves.

In one embodiment, the hydraulic line can interconnect both cylinders at the piston side thereof, whereas in another embodiment said hydraulic line interconnects both cylinders at the cylinder side thereof. This means that no volume difference will occur during the closing and opening strokes of both discharge valves as the displaced
10 hydraulic volume during opening of a discharge valve is added via the interconnecting hydraulic line to other discharge valve during closing. Since no volume fluctuations in the discharge flow of the displaced slurry medium will occur, this results in a product (the displaced slurry medium) with the same consistency and hence product quality.

In one embodiment, each hydraulic driven discharge valve can comprise a
15 first sensor for sensing the position of the piston in the closed position of the discharge valve as well as a second sensor for sensing the position of the piston in the open position of the discharge valve. Thus the opposite extreme positions of the pistons of both discharge valves are electronically monitored, as the assistance of these proximity switches guarantee a synchronized movement of both pistons. In addition, no change in
20 combined volume on the discharge side will occur.

Due to this synchronization the opening of one discharge valve will automatically result in the closing of the other discharge valve and hence no undesired fluctuation in the flow through the discharge outlet will occur.

In one embodiment, the system may further comprise an hydraulic refill
25 means for adding hydraulic medium to a hydraulic driven discharge valve based on signals generated by the first sensor of a discharge valve and the second sensor of the other discharge valve such that the combined hydraulic volume of both pistons chambers and the interconnecting hydraulic line is always so that the pistons will reach their extreme position during operation of the pump system. In such an arrangement, the opening of
30 one discharge valve will automatically result in the closing of the other discharge valve and unwanted fluctuation in the discharge flow is avoided.

In one embodiment, the pump system can further comprise one or more hydraulic driven suction valves for alternating closing and opening each suction inlet.

In one embodiment, the pump system can further comprise a pump
35 housing having a central inlet interconnecting both suction inlets as well as a central outlet

interconnecting both discharge outlets.

In one embodiment, said pump housing can comprise two pump chambers, each pump chamber being interconnected with one of said reciprocating positive displacement pumps, and each pump chamber being provided with a suction inlet and a discharge outlet. This provides a simple but effective construction of the pump system with limited dimensions is obtained, which is beneficial in case of installation and maintenance.

Other aspects, features, and advantages will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, which are a part of this disclosure and which illustrate, by way of example, principles of inventions disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings facilitate an understanding of the various embodiments:

Figure 1 is a first partial view of an embodiment of a pump system in accordance with the present disclosure;

Figure 2a a second partial view of an embodiment of a pump system in accordance with the present disclosure;

Figure 2b a partial view of another embodiment of a pump system in accordance with the present disclosure;

Figure 2c a partial view of yet another embodiment of a pump system in accordance with the present disclosure; and

Figure 3 a pump characteristic of an embodiment of a pump system in accordance with the present disclosure.

DETAILED DESCRIPTION

Figure 1 and Figure 2a combined disclose a non-limitative embodiment of an hydraulic pump system. The hydraulic pump system is denoted with reference numeral 10 and consists of at least two reciprocating positive displacement pumps 100 and 200 which are connected to a pump housing 11. Each of the reciprocating positive displacement pumps 100 and 200 consist of a pump structure in which a displacement element 101 (201), shaped as a piston, is movable accommodated in a cylinder housing

104 (204). The displacement element 101 (201) is connected via a piston rod 102 (202), which is displaced in a reciprocating manner using a pump drive mechanism 103 (203), not shown.

Such a reciprocating positive displacement pump is capable of pumping or
5 handling a slurry medium against relatively high pressure when compared to other types of pumps, such as centrifugal pumps. In particular, a positive displacement pump (as denoted with reference numeral 100 in Figure 1) can operate at a high pressure level and generate an accurate flow output of the slurry medium to be displaced, albeit with a relatively low flow capacity. For increasing the flow capacity of the slurry medium to be
10 displaced, multiple reciprocating positive displacement pumps (in Figure 1 two of such pumps 100, 200 are shown) are used in a parallel manner as depicted in Figure 1 and their combined pump characteristic is used for obtaining the required and necessary increased discharge flow of the slurry medium.

The pump drive mechanism 103 (203) are driven in such a manner that the
15 displacement elements 101 (201) are moving in a reciprocating manner, but also in an 'out-of-phase' manner. This means that one positive displacement pump performs its discharge stroke, whereas the other positive displacement pump performs its suction stroke. The alternating suction and discharge strokes of the two positive displacement pumps results in a combined discharge flow of the individual pumps, the sum of which
20 can meet the total flow requirements of the industrial application in which the hydraulic pump system is to be implemented.

Figure 2a discloses in more detail another part of the pump system 10 in particular the pump housing 11 to which both reciprocating positive displacement pumps 100 and 200 are connected.

25 The pump housing 11 is provided with a central suction inlet 12 and a central discharge outlet 18 for the intake and discharge of slurry medium to be pumped by the pump system 10. For each individual positive displacement pump 100 (200) the central suction inlet 12 is in fluid communication with suction inlet chambers 14a (14b) via suction inlets 13a (13b). Each individual suction inlet 13a (13b) can be opened and closed
30 by so-called hydraulic piston/cylinder driven suction valves 30a (30b). Each suction valve 30a (30b) comprises a valve body 31a (31b) which cooperates with the seat of the individual suction inlet 13a (13b) when said suction valve 30a (30b) is in his closed position. Each valve body 31a (31b) is mounted to a piston rod 32a' (32b'), which rod 32a' (32b') is provided with a piston element 32a (32b) which is movable accommodated in a
35 valve housing 30a' (30b'). The piston element 32a (32b) and the valve housing 30a' (30b')

define a cylinder chamber 33a (33b) which is filled with a hydraulic medium.

The hydraulic medium can be introduced in an alternating manner on either side of the piston element 32a (32b) via hydraulic lines 34a -35a (34b-35b) and by means of a manifold valve 36a (36b) which connects to supply lines P2 and T2. Supply line P2 contains a reservoir 40 for hydraulic medium. Supply of hydraulic medium to either side of the piston element 32a (32b) causes the hydraulic valve 30a (30b) to open or close the respective suction inlet 13a (13b) by means of the valve body 31a (31b).

Each suction chamber 14a (14b) is in fluid communication with the cylinder chamber 104 (204) in which the displacement element 101 (201) is displaced in a reciprocating manner during operation.

Each individual suction chamber 14a (14b) is furthermore provided with a discharge outlet 15a (15b). Both discharge outlets 15a (15b) communicates in a combined discharge chamber 16 and further with the central discharge outlet 18.

Both individual discharge outlets 15a (15b) are arranged to be opened and closed by discharge valves 20a (20b). Each discharge valve 20a (20b) comprises a valve body 21a (21b) which cooperates with the seat of the individual discharge outlet 15a (15b) when said discharge valve 20a (20b) is in his closed position.

In Figure 2a, the discharge valve 20b is depicted in its closed position where valve body 21b fits in the seat of the discharge outlet 15b thereby closing the suction chamber 14b from the combined discharge chamber 16. Likewise the discharge valve 20a is in its open position allowing fluid communication between the suction chamber 14a and the central discharge chamber 16 (and hence the central discharge outlet 18).

Also depicted in Figure 2a in this operational situation the suction valve 30a is in its closed position having a valve body 31a which closes the seat of the suction inlet 13a. Similarly, the other suction valve 30b is in its open condition allowing the suction inlet 13b to be in fluid communication with the central inlet 12 and the suction chamber 14b.

In this operational situation, the positive displacement pump 100 performs its discharge stroke wherein the discharge element 101 is displaced in the cylinder 104 discharging any slurry medium contained in the suction chamber 14 via the discharge outlet 15a, the central discharge chamber 16 towards the central discharge outlet 18, and hence out of the pump system. Likewise, the positive displacement pump 200 performs its suction stroke wherein the displacement element 201 performs a movement which is contrary to the movement of the displacement element 101 of the positive displacement pump 100 during the discharge stroke. During the suction stroke of the displacement

element 201 slurry medium is taken from the central suction inlet 12 through the suction inlet 13b into the suction chamber 14b.

In general, the intake amount of slurry via the suction inlet is defined by the amount of slurry medium being displaced by the previous discharge stroke of said positive displacement pump.

After completion of the suction stroke of the positive displacement pump 200 and the simultaneous completion of the discharge stroke of the other positive displacement pump 100, the suction valve 30b is closed under simultaneous opening of the suction valve 30a. Likewise the discharge valve 20a is closed whereas the discharge valve 20b is opened.

The subsequent suction stroke of the positive displacement pump 100 causes slurry medium to be taken in the now discharged pump chamber 14a via the suction inlet 13a and the slurry medium contained in the other suction chamber 14b is now being discharged by the positive displacement pump 200 during its discharge stroke. Said discharged slurry medium is forced through the now open discharge outlet 15b into the combined discharge chamber 16 and towards the central discharge outlet 18.

As already described in the preamble of this patent application, an accurate control of the reciprocating pump cycles of the individual pumps is desired to create a nearly pulsating free flow in the central discharge outlet. However, in the presently known prior art pump systems, pressure pulsations in the discharge flow still occur for several operational and hydraulic causes.

In the known pump systems, the discharge valves are operated independently. When looking to Figure 2a, and in particularly to the closed discharge valve 20b, it is evident that the valve body 21b together with the part of the piston rod 22b extending in the discharge chamber 16 represents a certain volume, which is not occupied by slurry medium present in the discharge chamber 16. At the time of opening of the discharge valve 20b, this volume previously occupied by the extended piston rod and valve body becomes available to the overall slurry medium volume in the discharge chamber 16. This extra volume becoming available causes a volume drop and hence a temporary pressure drop occurs.

Likewise when closing a discharge valve by displacing the valve body and the piston rod into the seat of their respective discharge outlet, this additional volume is added to the discharge chamber 16, causing an additional slurry medium volume change to the slurry medium volume being displaced via the central discharge outlet 18 and hence a temporary pressure increase. The independent control of the discharge valves in

the prior art pump systems creates undesired volume changes during opening and closing which adds to the small pressure fluctuations in the slurry medium being discharged via the central discharge outlet 18.

In addition to the above drawback, to make sure that the pressure across the discharge valve bodies 21a and 21b during the switching over between the suction and discharge strokes is as minimal as possible, each positive displacement pump performs a pre-compression stroke on the slurry medium to be discharged in their respective pumping chamber 14a (or 14b) prior to the opening of the respective valve body 21a (or 21b) of the discharge valves 20a (or 20b). Such pre-compression stroke is depicted in Figure 3, which discloses to the pump characteristic and sequence control of one displacement element 101 (201) of each positive displacement pump. Each pump performs three stages in a sequential manner:

a. First the discharge stroke in which starting from $t=0$ the velocity is ramped up from the pre-compression velocity to the required discharge velocity V_1 at t_{acc} .

b. After completing the discharge stroke the pump switches to the suction stroke. The actual required velocity V_2 of the suction stroke is determined by controlling the time on which the discharge valve of the pre-compressed pump is opened.

c. Finally, the pre-compression stroke, in which the pressure in the cylinder of the pump is pre-compressed to the same pressure as the pressure in the second pump, which performs at that moment the discharge stroke.

However, due to the mass and inertia of the heavy components of such pumps, pre-compression of the slurry medium requires extra drive time and therefore the speed of the respective cylinder is increased during its suction stroke. Unfortunately pressure fluctuations still occur because, in the known systems, the pre-compression of the cylinder is not 100% completed at the moment that the ramp up – ramp down step starts (the switching over between the suction and discharge stroke of positive displacement pumps 100 and 200), which can occur if the filling is lower than expected.

The above drawbacks together with mass and inertia constraints of the pump components still create small pressure fluctuations over the valve body 21b (or 21b) during the switching over from the discharge towards the suction stroke of each positive displacement pump 100 (200). Such small pressure fluctuations are undesirable when the slurry medium to be pumped by said pump system has a biomass nature.

Pump systems as described above when used in biomass applications, for example where the slurry medium to be pumped consists of wood pulp, requires no pressure pulsations in the central discharge outlet. No pressure fluctuations in the central

discharge outlet 18 leads to a better biomass product produced in the biomass installation connected to the central discharge outlet 18. In practice, it is evidenced that a small pressure fluctuation in the discharge flow leads to a biomass product having a different consistency and therefore an inferior quality.

5 The pump system 10 as disclosed in Figure 1 and 2a is capable of generating a discharge flow of the displaced slurry medium through the central discharge outlet 18 with no pressure fluctuations resulting in a constant consistency of the biomass slurry medium. This leads to an improved and constant product quality of the biomass slurry medium for further processing in a biomass installation.

10 According to the present disclosure, the pump system is now capable in providing a pulsation free flow in the discharge outlet 18. This is accomplished by means of control means, which control the alternate closing and opening of both piston/cylinder discharge valves 20a-20b, such that during operation no volume difference occurs in the discharge 18 of slurry medium. In Figure 2a said control means comprise a hydraulic line
15 24 which interconnects both cylinder chambers 23a and 23b of the discharge valves 20a and 20b.

As outlined, each discharge valve 20a comprises a valve body 21a (21b) which fits in the seat of the discharge outlet 15a (15b). The valve body is mounted on a piston rod 22a' (22b') which ends with a piston element 22a (22b), which is movable
20 accommodated in a valve housing 20a' (20b'). The piston element 22a (22b) and the valve housing 20a' (20b') define a cylinder chamber 23a (23b) which is filled with a hydraulic medium. Due to the hydraulic interconnection between both cylinder chambers 23a and 23b via the interconnecting hydraulic line 24, no volume difference between both discharge valves will occur during the simultaneous switching of both discharge valves
25 20a and 20b from their open and closed position.

This means that once the valve 21b of the discharge valve 20b is displaced from its closed position towards its open position (as shown in Figure 2a), the hydraulic medium contained in the cylinder chamber 23b is displaced by means of the piston element 22b via the interconnecting hydraulic line 24 towards the cylinder chamber 23a
30 causing the piston element 22a, the piston rod 22a' and the valve body 21a to be displaced towards the closed position until the valve body 21a rests in the seat of the discharge outlet 15a.

No volume differences will occur inside the discharge chamber 16 as the slurry medium volume increases, due to the withdrawal of the (volume of) piston rod 22b' into valve housing 20b' (and partly of valve body 21b), which will be simultaneously
35

compensated by the slurry medium volume decrease, due to the expansion of the (volume of) piston rod 22a' out of valve housing 20a (and partly of valve body 21a).

As a result, undesirable pressure differences across the discharge outlet will be avoided, and a fully pressure pulsation free discharge flow in the central discharge outlet 18 is obtained.

Furthermore, the pre-compression stroke is fully completed at the moment the ramp up - ramp down action is initiated and the sum of the hydraulic medium flows of both cylinders is always 100%.

In Figure 2a the hydraulic line 24 interconnects both valve housings 20a' and 20b' (cylinder chambers 23a and 23b) of the discharge valves 20a and 20b on the piston side thereof at the side of the piston elements 22a (22b). In Figure 2b another embodiment of a pump system is shown. The embodiment of Figure 2b is largely identical to the embodiment of the pump system disclosed in Figure 2a and described above and also its operation is identical. However in Figure 2b reference numeral 24' depicts a hydraulic line, similar to the hydraulic line 24 of Figure 2a, which interconnects both valve housings 20a' and 20b' of the discharge valves 20a and 20b on the cylinder side thereof at the side of the piston rods 22a'-22b' opposite to the side of the piston elements 22a (22b).

By interconnecting both valve housings 20a' and 20b' via the interconnecting hydraulic line 24-24', these small volume and pressure pulsations are no longer present as the displaced volume of one discharge valve is compensated by the same volume change created by the other discharge valve.

In order to guarantee the simultaneous closing and opening of both discharge valves such that no volume differences between both cylinder chambers 23a and 23b occurs, in both embodiments shown in Figure 2a, 2b and 2c each discharge valve 20a (20b) is provided with sensors 25a-26a (25b-26b) which detect the extreme positions of the piston elements 22a (22b) within the cylinder chamber 23a (23b) when in fully closed or fully open position.

In particular, the sensor 25a (25b) will generate a signal when the valve body 21a (21b) is completely closing their respective discharge outlet 15a (15b) as the sensor 25a (25b) will properly detect the position of the piston element 22a (22b) in that extreme closing position. Likewise, sensor 26a (26b) will detect the piston element 22a (22b) in its other extreme position, meaning that the discharge valve 20a (20b) is fully open. In particular the control mechanisms of both of the discharge valves 20a-20b are interconnected.

Sensor 25a (which detects the fully closed position of the discharge valve 20a) is interconnected with the sensor 26b (which detects the fully open position of the discharge valve 20b) and likewise sensor 25b (which detects the fully closed position of the discharge valve 20b) is interconnected with the sensor 26a (which detects the fully open position of the discharge valve 20a). By interconnecting the sensors of both discharge valves 20a-20b on opposite sides of the piston element 22a-22b, a proper control is obtained as their simultaneous actuation by their respective closing or opening valve guarantees a fully synchronization of the opening and closing of both discharge valves.

This also guarantees that no change will occur in the hydraulic medium volume in both cylinder chambers 23a-23b and the interconnecting hydraulic line 24 (24').

The opening of say the hydraulic valve 20b (starting from the situation in Figure 2) will be detected by the sensor 25b and will simultaneously also be detected by sensor 26a as the discharge valve 20a is being moved towards its closed position. The simultaneous actuation of the sensor 26b and 25a will trigger the fully open position of the discharge valve 20b and the fully closed position of the discharge valve 20a. Any deviation of the simultaneous actuation of both sensor pairs 25a-26b and 25b-26a will be a signal that a change in the volume occupied by the hydraulic medium in the cylinder chambers 23a and 23b and the hydraulic line 24-24' has occurred.

Any shortage of hydraulic medium can be supplied via the valve 29 and interconnecting line 24 (24'). Likewise, any surplus of hydraulic medium can be removed interconnecting line 24 (24') and valve 29.

In Figure 2c yet another embodiment of a pump system is disclosed, wherein the control means for controlling the alternate closing and opening of both piston/cylinder discharge valves, such that during operation no volume difference occurs in the discharge of slurry medium comprise a lever assembly 240 interconnecting the piston elements 22a-22b of both piston/cylinder valves 20a-20b.

As shown said lever assembly 240 comprises a lever 240 having two ends, each end being hingedly connected with either piston element 22a (22b) of one of said piston/cylinder driven valves 20a-20b. In addition, and as shown in Figure 2c the lever assembly 240 comprises two sub-lever elements 230a-230b, each connected to their respective piston element 22a-22b as well as with either end of the lever 240.

Preferably each connection is a hinge connection.

The lever 240 is hingedly connected at its mid-point 241a with the solid world.

In the foregoing description of preferred embodiments, specific terminology has been resorted to for the sake of clarity. However, the invention is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar technical purpose. Terms such as "front" and "rear", "inner" and "outer", "above", "below", "upper" and "lower" and the like are used as words of convenience to provide reference points and are not to be construed as limiting terms.

The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as, an acknowledgement or admission or any form of suggestion that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

In this specification, the word "comprising" is to be understood in its "open" sense, that is, in the sense of "including", and thus not limited to its "closed" sense, that is the sense of "consisting only of". A corresponding meaning is to be attributed to the corresponding words "comprise", "comprised" and "comprises" where they appear.

In addition, the foregoing describes only some embodiments of the invention(s), and alterations, modifications, additions and/or changes can be made thereto without departing from the scope and spirit of the disclosed embodiments, the embodiments being illustrative and not restrictive.

Furthermore, invention(s) have been described in connection with what are presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the invention(s). Also, the various embodiments described above may be implemented in conjunction with other embodiments, e.g., aspects of one embodiment may be combined with aspects of another embodiment to realize yet other embodiments. Further, each independent feature or component of any given assembly may constitute an additional embodiment.

CLAIMS

1. An hydraulic pump system for handling a slurry medium, the pump system comprising:

5 - at least two reciprocating positive displacement pumps, both pumps being arranged for alternating intake of slurry medium via a central suction inlet and discharge of slurry medium via a central discharge outlet; and the at least two reciprocating positive displacement pumps providing individual discharge outlets and

the pump system further comprising discharge valves for alternating
10 closing and opening each individual discharge outlet, wherein the individual discharge outlets communicate in a combined discharge chamber and further with the central discharge outlet, and wherein each discharge valve is driven by a piston and cylinder, with each discharge valve being mounted to a piston rod and a piston element respectively which are moveably accommodated within a cylinder chamber of a valve
15 housing respectively,

characterised in that the hydraulic pump system comprises control means for controlling the alternate closing and opening of the discharge valves, wherein the control means are configured to interconnect the discharge valves, such that during operation of the hydraulic pump system, the control means are arranged for simultaneous
20 closing and opening of the discharge valves, such that no volume difference occurs in the discharge of slurry medium.

2. An hydraulic pump system according to claim 1, wherein said control means comprise a lever assembly interconnecting the pistons of the discharge valves.

3. An hydraulic pump system according to claim 2, wherein said lever
25 assembly comprises a lever having two ends, each end being hingedly connected with the piston of one of the discharge valves.

4. An hydraulic pump system according to claim 1, wherein said discharge valves are hydraulic driven discharge valves and wherein said control means comprise a hydraulic line interconnecting both cylinders of said hydraulic discharge valves.

30 5. An hydraulic pump system according to claim 4, wherein said hydraulic line interconnects both cylinders at the piston side thereof.

6. An hydraulic pump system according to claim 4, wherein said hydraulic line interconnects both cylinders at the cylinder side thereof.

7. An hydraulic pump system according to any one of the claims 4 to 6,
35 wherein each hydraulic driven discharge valve comprises a first sensor for sensing the

position of the piston in the closed position of the discharge valve, as well as a second sensor for sensing the position of the piston in the open position of the discharge valve.

8. An hydraulic pump system according to claim 7, further comprising hydraulic refill means for adding hydraulic medium to a hydraulic driven discharge valve based on signals generated by the first sensor of a discharge valve and the second sensor of the other discharge valve.

9. An hydraulic pump system according to any one of the preceding claims, further comprising hydraulic driven suction valves for alternating closing and opening each suction inlet.

10. An hydraulic pump system according to anyone of the preceding claims, further comprising a pump housing having a central inlet interconnecting both suction inlets as well as a central outlet interconnecting both discharge outlets.

11. An hydraulic pump system according to claim 10, wherein said pump housing comprising two pump chambers, each pump chamber being interconnected with one of said reciprocating positive displacement pumps and each pump chamber being provided with a suction inlet and a discharge outlet.

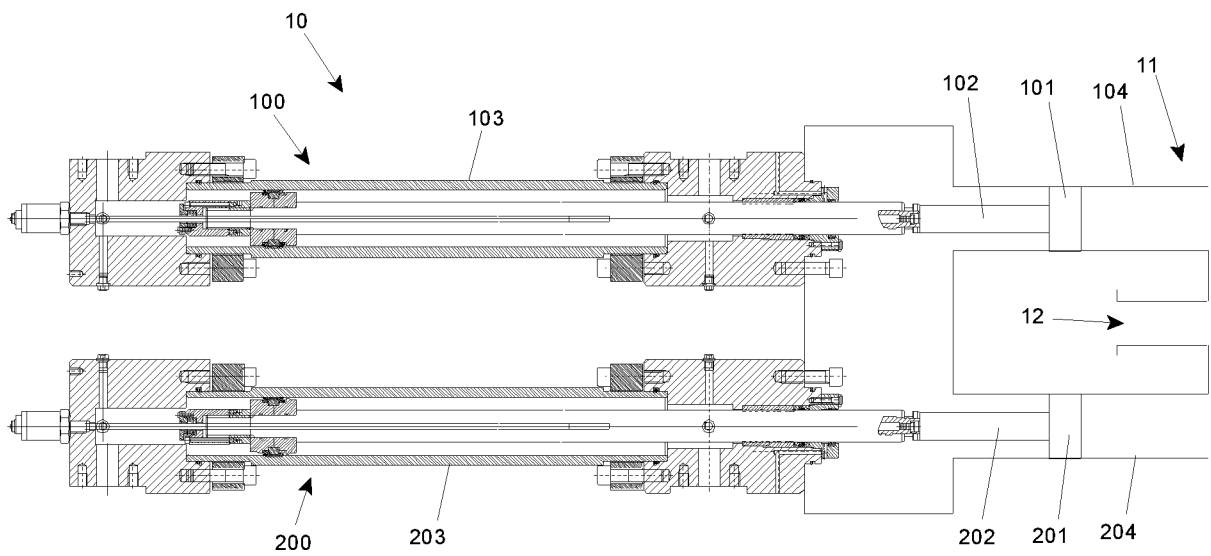
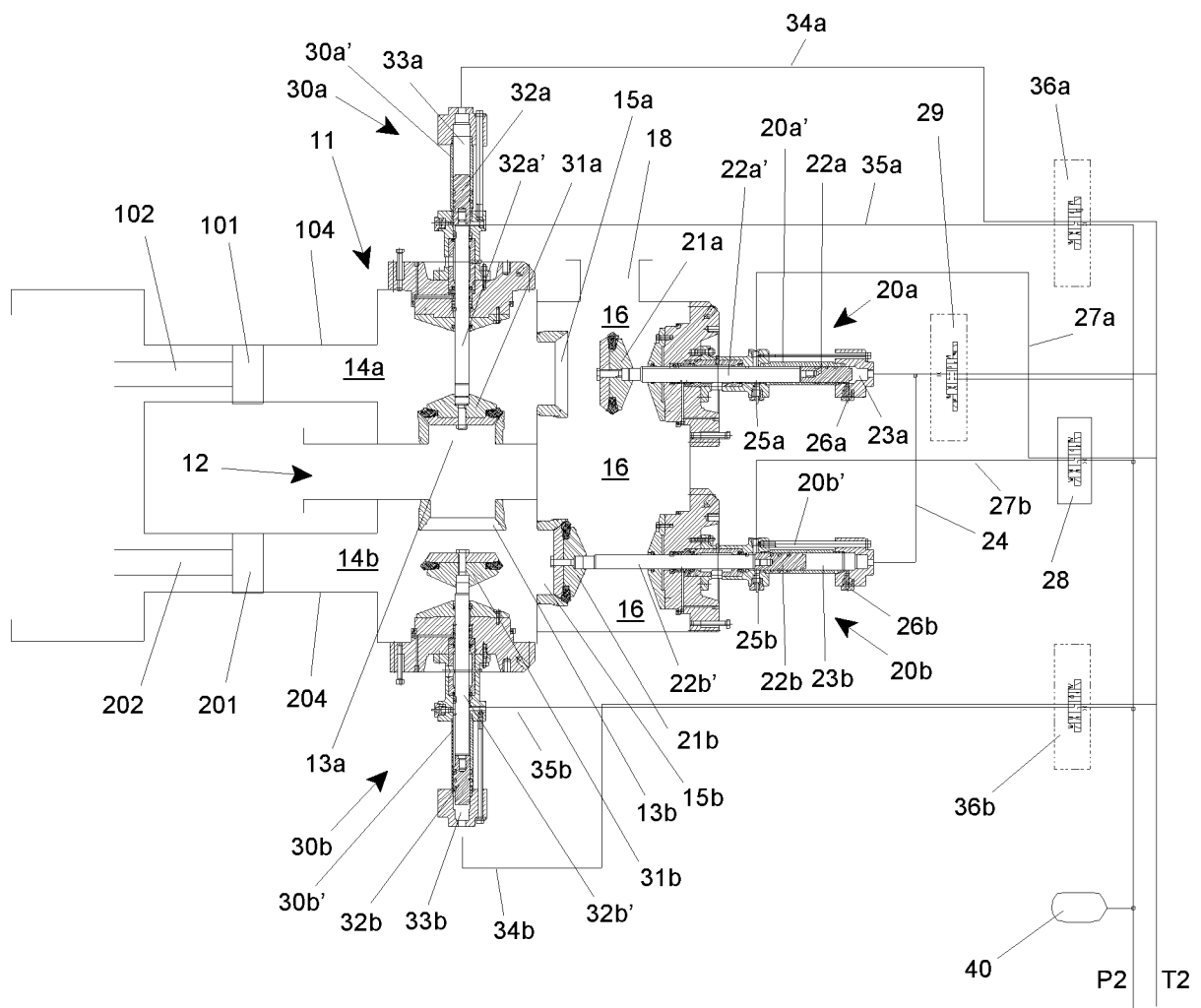
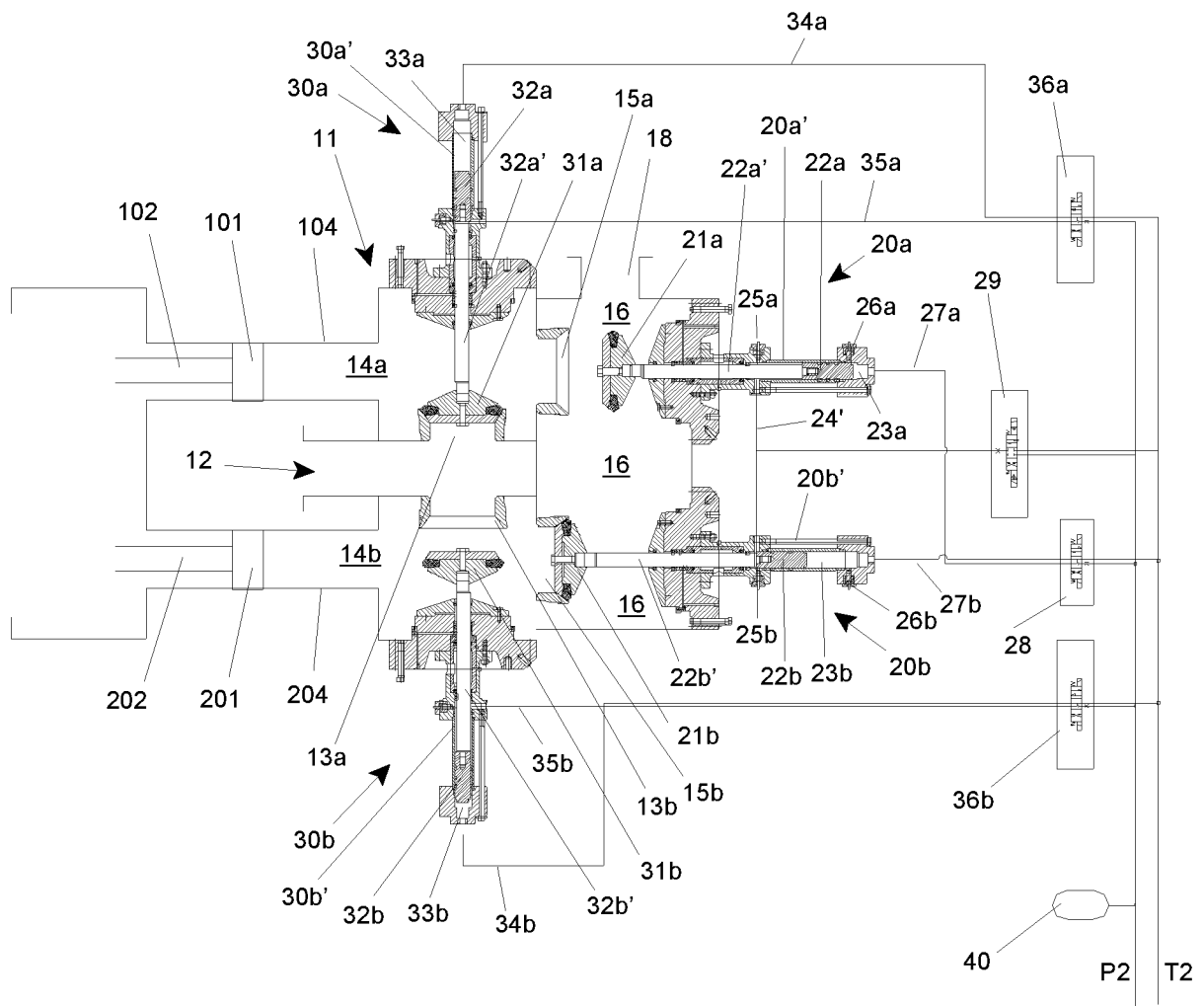
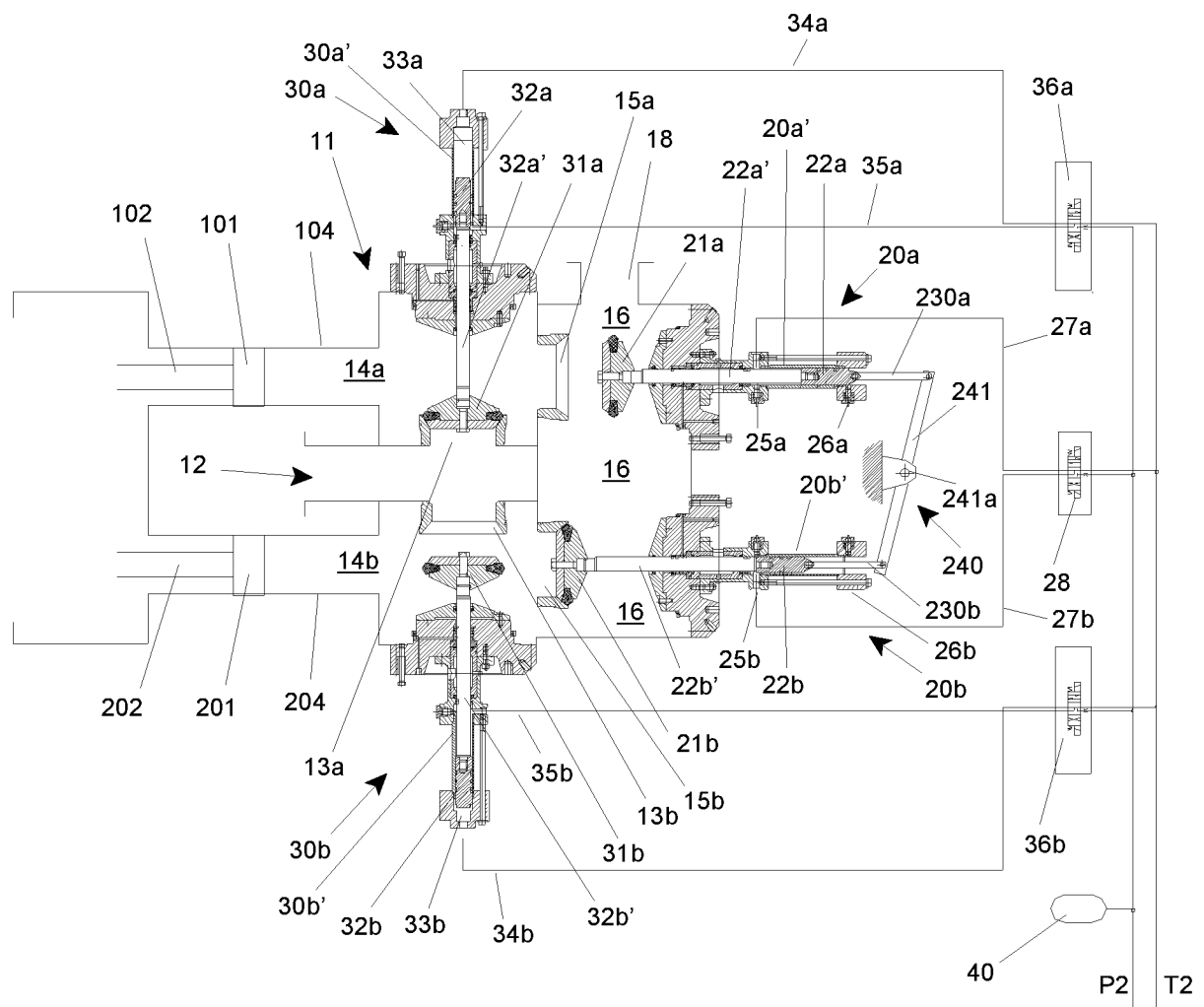


Fig. 1







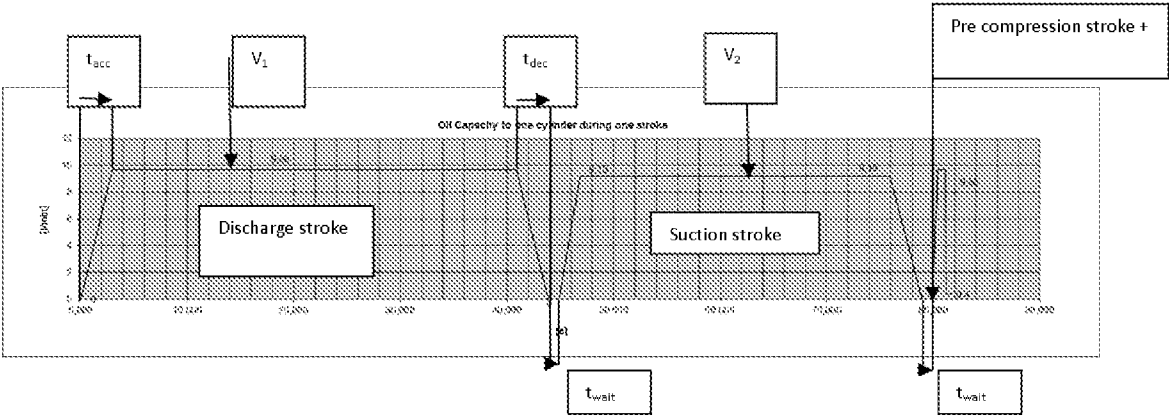


Fig. 3