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(54) Title: COMBINED BARRIER AND LUBRICATION FLUIDS PRESSURE REGULATION SYSTEM AND UNIT FOR A SUBSEA MOTOR AND PUMP MODULE

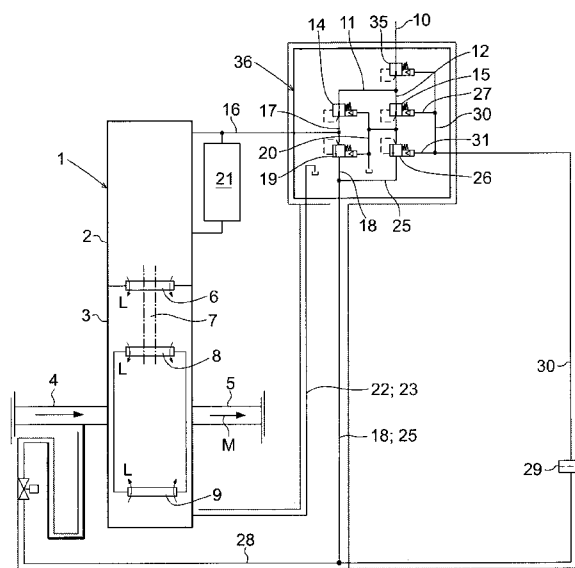


Fig. 2

(57) Abstract: A barrier and lubrication fluids pressure regulation system for a subsea motor and pump module is disclosed, comprising a lubrication fluid circuit in flow communication with a hydraulic fluid supply via a first pressure reducing regulator (15); and a barrier fluid circuit in flow communication with the hydraulic fluid supply via a second pressure reducing regulator (14). The first pressure reducing regulator (15) is configured to reduce the supply fluid pressure in response to the pumped medium pressure at the suction side (4) or at the discharge side (5) of the pump, and the second pressure reducing regulator (14) is configured to reduce the supply fluid pressure in response to the output pressure of the first pressure reducing regulator (15). A pressure regulation unit is likewise disclosed, and arranged for housing the components of the barrier and lubrication fluids pressure regulation system in a pressurized vessel.

**Combined barrier and lubrication fluids pressure regulation system and unit for a subsea motor and pump module**

TECHNICAL FIELD OF THE INVENTION

5 The present invention relates generally to subsea equipment involved in the transport of hydrocarbon production fluids from a production site at the sea floor to a sea surface or land based host facility. More specifically, the present invention is concerned with a system that is designed for management of barrier and lubrication fluid pressures in a subsea motor and pump module. In another aspect the present  
10 invention relates also to a pressure regulation unit for a subsea motor and pump module.

BACKGROUND AND PRIOR ART

A process fluid in subsea hydrocarbon production is typically a multiphase fluid  
15 comprising oil and gas and eventually solid matter, which is extracted from an underground reservoir. A motor/pump module is arranged on the sea floor and configured for transport of the process fluid from the reservoir to a surface or land based host facility. The motor/pump module is frequently subjected to substantial variations in pressure in the pumped medium, as well as substantial transitional  
20 loads during pump start and stop sequences. The pumped medium pressure at the suction side of the pump may be in the order of hundreds of bar, requiring corresponding measures in the motor/pump module to prevent process fluid and particulate matter from immigration from the pump interior into a motor housing via bearings and seals in the motor/pump module.

25 For the purpose of pumping a multiphase fluid in subsea production, screw rotor pumps are advantageously used. The screw rotor pump is a positive displacement type of pump having two screw shafts that are driven in rotation with intermeshing gears, between which a specific volume of fluid is displaced in the axial direction of  
30 the screws from a suction side of the pump to be discharged on the pressure side of the pump. The screws are journalled in bearings in a pump housing, and are drive-connected to a motor arranged in a motor housing. In case of a twin rotor screw pump, intermeshing timing gears carried on the screw shafts provide  
35 synchronization of the rotary motion. The motor housing interior is hydraulically separated from the pump housing interior by a seal arrangement, where the drive shaft is journalled to extend for connection with the pump rotor shaft. The pump bearings are separated from the pump medium by seal arrangements at both ends of the pump.

A hydraulic fluid in the motor housing is to be maintained at a pressure above the internal pressure of the pump, acting as a barrier which prevents intrusion of process fluid and particles into the motor housing via the seal and bearing arrangement. In result of the pressure difference, a leak flow of hydraulic fluid along the drive shaft is unavoidable. The leakage rate is dependent on fluid properties, differential pressure, the transient operating conditions of the pump, and the tightness of the seal(s). The leakage is compensated by refilling the motor housing from an external supply of hydraulic fluid. Likewise, hydraulic fluid is used for lubrication of pump bearings and timing gears. The pressure in the pump lubrication fluid is to be maintained above the pumped medium pressure internally of the pump, in order to prevent intrusion of process fluid and particles into pump bearings, seals and timing gears. Leakage via the pump seals into the pumped medium is compensated by refilling from an external supply of hydraulic fluid.

The motor and pump can be drive-connected inside the motor housing, or outside the motor housing. For instance, the motor and pump can share one and the same shaft with no separate coupling that connects them in a driving relation. In other designs the pump shaft can be coupled to the motor shaft inside the motor housing. In still other designs, the motor and pump is drive-connected by means of a coupling located in a coupling chamber defined between the motor housing and the pump. However, in all alternatives it is desirable to maintain at all times a pressure difference over the interfaces, i.e. between the motor housing, the coupling chamber when present, and the pump lubrication system and the pumped medium, respectively.

Conventionally, a motor barrier fluid and a pump lubrication fluid are each supplied from a host facility, and leakage compensation as well as pressure control are managed from the host facility, usually via an umbilical. As subsea hydrocarbon production sites are increasingly installed and operated at increasing depths and step-out distances, the response times and control requirements in lubrication and cooling systems increase correspondingly. As a consequence, there is a rising need for a barrier fluid and lubrication system that operates with improved control requirements and which provides increased reliability in operation.

## SUMMARY OF THE INVENTION

The present invention thus aims at providing a barrier and lubrication fluids pressure regulation system for a subsea motor and pump module which avoids the

problems of prior art systems, and specifically those problems which are associated with long step-out distances and great water depths.

5 The present invention specifically aims at providing a barrier and lubrication fluids pressure regulation system for a subsea motor and pump module, the system having an inherent capability to adapt to pressure changes in the pumped medium. The present invention further aims at providing a barrier and lubrication fluids pressure regulation system having an inherent capability to compensate for loss of hydraulic fluid caused by leakage via seals and bearings in the motor and pump  
10 module. Still another object of the present invention is to provide a barrier and lubrication fluids pressure regulation system wherein a preset pressure differential between a barrier fluid circuit and a lubrication fluid circuit is automatically maintained at all times, and balanced towards the pumped medium pressure.

15 The barrier and lubrication fluids pressure regulation system of the present invention may advantageously be applied to a subsea motor and pump module which comprises a pump motor disposed in a motor housing; a pump disposed in a pump housing having a pump inlet at a suction side and a pump outlet at a discharge side of the pump, and a pump-rotor assembly arranged there between  
20 and journalled in bearings in the pump housing. The pump-rotor assembly is drive-connected to the motor through a drive-shaft that reaches between the motor and pump housings via a seal and bearing arrangement and is configured to displace a fluid medium from the pump inlet for discharge via the pump outlet.

25 Briefly, the object of the present invention is achieved in a barrier and lubrication fluids pressure regulation system for a subsea motor and pump module that is operable for displacement of a pumped medium from a pump suction side to a pump discharge side, the pressure regulation system comprising:

- 30
- a lubrication fluid circuit in flow communication with a hydraulic fluid supply via a first pressure reducing regulator
  - a barrier fluid circuit in flow communication with the hydraulic fluid supply via a second pressure reducing regulator, wherein
  - the first pressure reducing regulator is configured to reduce the supply fluid  
35 pressure in response to the pumped medium pressure at the suction side or at the discharge side of the pump, and

- the second pressure reducing regulator is configured to reduce the supply fluid pressure in response to the output pressure of the first pressure reducing regulator.

5 A system according to the invention provides immediate response to any change in the pumped medium pressure, as well as a simple and robust solution which continuously maintains a predetermined pressure difference between the barrier and lubrication fluid circuits and which at all times keeps the circuit pressures in balance with the pressure of the pumped medium.

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Preferably, each of the first and second pressure reducing regulators are dome-loading regulators with adjustable bias set to deliver an output pressure exceeding the dome loading pressure within a range of 2-10 bar. The output pressure of these regulators may typically be set to exceed the dome loading pressure with about 5

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bar.

The pumped medium pressure is preferably applied to the dome of the first pressure reducing regulator via a diaphragm, or via a pressure compensator, arranged to separate the fluids in a pilot circuit connecting the first pressure reducing regulator with the pumped medium at the suction side or at the discharge side of the pump.

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The embodiment provides immediate response to pressure variations in the pumped medium on the suction side or on the discharge side of the pump, while avoiding intrusion of process fluids, sea water and particulate matter into the pump lubrication circuit.

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Optionally, the pumped medium pressure may also be applied via a pilot circuit to the dome of a third pressure reducing regulator arranged in the hydraulic fluid supply upstream of the first and second pressure reducing regulators. This optional third pressure reducing regulator can be set to deliver an output pressure exceeding its dome loading pressure within the order of 20-50 bar. The output pressure of this regulator may typically be set to exceed the dome loading pressure with about 30 bar.

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35 The embodiment improves reliability and service life of the first and second pressure reducing regulators by reducing the load applied from the supply fluid pressure, which may range to an order of about 500 bar, e.g. The optional pressure reducing regulator constitutes a stepwise reduction from the supply fluid pressure to a

pressure level that exceeds the pumped medium pressure sufficiently for an adequate response to changes in the medium pressure.

5 However, in order to avoid interruption of operation caused by excessive pressure peaks or pressure build-up in the circuits, each of the barrier fluid circuit and the lubrication fluid circuit will be arranged to communicate with the pumped medium flow at the pump inlet or outlet via respective pressure controlled pressure relief regulators opening into the pilot circuit. These pressure relief regulators can be realized as dome-loaded back pressure regulators that are normally effective to  
10 reduce and vent the pressure in the barrier and lubrication fluid circuits typically during system start-up. A secondary function of the pressure controlled pressure relief regulators is to serve as safety relief valves.

15 More specifically, the pressure relief regulator in the lubrication fluid circuit can be a dome-loading back pressure regulator responsive to the pumped medium pressure at the suction side or at the discharge side of the pump. The pressure relief regulator in the barrier fluid circuit can be a dome-loading back pressure regulator responsive to the output pressure of the first pressure reducing regulator. Each of the back pressure regulators is set to open for dumping hydraulic fluid into the pilot  
20 circuit if the pressure in the lubrication fluid circuit or in the barrier fluid circuit, respectively, exceeds the dome loading pressure for the subject regulator by a preset amount of pressure which is higher than the output pressures of the first and second pressure reducing regulators. The output pressure of these regulators may typically be set to exceed the dome loading pressure with about 8 bar. As indicated  
25 above, the pressure relief regulators can also be seen as ultimate safety relief valves for the circuitry.

The pressure reducing regulators, as well as the back pressure regulators, may each be associated with a motor drive which is operable for setting the bias and thereby  
30 the pressure level of the subject regulator. The embodiment permits remote control and adjustment of flows and pressures from a topside facility.

In another aspect the present invention relates to a pressure regulation unit comprising:

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- a pressure vessel arranged to be exposed to surrounding seawater, the pressure vessel housing a volume of hydraulic fluid and being hydraulically

connectable to a lubrication fluid circuit in a subsea motor and pump module;

- a first pressure reducing regulator arranged in the pressure vessel, and configured to regulate a fluid flow from an external hydraulic fluid supply into the pressure vessel interior;
- a second pressure reducing regulator arranged in the pressure vessel, and configured to regulate a fluid flow between the external hydraulic fluid supply and a barrier fluid circuit in the subsea motor and pump module,
- wherein the output flow of the first pressure reducing regulator controls the internal pressure of the pressure vessel, and the output flow of the second pressure reducing regulator is responsive to the internal pressure of the pressure vessel.

Preferably, the first pressure reducing regulator is configured to control the internal pressure in the pressure vessel by reducing the pressure of supplied hydraulic fluid in response to the pumped medium pressure at a suction side or at a discharge side of the pump, which is communicated to the first pressure reducing regulator via a pilot line extended into the pressure vessel.

The pressure vessel may further comprise:

- a flow line connection that provides hydraulic fluid flow from a topside (offshore or onshore) hydraulic fluid supply;
- a flow line connection via which pumped medium pressure is communicated from the suction side or the discharge side of the pump to the first pressure reducing regulator;
- a flow line connection via which barrier fluid is supplied to the motor from the second pressure reducing regulator;
- a flow line connection via which lubrication fluid is supplied to the pump from the pressure vessel interior, and a flow line connection via which hydraulic fluid can be dumped into the pumped medium at the suction side or at the discharge side of the pump.

Without being limited to any specific type or model of motor and pump module, the barrier fluid and lubrication system and pressure regulating unit of the present invention is advantageously applied to a pump equipped with a twin-screw rotor, and the lubrication circuit is arranged to supply oil to pump bearings, as well as to

timing gears that are installed in the pump for synchronizing the rotation of the rotors.

#### SHORT DESCRIPTION OF THE DRAWINGS

5 In the following, preferred embodiments of the invention will be described in more detail with reference made to the accompanying, schematic drawings, of which

Fig. 1 is a diagram of the barrier and lubrication fluids pressure regulation system for a subsea motor and pump module, and

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Fig. 2 is a schematic view of a pressure regulation unit for a subsea motor and pump module.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

15 In the drawing of Fig. 1, reference number 1 refers to a subsea motor and pump module comprising a motor that is encased in a pressurized, water tight enclosure or motor housing 2, as well as a pump rotor assembly encased in a pump housing 3. The motor driving the pump is typically an electric motor, although other drive units such as hydraulic motors or turbines may alternatively be employed.

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The pump rotor is configured for displacement of a pumped medium, typically a multi-phase production fluid from a reservoir below the sea floor, which enters the pump via a pump inlet 4 to be discharged via a pump outlet 5, as illustrated by an arrow F. The pump rotor is drive-connected to the motor, and the pump interior is  
25 hydraulically separated from the pressurized (typically oil-filled) motor housing by means of a seal arrangement 6 which seals against the outside of a rotary shaft (indicated by reference number 7) by which the pump rotor is drive-connected to the motor. The pump bearings are separated from the pump medium by seal arrangements 8 and 9 at both ends of the pump. The pump rotor is journalled in  
30 bearing arrangements (not shown) in the pump housing 3.

Since the invention is not limited to any specific type or model of motor and pump assembly, but indeed can be applied to various motor and pump configurations which are involved in the transport of a hydrocarbon production fluid and operated  
35 by the skilled person, the internals of the motor and pump module 1 need not be discussed in detail.

Hydraulic fluid is supplied to the motor and pump module 1 via lines 10, 11, 12 from a hydraulic fluid supply (indicated by reference number 13), which may be located topside on a surface platform, or on a land based host facility, e.g. All other components of the barrier and lubrication fluids pressure regulation system are  
5 advantageously installed subsea.

A pressure accumulator may be arranged in the fluid line 10 to deliver hydraulic fluid at an operating pressure, which may be in the order of about 500 bar, e.g. The hydraulic fluid is supplied via pressure reducing regulators 14 and 15, the output  
10 flow of which is automatically adjusted concurrently with a change in fluid pressure in the barrier fluid and lubrication system. The pressure changes are caused by varying pressure in the pumped medium, and by leakage of hydraulic fluid through the sealing arrangements as illustrated by arrows L in Fig. 1.

15 The regulators 14 and 15, as well as any other pressure reducing regulator discussed below, may be any available type of dome loading pressure regulator designed for use at full sea depth, and which operates at the subject system pressures. The regulators are additionally equipped with an adjustable spring bias by which a regulator set point can be varied above the dome loading pressure. The  
20 regulators may advantageously be equipped with an electric (or hydraulic) motor drive (not illustrated) for remote adjustment of the regulator set point.

More precisely, the regulator 14 serves for refilling and pressurizing a motor barrier fluid circuit acting as a barrier at the interface between the motor and pump  
25 housings 2 and 3, and typically also providing lubrication and cooling fluid for the motor. In Fig. 1, line 11 connects the barrier fluid circuit with the hydraulic fluid supply via the regulator 14. Line 16 opens for hydraulic fluid from the regulator 14 into the motor housing interior. The barrier fluid circuit is indirectly connectable for flow communication with the pump inlet 4 via lines 17 and 18 which serve for  
30 dumping hydraulic fluid from the motor barrier fluid circuit via a pressure relief regulator valve 19, in case of a rise of the fluid pressure to a too high level. The fluid pressure in lines 16 and 17 of the motor barrier fluid circuit is controlled by the output pressure of the regulator 14, which is responsive to the fluid pressure in a  
35 line 20 that is applied to the dome of the pressure reducing regulator 14. The pressure reducing regulator 14 is arranged to open when downstream pressure in the barrier fluid circuit falls below the pressure in line 20, which is the lubrication fluid pressure as will be understood from below, by a preset amount.

Similarly, the regulator 15 serves for refilling and pressurizing a pump lubrication fluid circuit providing lubrication fluid to pump rotor bearings and, if appropriate, to timing gears which effect rotor synchronization in a twin-screw rotor pump. Line 12 connects the lubrication fluid circuit with the hydraulic fluid supply via the  
5 regulator 15. Lines 22 and 23 open for hydraulic fluid from the regulator 15 into the pump housing. The lubrication fluid circuit is indirectly connectable for flow communication with the pump inlet via lines 24 and 25 which serve for dumping hydraulic fluid from the motor barrier fluid circuit via a pressure relief regulator valve 26, in case of a rise of the fluid pressure to a too high level. The fluid pressure  
10 in lines 20, 22, 23 and 24 of the lubrication fluid circuit is controlled by the output pressure of the regulator 15, which is responsive to the fluid pressure in a line 27 that is applied to the dome of the pressure reducing regulator 15. The pressure reducing regulator 15 is arranged to open when downstream pressure in the lubrication fluid circuit falls below the pressure in line 27 by a preset amount.

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More precisely, the dome loading pressure applied to the regulator 15 via line 27 is the pressure of the pumped medium, which is communicated from the suction side of the pump to the regulator 15 via a pilot line 28. A separating diaphragm 29 is preferably incorporated in the pilot line to effect isolation of the pumped medium  
20 from a hydraulic fluid that is included in a pilot circuit comprising lines 27, 30 and 31. In this connection it should be clarified, that the pumped medium pressure communicated to the system can either be the pumped medium pressure at the suction side or at the discharge side of the pump. The choice of side is determined by flow direction through the pump and location of motor/pump seals.

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In result, the fluid pressure in the barrier fluid circuit is in this way balanced relative to the pressure in the lubrication fluid circuit, and a constant pressure difference between the two circuits is maintained at varying actual pressures in the lubrication fluid circuit. The pressure differential is determined by the bias of the  
30 pressure reducing regulator 14 which may be adjustable. A pressure differential of typically about 5 bar (72,5 psi) is in most cases considered appropriate.

In addition, the fluid pressures in the barrier and lubrication fluid circuits are together balanced relative to the pressure of the pumped medium. The pressure  
35 level is set by the medium pressure at the pump inlet which is added to the preset bias of the second pressure reducing regulator 15 and applied to the fluid in the lubrication fluid circuit. The pressure difference between the pumped medium and circuit pressures is determined by the bias of the regulator 15, which may be

adjustable. A pressure differential of typically about 5 bar (72,5 psi) is in most cases considered appropriate.

5 With respect to the sequence of pressure regulation effected by the regulators 14 and 15 arranged in a series, the regulator 15 can be regarded as a first pressure reducing regulator and the regulator 14 can be regarded as a second pressure reducing regulator.

10 In order to manage a rise of pressure in any of the barrier and lubrication fluid circuits to a too high level, hydraulic fluid can be dumped from the circuits into the pilot line 28 via the pressure relief regulator valves 19 and 26. The pressure relief regulator valves are advantageously realized in the form of dome loading back pressure regulators. The regulator 19 is responsive to the lubrication fluid circuit pressure in line 20 which is communicated to the dome of the regulator 19, which is  
15 set to open when upstream pressure in the barrier fluid circuit 17 exceeds the lubrication fluid pressure in line 20 by a preset amount. Similarly, the regulator 26 is responsive to the pumped medium pressure which is communicated to the dome of the regulator 26 via line 31, and the regulator 26 is set to open when upstream pressure in the lubrication fluid circuit 24 exceeds the pumped medium pressure by  
20 a preset amount. In both cases, the regulators may be set to open at a pressure difference of about 8 bar.

Likewise in order to manage a sudden critical situation, such as hydrocarbon  
25 detection external to the pump e.g., an isolation valve 32 is preferably arranged to cut pressure communication between the pumped medium and the barrier and lubrication fluid circuits.

In order to avoid gas accumulation in the pilot line 28 or in the housing of the diaphragm 29, which could cause misreading of the actual pumped medium  
30 pressure due to compression or hydrate formation, a pipe loop 33 can be included in the pilot line to effect capture of a gas phase portion of a multi-phase production fluid.

35 Further, in order to avoid hydrate formation and solidification of gaseous and liquid components of a multi-phase production fluid in the pilot line 28, the pilot line as well as the fluid dumping lines 18 and 25 may be associated with a heating trace 34 which is effective for maintaining fluid temperature in these lines above a solidification temperature for the fluid components.

A dome loading pressure reducing regulator 35 may optionally be arranged in the hydraulic fluid supply 10 upstream of the first and second pressure reducing regulators 14 and 15. The regulator 35 is responsive to the pumped medium pressure which is communicated to the dome of the regulator 35 via the pilot circuit  
5 line 30. The regulator 35 reduces downstream pressure in the hydraulic fluid supply lines 11 and 12, and includes an adjustable spring bias by which the regulator 35 can be preset to deliver an output pressure exceeding its dome loading pressure within the order of 20-50 bar, preferably exceeding its dome loading pressure with about 30 bar.

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In order to complete the description of the set up of Fig. 1 it should also be mentioned that an external cooler 21 may be incorporated in the motor barrier fluid circuit.

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With reference to Fig. 2 a pressure regulation unit for the subsea motor and pump module 1 will now be explained. In Fig. 2, the system components already discussed with reference to Fig. 1 are referenced by the same reference numbers as those used in Fig. 1. Since the operation and interaction between the system components are also the same as previously discussed, these need no further explanation with  
20 reference to Fig. 2.

In the embodiment of Fig. 2, however, the pressure regulating components and associated fluid circuitry are housed in hydraulic fluid inside a pressure vessel 36. The pressure vessel 36 is configured to be located subsea and can be arranged for  
25 standing on the sea floor or arranged to be coupled to, or integrated with, the motor and pump module.

The pressure in pressure vessel 36 is controlled by the pressure reducing regulator 15 which provides flow communication between an external hydraulic fluid supply  
30 10 and the interior of pressure vessel 36. The volume of hydraulic fluid in pressure vessel 36 is in flow communication with the pump seals and bearings via fluid flow lines 22 or 23 of the lubrication fluid circuit, in which the pressure is determined by the internal pressure of pressure vessel 36. The same pressure is applied to the dome of the pressure reducing regulator 14 which supplies hydraulic fluid from the external fluid supply to the motor via lines 11, 16 and 17 of the barrier fluid circuit.  
35 Pumped medium pressure is communicated to the regulator 15 via a pilot pressure line 30 that is introduced through the wall of the pressure vessel, connecting to the pilot pressure circuit 27, 30 and 31 inside the pressure vessel. A supply fluid

pressure reducing regulator 35 as previously discussed may additionally be arranged inside the pressure vessel 36. Pressure relief regulator valves in the form of back pressure reducing regulators 19 and 26 may be arranged as illustrated to dump hydraulic fluid via a common flow line 18 or 25.

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A coupling interface to the motor and pump module can be reduced to a low number of flow line connections such as: a flow line connection via which pumped medium pressure is communicated from the suction side of the pump to a first pressure reducing regulator 15; a flow line connection via which barrier fluid is supplied to the motor from a second pressure reducing regulator 14; a flow line connection via which lubrication fluid is supplied to the pump from the pressure vessel interior, and a flow line connection via which hydraulic fluid can be dumped into the pumped medium at the suction side of the pump. Naturally, one connection that provides fluid flow from a topside hydraulic fluid supply is additionally required. An electrical interface may also be included in the pressure regulator unit, through which electrical power can be supplied to regulator motor drives, if appropriate, and via which the regulator settings and/or fluid circuit pressures can be returned to a control logic that is monitored and operated from a topside location.

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The pressure vessel 36 provides a compact unit configured for controlling the barrier and lubrication fluid pressures in a subsea motor and pump module. Except for the necessary connections, the pressure regulating unit may be given a non-complicated, box-like design, which is easy to handle and easy to install at a subsea production site. In order to allow for disconnection by a Remotely Operated Vehicle (ROV) so as to be retrieved to surface for replacement and/or repair, the pressure vessel advantageously comprises a base plate with automatic hydraulic couplings allowing the unit to be installed onto a mounting base arranged on the motor/pump module.

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The invention is of course not in any way restricted to the embodiments described above. On the contrary, many possibilities to modifications thereof will be apparent to a person with ordinary skill in the art without departing from the basic idea of the invention such as defined in the appended claims.

## CLAIMS

1. A barrier and lubrication fluids pressure regulation system for a subsea motor and pump module operable for displacement of a pumped medium from a pump suction side to a pump discharge side, the pressure regulation system comprising:  
- a lubrication fluid circuit (12, 22, 23, 24, 27, 30, 31) in flow communication with a hydraulic fluid supply via a first pressure reducing regulator (15);  
- a barrier fluid circuit (11, 16, 17, 20) in flow communication with the hydraulic fluid supply via a second pressure reducing regulator (14), wherein  
- the first pressure reducing regulator (15) is configured to reduce the supply fluid pressure in response to the pumped medium pressure at the suction side (4) or at the discharge side (5) of the pump, and the second pressure reducing regulator (14) is configured to reduce the supply fluid pressure in response to the output pressure of the first pressure reducing regulator (15).
2. The system of claim 1, wherein each of the first and second pressure reducing regulators (15; 14) are dome-loading regulators with adjustable bias set to deliver an output pressure exceeding the dome loading pressure within a range of 2-10 bar, preferably exceeding the dome loading pressure with about 5 bar.
3. The system of claim 2, wherein the pumped medium pressure is applied to the dome of the first pressure reducing regulator (15) via a diaphragm (29), or via a pressure compensator, arranged to separate the fluids in a pilot circuit (27, 28, 30) connecting the first pressure reducing regulator (15) with the pumped medium.
4. The system of any previous claim, wherein the pumped medium pressure is further applied via a pilot circuit (28, 30) to the dome of a third pressure reducing regulator (35) arranged in the hydraulic fluid supply upstream of the first and second pressure reducing regulators, the third pressure reducing regulator set to deliver an output pressure exceeding its dome loading pressure within a range of 20-50 bar, preferably exceeding its dome loading pressure with about 30 bar.
5. The system of any previous claim, wherein each of the barrier fluid circuit and the lubrication fluid circuit communicate with the pump inlet or the pump outlet via respective pressure controlled pressure relief regulator valves (19; 26) opening into the pilot line (28).
6. The system of claim 5, wherein the pressure relief regulator valve in the lubrication fluid circuit is a dome-loading back pressure regulator (26) responsive to

the pumped medium pressure at the suction side or at the discharge side of the pump.

5 7. The system of claim 5, wherein the pressure relief regulator valve in the barrier fluid circuit is a dome-loading back pressure regulator (19) responsive to the output pressure of the first pressure reducing regulator (15).

10 8. The system of any previous claim, wherein the pressure reducing regulators (14, 15) and the back pressure regulators (19, 26) are each associated with a motor drive, respectively, which is operable for setting the bias of the subject regulator.

9. A barrier and lubrication fluids pressure regulation unit comprising:  
- a pressure vessel (36) arranged to be exposed to surrounding seawater, the pressure vessel housing a volume of hydraulic fluid and being hydraulically  
15 connectable to a lubrication fluid circuit in a subsea motor and pump module;  
- a first pressure reducing regulator (15) arranged in the pressure vessel, and configured to regulate a fluid flow from an external hydraulic fluid supply into the pressure vessel interior;  
- a second pressure reducing regulator (14) arranged in the pressure vessel, and  
20 configured to regulate a fluid flow between the external hydraulic fluid supply and a barrier fluid circuit in the subsea motor and pump module,  
wherein the output flow of the first pressure reducing regulator (15) controls the internal pressure of the pressure vessel, and the output flow of the second pressure reducing regulator (14) is responsive to the internal pressure of the pressure vessel.

25 10. The pressure regulation unit of claim 9, wherein the first pressure reducing regulator (15) is configured to control the internal pressure in the vessel (36) by reducing the pressure of supplied hydraulic fluid in response to the pumped medium pressure at a suction side or at a discharge side of the pump via a pilot line  
30 (30) extended into the pressure vessel (36).

11. The pressure regulation unit of claim 10, wherein the pressure vessel (36) comprises:  
- a flow line connection that provides hydraulic fluid flow from a hydraulic fluid  
35 supply (10);  
- a flow line connection via which pumped medium pressure is communicated from the suction side or from the discharge side of the pump to the first pressure reducing regulator (15);

- a flow line connection via which barrier fluid is supplied to the motor from the second pressure reducing regulator (14);
- a flow line connection via which lubrication fluid is supplied to the pump from the pressure vessel interior, and
- 5 - a flow line connection via which hydraulic fluid can be dumped into the pumped medium at the suction side or at the discharge side of the pump.

12. The pressure regulation unit of any of claims 9-11, wherein the pressure vessel (36) houses the components of the barrier and lubrication fluids pressure regulation  
10 system according to any of claims 1-8.

13. The pressure regulation unit of any of claims 9-11, wherein the pressure vessel is made with a base plate with hydraulic couplings allowing the unit to be installed onto a mounting base allowing for disconnection by an Remotely Operated Vehicle  
15 (ROV) and retrieved to surface for replacement and/or repair.

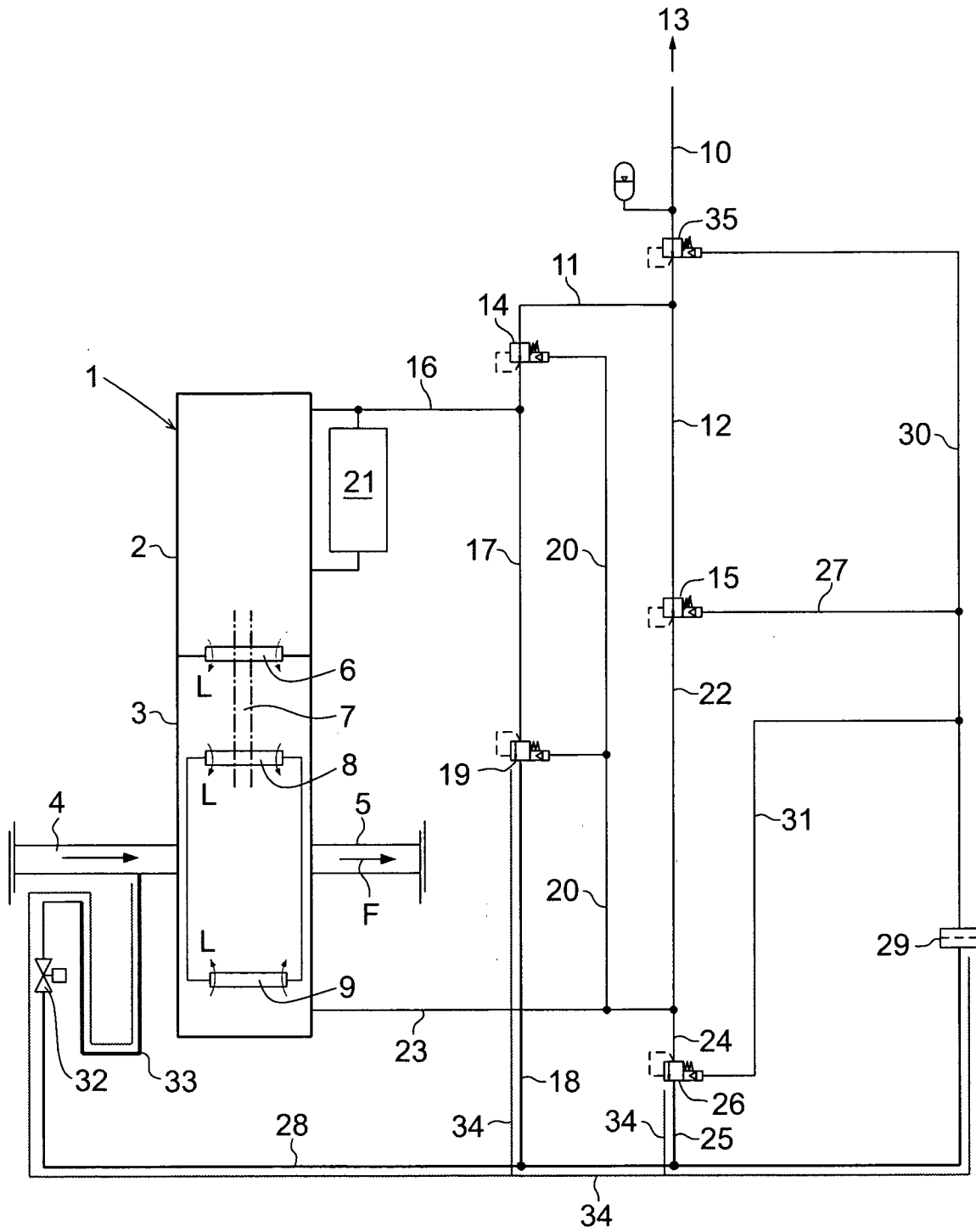


Fig. 1

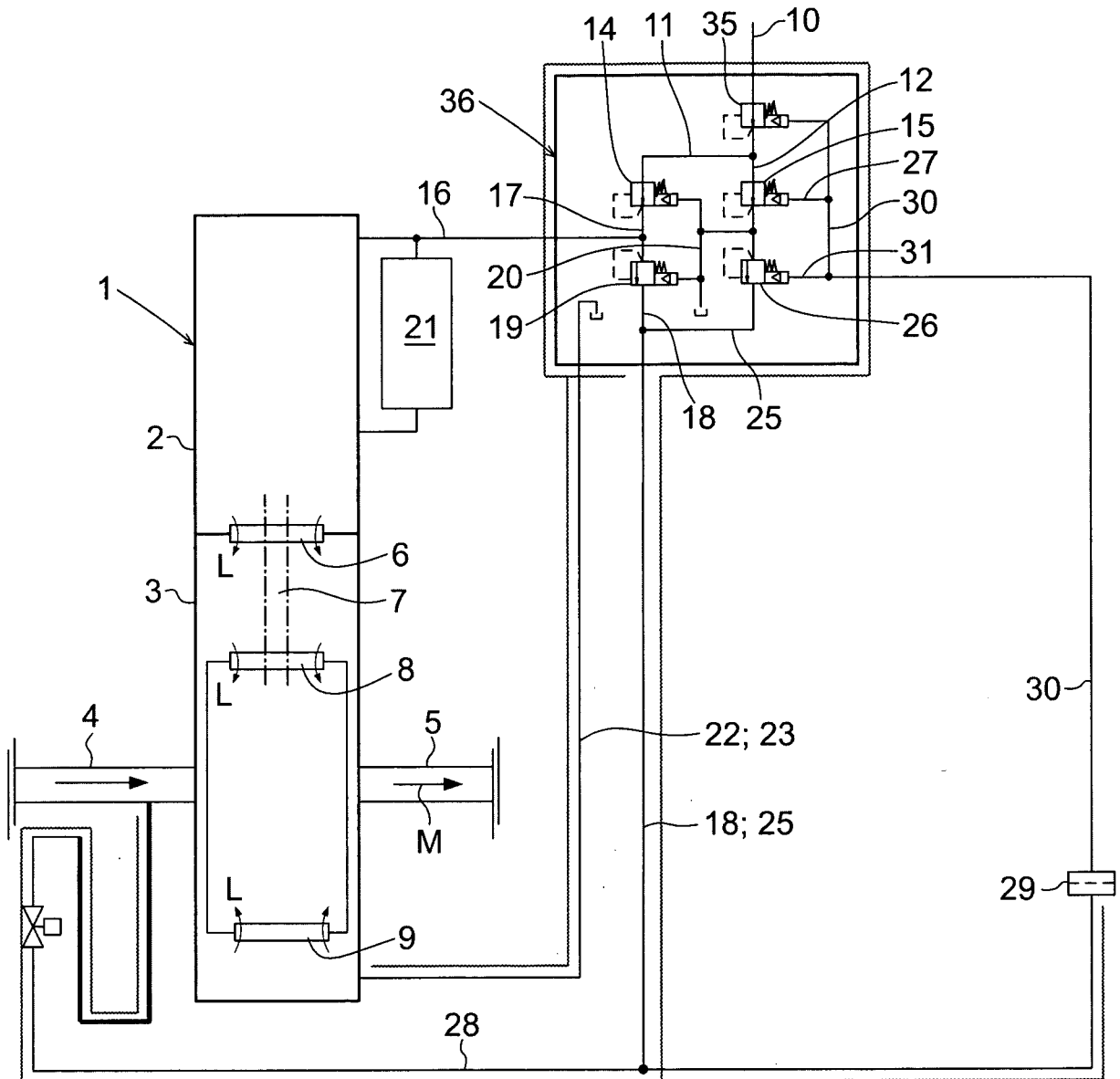


Fig. 2

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/IB2011/001399

A. CLASSIFICATION OF SUBJECT MATTER		
IPC: see extra sheet		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC: B63C, E21B, F04B, F04D, F16J, F16N		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE, DK, FI, NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EPO-Internal, PAJ, WPI data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9853182 A1 (WESTINGHOUSE ELECTRIC CORP), 26 November 1998 (1998-11-26); abstract; figures 1-4 --	1-13
A	WO 2008115064 A1 (FRAMO ENG AS ET AL), 25 September 2008 (2008-09-25); abstract; page 2, line 29 - line 36; figures 1-6; claims 1, 16 --	1-13
A	US 20060231265 A1 (MARTIN DAVID W), 19 October 2006 (2006-10-19); figures 1-3; claims 10, 16 -- -----	1-13
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
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Date of the actual completion of the international search 29-09-2011		Date of mailing of the international search report 11-10-2011
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86		Authorized officer Lena Nilsson Telephone No. + 46 8 782 25 00

**Continuation of:** second sheet

**International Patent Classification (IPC)**

**E21B 43/01** (2006.01)  
**B63C 11/00** (2006.01)  
**E21B 43/12** (2006.01)  
**F04B 53/16** (2006.01)  
**F04D 29/10** (2006.01)  
**F16J 15/40** (2006.01)  
**F16N 17/00** (2006.01)

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Cited literature, if any, will be enclosed in paper form.

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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