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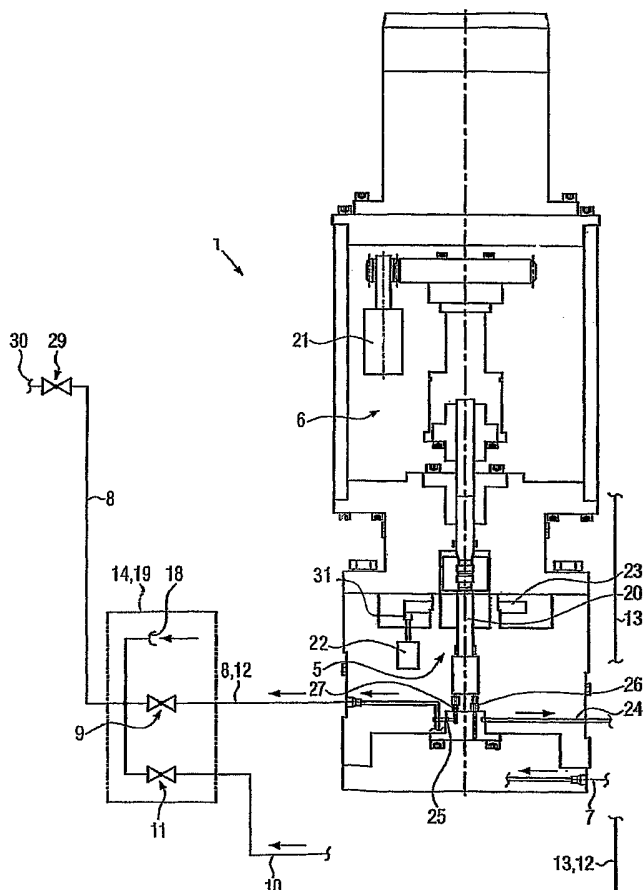
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[Continued on next page]

(54) Title: HYDRAULIC ACTUATION ASSEMBLY



(57) Abstract: An assembly for the hydraulic actuation of safety equipment includes a hydraulic actuator disposed between a fluid feed line and a supply line in fluid communication with the safety equipment. A pump valve in the supply line downstream of the hydraulic actuator is adjustable between open and closed positions for providing hydraulic fluid to supply line. A fluid source communicates with a bypass line is in fluid communication with the supply line. A bypass valve is disposed between the fluid source and the supply line and is lockable between open and closed positions for providing other hydraulic fluid to supply line.



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HYDRAULIC ACTUATION ASSEMBLY**CROSS-REFERENCE TO RELATED APPLICATION**

[0001] The present application claims priority to German Utility Model Application 202 005 006 719.9, filed April 27, 2005, hereby incorporated herein by reference. Related to the present application are U.S. patent application Serial No. 10/564,584 filed 13 January 2006, PCT/EP2004/007948 filed 16 July 2004, and German Application No. 203 11 033.1 filed 17 July 2003, all hereby incorporated herein by reference.

**STATEMENT REGARDING FEDERALLY SPONSORED
RESEARCH OR DEVELOPMENT**

[0002] Not Applicable.

BACKGROUND OF THE INVENTION

[0003] The invention relates to an assembly for the hydraulic actuation of equipment for particular use in hydrocarbon extraction, such as crude oil or natural gas extraction. Such equipment may be, for example, a safety valve assigned to a riser or a Christmas tree used in hydrocarbon extraction from subsea wells. The assembly comprises a pump device that includes a piston / cylinder unit and an electrical drive device which is movably connected to a piston of the piston / cylinder unit for intermittent pump movement. The pump device is disposed between a fluid feed line and a supply line communicating with the equipment.

[0004] Such a pump device is known from DE 203 11 033 and PCT/EP2004/007948, hereby incorporated herein by reference. A pump device as such comprises a screw drive, a reduction gear unit, a spurwheel gear unit and at least one drive shaft with at least one electric motor driving the drive shaft. The screw drive comprises a rotatable, but axially immovable spindle nut, and an axially movable threaded spindle which is connected at an actuating end to the piston of the piston / cylinder unit. The appropriate reduction gear unit can, for example, be a so-called harmonic drive gear unit

[0005] The piston is movably supported in a piston cavity of a cylinder of the piston / cylinder unit, wherein the piston cavity includes at least one suction hole and one discharge hole; and

non-return or check valves subject to force can be arranged in each of these holes in different directions.

[0006] A discharge hole or a discharge line, which leads to a pressure switch, can branch from the supply line. This can actuate a safety valve. An electrical servomotor can be provided to actuate the safety valve.

[0007] Reference is made to DE 203 11 033 for the further description of the pump device.

[0008] In order to improve the known pump device in a simple manner such that on site, which also means below the surface of the sea, it can be bypassed in a simple manner in an emergency in order to be able to continue to feed hydraulic fluid with an adequate pressure to the appropriate equipment, such as a subsea safety valve.

SUMMARY OF THE PREFERRED EMBODIMENTS

[0009] In order to bypass the pump device, an exemplary embodiment of the assembly includes, in the supply line leading from the pump device to the appropriate unit downstream and following a pump valve that is adjustable between the closed and open positions, a bypass pipe connected to the fluid feed line and opening into the supply line and in which a bypass valve that is adjustable between open and closed positions is arranged.

[0010] If the pump device is no longer suitable with its normal operation for supplying an adequate pressure for the actuation of the respective equipment, the pump valve closes and the bypass valve opens so that hydraulic fluid under appropriate pressure is passed directly from the fluid feed line to the respective equipment, such as the safety valve. For this purpose it may be necessary to increase the fluid pressure within the fluid feed line. In this way, in the event of a failure of the pump device, the equipment, such as the safety valve, may still be actuated properly.

[0011] Various hydraulic fluids can be used by the pump device. Preferably, hydraulic fluids already present locally are used. The use of an inhibitor may be of advantage. Such an inhibitor is added to the crude oil to be transported in order to optionally liquefy solid constituent parts of the crude oil, such as paraffin or similar substances, and to prevent blockage by these constituent

parts during the transport of the oil. Such an inhibitor is sufficiently present in the region of a tree in the vicinity of the wellbore, so that no supply problems arise locally. At the same time, a leak of the crude oil being transported is relatively uncritical, because the inhibitor is in any case already added to the crude oil for its transport.

[0012] Since only slight quantities of the inhibitor and/or other hydraulic fluid are needed for the pump device, the fluid feed line can branch from a feed line for the inhibitor or for the other hydraulic fluid.

[0013] With the failure of all equipment, irrespective of whether it is electrical, hydraulic or pneumatic, in order to be able to ensure that the safety equipment is capable of operation, it can be advantageous if the pump and bypass valves are accessible for actuation by a remotely controlled vehicle via an access device for the vehicle for adjustment between the open and closed positions. Such a remotely controlled vehicle is designated as an ROV (Remote Operated Vehicle) and is normally not manned. Under remote control, it can travel to the access device and adjust the pump or bypass valve using appropriate manipulators.

[0014] In order to also provide sufficient hydraulic pressure for the safety valve or another device using the remotely controlled vehicle, the access device can comprise a hydraulic connection for the feed of hydraulic fluid directly from the remotely controlled vehicle.

[0015] In this way there is a total of three ways of feeding sufficient hydraulic fluid to the safety equipment from three alternative sources for supplying hydraulic fluid under pressure. In the normal case the feed of the hydraulic fluid and the maintenance of an appropriate pressure occurs by the pumping of the pump device. This is always actuated when the pressure on the safety equipment reduces and, for example, falls below a specified set value. If pumping is not possible because, for example, the electrical supply has been interrupted, a switchover to the bypass can take place using the remotely controlled vehicle. Then the pressure is supplied directly from the surface via, for example, the inhibitor feed line. When doing this, it may be necessary to increase the pressure in the feed line in order to provide the pressure required for the safety equipment.

[0016] If this possibility is also not available, because for example a leak is present in the feed line, and sufficient pressure cannot be made available at the surface or a similar reason, there is still the possibility of providing hydraulic fluid and, therefore, pressure from the remotely controlled vehicle via the access device with the appropriate hydraulic connection. For this purpose the remotely controlled vehicle couples to the hydraulic connection and pumps hydraulic fluid until a sufficient pressure is obtained. The vehicle can then be switched into an idle state in that, for example, a non-return valve within the vehicle prevents the pressure from falling. The vehicle then remains on site and optionally feeds hydraulic fluid again until one of the two other possibilities becomes available.

[0017] The pump device can be part of a tree or at least can be arranged also on the sea bed in the vicinity of a tree. In order to be able to feed the hydraulic fluid to the safety equipment from the pump device in a simple manner, the supply line can in particular feed into a hydraulic line arranged directly in the riser or the transport system, which then leads within the riser or the system to the safety equipment, such as a safety valve or a wellbore safety valve or similar device. One example of such safety equipment is a so-called downhole safety valve (DHSV).

[0018] The access device itself can also be disposed directly on the tree or also on the pump device directly as an access panel. The panel includes appropriate equipment to facilitate the coupling of the remotely controlled vehicle to its corresponding manipulators in order for example to adjust the valves or to couple to the hydraulic connection. The access panel can also be formed as a device, which is separate from the pump device and is independent.

[0019] There is of course also the possibility that the adjustment of the valves occurs not by such a remotely controlled vehicle, but rather manually by a diver or similar person.

[0020] With the pump device, it should be noted that it is not normally in permanent operation, but is rather actuated intermittently by remote control to maintain a specified hydraulic pressure. This means that the pump device is operated in order, for example in the case of a downhole safety valve, to increase the hydraulic pressure so far that it is open against the pressure of the

crude oil to be transported and is only closed in an emergency. Thereafter, the pump device can be switched into a standby state.

[0021] In order to be able to feed hydraulic fluid and thus maintain sufficient hydraulic pressure for a certain time without actuating the pump device, or optionally if a leak has developed, a pressure accumulator can be assigned to the pump device. Hydraulic fluid is transported in the direction of the downhole safety valve through the pressure accumulator at least for a sufficient time so that pumping by the pump device only takes place again when the pressure in the pressure accumulator has fallen to a specified set value.

[0022] It may be convenient if at least parts of the drive device are constructed redundantly and the pump device is overall of modular construction. Indeed, the foregoing summary merely provides exemplary embodiments of the present invention and is not intended to limit the scope of the appended claims to what is summarized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] In the following, an advantageous embodiment of the invention is explained in more detail based on the figures enclosed in the drawings.

The following are shown:

[0024] Figure 1 is a longitudinal section of a schematic diagram of a pump device according to the invention with the assigned access device, and

[0025] Figure 2 is a longitudinal section through a riser in the region of a tree or well head.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] Figure 1 shows a longitudinal section of an actuator or pump device 1 illustrated schematically in accordance with one embodiment of the present invention. The pump device, as is illustrated, is described in detail in DE 203 11 033. The pump device 1 comprises a drive device 6 with an electrical motor 21, via which a threaded spindle device is driven, such that a piston 20 of a piston / cylinder unit 5 can be moved to and fro in the longitudinal direction of the pump device. This movement causes pumping of a hydraulic fluid. The fluid is pumped via a fluid feed line 7 and a non-return or check valve 26 into the cylinder cavity 61 of the piston /

cylinder unit 5. Subsequently, fluid is pumped to a non-return or check valve 27 configured in the reverse direction and an annular pipe 25 that on one hand provides fluid to supply line 8 and on the other hand to the pressure accumulator line 24. The pressure accumulator line 24 extends to a pressure accumulator, which is not illustrated in Figure 1, and details of this pressure accumulator can be, in this respect, found in DE 203 11 033.

[0027] The fluid feed line 7 opens into an inhibitor feed line 13, which in Figure 1 is only shown in section and which extends for example from the surface of the sea to the subsea wellhead or wellbore and the corresponding Christmas tree. The inhibitor is transported in the inhibitor feed line 13 as hydraulic fluid 12 with a certain pressure.

[0028] A bypass line 10, via which the inhibitor is fed as a hydraulic fluid directly to an access device 14, thus bypassing the actual pump of the pump device 1, is in fluid communication with the inhibitor feed line 13.

[0029] The supply line 8 feeds to the access device 14. Both lines, *i.e.*, the supply line 8 and bypass line 10, are in fluid communication with the access device 14, via the pump valve 9 or, respectively, the bypass valve 11. The access device 14 can adjust the valves 9, 11 between their open and closed positions.

[0030] Furthermore, the access device 14 includes a hydraulic connection 18, also designated an ROV hot step, to which a remotely controlled vehicle can be coupled to feed hydraulic fluid from the vehicle directly via the hydraulic connection 18 to the supply line 8 leading from the access device 14.

[0031] Through the access device 14, which can be disposed in the access panel 19 directly on the pump device 1 or also arranged remotely to it, there are various ways of providing sufficient hydraulic fluid for safety equipment such as shown in Figure 2.

[0032] With the first possibility, the feed of hydraulic fluid occurs from the piston / cylinder unit 5 by appropriate pumping or from the corresponding pressure accumulator, which is omitted in Figure 1 for simplification. If a fault occurs in the actual pump, there is the second possibility of

using the bypass line 10. When employing the bypass line 10, the corresponding bypass valve 11 is opened and the pump valve 9 is closed. This actuation of valves can occur through the already mentioned remotely controlled vehicle, which is normally an ROV (Remote Operated Vehicle). With the second possibility, the direct feed of the inhibitor occurs via the bypass line 10 from the inhibitor feed line 13. Optionally, on the inlet to the inhibitor feed line, which can be arranged at the sea surface, the pressure in the line is increased to provide sufficient pressure for the safety equipment 2 shown in Figure 2.

[0033] As the third possibility, if the two first possibilities are not fruitful or not desired, appropriate hydraulic fluid can be fed via the hydraulic connection 18 directly from the remotely controlled vehicle. This can similarly be inhibitor or also another hydraulic fluid. To achieve this, the remotely controlled vehicle is equipped with an appropriate pump device to which a non-return or check valve is also optionally assigned. The vehicle remains coupled to the hydraulic connection 18 until one of the two other possibilities becomes possible again or is selected, for instance. Due to the non-return valve in the vehicle, it is not necessary that its pump be continually in operation.

[0034] The pump device 1 also comprises a safety valve 22, which is actuated via a rotatable cam plate 23 with a protruding cam 31. This valve 22 comes into operation when a pressure, such as in the pressure accumulator line 24 or supply line 8 becomes too high, wherein these can be practically short-circuited with the fluid feed line 7.

[0035] Figure 2 illustrates a longitudinal section through a transport head system 15 with the riser 3. This transport system 15 is part of a tree and at the connecting point 30 a connection is made from it to the supply line 8 shown in Figure 1. Here, a tree valve 29 is also assigned to the connecting point or also directly to the transport system 15.

[0036] The supply line 8 opens within the riser 3 to a hydraulic line 16, which extends along the riser 3 to the safety equipment 2, which for example is a safety valve 17 and in particular a so-

called wellbore safety valve (downhole safety valve). This optionally closes the riser 3 if the pressure fed externally drops below a predetermined value.

[0037] The transport system 15 consists of a series of coaxially arranged pipes, wherein the appropriate crude material, such as crude oil or natural gas is transported in the interior of the riser 3.

[0038] While a preferred embodiment of the invention has been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit of the invention.

CLAIMS

1. A pump device (1) used in oil and gas wells for the hydraulic actuation of equipment (2), comprising:

a piston / cylinder unit (5) and an electrical drive device (6), movably connected to the piston (20) of the piston / cylinder unit (5) for at least intermittent pump movement, wherein the pump device (1) is arranged between a fluid feed line (7) and a supply line (8) communicating with the equipment (2);

a bypass line (10) connected to the supply line (8) downstream to a pump valve (9) adjustable between a closed and an open position and following the pump device (1); and

a bypass valve (11) disposed in the bypass line (10), lockable between the open and closed positions.

2. The pump device according to Claim 2,

wherein the hydraulic fluid (13) is an inhibitor.

3. The pump device according to Claim 1 or 2, wherein the fluid feed line (7) is branched from an inhibitor feed line (13).

4. The pump device according to one of the aforementioned claims,

wherein the pump and bypass valves (9, 11) are accessible for actuation by a remotely controlled vehicle via an access device (14) from the vehicle for adjustment between the open and closed positions.

5. The pump device according to one of the aforementioned claims,

wherein the supply line (8) opens into a hydraulic line (16) disposed in the riser (3) of a transport system, which leads to a wellbore safety valve (17).

6. The pump device according to one of the aforementioned claims,

wherein the access device (14) comprises a hydraulic connection (18) for the feed of hydraulic fluid from the remotely controlled vehicle.

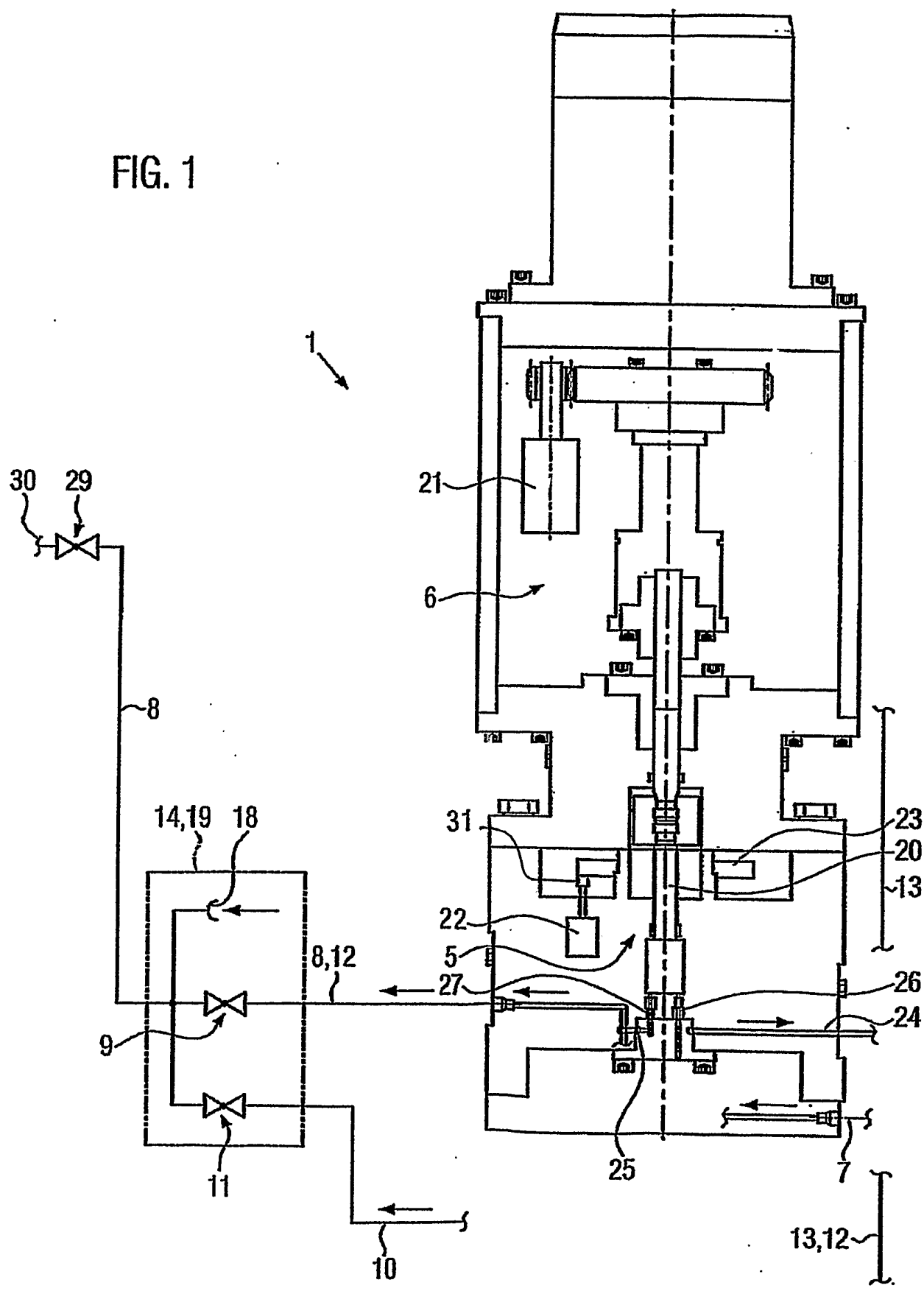
7. The pump device according to one of the aforementioned claims,

wherein the access device (14) is arranged on a tree or the pump device (1) directly as an access panel (19).

8. The pump device according to one of the aforementioned claims,
wherein
it can be intermittently actuated by remote control for maintaining a certain hydraulic pressure.
9. The pump device according to one of the aforementioned claims,
wherein
a pressure accumulator is assigned to it.
10. The pump device according to one of the aforementioned claims,
wherein it is constructed redundantly at least with regard to its drive device (6) and overall is of modular construction.
11. The pump device according to one of the aforementioned claims,
wherein it comprises a rotatable cam plate (23) with at least one in particular axially protruding cam (31) for the actuation of a safety valve (22).
12. An assembly for the hydraulic actuation of safety equipment (2), comprising:
a hydraulic actuator (1) disposed between a fluid feed line (7) and a supply line (8) in fluid communication with the safety equipment (2);
a pump valve (9) in the supply line (8) downstream of the hydraulic actuator (1) and adjustable between open and closed positions for providing hydraulic fluid to supply line (8);
a fluid source communicating with a bypass line (10) in fluid communication with the supply line (8); and
a bypass valve (11) disposed between the fluid source and the supply line (8) and lockable between open and closed positions for providing other hydraulic fluid to supply line (8).
13. The assembly according to claim 12 further including a second fluid source communicating in fluid communication with the supply line (8); and an access connection (18) disposed between the second fluid source and the supply line (8) for providing additional hydraulic fluid to supply line (8).

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FIG. 1



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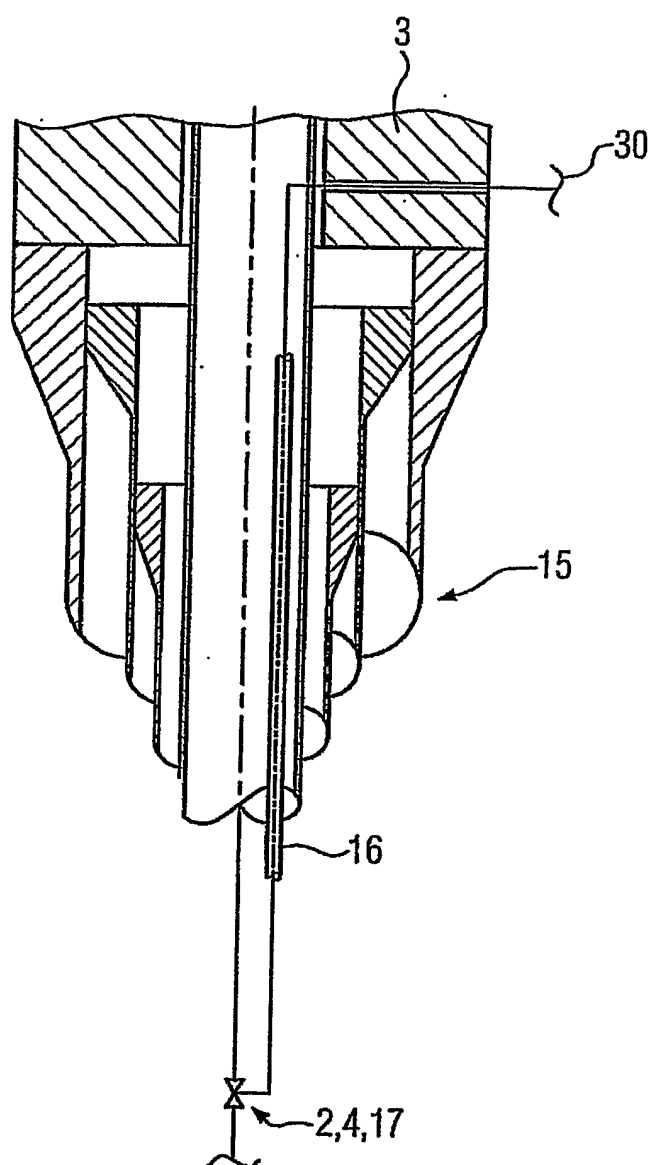


FIG. 2