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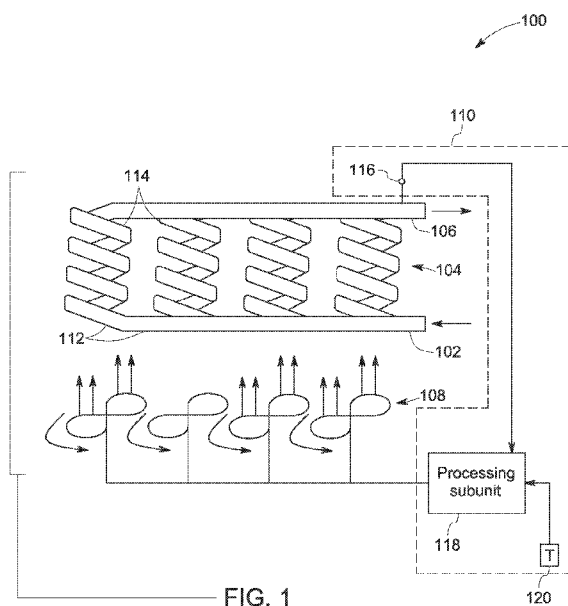
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[Continued on next page]

(54) Title: SYSTEM AND METHOD FOR CONTROLLING TEMPERATURE OF A WORKING FLUID



(57) Abstract: A heat exchanging device (100) is presented. The heat exchanging device includes an inlet header (102) configured to receive a working fluid. Further, the heat ex-
changing device includes at least one coil segment (104) hav-
ing a first end and a second end, where the first end of the at
least one coil segment is coupled to the inlet header and con-
figured to receive the working fluid from the inlet header. In
addition, the heat exchanging device includes an outlet header
(106) coupled to the second end of the at least one coil seg-
ment and configured to receive the working fluid from the at
least one coil segment. Also, the heat exchanging device in-
cludes at least one propeller (108) disposed proximate to the
at least one coil segment and configured to propel subsea wa-
ter across the at least one coil segment to control a tempera-
ture of the working fluid in the outlet header.



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SYSTEM AND METHOD FOR CONTROLLING TEMPERATURE OF A WORKING FLUID

BACKGROUND

[0001] Embodiments of the present disclosure relate generally to a subsea heat exchanger, and more particularly to a system and method for controlling temperature of a process or working fluid in subsea equipment.

[0002] Typically, one or more products, such as oil, natural gas, or a combination of the two are extracted from subsea wells and processed on an ocean bed. Further, these products may be used as working fluids for one or more applications. However, the products that are extracted from the subsea wells may have a very high temperature, and processing these products at this high temperature is challenging. In one example, the temperature of these products may be in a range from about 80 degrees to about 200 degrees. Thus, it is important to control the temperature of the products prior to processing the products on the ocean bed.

[0003] In conventional systems, one or more heat exchangers may be used underwater to regulate or control the temperature of the products that are extracted from the subsea wells. These heat exchangers may leverage subsea water to cool these products. Typically, the subsea water may have a temperature that is relatively lower than the temperature of the products. Also, the subsea water may have high heat capacity that aids in controlling or absorbing heat from the products. However, these heat exchangers depend upon natural or free convection of the subsea water to cool the products. Also, as the temperature of these products is very high, a large amount of heat needs to be dissipated from the products. Hence, dissipating heat from these products calls for the use of heat exchangers with a large heat transfer area. In addition, as these heat exchangers rely upon natural or free convection with its inherent low heat transfer coefficient, the size tends to be further increased. As a result, these large heat exchangers are very expensive to manufacture. In addition,

these heat exchangers tend to be bulky and are difficult to move to a location on the ocean bed or seabed.

BRIEF DESCRIPTION

[0004] In accordance with aspects of the present disclosure, a heat exchanging device is presented. The heat exchanging device includes an inlet header configured to receive a working fluid. Further, the heat exchanging device includes at least one coil segment having a first end and a second end, where the first end of the at least one coil segment is coupled to the inlet header and configured to receive the working fluid from the inlet header. In addition, the heat exchanging device includes an outlet header coupled to the second end of the at least one coil segment and configured to receive the working fluid from the at least one coil segment. Also, the heat exchanging device includes at least one propeller disposed proximate to the at least one coil segment and configured to propel subsea water across the at least one coil segment to control a temperature of the working fluid in the outlet header.

[0005] In accordance with further aspects of the present disclosure, a method for controlling a temperature of a working fluid is presented. The method includes directing, by at least one coil segment, working fluid from an inlet header to an outlet header in a heat exchanging device. Also, the method includes determining, by a control unit, a temperature of the working fluid in the outlet header. Further, the method includes propelling, by at least one propeller, subsea water across the at least one coil segment to control the temperature of the working fluid in the outlet header.

[0006] In accordance with another aspect of the present disclosure, a system is presented. The system includes an inlet header. Also, the system includes an outlet header. Further, the system includes a plurality of coil segments disposed between the inlet header and the outlet header and configured to direct working fluid from the inlet header to the outlet header. In addition, the system includes a plurality of propellers disposed proximate to the plurality of coil segments and configured to propel subsea water across the plurality of coil segments to control a temperature of the working fluid in the outlet header.

DRAWINGS

[0007] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0008] FIG. 1 is a diagrammatical representation of one embodiment of a heat exchanging device, in accordance with aspects of the present disclosure;

[0009] FIG. 2 is a diagrammatical representation of another embodiment of a heat exchanging device, in accordance with aspects of the present disclosure;

[0010] FIG. 3 is a diagrammatical representation of a propeller disposed in a nozzle, in accordance with aspects of the present disclosure;

[0011] FIGs. 4-7 are diagrammatical representations of different embodiments of a coil segment for use in a heat exchanging device, in accordance with aspects of the present disclosure; and

[0012] FIG. 8 is a flow chart illustrating a method for controlling temperature of a working fluid, in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0013] As will be described in detail hereinafter, various embodiments of exemplary systems and methods for controlling temperature of a working fluid are presented. By employing the methods and the various embodiments of the system described hereinafter, the working fluid may be cooled at a very low cost.

[0014] Turning now to the drawings and referring to FIG. 1, a diagrammatical representation of a heat exchanging device 100, in accordance with aspects of the present disclosure, is depicted. The heat exchanging device 100 may be used for underwater applications to control a temperature of a working fluid that is extracted from subsea wells. In one example, the working fluid may include well products, such as gas, liquids, and/or water. In another example, the working fluid may be any

coolant that is used to cool components, such as a motor in subsea equipment. The working fluid may have a temperature that is in a range from about 80 degrees to about 200 degrees. As will be appreciated, processing or using the working fluid at these high temperatures may be a challenging task. In accordance with aspects of the present disclosure, the heat exchanging device 100 may be employed to control the temperature of the working fluid.

[0015] In a presently contemplated configuration, the heat exchanging device 100 may include an inlet header 102, one or more coil segments 104, an outlet header 106, one or more propellers 108, and a control unit 110. In one embodiment, the one or more coil segments 104 may be disposed between the inlet header 102 and the outlet header 106. In the embodiment of FIG. 1, four coil segments 104 are positioned between the inlet header 102 and the outlet header 106. Each of the coil segments 104 may include a first end 112 and a second end 114. The first ends 112 of the coil segments 104 may be coupled to the inlet header 102, while the second ends 114 of the coil segments 104 may be coupled to the outlet header 106. It may be noted that the coil segments 104 may include a bundle of coils that are arranged in one or more determined patterns. These patterns will be described in greater detail with respect to FIGs. 4-7. Also, the inlet header 102 and the outlet header 106 may be referred to as channels that are used for circulating the working fluid through the bundle of coils in the coil segments 104. It may be noted that the heat exchanging device 100 may have any number of coil segments, and is not limited to the number of coil segments shown in FIG. 1.

[0016] As depicted in FIG. 1, the inlet header 102 may be configured to receive the working fluid from an external unit (not shown). The received working fluid may be distributed equally through each of the coil segments 104. The working fluid may be channeled through each of the coil segments 104 and collected by the outlet header 106. Further, the outlet header 106 may be configured to route the collected working fluid back to the external unit. In one embodiment, the external unit may include one or more components, such as a subsea motor or a compressor in subsea equipment (not shown).

[0017] In conventional systems, heat exchangers employ natural or free convection of the subsea water to transfer heat from the working fluid to the subsea water. However, these heat exchangers are large in size as they rely on natural or free convection of the subsea water to cool the working fluid. Also, the conventional systems entail use of a greater number of heat exchangers for dissipating the heat from the working fluid. Moreover, these large heat exchangers are very expensive to manufacture and difficult to move to a location on the ocean bed or seabed.

[0018] To overcome the above shortcomings, in one exemplary embodiment, the heat exchanging device 100 may employ the one or more propellers 108 to force the flow of the subsea water across the coil segments 104, rather than relying on the natural or free convection of the subsea water. This forced flow of the subsea water may enhance the external heat transfer, thus increasing the transfer of heat from the working fluid to the seawater, and thereby aid in controlling the temperature of the working fluid.

[0019] As depicted in FIG. 1, each of the propellers 108 may be disposed proximate to a corresponding coil segment 104. In one embodiment, these propellers 108 may be operated at a fixed speed. Further, the propellers 108 may be configured to propel the subsea water across the coil segments 104. More particularly, the subsea water may be forced to flow across the coil segments 104. This forced flow of the subsea water in turn aids in transferring the heat from the working fluid that is flowing within the coil segments 104 to the surrounding seawater.

[0020] Furthermore, the control unit 110 may be configured to regulate the flow of subsea water across the coil segments 104. More particularly, the control unit 110 may be configured to activate or deactivate one or more propellers 108 so as to regulate the flow of subsea water across the coil segments 104.

[0021] In accordance with aspects of the present disclosure, the control unit 110 may be configured to regulate the flow of the subsea water across the coil segments 104 based on the temperature of the working fluid in the outlet header 106. It may be desirable to maintain the temperature of the working fluid within a determined temperature range. The determined temperature range may have an upper bound and

a lower bound, in one example. Accordingly, in one embodiment, the control unit 110 may include a first sensor 116 and a processing subunit 118. The first sensor 116 may be operatively coupled to the outlet header 106 and configured to determine the temperature of the working fluid at a determined location in the outlet header 106. In one embodiment, the determined location may be a location in the outlet header 106, where the working fluid exits the outlet header 106. Further, the first sensor 116 may be configured to communicate the determined temperature to the processing subunit 118.

[0022] Moreover, in accordance with aspects of the present disclosure, the processing subunit 118 may be configured to determine a number of propellers 108 to be activated and/or deactivated based on the temperature of the working fluid in the outlet header 106. In particular, the processing subunit 118 may be configured to determine the number of propellers 108 to be activated and/or deactivated based on an amount of heat to be dissipated from the working fluid. To that end, in one embodiment, the processing subunit 118 may be configured to determine if the temperature received from the first sensor 116 lies outside the determined temperature range. If it is determined that the temperature of the working fluid received from the first sensor 116 lies outside the determined temperature range, the processing subunit 118 may be configured to activate or deactivate a determined number of propellers 108. In one example, if the received temperature is greater than the upper bound of the determined temperature range, the processing subunit 118 may be configured to activate a first subset of the propellers 108. In a similar fashion, if the received temperature is less than the lower bound of the determined temperature range, the processing subunit 118 may be configured to deactivate a second subset of the propellers 108. In one embodiment, the processing subunit 118 may be configured to activate or deactivate the one or more propellers 108 by communicating a first control signal to a corresponding propeller.

[0023] In accordance with further aspects of the present disclosure, the processing subunit 118 may be configured to activate or deactivate the propellers 108 based on a temperature of the subsea water. Particularly, if the temperature of the subsea water is greater than the temperature of the working fluid then propelling this subsea water

across the coil segments 104 may further increase the temperature of the working fluid. Thus, it may also be desirable to activate or deactivate the propellers 108 based upon the temperature of the subsea water.

[0024] Accordingly, in one embodiment, the control unit 110 may include a second sensor 120 configured to determine the temperature of the subsea water. In one embodiment, the second sensor 120 may be disposed in the subsea water. Further, the second sensor 120 may be configured to communicate the temperature of the subsea water to the processing subunit 118. The processing subunit 118 may be configured to compare the temperature of the subsea water with the temperature of the working fluid. Further, the processing subunit 118 may be configured to transmit a second control signal to one or more propellers 108 to activate a subset of propellers 108 if the temperature of the subsea water is less than the temperature of the working fluid in the outlet header 106. Otherwise, the processing subunit 118 may be configured to transmit a third control signal to one or more propellers 108 to deactivate the subset of propellers 108. In one embodiment, the processing subunit 118 may be configured to select the number of propellers 108 to be activated or deactivated based on a difference between the temperature of the subsea water and the temperature of the working fluid.

[0025] Thus, by employing the one or more propellers 108 and the control unit 110, the heat exchanging device 100 may effectively control the temperature of the working fluid. Also, the size and cost of manufacturing the heat exchanging device 100 may be substantially reduced as the heat exchanging device 100 is configured to rely on the force flow of the subsea water across the coil segments 104 to dissipate heat or control the temperature of the working fluid.

[0026] Referring to FIG. 2, a diagrammatical representation of another embodiment of a heat exchanging device 200, in accordance with another aspect of the present disclosure, is depicted. In the embodiment of FIG. 2, the heat exchanging device 200 includes coil segments 202 that are serially connected to each other. Particularly, in the embodiment of FIG. 2, each of the coil segments 202 may have corresponding inlet and outlet headers. An outlet header of one coil segment 202 may

be operatively coupled to an inlet header of an adjacent coil segment 202. More specifically, an inlet header 204 of a first coil segment 206 may be configured to receive a working fluid from an external unit (not shown). Further, the received working fluid may be directed through the first coil segment 206. The outlet header 208 of the first coil segment 206 may be configured to collect the working fluid from the first coil segment 206 and route the working fluid to an inlet header 210 of a second coil segment 212. In a similar manner, the working fluid may be routed from the second coil segment 212 to a third coil segment 214 and further to a fourth coil segment 216 via respective inlet and outlet headers. The working fluid may be collected by an outlet header 218 of the fourth or last coil segment 216. Further, the outlet header 218 of the fourth coil segment 216 may be configured to route the working fluid to the external unit. It may be noted that the coil segments 202 may be arranged in a variety of configurations, and the arrangement is not limited to the arrangements shown in FIGs. 1 and 2. In addition, a control unit 226 may be coupled to propellers 228 and configured to regulate the flow of subsea water across the coil segments 202. The control unit 226 may include a first sensor 220, a processing subunit 222, and a second sensor 224.

[0027] In this embodiment, the first sensor 220 of the control unit 226 may be coupled to the outlet header 218 of the fourth coil segment 216. It may be noted that the first sensor 220 may be representative of the first sensor 116 of FIG. 1. Also, the processing subunit 222 and the second sensor 224 may be representative of the processing subunit 118 and the second sensor 120, respectively. In addition, propellers 228 may be representative of the propellers 108 of FIG. 1.

[0028] Referring to FIG. 3, a diagrammatical representation 300 of a propeller disposed in a nozzle configured for use in the heat exchanging devices 100, 200, in accordance with aspects of the present disclosure, is depicted. Reference numeral 302 may be representative of one of the propellers 108 of FIG. 1. In accordance with exemplary aspects of the present disclosure, the propeller 302 may be enclosed by a nozzle 306. The nozzle 306 may be configured to aid in directing the flow of the subsea water towards a coil segment 304. The propeller 302 surrounded by the nozzle 306 may be used to propel the subsea water across a corresponding coil segment 304

such that the subsea water may absorb the heat from the working fluid in the coil segment 304. This transfer of heat from the working fluid may aid in reducing the temperature of the working fluid. With the inclusion of the nozzle 306, the flow of subsea water may be further streamlined towards the coil segment 304. This in turn improves the efficiency of the propeller 302. Also, overall efficiency of a heat exchanging device, such as the heat exchanging device 100 may be improved. It may be noted that the coil segment 304 may be representative of one of the coil segments 104 in FIG. 1.

[0029] As depicted in FIG. 3, the nozzle 306 may include an inlet 308 and an outlet 310. The inlet 308 may be provided along a bottom surface of the nozzle 306, while the outlet 310 may be provided along a top surface of the nozzle 306. The top surface of the nozzle 306 may be representative of a surface of the nozzle 306 that is disposed closer to the coil segment 304, while the bottom surface may be representative of a surface of the nozzle 306 that is disposed away from the coil segment 304. Also, an aperture of the outlet 310 of the nozzle may be smaller than an aperture of the inlet 308 of the nozzle 306, in one embodiment.

[0030] Referring to FIGs. 4-7, diagrammatical representations of different embodiments of a coil segment configured for use in the heat exchanging devices 100, 200 of FIGs. 1-2, in accordance with aspects of the present disclosure, are depicted. In FIG. 4, reference numeral 400 may be representative of one coil segment, such as the coil segment 104 of FIG. 1. The coil segment 400 may include a helix bundle of coils 402 that may be coupled between an inlet header and an outlet header of the heat exchanging device 100. Particularly, this helix bundle of coils 402 may have a first end that is coupled to the inlet header and a second end that is coupled to the outlet header of the heat exchanging device 100.

[0031] Moreover, in the example depicted in FIG. 5, a coil segment 500 may include a bundle of vertical pipes or coils 502. Similarly, as depicted in FIG. 6, a coil segment 600 may include a horizontal inline bundle of coils 602. Furthermore, in FIG. 7, a coil segment 700 may include a horizontal staggered bundle of coils 702.

[0032] Referring to FIG. 8, a flow chart illustrating a method 800 for controlling a temperature of a working fluid, in accordance with aspects of the present disclosure, is depicted. For ease of understanding, the method 800 is described with reference to the components of FIG. 1. The method begins at step 802, where the working fluid may be directed from the inlet header 102 to the outlet header 106. The one or more coil segments 104 may be used to channel or direct the working fluid from the inlet header 102 to the outlet header 106. Particularly, the inlet header 102 may receive the working fluid from the external unit (not shown) and the working fluid may be distributed equally to the coil segments 104. Thereafter, the outlet header 106 may collect the working fluid from the one or more coil segments 104 and route the working fluid to the external unit.

[0033] Subsequently, at step 804, the temperature of the working fluid in the outlet header 106 may be determined. To that end, the control unit 110 may be configured to determine the temperature of the working fluid in the outlet header 106. Particularly, the control unit 110 may include the first sensor 116 that is coupled to the outlet header 106. The first sensor 116 may be configured to determine the temperature of the working fluid in the outlet header 106. Further, the determined temperature of the working fluid may be communicated to the processing subunit 118 in the control unit 110.

[0034] In addition, at step 806, the subsea water may be propelled across the one or more coil segments 104 to control the temperature of the working fluid in the outlet header 106. To that end, the one or more propellers 108 may be used to propel the subsea water across the coil segments 104. Specifically, the processing subunit 118 may be configured to activate or deactivate the one or more propellers 108 to regulate the flow of subsea water across the coil segments 104. In one example, if the temperature of the working fluid is greater than an upper bound of a determined temperature range, the processing subunit 118 may be configured to activate the one or more propellers so as to lower the temperature of the working fluid to lie within the determined temperature range. Similarly, if the temperature of the working fluid is less than a lower bound of the determined temperature range, the processing subunit 118 may be configured to deactivate one or more propellers so as to decrease the

amount of heat removed by the heat exchanging device 100 and thus reducing the temperature of the working fluid in the outlet header 106. In one embodiment, the processing subunit 118 may be configured to select the number of propellers 108 to be activated or deactivated based on the amount of heat to be dissipated from the working fluid.

[0035] The various embodiments of the system and method aid in controlling the temperature of the working fluid. Also, as the heat exchanging device employs the propellers, the size and number of the heat exchanging devices used to cool a working fluid may be substantially reduced. This in turn helps to simplify the transport and installation of the heat exchanging device at a desired location. Also, the manufacturing cost of the heat exchanging device may be substantially reduced.

[0036] While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

CLAIMS:

1. A heat exchanging device, comprising:

an inlet header configured to receive a working fluid;

at least one coil segment having a first end and a second end, wherein the first end of the at least one coil segment is coupled to the inlet header and configured to receive the working fluid from the inlet header;

an outlet header coupled to the second end of the at least one coil segment and configured to receive the working fluid from the at least one coil segment; and

at least one propeller disposed proximate to the at least one coil segment and configured to propel subsea water across the at least one coil segment to control a temperature of the working fluid in the outlet header.

2. The heat exchanging device of claim 1, further comprising a control unit operatively coupled to the at least one propeller and configured to activate or deactivate the at least one propeller to regulate flow of the subsea water across the at least one coil segment.

3. The heat exchanging device of claim 2, wherein the control unit comprises:

a first sensor operatively coupled to the outlet header and configured to determine the temperature of the working fluid in the outlet header; and

a processing subunit electrically coupled to the first sensor and configured to communicate a first control signal to the at least one propeller when the temperature of the working fluid in the outlet header is outside a determined temperature range.

4. The heat exchanging device of claim 3, wherein the processing subunit is configured to communicate the first control signal to the at least one propeller to activate or deactivate the at least one propeller.

5. The heat exchanging device of claim 3, wherein the control unit further comprises a second sensor operatively coupled to the processing subunit and configured to determine a temperature of the subsea water.

6. The heat exchanging device of claim 5, wherein the processing subunit is configured to:

compare the temperature of the subsea water with the temperature of the working fluid in the outlet header; and

communicate a second control signal to the at least one propeller to activate the at least one propeller when the temperature of the subsea water is less than the temperature of the working fluid in the outlet header.

7. The heat exchanging device of claim 6, wherein the processing subunit is configured to transmit a third control signal to the at least one propeller to deactivate the at least one propeller when the temperature of the subsea water is greater than the temperature of the working fluid in the outlet header.

8. The heat exchanging device of claim 1, wherein the outlet header is configured to supply the working fluid received from the at least one coil segment to an external device.

9. The heat exchanging device of claim 1, further comprising a nozzle enclosing the at least one propeller and configured to streamline a flow of the subsea water towards the at least one coil segment.

10. A method for controlling a temperature of a working fluid, comprising:
directing, by at least one coil segment, working fluid from an inlet header to an outlet header in a heat exchanging device;

determining, by a control unit, a temperature of the working fluid in the outlet header; and

propelling, by at least one propeller, subsea water across the at least one coil segment to control the temperature of the working fluid in the outlet header.

11. The method of claim 10, further comprising activating, by the control unit, the at least one propeller when the determined temperature of the working fluid in the outlet header is outside a determined temperature range.

12. The method of claim 10, further comprising:

determining, by the control unit, a temperature of the subsea water;

comparing the temperature of the subsea water with the temperature of the working fluid in the outlet header; and

activating the at least one propeller when the temperature of the subsea water is less than the temperature of the working fluid in the outlet header.

13. The method of claim 12, further comprising deactivating the at least one propeller when the temperature of the subsea water is greater than the temperature of the working fluid in the outlet header.

14. The method of claim 10, further comprising:

encapsulating a nozzle around the at least one propeller; and

directing, by the nozzle, flow of the subsea water towards the at least one coil segment.

15. A system, comprising:

an inlet header;

an outlet header;

a plurality of coil segments disposed between the inlet header and the outlet header and configured to direct a working fluid from the inlet header to the outlet header; and

a plurality of propellers disposed proximate to the plurality of coil segments and configured to propel subsea water across the plurality of coil segments so as to control a temperature of the working fluid in the outlet header.

16. The system of claim 15, further comprising a control unit operatively coupled to the plurality of propellers and configured to activate or deactivate each of the plurality of propellers to regulate a flow of the subsea water across the plurality of coil segments.

17. The system of claim 15, wherein the control unit comprises:

a first sensor operatively coupled to the outlet header and configured to determine the temperature of the working fluid at a determined location in the outlet header; and

a processing subunit electrically coupled to the first sensor and the plurality of propellers and configured to activate or deactivate one or more propellers in the plurality of propellers based on the determined temperature of the working fluid.

18. The system of claim 17, wherein the control unit further comprises a second sensor operatively coupled to the processing subunit and configured to determine a temperature of the subsea water.

19. The system of claim 18, wherein the processing subunit is configured to:

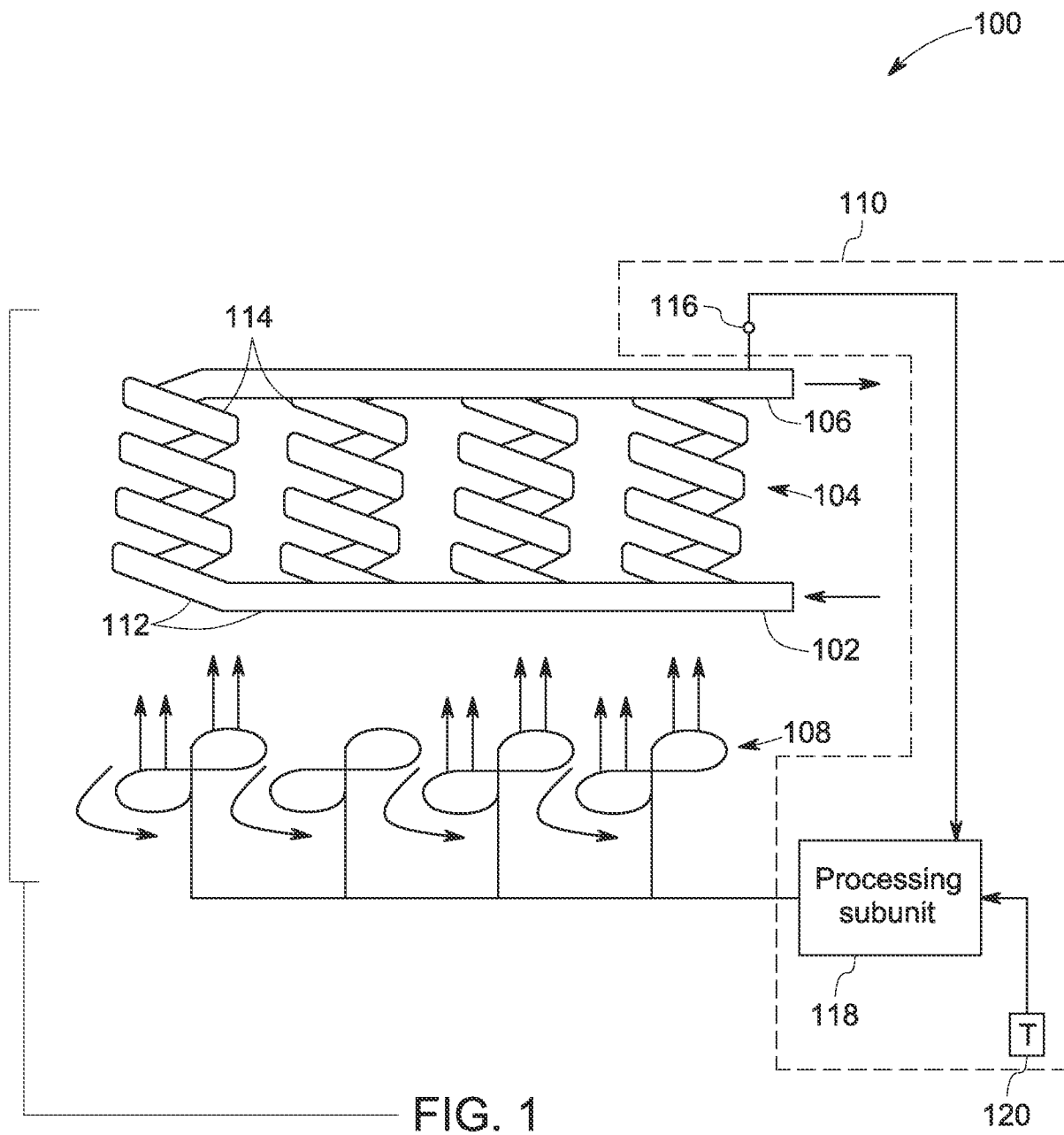
compare the temperature of the subsea water with the temperature of the working fluid in the outlet header; and

activate one or more propellers in the plurality of propellers when the temperature of the subsea water is less than the temperature of the working fluid in the outlet header.

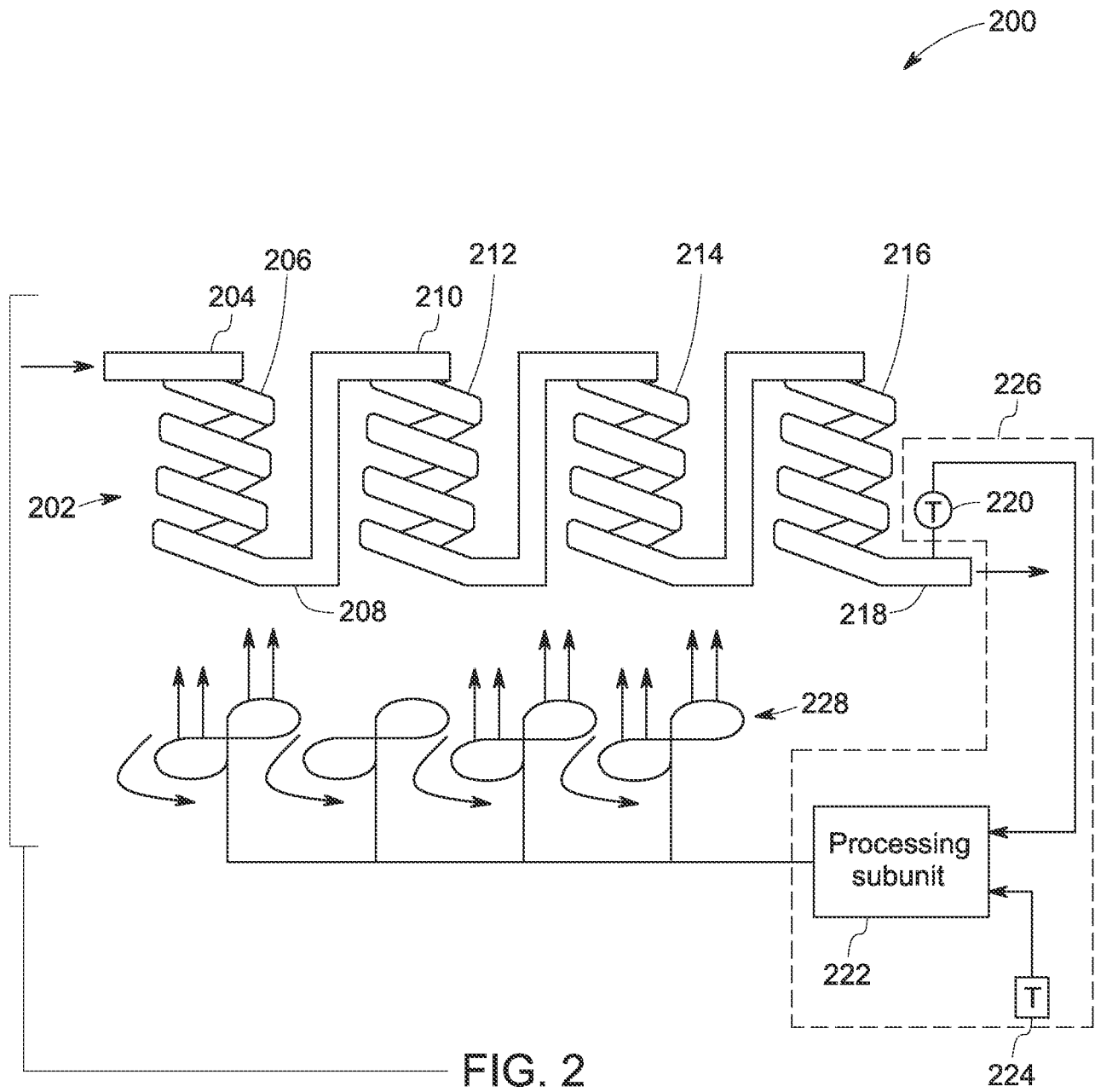
20. The system of claim 19, wherein the processing subunit is configured to deactivate one or more propellers in the plurality of propellers when the temperature of the subsea water is greater than the temperature of the working fluid in the outlet header.

21. The system of claim 15, further comprising a plurality of nozzles, wherein each of the plurality of nozzles encloses a corresponding propeller and is configured to direct the flow of the subsea water towards at least one coil segment of the plurality of coil segments.

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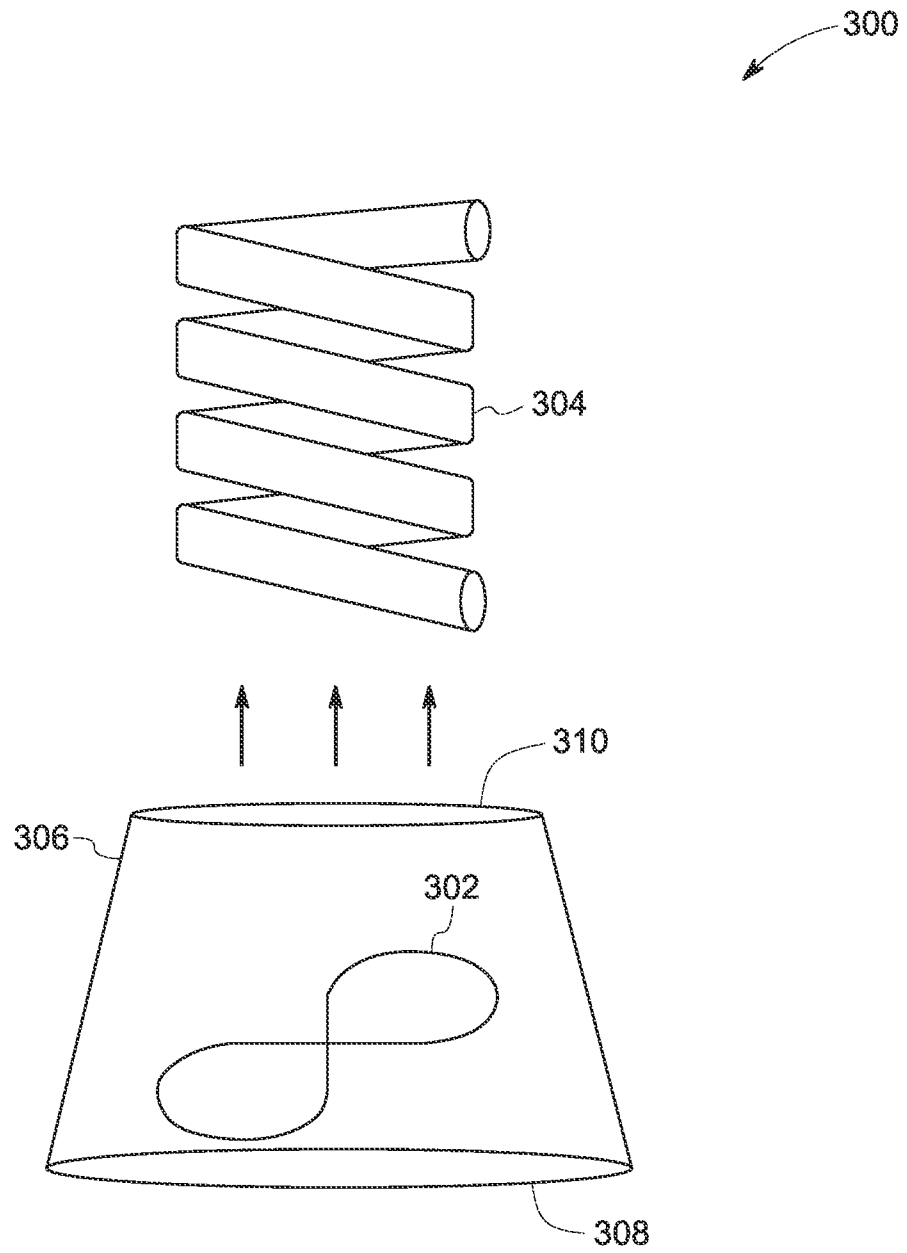


FIG. 3

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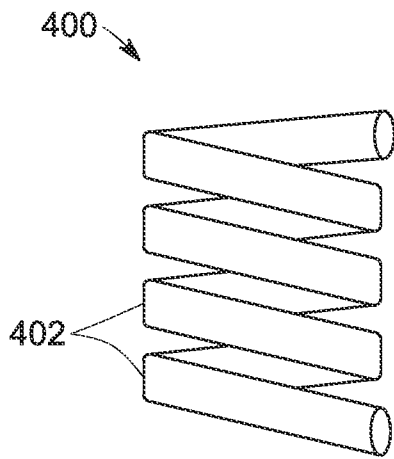


FIG. 4

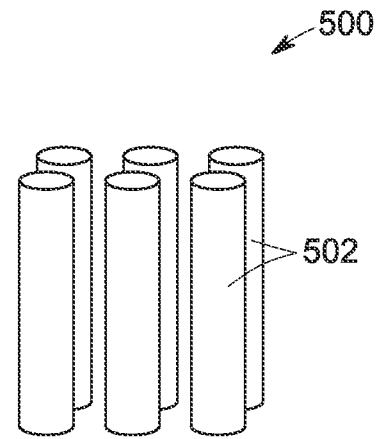


FIG. 5

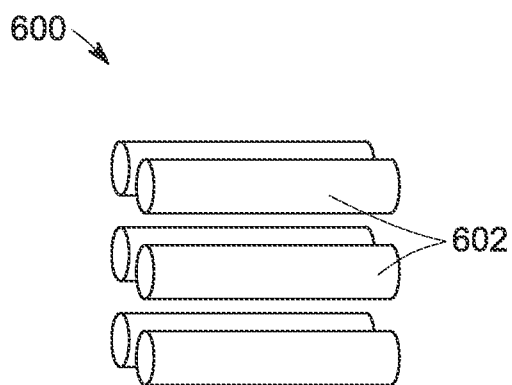


FIG. 6

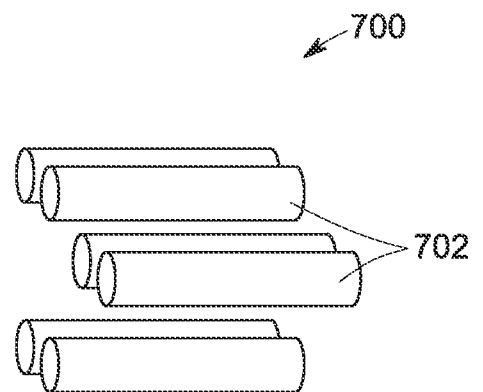


FIG. 7

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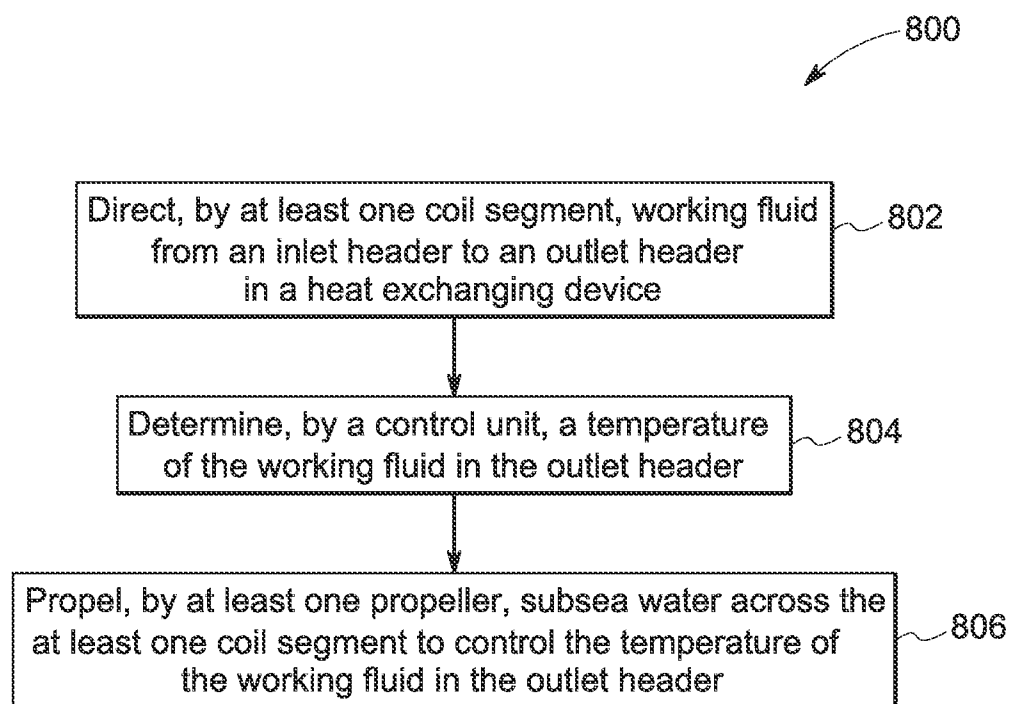


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2014/064515

A. CLASSIFICATION OF SUBJECT MATTER

INV. E21B36/00 E21B41/00 F28D7/02
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

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.
X	WO 2008/147219 A2 (FMC KONGSBERG SUBSEA AS [NO]; STEN-HALVORSEN VIDAR [NO]; BAGGERUD ERIK) 4 December 2008 (2008-12-04)	1-15
Y	the whole document	16-21

X	WO 2013/174584 A1 (FMC KONGSBERG SUBSEA AS [NO]) 28 November 2013 (2013-11-28)	1,9,10,15
Y	page 4, line 20	16-21

X	WO 2010/110676 A2 (FRAMO ENG AS [NO]; KANSTAD STIG KAARE [NO]; KANGAS NILS-EGIL [NO]; VAL) 30 September 2010 (2010-09-30)	1,10,15
	figure 17a	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

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"&" document member of the same patent family

Date of the actual completion of the international search

24 April 2015

Date of mailing of the international search report

06/05/2015

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2014/064515

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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WO 2010110676 A2	30-09-2010	AU 2010229460 A1 CN 102428250 A EP 2411625 A2 US 2012097362 A1 WO 2010110676 A2	20-10-2011 25-04-2012 01-02-2012 26-04-2012 30-09-2010