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- (71) **Applicant:** ABB TECHNOLOGY LTD [CH/CH]; Affolternstrasse 44, CH-8050 Zürich (CH).
- (72) **Inventors:** SPINDLER, Christian; Obere Schöneeggstrasse 5, CH-8707 Uetikon am See (CH). GRADINGER, Thomas; Birkenweg 3, CH-5032 Aarau Rohr (CH).
- (74) **Agent:** SAVELA, Reino; ABB AB, Intellectual Property, Ingenjör Bååths Gata 11, S-721 83 Västerås (SE).
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(54) **Title:** SUBSEA UNIT COMPRISING A TWO-PHASE COOLING SYSTEM

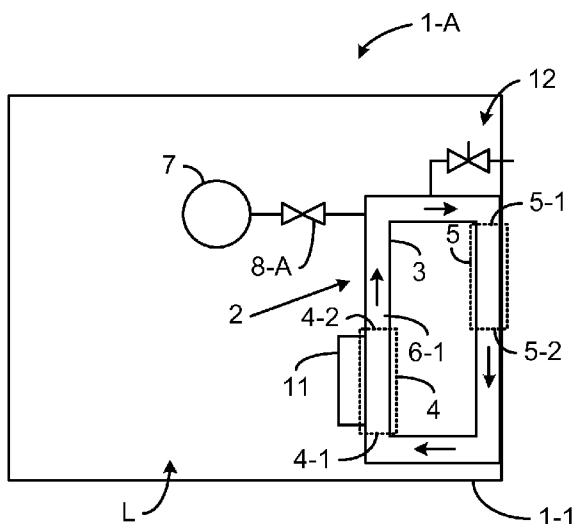


Fig. 1a

(57) **Abstract:** The present disclosure relates to a subsea unit (1-A) arranged to house an electric or electronic device (11). The subsea unit (1-A) comprises a two-phase cooling system (2) arranged to cool the electric or electronic device (11), which two-phase cooling system (2) has an evaporator (4), a condenser (5), and a conduit (3) which together with the evaporator (4) and condenser (5) forms a closed loop for circulating a cooling fluid, wherein the evaporator (4) is arranged to be in thermal connection with the electric or electronic device (11), and wherein the subsea unit (1-A) has an enclosure (1-1) arranged to enclose the two-phase cooling system (2), which enclosure (1-1) has a portion that is mechanically flexible such that an ambient subsea pressure can be transmitted to the inside of the enclosure, and wherein the subsea unit (1-A) comprises a liquid (L) for counter-acting deformation of the enclosure when subject to an ambient subsea pressure higher than a pressure that the enclosure can withstand. A subsea power system is also presented herein.

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SUBSEA UNIT COMPRISING A TWO-PHASE COOLING SYSTEM

TECHNICAL FIELD

- 5 The present disclosure generally relates to subsea installations and in particular to a subsea unit comprising a two-phase cooling system for cooling an electric or electronic device arranged in the subsea unit.

BACKGROUND

Power semiconductors are employed as main switching elements in power
10 electronic equipment such as frequency converters. Cooling systems are essential in power electronic devices to transfer the heat generated by the power semiconductors. Frequency converters in the medium voltage and power range drive electric motors by controlling the speed and torque of these machines and are a well proven equipment in the entire onshore and
15 offshore platform based industry.

In recent years, there has been a growing interest in installing electrical installations on the sea floor in depths from a few tens of meters to even kilometres. Oil and gas production subsea employs electric equipment like drilling motors, pumps, and compressors that are currently driven by
20 frequency converters located on topside platforms. Electric power is provided to the subsea machinery by expensive umbilicals. By installing frequency converters and other power electronic equipment subsea, cables and topside installations could be spared and enormous cost savings could be achieved.

In bringing power electronics subsea, two general concepts exist: (1) the
25 equipment stays at atmospheric pressure; and (2) the equipment is pressurized to the hydrostatic pressure level on seabed. The two concepts can be differentiated as follows. Concept (1) has the advantage that standard electric/electronic components, known from onshore installations, can be used, while disadvantages include thick walls needed for the enclosure to

- withstand the pressure difference between inside and outside. Thick walls make the equipment heavy and costly. In addition, heat transfer through thick walls is not very efficient and huge, expensive cooling units are required. Concept (2) has the advantage that no thick walls are needed for the enclosure since no pressure difference exists between inside and outside the containment. Cooling is greatly facilitated by thin walls. Disadvantages of concept (2) are that all the components must be free of gas inclusions and compressible voids, otherwise they implode during pressurization and are destroyed.
- 10 “Controlled subsea electric power distribution with SEPDIS™” by Sølviik et al. published in ABB Review 2/2000 discloses a two-phase cooling system relating to concept (1). In particular this paper discloses a passive cooling system arranged to cool a subsea frequency converter of a very thick wall pressure vessel.
- 15 The problem of cooling power electronics in subsea equipment is however not yet solved satisfyingly. Challenges include *inter alia* reducing the size and cost of currently applied, thick-walled heat exchangers.

SUMMARY

In view of the above, a general object of the present disclosure is to provide a subsea unit that solves or at least mitigates the problems of the prior art.

Hence, according to a first aspect of the present disclosure there is provided a subsea unit arranged to house an electric or electronic device, wherein the subsea unit comprises a two-phase cooling system arranged to cool the electric or electronic device, which two-phase cooling system has an evaporator, a condenser, and a conduit which together with the evaporator and condenser forms a closed loop for circulating a cooling fluid, wherein the evaporator is arranged to be in thermal connection with the electric or electronic device, and wherein the subsea unit has an enclosure arranged to enclose the two-phase cooling system, which enclosure has a portion that is mechanically flexible such that an ambient subsea pressure can be

transmitted to the inside of the enclosure, and wherein the subsea unit comprises a liquid for counteracting deformation of the enclosure when subject to an ambient subsea pressure higher than a pressure that the enclosure can withstand.

- 5 By means of a two-phase cooling system in a pressurised subsea unit which has an enclosure having a portion that is mechanically flexible to allow ambient subsea pressure to be transmitted to the inside of the subsea unit, robust, efficient and affordable subsea cooling may be provided. When the subsea unit is submerged into water, water flowing on the outside of the
10 enclosure may for example have a cooling effect on e.g. the condenser.

According to one embodiment the conduit has a portion that is mechanically flexible so as to allow pressure inside the enclosure and outside the conduit to be transmitted to the inside of the conduit.

- 15 According to one embodiment the two-phase cooling system comprises a cooling fluid comprising at least two components that provide a thermodynamic two-phase state of the cooling fluid at a pressure higher than the critical pressure of any of the individual components of the cooling fluid. When a single-component two-phase cooling system is pressurised to ambient sea-water pressure, which for example may be in the range of 100
20 to 400 bar and above the critical pressure of the single component, there is no difference between liquid and gas any more, and hence there is no liquid-gas two-phase equilibrium any more. At pressures equal to or higher than the critical pressure, vapour-liquid cooling is not possible any more, since there is no latent heat or vaporisation anymore and no density difference between
25 vapour and liquid can drive the fluid motion in a passive cooling cycle. Even at pressures slightly below the critical pressure, two-phase cooling does not work efficiently, since the latent heat of vaporisation decreases strongly towards the critical pressure. No known single-component fluids have critical pressures suitable for deep sea applications. Moreover, apart from the
30 requirement of a sufficiently high critical pressure, also the boiling temperature at the pressure of interest should be in the right range. The

boiling temperature should be around 60 °C for power-electronics cooling. Hence, the boiling temperatures of those single-component fluids available for higher pressures, e.g. ammonium and water, are far too high even for pressures around 100 bar.

- 5 According to one embodiment the at least two components are adapted to provide a thermodynamic two-phase state of the cooling fluid at ambient pressure at a depth at which the subsea unit is to be installed. Advantageously, the at least two components are adapted to provide a vapour-liquid two phase state at ambient pressures at a depth at which the
10 subsea unit is to be installed

- According to one embodiment the conduit is partially filled with the cooling fluid when the conduit is subjected to sea level pressure, and wherein the subsea unit comprises a pressure compensating vessel comprising additional cooling fluid, and a valve, wherein the conduit is arranged to be in fluid
15 connection with the pressure compensation vessel via the valve such that the additional cooling fluid is able to flow from the pressure compensating vessel to the conduit when the subsea unit is subjected to a pressure that is higher than a pressure inside the conduit. Thereby thick walls of the conduit of the two-phase cooling system may be avoided. Thick walls are costly and are
20 detrimental to the thermal performance. In order to avoid thick walls, pressure differences across the conduit walls should be kept low. In particular, the pressure in the conduit should be continuously adapted to the outside pressure when lowering the equipment to seabed; i.e. the pressure in the conduit should successively be increased from atmospheric pressure to
25 water pressure on the seabed.

- According to one embodiment the additional cooling fluid in the pressure compensating vessel is pressurised to seabed pressure of a depth at which the subsea unit is to be installed. Hence, during the lowering of the subsea unit to seabed, the valve may open just enough to let as much additional cooling
30 fluid pass to the conduit as is necessary to increase the conduit pressure to about ambient pressure.

According to one embodiment the valve has a body having a through opening in the axial direction of a conduit portion connected to the valve, which valve is movable in a radial direction of the conduit portion between a first position in which the body blocks the additional cooling fluid from flowing from the pressure compensating vessel to the conduit and a second position in which the through opening is aligned with the interior of the conduit portion to thereby allow the additional cooling fluid to flow from the pressure compensating vessel to the conduit. Hence, a simple passive mechanical valve construction may be provided, reducing the risk of equipment failure.

10 According to one embodiment the valve has a first end in fluid communication with the cooling fluid in the conduit and a second end, opposite the first end, subjected to ambient pressure, wherein a pressure difference between the first end and the second end allows the body to move between the first position and the second position.

15 One embodiment comprises a mechanical spring arranged to provide a force in the radial direction at the first end of the valve so as to enable the body to move from the second position to the first position.

As an alternative to the mechanical valve construction, one embodiment may comprise a first pressure sensor and a second pressure sensor arranged to measure a pressure in the conduit and outside the conduit in the subsea unit, respectively, and a control unit arranged to control the valve based on measurements of the first pressure sensor and the second pressure sensor.

One embodiment comprises a pressure-relief valve connecting the conduit and an exterior of the subsea unit, wherein the pressure-relief valve is arranged to open when the ambient pressure in the subsea unit is lower than the pressure in the conduit to thereby let a portion of the cooling fluid escape the subsea unit. Thereby the subsea unit may be raised from the seabed to atmospheric pressure for servicing, as the cooling fluid can escape to ambience via the pressure-relief valve. The pressure-relief valve may be a passive device that opens once the pressure in the conduit exceeds the

ambient pressure by a certain amount, similar to a steam cooker. This way, significant overpressure in the conduit is avoided at any time. The cooling fluid may be environmentally friendly, such that the cooling fluid that has escaped will not harm the environment.

- 5 According to one embodiment the condenser is in thermal connection with an exterior of the enclosure.

According to one embodiment, the two-phase cooling system comprises a cooling liquid, and wherein the conduit, the evaporator and the condenser have walls that are thick enough to withstand a pressure difference between a
10 sealing pressure inside the conduit, the evaporator and the condenser, which sealing pressure is a pressure at which the cooling liquid has been sealed in the two-phase cooling system, and ambient pressure at a depth at which the subsea unit is to be installed

The subsea unit may advantageously be included in a subsea power system
15 such as a transmission system or distribution system.

Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, etc. are to be interpreted openly as referring to at least one instance of the
20 element, apparatus, component, means, etc., unless explicitly stated otherwise. Moreover, any step in a method need not necessarily have to be carried out in the presented order, unless explicitly stated otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

The specific embodiments of the inventive concept will now be described, by
25 way of example, with reference to the accompanying drawings, in which:

Fig. 1a is a side view of a first example of a subsea unit for subsea installation;

Fig. 1b is a side view of a second example of a subsea unit for subsea installation; and

Figs 2a-b depict an example of a valve for ambient pressure adaptation of the cooling system of the subsea unit in Fig. 1a when lowering the subsea unit to the seabed.

DETAILED DESCRIPTION

5 The inventive concept will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplifying embodiments are shown. The inventive concept may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by
10 way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the inventive concept to those skilled in the art. Like numbers refer to like elements throughout the description.

Fig. 1a depicts a side view, with the enclosure on the side cut-away, of a first example of a subsea unit for installation on the seabed. Subsea unit 1-A has
15 an enclosure 1-1, and comprises an electric or electronic device 11, a two-phase cooling system 2 arranged to cool the electric or electronic device 11, a pressure compensating vessel 7, a valve 8-A, and a pressure relief-valve 12.

Examples of an electronic device are power electronic devices such as insulated gate bipolar transistors (IGBT) or integrated gate-commutated
20 thyristors (IGCT) while examples of an electric device is a frequency converter or a transformer, which in the former case includes power electronic devices such as IGBTs.

The two-phase cooling system 2 comprises a conduit 3, an evaporator 4, a condenser 5 and cooling fluid 6-1. The conduit 3 forms a closed loop together
25 with the evaporator 4 and the condenser 5 for circulating the cooling fluid 6-1 to thereby achieve cooling of the electric or electronic device 11.

According to one variation of the two-phase cooling system 2, the evaporator 4 has an inlet 4-1 and an outlet 4-2, and the condenser 5 has an inlet 5-1 and an outlet 5-2, wherein the conduit 3 connects the outlet 4-2 of the evaporator

4 with the inlet 5-1 of the condenser 5 and the outlet 5-2 of the condenser 5 with the inlet 4-1 of the evaporator 4. To that end, the conduit may either be a single piece conduit, or it may alternatively comprise several parts, e.g. a first part connecting the outlet of the evaporator to the inlet of the condenser and
5 a second part connecting the outlet of the condenser to the inlet of the evaporator.

The two-phase cooling system 2 is preferably vertically oriented in the subsea unit 1-A when the subsea unit 1-A is installed on the seabed to thereby allow gravity-driven circulation of the cooling fluid 6-1. Thus, when the subsea unit
10 1-A is installed on the seabed, the section of the conduit 3 provided with the evaporator 4 provides a cooling fluid flow vertically upwards, and the section of the conduit 3 provided with the condenser 5 provides a cooling fluid flow vertically downwards in the direction of the seabed. According to one variation of the two-phase cooling system 1-1, the evaporator 4 and the
15 condenser 5 are arranged in different horizontal planes when the subsea unit 1-A is arranged on the seabed. The evaporator 4 is arranged at a lower end of a first vertical portion of the conduit 3, through which the cooling fluid 6-1 is arranged to flow upwards, and the condenser 5 is arranged at an upper end of a second vertical portion of the conduit 3, through which the cooling fluid 6-1
20 is arranged to flow downwards, as shown in Figs 1a-b.

According to one variation of the subsea unit 1-A, the evaporator 4 is in thermal connection with the electronic or electric device 11 such that the heat emitted by the electronic or electric device 11 may be transmitted to the cooling fluid 6-1 for vaporisation thereof. According to one variation of the
25 subsea unit 1-A, the condenser 5 is in thermal connection with an exterior of the enclosure 1-1 such that condensation of the cooling fluid 6-1 in vaporised state may be obtained. Optionally, fins may be provided on the external surface of the enclosure. As an alternative, the condenser could be provided outside the enclosure for direct seawater cooling of the condenser.

30 For the purpose of transmitting the ambient subsea pressure to the inside of the enclosure 1-1, the enclosure 1-1 has a portion that is mechanically flexible.

Furthermore, subsea unit 1-A comprises a liquid L for counteracting deformation of the enclosure 1-1 when the subsea unit 1-A is subject to an ambient subsea pressure higher than a pressure that the enclosure can withstand without deformation. Hereto, the liquid L fills the interior space of the subsea unit 1-A so as to prevent the occurrence of any air gaps between the inside surface of the enclosure 1-1 and any internal component of the subsea unit 1-A. The liquid L is advantageously a dielectric liquid such as oil in order to prevent short circuit of the electric or electronic device 11.

According to one variation of the two-phase cooling system 2, conduit 3 has a portion that is mechanically flexible so as to allow external pressure on the mechanically flexible portion of the conduit 3 to be transmitted to the interior of the conduit 3. Ambient pressure adaptation in the conduit 3 may thereby be obtained. Alternatively, the conduit, the evaporator and the condenser may have walls that are thick enough to withstand a pressure difference between a sealing pressure inside the conduit, the evaporator and the condenser and ambient pressure at a depth at which the subsea unit is to be installed. By sealing pressure is meant the pressure at which the cooling liquid is sealed in the two-phase cooling system when the two-phase cooling system is manufactured. According to this latter alternative, the pressure compensating vessel, the valve connecting the two-phase cooling system and the pressure compensating vessel, and the pressure-relief valve may be dispensed with as the pressure, i.e. the sealing pressure, in the two-phase cooling system is essentially constant at any ambient pressure which it has been constructed to withstand.

Preferably the cooling fluid 6-1 comprises at least two components which provide a thermodynamic two-phase state of the cooling fluid 6-1 at a pressure higher than the critical pressure of any of the individual components of the cooling fluid 6-1. In particular, the at least two components are selected so as to provide a thermodynamic two-phase state of the cooling liquid 6-1 also at ambient pressures at the depth at which the subsea unit 1-A is to be installed. More specifically, the at least two components are selected so as to provide a vapour-liquid two phase state also at ambient pressures at the

depth at which the subsea unit 1-A is to be installed. The cooling fluid 6-1 may be a two-component mixture or a multi-component mixture comprising more than two components. The at least two components of the cooling fluid 6-1 may according to one variation be selected in such a way that they provide
5 thermodynamic two-phase state of the cooling fluid also at atmospheric pressure. There exist a plurality of two-component and multi-component fluids suitable for the deep sea cooling purposes of this disclosure, for which ambient pressures on the seabed typically ranges from 100 to 400 bar.

When the subsea unit 1-A, and thus the conduit 3, is subjected to atmospheric
10 pressure prior to installation on the seabed, the conduit 3 is advantageously only partially filled with cooling fluid 6-1. In order to be able to adapt the pressure in the conduit to ambient pressure, the pressure compensating vessel 7 comprises additional cooling fluid of the same kind as cooling fluid 6-1 in the conduit 3. The valve 8-A provides a fluid connection between the
15 pressure compensating vessel 7 and the conduit 3 such that the additional cooling fluid may flow from the pressure compensating vessel 7 to the conduit 3 through the valve 8-A when the ambient pressure in the subsea unit 1-A becomes higher than the pressure inside the conduit 3. When manufacturing the subsea unit 1-A, the additional cooling fluid in the
20 pressure compensating vessel is advantageously pressurised to seabed pressure of a depth at which the subsea unit is to be installed.

Fig. 2a is a cross-sectional side view of a portion 3-1 of the conduit 3 when connected to the valve 8 and the pressure compensating vessel 7. The valve 8-A, which is arranged in a valve case 8-0 at the interface between the conduit 3
25 and the pressure compensating vessel 7, has a body 8-1 having a through opening 8-2 in the axial direction A of the conduit portion 3-1 connected to the valve 8, a first end 8-3 and a second end 8-4 opposite the first end 8-3. The valve 8 further comprises a mechanical spring 8-5 arranged to apply a force in a radial direction r of the conduit portion 3-1 at the first end 8-3 of
30 the valve 8.

The body 8-1 is movable in the valve case 8-0 in the radial direction r between a first position in which the body 8-1 blocks additional cooling fluid from flowing from the pressure compensating vessel 7 to the conduit 3, as shown in Fig. 2a, and a second position in which the through opening 8-2 is aligned with the interior of the conduit portion 3-1 to thereby allow
5 additional cooling fluid 6-2, pressurised to a pressure $P-2$ corresponding to the pressure at which the subsea unit 1-A is to be installed, to flow from the pressure compensating vessel 7 to the conduit 3, as shown in Fig. 2b. The body 8-1 moves from the first position when there is a sufficient pressure
10 difference between ambient pressure $P-3$ applied to the second end 8-4 of the body 8-1 and a pressure P_4 applied to the first end 8-3 by the mechanical spring 8-5 and a pressure $P-1$ in the conduit 3. When the pressure $P-1$ in the conduit 3 has been adapted to ambient pressure $P-3$, the body 8-1 moves from the second position to the first position due to the force applied by the
15 mechanical spring 8-5 on the first portion 8-3 of the body 8-1, thereby blocking further additional cooling fluid 6-2 from flowing from the pressure compensating vessel 7 to the conduit 3.

The pressure-relief valve 12 connects the conduit 3 and an exterior of the subsea unit 1-A. Similarly to a pressure cooker, the pressure-relief valve 12 is
20 arranged to open when the ambient pressure in the subsea unit 1-A is lower than the pressure in the conduit to thereby let a portion of the cooling fluid 6-1 escape the subsea unit 1-A.

Fig. 1b shows a second example of a subsea unit. Subsea unit 1-B is similar to subsea unit 1-A of the first example, except for valve 8-B connecting the
25 pressure compensating vessel 7 and the conduit 3, a control unit 9, a first pressure sensor 10-1 and a second pressure sensor 10-2. The first pressure sensor 10-1 is arranged to measure a pressure in the conduit 3 and the second pressure sensor 10-2 is arranged to measure the ambient pressure in the subsea unit 1-B, outside the conduit 3. The control unit 9 is connected to each
30 of the sensors 10-1 and 10-2, and is arranged to provide a control signal to the valve 8-B to open when the ambient pressure outside the conduit measured by the second pressure sensor 10-2 is sufficiently higher than the pressure

measured by the first pressure sensor 10-1. When the pressure inside the conduit 3 has been adapted to the ambient pressure, the control unit 9 is arranged to send a control signal to the valve 8-B to close.

5 It is envisaged that the subsea unit presented herein finds applications within the oil and gas industry, subsea HVDC/HVAC transmission and distribution systems as well as offshore power generation such as wind energy, tidal energy, wave energy, and ocean current energy.

10 The inventive concept has mainly been described above with reference to a few examples. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the inventive concept, as defined by the appended claims.

CLAIMS

1. A subsea unit (1-A; 1-B) arranged to house an electric or electronic device (11), wherein the subsea unit (1-A; 1-B) comprises a two-phase cooling system (2) arranged to cool the electric or electronic device (11), which two-phase
5 cooling system (2) has an evaporator (4), a condenser (5), and a conduit (3) which together with the evaporator (4) and condenser (5) forms a closed loop for circulating a cooling fluid, wherein the evaporator (4) is arranged to be in thermal connection with the electric or electronic device (11), and wherein the subsea unit (1-A; 1-B) has an enclosure (1-1) arranged to enclose the two-
10 phase cooling system (2), which enclosure (1-1) has a portion that is mechanically flexible such that an ambient subsea pressure can be transmitted to the inside of the enclosure, and wherein the subsea unit (1-A; 1-B) comprises a liquid (L) for counteracting deformation of the enclosure when subject to an ambient subsea pressure higher than a pressure that the
15 enclosure can withstand.
2. The subsea unit (1-A; 1-B) as claimed in claim 1, wherein the conduit (3) has a portion that is mechanically flexible so as to allow pressure inside the enclosure and outside the conduit to be transmitted to the inside of the conduit.
- 20 3. The subsea unit (1-A; 1-B) as claimed in claim 1 or 2, wherein the two-phase cooling system (2) comprises a cooling fluid (6-1) comprising at least two components that provide a thermodynamic two-phase state of the cooling fluid (6-1) at a pressure higher than the critical pressure of any of the individual components of the cooling fluid.
- 25 4. The subsea unit (1-A; 1-B) as claimed in claim 3, wherein the at least two components are adapted to provide a thermodynamic two-phase state of the cooling fluid (6-1) at ambient pressure at a depth at which the subsea unit (1-A; 1-B) is to be installed.
5. The subsea unit (1-A; 1-B) as claimed in claim 3 or 4, wherein the conduit
30 (3) is partially filled with the cooling fluid (6-1) when the conduit (3) is

subjected to sea level pressure, and wherein the subsea unit (1-A; 1-B) comprises a pressure compensating vessel (7) comprising additional cooling fluid (6-2), and a valve (8-A; 8-B), wherein the conduit (3) is arranged to be in fluid connection with the pressure compensation vessel (7) via the valve
5 (8-A; 8-B) such that the additional cooling fluid (6-2) is able to flow from the pressure compensating vessel (7) to the conduit (3) when the subsea unit (1-A; 1-B) is subjected to a pressure that is higher than a pressure inside the conduit.

6. The subsea unit (1-A; 1-B) as claimed in claim 5, wherein the additional
10 cooling fluid (6-2) in the pressure compensating vessel (7) is pressurised to seabed pressure of a depth at which the subsea unit (1-A; 1-B) is to be installed.

7. The subsea unit (1-A) as claimed in claim 5 or 6, wherein the valve (8-A) has a body (8-1) having a through opening (8-2) in the axial direction of a
15 conduit portion (3-1) connected to the valve (8-A), which valve (8-A) is movable in a radial direction (r) of the conduit portion (3-1) between a first position in which the body (8-1) blocks the additional cooling fluid (6-2) from flowing from the pressure compensating vessel (7) to the conduit (3) and a second position in which the through opening (8-2) is aligned with the
20 interior of the conduit portion (3-1) to thereby allow the additional cooling fluid (6-2) to flow from the pressure compensating vessel (7) to the conduit (3).

8. The subsea unit (1-A) as claimed in claim 7, wherein the valve (8-A) has a
25 first end (8-3) in fluid communication with the cooling fluid (6-1) in the conduit and a second end (8-4), opposite the first end (8-3), subjected to ambient pressure, wherein a pressure difference between the first end (8-3) and the second end (8-4) allows the body (8-1) to move between the first position and the second position.

9. The subsea unit (1-A) as claimed in claim 8, comprising a mechanical
30 spring (8-5) arranged to provide a force in the radial direction (r) at the first

end (8-3) of the valve (8-A) so as to enable the body (8-1) to move from the second position to the first position.

10. The subsea unit (1-B) as claimed in any of claims 1-6, comprising a first pressure sensor (10-1) and a second pressure sensor (10-2) arranged to
5 measure a pressure in the conduit (3) and outside the conduit in the subsea unit (1-B), respectively, and a control unit (9) arranged to control the valve (8-B) based on measurements of the first pressure sensor (10-1) and the second pressure sensor (10-2).

11. The subsea unit (1-A; 1-B) as claimed in any of the preceding claims,
10 comprising a pressure-relief valve (12) connecting the conduit (3) and an exterior of the subsea unit (1-A; A-B), wherein the pressure-relief valve (12) is arranged to open when the ambient pressure in the subsea unit (1-A; 1-B) is lower than the pressure in the conduit (3) to thereby let a portion of the cooling fluid (6-1, 6-2) escape the subsea unit (1-A; 1-B).

12. The subsea unit (1-A; 1-B) as claimed in any of the preceding claims,
15 wherein the condenser (5) is in thermal connection with an exterior of the enclosure (1-1).

13. The subsea unit as claimed in claim 1, wherein the two-phase cooling system comprises a cooling liquid, and wherein the conduit, the evaporator
20 and the condenser have walls that are thick enough to withstand a pressure difference between a sealing pressure inside the conduit, the evaporator and the condenser, which sealing pressure is a pressure at which the cooling liquid has been sealed in the two-phase cooling system, and ambient pressure at a depth at which the subsea unit is to be installed.

14. A subsea power system comprising a subsea unit as claimed in any of
25 claims 1-13.

15. The subsea power system as claimed in claim 14, wherein the subsea power system is a transmission system.

16. The subsea power system as claimed in claim 14, wherein the subsea power system is a distribution system.

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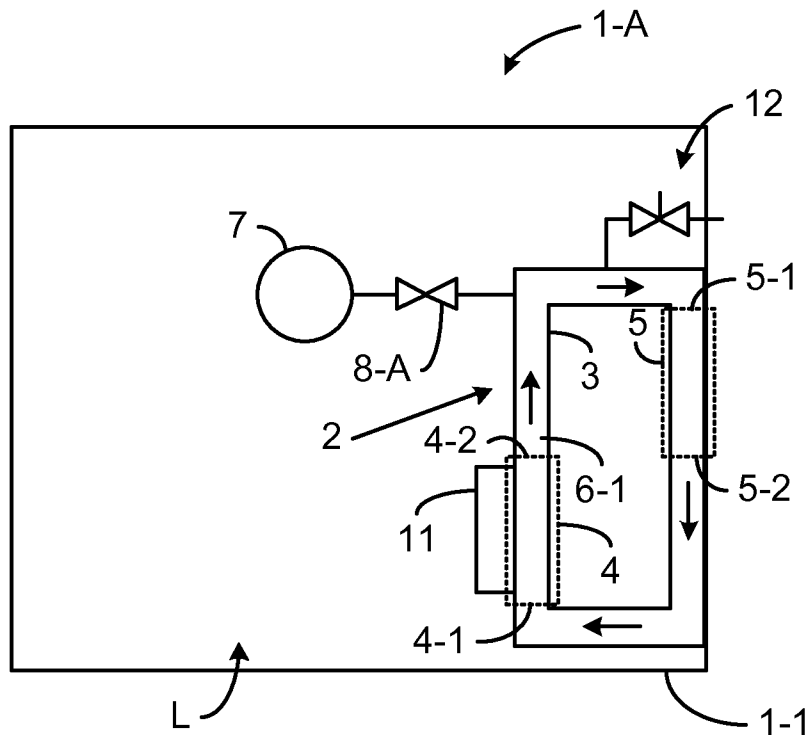


Fig. 1a

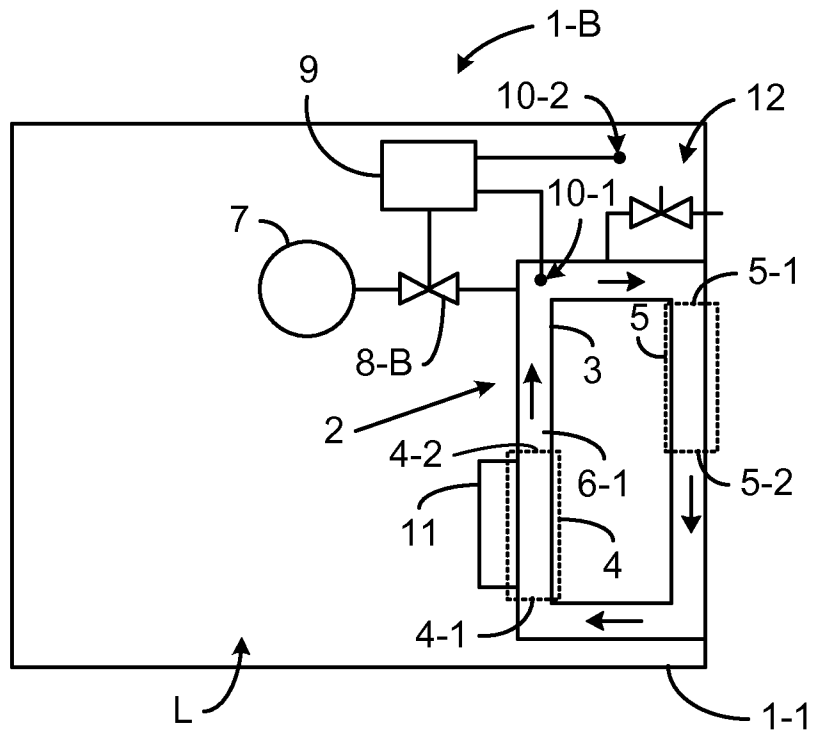


Fig. 1b

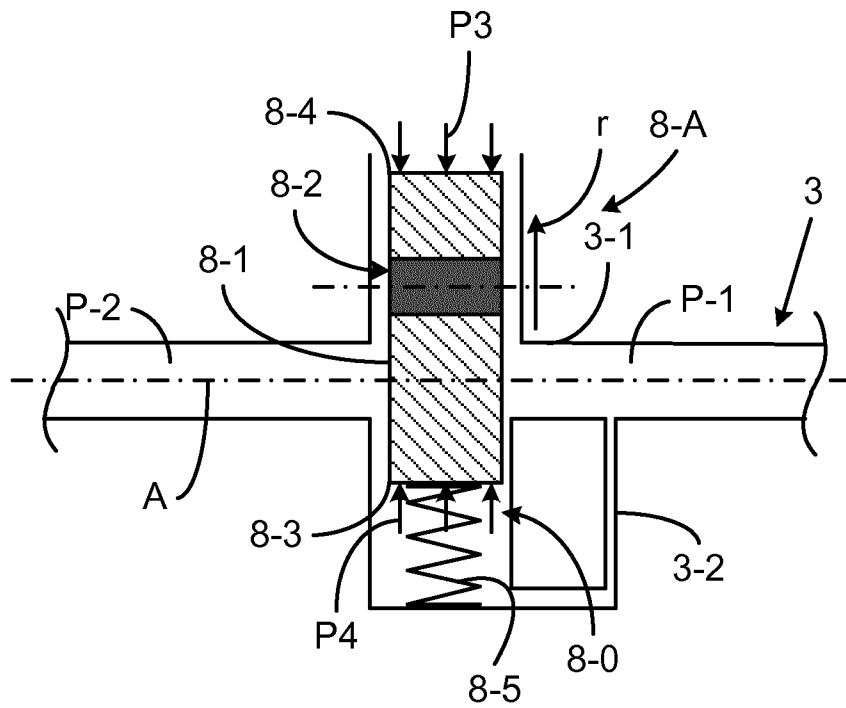


Fig. 2a

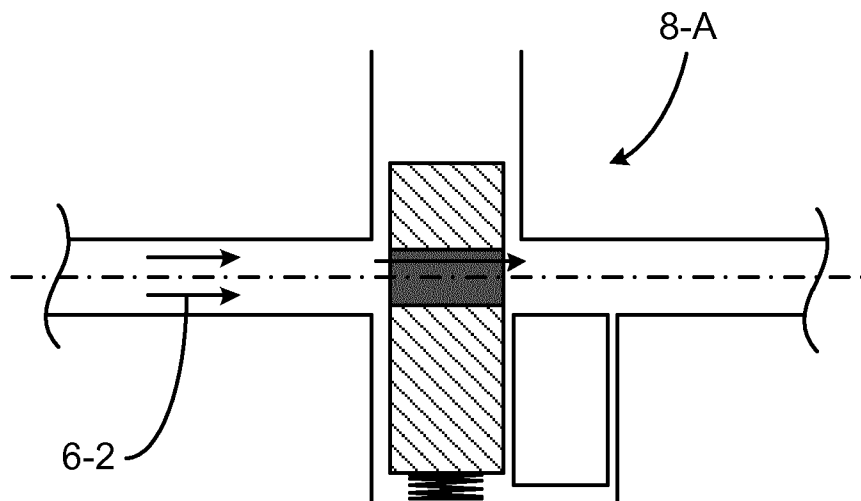


Fig. 2b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/063368

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B36/00 H05K5/06 F28D1/02
ADD.
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)
E21B F28D H01L H05K F25D F25B
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 5 265 677 A (SCHULTZ ROGER L [US]) 30 November 1993 (1993-11-30) column 9, line 43 - column 10, line 63; figure 3 -----	1-16
A	GB 2 313 181 A (SCHLUMBERGER LTD [US]) 19 November 1997 (1997-11-19) abstract; figures 1-3 -----	1-16
A	US 2008/302115 A1 (EKNES ERIK [NO] ET AL) 11 December 2008 (2008-12-11) abstract; figure 1 -----	1-16
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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 23 July 2013	Date of mailing of the international search report 01/08/2013
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Strømmen, Henrik
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/063368

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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