(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 382 312 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.10.2018 Bulletin 2018/40

(51) Int Cl.:
F28D 7/10 *(2006.01)* ***F28D 1/02*** *(2006.01)*

(21) Application number: **17164210.1**

(22) Date of filing: **31.03.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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(54) A SUBSEA HEAT EXCHANGER

(57) The invention relates to a subsea heat exchanger (1) comprising a first (2) and a second (3) chamber, the first chamber (2) comprising a fluid inlet (4) and the second chamber (3) comprising a fluid outlet (5), wherein the first chamber (2) and the second chamber (3) are connected with at least one outer pipe (6). The heat exchanger (1) comprises an inner pipe (7) surrounded by the outer pipe (6). A first end (8) of the inner pipe (7) extends into the first chamber (2) and is connected to a first connection point (9a) in the first chamber (2), a second end (10) of the inner pipe (7) extends into the second chamber (3) and is connected to a second connecting point (9b) in the second chamber (3). Between the outer pipe (6) and the inner pipe (7) is a gap (12) open to the first (2) and the second chamber (3) providing a fluid communication between the first chamber (2) and the second chamber (3). The first (8) and the second ends (10) of the inner pipe (7) are open providing a flow path for surrounding fluid (13) through the inner pipe (7).The invention relates also to a subsea assembly comprising the subsea heat exchanger (1) and to a use of a subsea heat exchanger (1).

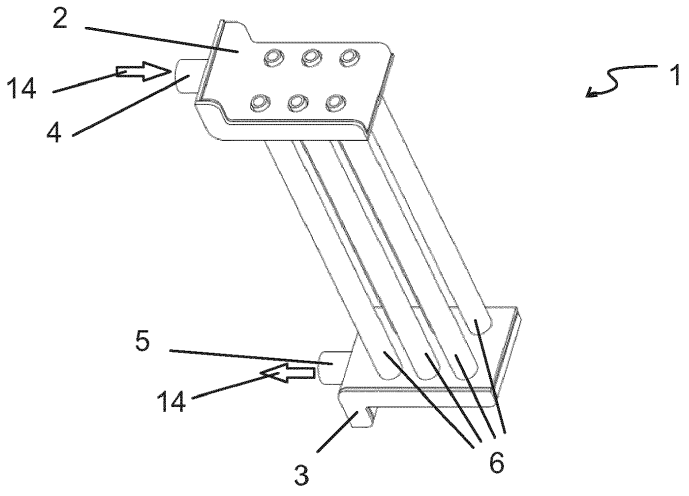

FIG. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a subsea heat exchanger, and particularly to a subsea heat exchanger for subsea assemblies.

BACKGROUND OF THE INVENTION

[0002] Subsea installations are assemblies comprising several apparatuses used under water. Said assemblies can be installed for example on the bottom ground of a sea. As an example of said subsea assemblies power transformers used under water can be mentioned. Typically these power transformers comprise a tank filled with insulation and/or cooling fluid to encounter for the high pressure due to deep water depth. Examples of the other subsea liquid filled objects are subsea motors, subsea switchgears, subsea frequency converters, rectifiers and hydraulic store tanks.

[0003] During operation of the subsea installation, the power losses of the electrical installations inside the tank increase the temperature and volume of the insulation and/or cooling fluid. The volume variation is often compensated with a pressure compensator, which is in fluid communication with the tank of the installation. The insulation and/or cooling fluid is often cooled via the outer surface of the tank to the surrounding sea water. As the area of the outer surface of the tank is limited there is a need to provide additional cooling for the insulation and/or cooling fluid.

BRIEF DESCRIPTION OF THE INVENTION

[0004] An object of the present invention is to provide a subsea heat exchanger to solve the above problems. The objects of the invention are achieved by a subsea heat exchanger which is characterized by what is stated in the independent claims. The preferred embodiments of the invention are disclosed in the dependent claims.

[0005] The invention is based on the idea of providing a subsea heat exchanger comprising a first and a second chamber. The first chamber comprising a fluid inlet and the second chamber comprising a fluid outlet, wherein the first chamber and the second chamber are connected with at least one outer pipe. The exchanger comprises an inner pipe surrounded by the outer pipe, a first end of the inner pipe extends into the first chamber and is connected to a first connection point in the first chamber, a second end of the inner pipe extends into the second chamber and is connected to a second connection point in the second chamber. Between the outer pipe and the inner pipe is a gap open to the first and the second chamber providing a fluid communication between the first chamber and the second chamber. The first and the second ends of the inner pipe are open providing a flow path of sea water through the inner pipe.

[0006] The subsea heat exchanger of the invention can be driven by natural convection without any pumps. Further, the fluid volume in the heat exchanger is small compared to the outer surface available for heat transfer. The subsea heat exchanger provides also a scalable solution where the number and length of the pipes can be varied.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 shows a perspective view of a subsea heat exchanger;
Figure 2 shows a part view of a subsea heat exchanger;
Figure 3 shows a cross section of a subsea assembly comprising a subsea heat exchanger;
Figure 4 shows a perspective view of a cross section of a subsea heat exchanger.

DETAILED DESCRIPTION OF THE INVENTION

[0008] Figure 1 shows a subsea heat exchanger. The subsea heat exchanger 1 comprises a first 2 and a second chamber 3. The first chamber 2 comprises a fluid 14 inlet 4 and the second chamber 3 comprises a fluid 14 outlet 5. The fluid 14 is indicated with arrows in Fig.1. The first chamber 2 and the second chamber 3 are connected with at least one outer pipe 6. The heat exchanger 1 comprises an inner pipe 7 surrounded by the outer pipe 6. A first end 8 of the inner pipe 7 extends into the first chamber 2 and is connected to a first connection point 9a in the first chamber 2. A second end 10 of the inner pipe 7 extends into the second chamber 3 and is connected to a second connection point 9b in the second chamber 3.

[0009] Between the outer pipe 6 and the inner pipe 7 is a gap 12 open to the first 2 and the second chamber 3 providing a fluid communication between the first chamber 2 and the second chamber 3. The first 8 and the second 10 ends of the inner pipe 7 are open to the surroundings providing a flow path of surrounding fluid 13 through the inner pipe 7.

[0010] As the subsea heat exchanger 1 is submerged into a sea the surrounding fluid 13 flowing in the inner pipe 7 is sea water.

[0011] An advantage of the heat exchanger 1 is the small volume for the fluid 14 between the outer pipes 6 and inner pipes 7 of the heat exchanger 1 compared to the surface available for the heat transfer from the fluid 14. The gap 12 between the outer pipe 6 and the inner pipe 7 form an annular flow channel for the fluid 14. The heat can be transferred from the fluid 14 through the inner wall and through the outer wall of the flow channel, i.e. through the wall of the inner pipe 7 and through the wall of outer pipe 6, to the surrounding fluid 13.

[0012] Fig.2 shows a part view of a cross section of a subsea heat exchanger 1. In the embodiment the subsea heat exchanger 1 comprises a chamber 2 comprising a manifold 15. Figure 4 shows a perspective view of a cross section of a subsea heat exchanger 1 presenting a first 2 and a second chamber 3 comprising manifolds 15. The manifold 15 of the first chamber 2 and the manifold 15 of the second chamber 3 are connected with multiple outer pipes 6 and inner pipes 7.

[0013] In another embodiment the manifold 15 comprises a substantially L shaped body 16. The body 16 comprises a horizontal 17 and a vertical portion 18. The vertical portion 18 comprises a connection to the fluid inlet 4 or to the fluid outlet 5.

[0014] The manifold 15 may also comprise only a horizontal portion 18, to which a fluid inlet 4 or fluid outlet 5 can be attached.

[0015] The horizontal portion 17 comprises connection points 9a-b to the outer pipes 6 and connection points 11 the inner pipes 7. The connection points 9a-b to the outer pipes 6 and/or the connection points 11 the inner pipes 7 may be openings in the manifold 15 where the outer pipes 6 can be installed and joined. Further, the connection points of outer pipes 6 and/or inner pipes 7 may comprise means for attaching, for instance sockets or flanges, for attaching the outer pipes 6 and/or inner pipes 7 to the manifold 15.

[0016] In yet another embodiment the horizontal portion 17 comprises a first horizontal surface 19a and a second horizontal surface 19b. The first horizontal surface 19a comprises multiple first or second connection points 9a-b and the second horizontal surface 19b comprises connection points 11 of the outer pipes 6.

[0017] As shown in Figures the inner pipes 7 extend through the interior of the chambers 2,3. The connection points of the inner tubes 9a-b and the connection points of the outer tubes 11 are arranged on the opposed walls of the manifold 15, i.e. on the first 19a and second 19b horizontal surfaces. As the inner pipes 7 extend through the interior of the first chamber 2 the fluid 14 entering the first chamber 2 is in a heat transfer contact with the inner pipes 7 before flowing into the gap 12. As the inner pipes 7 extend through the interior of the second chamber 3 the fluid 14 flowing from the gap 12 is in a heat transfer contact with the inner pipes 7 before exiting the second chamber 3 through the fluid outlet 5.

[0018] In a further embodiment the ends 8, 10 of the inner pipe 7 are on the level of the first horizontal surface 19a.

[0019] In another further embodiment the ends 8, 10 of the inner pipe 7 protrude from the first horizontal surface 19a. The ends 8, 10 of the inner pipe 7 may comprise means for guiding the surrounding fluid 13 flow to and from the open ends 8, 10 of the inner pipes 7. Further, the ends 8, 10 of the inner pipes 7 open to the surrounding fluid 13 may be covered with a screen for preventing dirt entering the inner pipes 7.

[0020] In yet another further embodiment the inlet 4 and/or outlet 5 comprises a circular pipe.

[0021] In still another embodiment the vertical portion 18 of the first chamber manifold 15 and the vertical portion of the second chamber manifold 18 are arranged on the same side of the heat exchanger 1 in the horizontal direction x.

[0022] If the heat exchanger 1 is arranged between two tanks then it is preferred to arrange the fluid inlet 4 of the first chamber 2 manifold 15 and the fluid outlet 5 of the second chamber 3 manifold 15 on the opposing sides of the heat exchanger 1 in the horizontal direction x.

[0023] The heat exchanger 1 may be a welded construction where the outer pipe 6 and the inner pipe 7 are connected to the first 2 and the second chamber 3 by welding.

[0024] The subsea heat exchanger 1 provides a scalable solution where the number and length of the inner 7 and outer 8 pipes can be varied for generating additional cooling. The subsea heat exchanger 1 can be dimensioned based on the required power for example for the insulation and/or cooling fluid in a subsea tank.

[0025] Figure 3 shows a cross section of a subsea assembly 20 comprising a subsea heat exchanger 1. The subsea assembly 20 comprises a tank 21 comprising a fluid 14, for instance an insulation fluid or other fluid. The subsea heat exchanger 1 is in fluid communication with the tank 21. The subsea assembly 20 comprises a heat generating electric apparatus 22 located within the tank 21.

[0026] In Fig.3 shown example of a subsea assembly 20 the heat generating electric apparatus 22 is a subsea transformer and the fluid 14 in the tank is transformer oil. The transformer windings and a transformer core are located in the tank 21. The transformer oil is mineral oil or silicon oil, for instance. Examples of other heat generating apparatuses 22 are motors, switchgears, frequency converters, rectifiers and hydraulic store tanks.

[0027] In an embodiment the inlet 4 of the first chamber 2 and the outlet 5 of the second chamber 3 are connected to a wall of the tank 21 and the inlet 4 is positioned above the outlet 5 in vertical direction y.

[0028] In another embodiment the inlet 4 and the outlet 5 are positioned to arrange the outer pipes 6 to extend substantially in a vertical direction y.

[0029] In a further embodiment the tank 21 comprises insulation or cooling fluid, and transformer windings and a transformer core, an electric power switch and /or a variable speed drive are located within the tank 21.

[0030] The subsea heat exchanger 1 can be driven by natural convection without any pumps or suction devices. The temperature difference between the fluid 14 in a subsea tank 21 and the surrounding fluid 13, sea water, causes heat to transfer from the fluid 14 to the surrounding sea water. The heat transfer causes a temperature gradient to the fluid 14 and to the surrounding sea water in the pipes 6,7. The temperature gradient in the fluid 14 causes the fluid 14 to move downwards in the outer pipe 6. Respectively the temperature gradient in the surround-

ing sea water in the inner pipe 7 causes the sea water to move upwards in the inner pipe 7. The surrounding fluid 13 flow direction is indicated with small arrows and the fluid 14 flow direction is indicated with large arrows in Fig.3.

[0031] The subsea heat exchanger 1 may also be used for cooling in a subsea processing unit performing compression of gas from subsea fields or separation of well stream compounds. Then between the outer 6 and inner pipe 7 flows gas from subsea fields or a well stream compound.

[0032] The subsea heat exchanger 1 can be used in a subsea environment, e.g. exist on the sea bed. The subsea heat exchanger 1 is also suitable for deep waters, where the water depth is high, 1000...3000 m, and the prevailing pressure is 100...300 bar. The water temperature in an ocean is typically 5-6°C in the depth of 1000 m and 0-3°C in the depth of 3000 m.

[0033] The invented subsea heat exchanger 1 can be applied to different types of subsea assemblies 20. The subsea assemblies 20 may comprise insulation fluid or other fluid in a tank. Examples of such subsea assemblies are subsea motors, subsea switchgears, subsea frequency converters, rectifiers and hydraulic store tanks.

[0034] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

[0035] Part list: 1 a heat exchanger; 2 a first chamber; 3 a second chamber; 4 an inlet; 5 an outlet; 6 an outer pipe; 7 an inner pipe; 8 a first end; 9a a first connection point of outer pipe, 9b a second connection point of outer pipe; 10 a second end; 11 a connection point of outer pipe; 12 a gap; 13 a surrounding fluid; 14 a fluid; 15 a manifold; 16 body; 17 a horizontal portion; 18 vertical portion; 19a a first horizontal surface, 19b a second horizontal surface; 20 a subsea assembly; 21 a tank; 22 heat generating electric apparatus.

[0036] x horizontal direction; y vertical direction.

Claims

1. A subsea heat exchanger (1) comprising a first (2) and a second (3) chamber, the first chamber (2) comprising a fluid inlet (4) and the second chamber (3) comprising a fluid outlet (5), wherein the first chamber (2) and the second chamber (3) are connected with at least one outer pipe (6), **characterized**in that the heat exchanger (1) comprises an inner pipe (7) surrounded by the outer pipe (6), a first end (8) of the inner pipe (7) extends into the first chamber (2) and is connected to a first connection point (9a) in the first chamber (2), a second end (10) of the inner pipe (7) extends into the second chamber (3) and is connected to a second connecting point (9b) in the second chamber (3), and between the outer pipe (6) and the inner pipe (7) is a gap (12) open to the first (2) and the second chamber (3) providing a fluid communication between the first chamber (2) and the second chamber (3), and the first (8) and the second ends (10) of the inner pipe (7) are open providing a flow path for surrounding fluid (13) through the inner pipe (7).

2. A subsea heat exchanger according to claim 1, **characterized in that** the first chamber (2) and the second chamber (3) comprise manifolds (15) and the first chamber manifold (15) and the second chamber manifold (15) are connected with multiple outer pipes (6) and inner pipes (7).

3. A subsea heat exchanger according to claim 2, **characterized in that** the manifold (15) comprises a substantially L shaped body (16) having a horizontal (17) and a vertical portion (18), wherein the vertical portion (18) comprises a connection to the inlet (4) or to the outlet (5) and the horizontal portion (17) comprises connection points (9a-b,11) to the outer pipes (6) and the inner pipes (7).

4. A subsea heat exchanger according to claim 3, **characterized in that** the horizontal portion (17) comprises a first horizontal surface (19a) and a second horizontal surface (19b), and the first horizontal surface (19a) comprises multiple first or second connection points (9a-b) and the second horizontal surface (19b) comprises connection points of the outer pipes (11).

5. A subsea heat exchanger according to claim 4, **characterized in that** the ends (8,10) of the inner pipe (7) are on the level of the first horizontal surface (19a).

6. A subsea heat exchanger according to claim 4, **characterized in that** the ends (8,10) of the inner pipe (7) protrude from the first horizontal surface (19a).

7. A subsea heat exchanger according to any of claims 3-6, **characterized in that** the inlet (4) and/or outlet (5) comprises a circular pipe.

8. A subsea heat exchanger according to any of claims 3-7, **characterized in that** the vertical portion (18) of the first chamber (2) manifold (15) and the vertical portion (18) of the second chamber (3) manifold (15) are arranged on the same side of the heat exchanger in the horizontal direction (x).

9. A subsea heat exchanger according to claim 1, **characterized in that** the outer pipe (6) and the inner pipe (7) are connected to the first (2) and the second chamber (3) by welding.

10. A subsea assembly comprising the subsea heat exchanger according to any of claims 1- 9, **characterized in that** the assembly comprises a tank (21) and the inlet (4) of the first chamber (2) and the outlet (5) of the second chamber (3) are connected to a wall of the tank (21) and the inlet (4) is positioned above the outlet (5) in vertical direction (y).

11. A subsea assembly according to claim 10, **characterized in that** the inlet (4) and the outlet (5) are positioned to arrange the outer pipes (6) to extend substantially in a vertical direction (y).

12. A subsea assembly according to any of claims 10-11, **characterized in that** the tank (21) comprises insulation or cooling fluid, and transformer windings and a transformer core, an electric power switch and /or a variable speed drive are located within the tank (21).

13. Use of a subsea heat exchanger (1) according to any of claims 1-9 in a subsea environment.

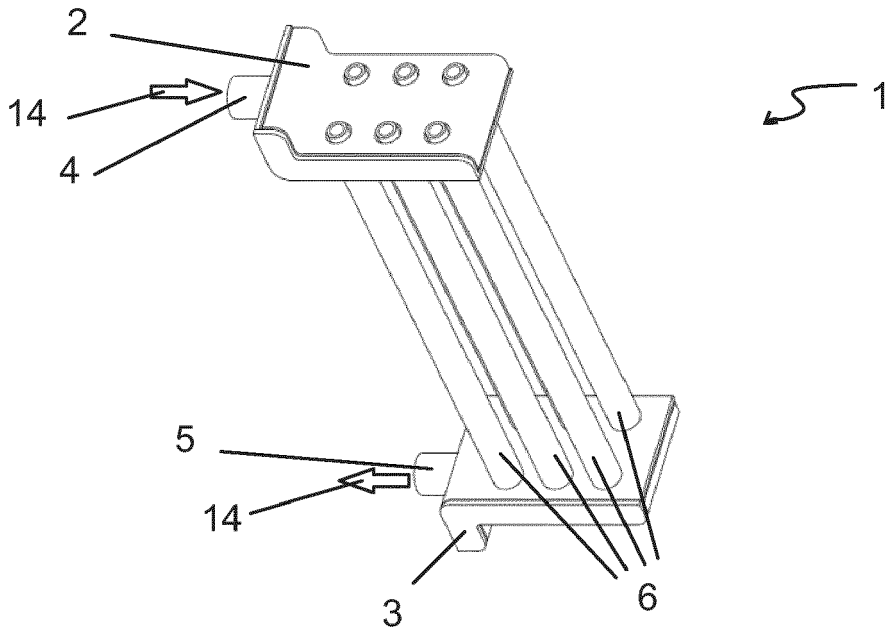

FIG. 1

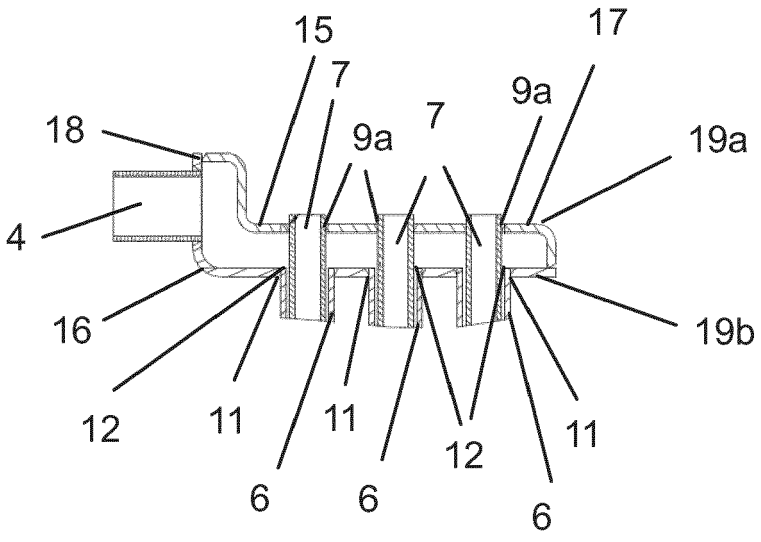

FIG. 2

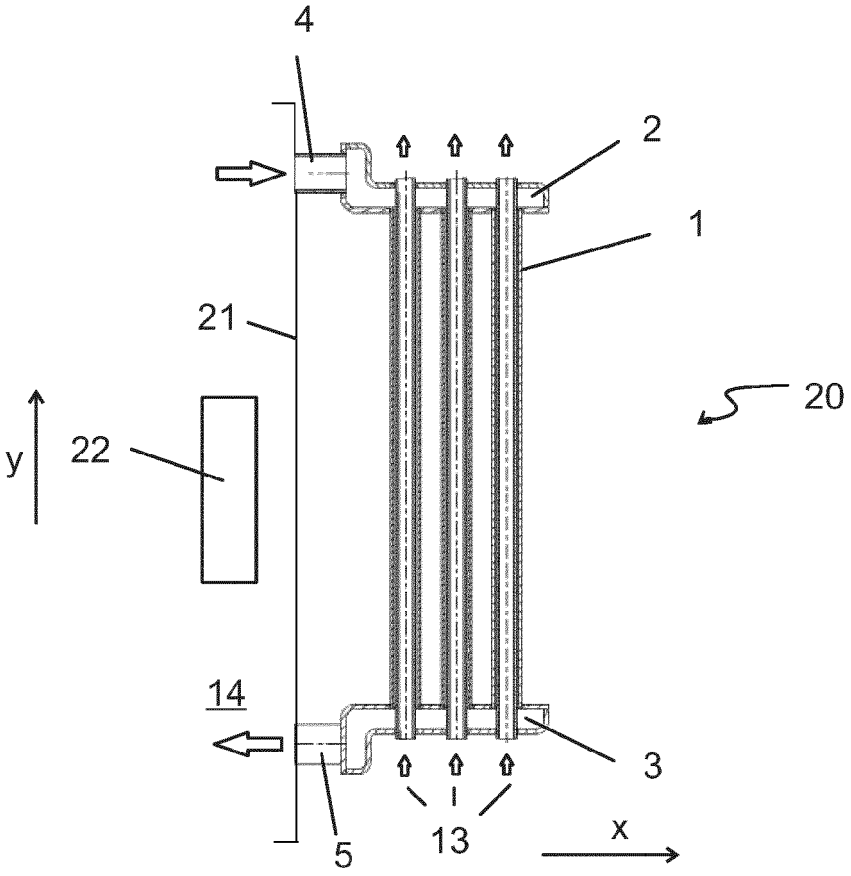

FIG. 3

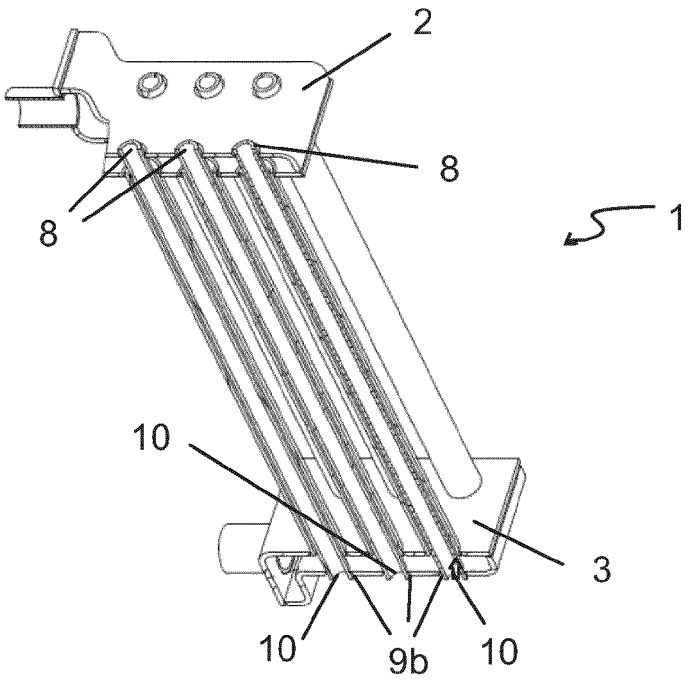

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 17 16 4210

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2008/004886 A1 (NORSK HYDRO PRODUKSJON A S [NO]; SHELL INT RESEARCH [NL]; POORTE EDWIN) 10 January 2008 (2008-01-10) * figures *	1-13	INV. F28D7/10 F28D1/02
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A	WO 2015/026237 A1 (AKER SUBSEA AS [NO]) 26 February 2015 (2015-02-26) * figure 5 *	1-13	
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			TECHNICAL FIELDS SEARCHED (IPC) F28D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 September 2017	Mellado Ramirez, J

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 16 4210

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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06-09-2017

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