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(54) **STEERING SYSTEM, AZIMUTHING PROPULSION SYSTEM, AND METHOD FOR ABSORBING HEAT**

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SYSTÈME DE DIRECTION, SYSTÈME DE PROPULSION ORIENTABLE EN AZIMUT, ET PROCÉDÉ D'ABSORPTION DE CHALEUR

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Description

FIELD

[0001] The present invention relates to a steering system of an azimuthing propulsion system. Additionally, the invention relates to a method for absorbing heat generated during an over torque situation of a steering system of an azimuthing propulsion system.

BACKGROUND

[0002] Document WO 2000/15495 A1 describes common propeller propulsion systems of vessels such as passenger ships, ferries, cargo vessels, lighters, oil tankers, ice-breakers, off-shore vessels, etc. and propeller units in which the equipment creating the propulsion power for the propeller shaft and any gearing are positioned outside the hull of the vessel within a special chamber, pod, or propulsion unit supported for rotating in relation to the hull. The propeller unit can be also used for steering the vessel instead of separate rudder gear. Generally, these units are referred to as azimuthing propulsion systems or rudder propeller devices, and, e.g., the applicant in the present application provides azimuthing units of this kind under the trademark "AZIPOD". Presently, azimuthing propulsion systems with a power of more than 20 MW are being designed.

[0003] An azimuthing propulsion system includes one or several propulsion propellers mounted on a shaft journalled in the propulsion unit, which is substantially turnable around a vertical axis. The propulsion unit is attached to the lower end of a shaft structure which is turnably journalled in the hull of the ship and is normally a straight tubular member. By turning the so called turning shaft it is possible to direct the propulsion unit and thus also the propeller flow in any desired direction.

[0004] The azimuthing propulsion system's steering arrangement has generally been implemented so that a geared tiller ring or the like tiller rim has been attached to the tubular shaft which forms the system's swivelling axis, which tiller is rotated with the aid of hydraulic or electric motors adapted to cooperate with it.

[0005] In a case that a hydraulic turning system has been employed, the operating machinery which creates the hydraulic pressure required in the motors comprises of one or more hydraulic pumps and of one or more electric motors. In order to enhance the service reliability of the steering gear and for meeting the redundancy level required, the hydraulic motors can be arranged in two or more separate hydraulic circuits, each of which can be separated from the system and put to idling in a case of malfunction.

[0006] In case of electric steering, the corresponding redundancy level and idling functions are gained by either direct connection of electric motors to the tiller rim, or preferably via a reduction gear.

[0007] Normally, in operation the torque required for

the turning of the propulsion unit is dependent on the distance of the propeller plane from the so called turning axis or swivelling axis of the propulsion unit. Typically, the propeller is located at the end of the propulsion unit, and hence, is relatively far from the propulsion unit's turning axis. Consequently, a relatively high torque is required for turning the propulsion unit. The steerability of a vessel equipped with an azimuthing propulsion system is excellent, but the torque required for turning the propulsion unit can be high and increases as a function of the propulsion power. The high torque causes problems in particular in slow moving ships with high propeller thrust such as tugs and ice breakers. The torque required for turning the propulsion unit can reach high values and thus requires a very strong steering machinery. Further, over torque situations may, for example, occur due to collisions of at least a part of the system with blocks of ice or other objects when the propulsion unit is forced to turn along the colliding object in order to avoid damage.

[0008] A hydraulic turning system has been employed, because hydraulics readily allow the relatively high torque required for turning an azimuthing propulsion unit to be obtained at a relatively low speed of rotation. At the same time, the turning and steering of the vessel by means of the hydraulics can be readily and relatively precisely controlled with the aid of the traditional pumps and valve gears and corresponding hydraulic components. Further, the shock-absorption- and torque limitation features that are protecting the mechanical parts of the power transmission of the steering system have most suitably been implemented with hydraulics due to an excellent response time and accuracy of the hydraulic pressure relief valves. Hence, the hydraulic power transmission system has been considered as the most suitable solution for steering systems that are frequently exposed for high external loads that are causing over torque situations.

[0009] The propulsion unit has to be able to turn along with a colliding object so that no damage is caused to the steering system. The amount of absorbed heat corresponds to the loss energy that is created at the pressure relief valves when the propulsion unit is forced to turn by a colliding object. Traditionally, the azimuthing propulsion systems with hydraulic steering have four very large hydraulic motors directly connected to the steering gear including pinions. The pressure relief valves are preferably integrated to the same package with the motors, to gain a standard solution with highly predictable dynamic properties. The large motors are containing a sufficient oil volume to absorb the heat generated in an over torque situation. An over torque situation may, for example, occur in arctic environments when the propulsion system is frequently exposed to collisions with blocks of ice during operation.

[0010] Over-dimensioning of parts of the steering system should be avoided. However, use of smaller hydraulic motors operating at an increased rotation speed compared to a system comprising the large hydraulic motors

can create a heating problem during an over torque movement due to the small motor volume, the high rotation speed and small volumes in the working lines between the pressure relief valves and the motor ports.

[0011] Document WO 2013/034797 A1 discloses a hydraulic steering arrangement for a thruster of a marine vessel. The hydraulic steering arrangement is specifically designed for thrusters intended to operate in an arctic environment where ice is present. To meet the arctic demands the steering arrangement is provided with a cross-over safety block arranged close to the hydraulic steering motor for absorbing the torque subjected to the thruster by ice, for instance.

[0012] In view of the foregoing, it would be beneficial to provide an azimuthing propulsion system or a steering system which comprises a shock absorption system that can absorb the heat generated during an over torque situation of a steering system of the propulsion system in order to utilize small motors without running into heating problems.

SUMMARY OF THE INVENTION

[0013] The invention is defined by the features of the independent claims. Some specific embodiments are defined in the dependent claims.

[0014] According to a first aspect of the present invention, there is provided a steering system of an azimuthing propulsion system, the steering system comprising at least one hydraulic motor configured to operate an azimuthing system of a propulsion unit, the propulsion unit configured to being arranged outside a vessel, a fluid cycle from the at least one hydraulic motor via a separate hydraulic overload protection unit and back to the motor, wherein the overload protection unit comprises a pressure relief unit and a heat management unit and wherein the pressure relief unit comprises a pressure relief valve and the heat management unit comprises a heat storage comprising a temperature balance tank, wherein the temperature balance tank is configured to receive a heated outlet fluid flow of the pressure relief valve and to provide a filling fluid flow to a hydraulic motor inlet volume so that the fluid cycle comprising the overload protection unit is configured to at least partially absorb heat generated during turning of the propulsion unit caused by a critical torque caused by an external force, wherein the steering system is configured to allow the propulsion unit to turn along with a colliding object, and wherein the steering system comprises a further tank containing a fluid, a booster line inlet check valve connecting the temperature balance tank to the further tank, and a booster pump connected to the temperature balance tank via said booster line inlet check valve so that the temperature balance tank can be flushed with the fluid by means of the booster pump.

[0015] Various embodiments of the first aspect may comprise at least one feature from the following bulleted list:

- the turning of the propulsion unit caused by an external force represents an over torque situation of the steering system
- 5 • the heat storage comprises a pipeline
- at least a part of the heat management unit is arranged in series with the pressure relief unit
- 10 • a temperature of a temperature balance tank fluid outlet flow is less than the temperature of a pressure relief fluid outlet flow
- the temperature balance tank is configured to increase a rotation volume of the fluid cycle
- 15 • the temperature balance tank is configured to increase a heat capacity of the fluid cycle
- 20 • the steering system comprises hydraulic interconnections between the at least one hydraulic motor and the overload protection unit
- the hydraulic interconnection, the at least one hydraulic motor and the overload protection unit are configured to circulate a fluid
- 25 • the fluid cycle is configured to decrease a temperature of a fluid in the fluid cycle by means of a heat sink or cooler
- 30 • the temperature balance tank is configured to decrease a temperature of a fluid in the fluid cycle by means of a heat sink or cooler
- 35 • the fluid cycle comprises a boost pressure fluid system coupled to the overload protection unit
- a gear is arranged between the at least one hydraulic motor and a steering gear of the propulsion system
- 40 • the heat management unit is separated from the pressure relief unit
- 45 • the heat management unit and the pressure relief unit are integrated
- the temperature of the temperature balance tank fluid outlet flow is less than 10 [°C], less than 15 [°C], less than 20 [°C], or less than 35 [°C] than the temperature of the pressure relief fluid outlet flow
- 50 • a volume of the temperature balance tank is adapted to hold at least 5 [l], at least 10 [l], at least 15 [l], or at least 20 [l] of fluid
- 55 • the steering system is implemented in or coupled to an azimuthing propulsion system

[0016] According to an example, there is provided an azimuthing propulsion system comprising at least one hydraulic motor configured to operate a azimuthing system of a propulsion unit, the propulsion unit being arranged outside a vessel, a fluid cycle from the at least one hydraulic motor via a separate hydraulic overload protection unit and back to the motor, the overload protection unit comprises a pressure relief unit and a heat management unit, and wherein the pressure relief unit comprises a pressure relief valve, and the heat management unit comprises a heat storage, and wherein the fluid cycle comprising the overload protection unit is configured to at least partially absorb heat generated during turning of the propulsion unit.

[0017] The example may comprise at least one feature from the following bulleted list:

- the azimuthing propulsion system is configured to allow the propulsion unit to turn along with a colliding object, as a certain predefined load pressure level has been exceeded
- turning of the propulsion unit is caused by a critical torque caused by an external force
- the turning of the propulsion unit caused by an external force represents an over torque situation of a steering system
- at least a part of the heat management unit is arranged in series with the pressure relief unit
- the heat storage comprises a pipeline or a temperature balance tank or both
- the temperature balance tank is configured to receive a heated outlet fluid flow of the pressure relief valve and to provide a filling fluid flow to a hydraulic volume where a hydraulic motor inlet is connected to
- the temperature balance tank is configured to increase a rotation volume of the fluid cycle
- the temperature balance tank is configured to increase a heat capacity of the fluid cycle
- a temperature of a temperature balance tank fluid outlet flow is less than the temperature of a pressure relief fluid outlet flow
- the system comprises hydraulic interconnections between the at least one hydraulic motor and the overload protection unit
- the hydraulic interconnection, the at least one hydraulic motor and the overload protection unit are configured to circulate a fluid
- a gear is arranged between the at least one hydraulic motor and a steering gear of the propulsion system

[0018] According to a second aspect of the present invention, there is provided a method for absorbing heat generated during an over torque situation of a steering system of an azimuthing propulsion system, the method comprising allowing a propulsion unit to turn along with a colliding object, the propulsion unit being arranged outside a vessel, circulating fluid from a hydraulic motor via a separate hydraulic overload protection unit and back

to the motor, and wherein the overload protection unit comprises a pressure relief unit and a heat management unit, and wherein the pressure relief unit comprises a pressure relief valve, and the heat management unit comprises a heat storage comprising a temperature balance tank, and receiving by the temperature balance tank a heated outlet fluid flow of the pressure relief valve and providing by the temperature balance tank a filling fluid flow to a hydraulic motor inlet volume in order to absorb at least a part of the generated heat by means of the overload protection unit, wherein the steering system comprises a further tank connected to the temperature balance tank via a booster line inlet check valve, and flushing the temperature balance tank by a booster pump.

[0019] Various embodiments of the second aspect may comprise at least one feature from the following bulleted list:

- the method further comprising receiving a heated outlet fluid flow of the pressure relief valve, and providing a filling fluid flow to a hydraulic motor inlet volume
- the method yet further comprising transferring heat away from the fluid present in the overload protection unit by means of a heat sink which is coupled to the heat storage or integrated in the heat storage

[0020] According to a further example, there is provided a method for operating an azimuthing propulsion system, the method comprising allowing a propulsion unit to turn, the propulsion unit being arranged outside a vessel, circulating fluid from a hydraulic motor via a pressure relief valve to a temperature balance tank and back to the motor, and absorbing at least a part of heat generated during an over torque situation of a steering system of the propulsion system due to a collision of at least a part of the system with ice or any other object by means of the temperature balance tank.

[0021] According to an even further example, there is provided a computer readable memory having stored thereon a set of computer implementable instructions capable of causing a computing device, in connection with an azimuthing propulsion system or in connection with a steering system 30 of an azimuthing propulsion system, to couple a heat exchanger to a fluid cycle based on a fluid temperature measurement in a part of an overload protection unit, or to control a fluid flow of a coolant of the heat exchanger coupled to the fluid cycle, based on a fluid temperature measurement in a part of the overload protection unit, or to directly exchange fluid present in the overload protection unit by means of an actively controllable valve connection from a fluid volume of a heat storage to a tank line or corresponding lower pressure line.

[0022] Considerable advantages are obtained by means of certain embodiments of the present invention. Certain embodiments of the present invention provide an

azimuthing propulsion system. Certain other embodiments of the present invention provide a method for absorbing heat generated during an over torque situation of a steering system of an azimuthing propulsion system. Additionally, certain other embodiments of the present invention provide a method for operating an azimuthing propulsion system.

[0023] According to certain embodiments of the present invention, heat generated during an over torque situation of a steering system of an azimuthing propulsion system can be absorbed. Therefore, significantly smaller hydraulic motors can be used in the system. Certain embodiments of the present invention enable the use of relatively small hydraulic motors on arctic vessels or ice breakers, for instance.

[0024] The small hydraulic motors are more compact than the motors currently used, thus reducing weight, dimensions and costs of the propulsion system. The availability and diversity of smaller motors is further much better than of large ones on the market. The propulsion unit can be built by using standard components without making any further changes to the system. Additionally, the system can be manufactured in industrial scale.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] For a more complete understanding of particular embodiments of the present invention and their advantages, reference is now made to the following descriptions, taken in conjunction with the accompanying drawings. In the drawings:

FIGURE 1 illustrates a schematic view of an example of an azimuthing propulsion system outside of the scope of the claims,

FIGURE 2 illustrates a schematic view of an example of an azimuthing propulsion system comprising a heat sink outside of the scope of the claims,

FIGURE 3 illustrates a schematic view of an example of an azimuthing propulsion system comprising a gear outside of the scope of the claims,

FIGURE 4 illustrates a schematic view of an example of a fluid cycle diagram outside of the scope of the claims,

FIGURE 5 illustrates a schematic view of a fluid cycle diagram of a steering system of an azimuthing propulsion system in accordance with at least some embodiments of the present invention during an over torque situation of the steering system,

FIGURE 6 illustrates a schematic view of a fluid cycle diagram of a steering system of an azimuthing propulsion system in accordance with at least some embodiments of the present invention during an over

torque situation of the steering system, and

FIGURE 7 illustrates a schematic view of an example of a fluid cycle diagram of a steering system of an azimuthing propulsion system comprising an overload protection unit outside of the scope of the claims.

EMBODIMENTS

[0026] Certain embodiments of the present invention relate to an azimuthing propulsion system comprising a shock absorption system. The shock absorption system is designed to absorb heat generated during an over torque situation of a steering system of the propulsion system. Such an over torque situation may, for example, take place when at least a part of the propulsion system is exposed to collisions with blocks of ice or any other objects. The system is capable of absorbing such shocks by allowing the propulsion unit to turn along with the colliding object in a suitable direction and absorbing the generated heat.

[0027] In FIGURE 1 a schematic view of an example of an azimuthing propulsion system 1 outside of the scope of the claims is illustrated. The propulsion system 1 includes equipment for creating the propulsion power for the propeller shaft and gearing positioned outside the hull 12 of a vessel within a special propulsion unit 3 supported for rotating in relation to the hull 12.

[0028] The azimuthing propulsion system 1 comprises a plurality of hydraulic motors 2 configured to operate the steering system of the propulsion unit 3 which is arranged outside the vessel. The term "operate" means that the propulsion unit 3 of the propulsion system 1 can be turned relative to the hull 12 around a vertical axis of rotation. Typically, the propulsion unit 3 can be turned unlimitedly in both directions relative to the hull 12. The propulsion system may, for example, include four or six hydraulic motors coupled to the steering gear of the propulsion system 1. In FIGURE 1 only one hydraulic motor 2 is shown.

[0029] The system 1 further includes a shock absorption system comprising a fluid cycle from the hydraulic motor 2 via a pressure relief valve 5 to a temperature balance tank 6 and back to the motor 2. Typically, oil is used as fluid in the fluid cycle. The temperature balance tank 6 is configured to at least partially absorb heat generated during an over torque situation of the steering system of the propulsion system 1. The temperature balance tank 6 may be also called fluid warren or temperature stabilization reservoir, for instance. The hydraulic motor 2, the pressure relief valve 5 and the temperature balance tank 6 of each fluid cycle are arranged inside the vessel.

[0030] For example, in case that at least a part of the propulsion system 1 is exposed to collisions with blocks of ice or any other object 14 during operation, the propulsion unit 3 is able to turn along with the colliding object 14 so that no damage is caused to the steering system.

Therefore, the pressure in the hydraulic motor 2 increases. At a certain pressure level the pressure relief valve 5 is opened as the work pressure exceeds the set pressure of the pressure relief valve. Such a turning of the propulsion unit 3 caused by an external force represents an over torque situation of the steering system, where the fluid of the hydraulic system is heated. A hydraulic motor fluid outlet flow 13 flows from the hydraulic motor 2 to the pressure relief valve 5. Subsequently, the pressure relief valve fluid outlet flow 7 flows in the direction of a heat storage such as the temperature balance tank 6 and/or a heat exchanger via piping 9. The temperature balance tank 6 represents a substitute for a long pipeline and can act as a buffer volume for the hot pressure relief fluid outlet flow 7. The temperature balance tank 6 may, for example, comprise a piping labyrinth in order to provide a substitute for a long pipeline. Additionally, in the temperature balance tank 6 the temperature of the fluid may be reduced, for instance. In other words, the temperature balance tank 6 may be configured to decrease a temperature of the heated incoming pressure relief valve fluid outlet flow 7. The amount of absorbed heat corresponds to the loss energy that is created when the fluid is forced to flow through the pressure relief valve by the motor 2 that is acting as a pump as the propulsion unit is forced to turn by the colliding object 14. Next, the temperature balance tank fluid outlet flow 8 can flow back to the hydraulic motor 2. The temperature of the temperature balance tank fluid outlet flow 8 returning to the hydraulic motor 2 is less than the temperature of the pressure relief valve fluid outlet flow 7.

[0031] The temperature balance tank 6 increases the rotation volume of the fluid cycle. According to certain embodiments, the volume of the temperature balance tank 6 is adapted to hold fluid in the range between 5 [l] and 20 [l], for example at least 10 [l] or at least 15 [l]. The temperature of the temperature balance tank fluid outlet flow 8 is relatively cool as long as the total capacity of the temperature balance tank 6 has not been significantly exceeded by the pressure relief valve fluid outlet flow 7.

[0032] It is noted, that instead of including a temperature balance tank 6 between the pressure relief valve 5 and the hydraulic motor 2, only a straight or bended piping may be arranged between the pressure relief valve 5 and the hydraulic motor 2 in order to form a fluid circle. The piping may have a suitable cross-sectional area and/or length in order to provide a sufficient fluid volume in the fluid cycle.

[0033] The system 1 is able to avoid a heating problem in the work line between the pressure relief valve 5 and the motor port during an over torque situation of the steering system. The fluid present in the fluid cycle can circulate multiple times through the same loop from the hydraulic motor 2, via the pressure relief valve 5, and via the temperature balance tank 6.

[0034] In FIGURE 2 a schematic view of an example of an azimuthing propulsion system 1 comprising a heat sink 10 outside of the scope of the claims is illustrated.

For example, a heat storage may include a heat sink 10 comprising a piping system for guiding a working fluid through the piping system, i.e. a gas or liquid can flow through the piping system of the heat sink 10 in order to transfer heat away from the fluid present in the heat storage, e.g. the temperature balance tank 6. Typically, a liquid such as oil, water, or water-glycol mixture is used as a working fluid.

[0035] According to other embodiments, the heat sink 10 may comprise cooling fins or other objects protruding away from the temperature balance tank 6 in order to increase the effective area of heat transfer. Such cooling fins or objects protruding away from the temperature balance tank 6 may be arranged instead of or in addition to a heat sink 10 comprising a piping system for guiding a working fluid through the piping system. The cooling fins or objects protruding away from the temperature balance tank 6 may be, for example, made of copper, aluminium or any other material having a suitable thermal conductivity.

[0036] According to another embodiment, a boost pressure fluid can flow through the temperature balance tank 6 so that it flushes the temperature balance tank 6 constantly. Of course, also such an active cooling system may further comprise cooling fins or objects protruding away from the temperature balance tank 6.

[0037] The time period allowed in between successive ice collisions or collisions with other objects 14 without overheating of the hydraulic system can be very short due to cooling the fluid present in the temperature balance tank 6. Therefore, arctic vessels and ice breakers including an azimuthing propulsion system 1 for propulsion of the vessel may comprise such a system for (actively) cooling the fluid present in the temperature balance tank 6, for instance.

[0038] The system 1 is able to avoid a heating problem in the work line between the pressure relief valve 5 and the motor port during an over torque situation of the steering system. The fluid present in the fluid cycle can circulate multiple times through the same loop from the hydraulic motor 2, via the pressure relief valve 5, and via the temperature balance tank 6.

[0039] In FIGURE 3 a schematic view of an example of an azimuthing propulsion system 1 comprising a gear 11 outside of the scope of the claims is illustrated. The hydraulic motor 2 is coupled to the steering gear of the propulsion system via a gear 11, for example a planetary gear. The propulsion system 1 further additionally includes a heat storage, e.g. a temperature balance tank comprising a heat sink 10.

[0040] By means of placing the gear 11 between the hydraulic motor 2 and the pinions of the steering gear of the system 1, torque capacity demands can be met while simultaneously using a smaller hydraulic motor. The system 1 is also able to avoid a heating problem in the work line between the pressure relief valve 5 and the motor port during an over torque situation of the steering system. The fluid present in the fluid cycle can circulate mul-

multiple times through the same loop from the hydraulic motor 2, via the pressure relief valve 5, and via the temperature balance tank 6.

[0041] In FIGURE 4 a schematic view of an example of a fluid cycle diagram outside of the scope of the claims is illustrated. A fluid cycle 4 from the hydraulic motor to the pressure relief valve to the heat storage and back to the hydraulic motor is shown. The heat storage may be a temperature balance tank 6, for instance.

[0042] In FIGURE 5 a schematic view of a fluid cycle diagram of a steering system 30 of an azimuthing propulsion system 1 in accordance with at least some embodiments of the present invention during an over torque situation of the steering system 30 is illustrated. The steering system 30 includes a pump module 16 and a motor module 15.

[0043] The pump module 16 comprises an electric motor 17 which rotates a hydraulic pump 18. The pump module 16 may further comprise a booster pump 19, filling functions 20, and flushing functions 21.

[0044] The motor module 15 comprises a hydraulic motor 2, which is coupled to pinions 29 via a gear 11. The motor module 15 further comprises a fluid cycle 4 from the hydraulic motor 2 via the second pressure relief valve 23 to a heat storage, for example a temperature balance tank 6, via the first filling check valve 24 and back to the motor 2. The motor module 15 further comprises a first pressure relief valve 22 and a second filling check valve 25. The first pressure relief valve 22 and the second filling check valve 25 are not a part of the fluid cycle 4 during over torque situation with counter-clockwise movement of the pinion 29 as shown in FIGURE 5. Additionally, motor module 15 comprises a valve connection 26 which may be a shut-off valve or proportional valve, for instance.

[0045] The booster pump 19 is connected to the temperature balance tank 6 via a booster line inlet check valve 27. The temperature balance tank 6 can be constantly flushed with the fluid by means of the booster pump 19.

[0046] In FIGURE 6 a schematic view of a fluid cycle diagram of a steering system 30 of an azimuthing propulsion system 1 in accordance with at least some embodiments of the present invention during an over torque situation of the steering system 30 is illustrated. The steering system includes a pump module 16 and a motor module 15.

[0047] The pump module 16 comprises an electric motor 17 and a hydraulic pump 18, and it may also comprise a booster pump 19, filling functions 20, and flushing functions 21.

[0048] The motor module 15 comprises a hydraulic motor 2, which is coupled to pinions 29 via a gear 11. The motor module 15 further comprises a fluid cycle 4 from the hydraulic motor 2 via the first pressure relief valve 22 to a heat storage, for example a temperature balance tank 6, via the second filling check valve 25 and back to the motor 2. The motor module 15 further com-

prises a second pressure relief valve 23 and a first filling check valve 24. The second pressure relief valve 23 and the first filling check valve 24 are not a part of the fluid cycle 4 during clockwise movement of the pinion 29 as shown in FIGURE 6.

[0049] The booster pump 19 may be connected to the temperature balance tank 6 via a booster line inlet check valve 27. The temperature balance tank 6 can be constantly flushed with the fluid by means of the booster pump 19.

[0050] The steering system 30 further comprises a computing device 31. There is provided a computer readable memory having stored thereon a set of computer implementable instructions capable of causing a computing device 31, in connection with an azimuthing propulsion system 1 or in connection with a steering system 30 of an azimuthing propulsion system 1, to couple a heat exchanger to a fluid cycle 4 based on a fluid temperature measurement in a part of an overload protection unit, or to control a fluid flow of the coolant of the heat exchanger, coupled to the fluid cycle, based on a fluid temperature measurement in a part of the overload protection unit, or to directly exchange fluid present in the overload protection unit by means of an actively controllable valve connection 26 from a fluid volume of the heat storage to a tank line or corresponding lower pressure line. The valve connection 26 may be a shut-off valve or proportional valve, for instance.

[0051] In FIGURE 7 a schematic view of an example of a fluid cycle diagram of a steering system 30 of an azimuthing propulsion system 1 comprising an overload protection unit 32 outside of the scope of the claims is illustrated. The steering system 30 comprises at least one hydraulic motor 2 configured to operate an azimuthing system of a propulsion unit 3 which is arranged outside a vessel. The steering system 30 further includes a fluid cycle 4 from the at least one hydraulic motor 2 via a separate hydraulic overload protection unit 32 and back to the motor 2. The overload protection unit 32 is a part of the fluid cycle 4. In other words, the fluid cycle 4 comprises the overload protection unit 32. The overload protection unit 32 comprises a pressure relief unit 34 and a heat management unit 33. The pressure relief unit 34 comprises a pressure relief valve 5, and the heat management unit 33 comprises a heat storage, a heat exchanger, or a combination of both. The fluid cycle 4 is configured to at least partially absorb heat generated during turning of the propulsion unit 3.

[0052] The steering system 30 is configured to allow the propulsion unit 3 to turn along with a colliding object. The turning of the propulsion unit 3 is caused by a critical external force. The turning of the propulsion unit 3 caused by the external force represents an over torque situation of the steering system 30. At least a part of the heat management unit is arranged in series with the pressure relief unit. The heat storage may comprise a pipeline or a temperature balance tank 6 or both, for instance. The temperature balance tank 6 is configured to receive a heated

outlet fluid flow of the pressure relief valve 5 and to provide a filling fluid flow to a hydraulic volume where a hydraulic motor inlet is connected to. A temperature of a temperature balance tank fluid outlet flow 8 is less than the temperature of a pressure relief fluid outlet flow 7. The steering system 30 comprises hydraulic interconnections between the at least one hydraulic motor 2 and the overload protection unit 32. The hydraulic interconnection, the at least one hydraulic motor 2 and the overload protection unit 32 are configured to circulate a fluid.

[0053] It is to be understood that the embodiments of the invention disclosed are not limited to the particular structures, process steps, or materials disclosed herein, but are extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

[0054] Reference throughout this specification to one embodiment or an embodiment means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Where reference is made to a numerical value using a term such as, for example, about or substantially, the exact numerical value is also disclosed.

[0055] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present invention may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as de facto equivalents of one another, but are to be considered as separate and autonomous representations of the present invention.

[0056] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In this description, numerous specific details are provided, such as examples of lengths, widths, shapes, etc., to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the inven-

tion.

[0057] While the forgoing examples are illustrative of the principles of the present invention in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

[0058] The verbs "to comprise" and "to include" are used in this document as open limitations that neither exclude nor require the existence of also un-recited features. The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated. Furthermore, it is to be understood that the use of "a" or "an", that is, a singular form, throughout this document does not exclude a plurality.

20 INDUSTRIAL APPLICABILITY

[0059] At least some embodiments of the present invention find industrial application in propulsion of arctic vessels and ice breakers.

25

REFERENCE SIGNS LIST

[0060]

- | | | |
|----|----|--|
| 30 | 1 | propulsion system |
| | 2 | hydraulic motor |
| | 3 | propulsion unit |
| | 4 | fluid cycle |
| | 5 | pressure relief valve |
| 35 | 6 | temperature balance tank |
| | 7 | pressure relief valve fluid outlet flow |
| | 8 | temperature balance tank fluid outlet flow |
| | 9 | pipng |
| | 10 | heat sink |
| 40 | 11 | gear |
| | 12 | hull |
| | 13 | hydraulic motor fluid outlet flow |
| | 14 | object |
| | 15 | motor module |
| 45 | 16 | pump module |
| | 17 | electric motor |
| | 18 | hydraulic pump |
| | 19 | booster pump |
| | 20 | filling functions |
| 50 | 21 | flushing functions |
| | 22 | first pressure relief valve |
| | 23 | second pressure relief valve |
| | 24 | first filling check valve |
| | 25 | second filling check valve |
| 55 | 26 | valve connection |
| | 27 | booster line inlet check valve |
| | 28 | flushing flow metering orifice |
| | 29 | pinion |

- 30 steering system
- 31 computing device
- 32 overload protection unit
- 33 heat management unit
- 34 pressure relief unit

CITATION LIST

Patent Literature

[0061]

WO 2000/15495 A1

WO 2013/034797 A1

Non Patent Literature

Claims

1. A steering system (30) of an azimuthing propulsion system (1), the steering system (30) comprising:

- at least one hydraulic motor (2) configured to operate an azimuthing system of a propulsion unit (3), the propulsion unit (3) configured to being arranged outside a vessel,
- a fluid cycle (4) from the at least one hydraulic motor (2) via a separate hydraulic overload protection unit (32) and back to the motor (2),
- wherein the overload protection unit comprises a pressure relief unit (34) and a heat management unit (33), and wherein
- the pressure relief unit (34) comprises a pressure relief valve (5), **characterized in that**
- the heat management unit (33) comprises a heat storage comprising a temperature balance tank (6), wherein the temperature balance tank (6) is configured to receive a heated outlet fluid flow of the pressure relief valve (5) and to provide a filling fluid flow to a hydraulic motor inlet volume so that the fluid cycle (4) comprising the overload protection unit (32) is configured to at least partially absorb heat generated during turning of the propulsion unit (3) caused by a critical torque caused by an external force, wherein the steering system (30) is configured to allow the propulsion unit (3) to turn along with a colliding object,
- and **in that** the steering system (30) comprises a further tank containing a fluid, a booster line inlet check valve (27) connecting the temperature balance tank (6) to the further tank, and a booster pump (19) connected to the temperature balance tank (6) via said booster line inlet

check valve (27) so that the temperature balance tank (6) can be flushed with the fluid by means of the booster pump (19).

- 5 2. The steering system (30) according to claim 1, wherein the turning of the propulsion unit (3) caused by an external force represents an over torque situation of the steering system (30).
- 10 3. The steering system (30) according to claim 1 or 2, wherein at least a part of the heat management unit (33) is arranged in series with the pressure relief unit (34).
- 15 4. The steering system (30) according to any one of claims 1-3, wherein the temperature balance tank (6) is configured to increase a rotation volume of the fluid cycle (4).
- 20 5. The steering system (30) according to any one of claims 1-4, wherein a temperature of a temperature balance tank fluid outlet flow (8) is less than the temperature of a pressure relief fluid outlet flow (7).
- 25 6. The steering system (30) according to any one of claims 1-5, wherein the steering system (30) comprises hydraulic interconnections between the at least one hydraulic motor (2) and the overload protection unit (32).
- 30 7. The steering system (30) according to claim 6, wherein the hydraulic interconnection, the at least one hydraulic motor (2) and the overload protection unit (32) are configured to circulate a fluid.
- 35 8. The steering system (30) according to any one of claims 1-8, wherein a gear (11) is arranged between the at least one hydraulic motor (2) and a steering gear (29) of the propulsion system (1).
- 40 9. The steering system (30) according to any one of claims 1-9, wherein the heat management unit (33) is separated from the pressure relief unit (34) or the heat management unit (33) and the pressure relief unit (34) are integrated.
- 45 10. A method for absorbing heat generated during an over torque situation of a steering system (30) of an azimuthing propulsion system (1), the method comprising:
 - allowing a propulsion unit (3) to turn along with a colliding object (14), the propulsion unit (3) being arranged outside a vessel,
 - circulating fluid from a hydraulic motor (2) via a separate hydraulic overload protection unit and back to the motor (2), and wherein
- 50
- 55

◦ the overload protection unit comprises a pressure relief unit (34) and a heat management unit (33), and wherein

- the pressure relief unit (34) comprises a pressure relief valve (5), and
- the heat management unit (33) comprises a heat storage comprising a temperature balance tank (6), and

- receiving by the temperature balance tank (6) a heated outlet fluid flow of the pressure relief valve (5) and providing by the temperature balance tank (6) a filling fluid flow to a hydraulic motor inlet volume in order to absorb at least a part of the generated heat by means of the overload protection unit, wherein the steering system (30) comprises a further tank connected to the temperature balance tank (6) via a booster line inlet check valve (27), and

- flushing the temperature balance tank (6) by a booster pump (19).

Patentansprüche

1. Lenksystem (30) eines Azimutantriebssystems (1), wobei das Lenksystem (30) Folgendes umfasst:

- mindestens einen Hydraulikmotor (2), der dazu konfiguriert ist, ein Azimutsystem einer Antriebseinheit (3) zu betreiben, wobei die Antriebseinheit (3) dazu konfiguriert ist, außerhalb eines Schiffes eingerichtet zu sein,
- einen Fluidkreislauf (4) von dem mindestens einen Hydraulikmotor (2) über eine separate hydraulische Überlastschutzeinheit (32) und zurück zu dem Motor (2),
- wobei die Überlastschutzeinheit eine Druckentlastungseinheit (34) und eine Wärmemanagementeinheit (33) umfasst, und wobei
- die Druckentlastungseinheit (34) ein Druckentlastungsventil (5) umfasst,

dadurch gekennzeichnet, dass

- die Wärmemanagementeinheit (33) einen Wärmespeicher umfasst, der einen Temperaturspeicherbehälter (6) umfasst, wobei der Temperaturspeicherbehälter (6) dazu konfiguriert ist, einen erwärmten Auslassfluidstrom des Druckentlastungsventils (5) aufzunehmen und einen Füllfluidstrom an ein Hydraulikmotor-Einlassvolumen derart bereitzustellen, dass der Fluidkreislauf (4), der die Überlastschutzeinheit (32) umfasst, dazu konfiguriert ist, mindestens teilweise Wärme zu absorbieren, die während des Drehens der Antriebseinheit (3) erzeugt

wird, das durch ein kritisches Drehmoment verursacht wird, das durch eine externe Kraft verursacht wird, wobei das Lenksystem (30) dazu konfiguriert ist, das Mitdrehen der Antriebseinheit (3) mit einem kollidierenden Objekt zu erlauben,

- und dass das Lenksystem (30) einen weiteren Behälter umfasst, der ein Fluid enthält, ein Einlassrückschlagventil (27) der Druckerhöhungsleitung, das den Temperaturspeicherbehälter (6) mit dem weiteren Behälter verbindet, und eine Druckerhöhungspumpe (19), die über das Einlassrückschlagventil (27) der Druckerhöhungsleitung mit dem Temperaturspeicherbehälter (6) derart verbunden ist, dass der Temperaturspeicherbehälter (6) mittels der Druckerhöhungspumpe (19) mit dem Fluid gespült werden kann.

2. Lenksystem (30) nach Anspruch 1, wobei das Drehen der Antriebseinheit (3), das durch eine externe Kraft verursacht wird, eine Überdrehmomentsituation des Lenksystems (30) darstellt.

3. Lenksystem (30) nach Anspruch 1 oder 2, wobei mindestens ein Teil der Wärmemanagementeinheit (33) in Reihe mit der Druckentlastungseinheit (34) eingerichtet ist.

4. Lenksystem (30) nach einem der Ansprüche 1-3, wobei der Temperaturspeicherbehälter (6) dazu konfiguriert ist, ein Drehvolumen des Fluidkreislaufs (4) zu erhöhen.

5. Lenksystem (30) nach einem der Ansprüche 1-4, wobei eine Temperatur eines Fluidauslassstroms (8) eines Temperaturspeicherbehälters niedriger ist als die Temperatur eines Druckentlastungs-Fluidauslassstroms (7).

6. Lenksystem (30) nach einem der Ansprüche 1-5, wobei das Lenksystem (30) hydraulische Verbindungen zwischen dem mindestens einen Hydraulikmotor (2) und der Überlastschutzeinheit (32) umfasst.

7. Lenksystem (30) nach Anspruch 6, wobei die hydraulische Verbindung, der mindestens eine Hydraulikmotor (2) und die Überlastschutzeinheit (32) dazu konfiguriert sind, ein Fluid zirkulieren zu lassen.

8. Lenksystem (30) nach einem der Ansprüche 1-8, wobei zwischen dem mindestens einen Hydraulikmotor (2) und einem Lenkgetriebe (29) des Antriebssystems (1) ein Getriebe (11) eingerichtet ist.

9. Lenksystem (30) nach einem der Ansprüche 1-9, wobei die Wärmemanagementeinheit (33) von der Druckentlastungseinheit (34) getrennt ist oder die Wär-

memanagementeinheit (33) und die Druckentlastungseinheit (34) integriert sind.

10. Verfahren zum Absorbieren von Wärme, die während einer Überdrehmomentsituation eines Lenksystems (30) eines Azimutantriebssystems (1) erzeugt wird, wobei das Verfahren Folgendes umfasst:

- Erlauben einer Antriebseinheit (3), sich mit einem kollidierenden Objekt (14) mitzudrehen,

wobei die Antriebseinheit (3) außerhalb eines Schiffes eingerichtet ist,

- Zirkulieren von Fluid von einem Hydraulikmotor (2) über eine separate hydraulische Überlastschutzeinheit und zurück zu dem Motor (2), und wobei

- die Überlastschutzeinheit eine Druckentlastungseinheit (34) und eine Wärmemanagementeinheit (33) umfasst, und wobei

- die Druckentlastungseinheit (34) ein Druckentlastungsventil (5) umfasst, und

- die Wärmemanagementeinheit (33) einen Wärmespeicher umfasst, der einen Temperatenausgleichsbehälter (6) umfasst, und

- Empfangen eines erwärmten Auslassfluidstroms des Druckentlastungsventils (5) durch den Temperatenausgleichsbehälter (6) und Bereitstellen eines Füllfluidstroms durch den Temperatenausgleichsbehälter (6) an ein Hydraulikmotor-Einlassvolumen, um mittels der Überlastschutzeinheit mindestens einen Teil der erzeugten Wärme aufzunehmen, wobei das Lenksystem (30) einen weiteren Behälter umfasst, der über ein Einlassrückschlagventil (27) der Druckerhöhungsleitung mit dem Temperatenausgleichsbehälter (6) verbunden ist, und

- Spülen des Temperatenausgleichsbehälters (6) durch eine Druckerhöhungspumpe (19).

Revendications

1. Système de direction (30) d'un système de propulsion azimutale (1), le système de direction (30) comprenant :

- au moins un moteur hydraulique (2) configuré pour actionner un système azimutal d'une unité de propulsion (3), l'unité de propulsion (3) étant configurée pour être agencée à l'extérieur d'un navire,

- un cycle fluide (4) partant du au moins un moteur hydraulique (2), passant par une unité de protection contre les surcharges hydrauliques (32) distincte, pour revenir au moteur (2), - dans lequel l'unité de protection contre les surcharges comprend une unité de surpression (34) et une unité de gestion thermique (33), et dans lequel

- l'unité de surpression (34) comprend une soupape de surpression (5),

caractérisé en ce que

- l'unité de gestion thermique (33) comprend un stockage de chaleur comprenant un réservoir d'équilibrage de température (6), dans lequel le réservoir d'équilibrage de température (6) est configuré pour recevoir un écoulement de fluide de sortie chauffé de la soupape de surpression (5) et pour fournir un écoulement de fluide de remplissage à un volume d'entrée de moteur hydraulique de sorte que le cycle fluide (4) comprenant l'unité de protection contre les surcharges (32) soit configuré pour absorber au moins partiellement la chaleur générée pendant la rotation de l'unité de propulsion (3) provoquée par un couple critique causé par une force externe, dans lequel le système de direction (30) est configuré pour permettre à l'unité de propulsion (3) de tourner avec un objet en collision,

- et **en ce que** le système de direction (30) comprend un autre réservoir contenant un fluide, un clapet anti-retour d'entrée de conduite d'appoint (27) reliant le réservoir d'équilibrage de température (6) à l'autre réservoir, et une pompe d'appoint (19) reliée au réservoir d'équilibrage de température (6) via ledit clapet anti-retour d'entrée de conduite d'appoint (27) de sorte que le réservoir d'équilibrage de température (6) puisse être rincé avec le fluide au moyen de la pompe d'appoint (19).

2. Système de direction (30) selon la revendication 1, dans lequel la rotation de l'unité de propulsion (3) provoquée par une force externe représente une situation de surcouple du système de direction (30).

3. Système de direction (30) selon la revendication 1 ou 2, dans lequel au moins une partie de l'unité de gestion thermique (33) est agencée en série avec l'unité de surpression (34).

4. Système de direction (30) selon l'une quelconque des revendications 1-3, dans lequel le réservoir d'équilibrage de température (6) est configuré pour augmenter un volume de rotation du cycle fluide (4).

5. Système de direction (30) selon l'une quelconque des revendications 1-4, dans lequel une température d'un écoulement de sortie de fluide de réservoir d'équilibrage de température (8) est inférieure à la température d'un écoulement de sortie de fluide de surpression (7). 5
6. Système de direction (30) selon l'une quelconque des revendications 1-5, dans lequel le système de direction (30) comprend des raccordements hydrauliques entre le au moins un moteur hydraulique (2) et l'unité de protection contre les surcharges (32). 10
7. Système de direction (30) selon la revendication 6, dans lequel le raccordement hydraulique, le au moins un moteur hydraulique (2) et l'unité de protection contre les surcharges (32) sont configurés pour faire circuler un fluide. 15
8. Système de direction (30) selon l'une quelconque des revendications 1-8, dans lequel un engrenage (11) est agencé entre le au moins un moteur hydraulique (2) et un mécanisme de direction (29) du système de propulsion (1). 20
9. Système de direction (30) selon l'une quelconque des revendications 1-9, dans lequel l'unité de gestion thermique (33) est séparée de l'unité de surpression (34) ou l'unité de gestion thermique (33) et l'unité de surpression (34) sont solidaires. 25 30
10. Procédé d'absorption de chaleur générée lors d'une situation de surcouple d'un système de direction (30) d'un système de propulsion azimutale (1), le procédé comprenant : 35
- le fait de permettre à une unité de propulsion (3) de tourner avec un objet en collision (14),
- l'unité de propulsion (3) étant agencée à l'extérieur d'un navire, 40
- la mise en circulation d'un fluide provenant d'un moteur hydraulique (2), passant par une unité de protection contre les surcharges hydrauliques distincte, pour revenir au moteur (2), et dans lequel 45
 - l'unité de protection contre les surcharges comprend une unité de surpression (34) et une unité de gestion thermique (33), et dans lequel 50
 - l'unité de surpression (34) comprend une soupape de surpression (5), et 55
 - l'unité de gestion thermique (33) comprend un stockage de chaleur comprenant un réservoir d'équilibrage de tem-

pérature (6), et

- la réception, par le réservoir d'équilibrage de température (6), d'un écoulement de fluide de sortie chauffé de la soupape de surpression (5) et la fourniture, par le réservoir d'équilibrage de température (6), d'un écoulement de fluide de remplissage à un volume d'entrée de moteur hydraulique afin d'absorber au moins une partie de la chaleur générée au moyen de l'unité de protection contre les surcharges, dans lequel le système de direction (30) comprend un autre réservoir relié au réservoir d'équilibrage de température (6) via un clapet anti-retour d'entrée de conduite d'appoint (27), et
- le rinçage du réservoir d'équilibrage de température (6) par une pompe d'appoint (19).

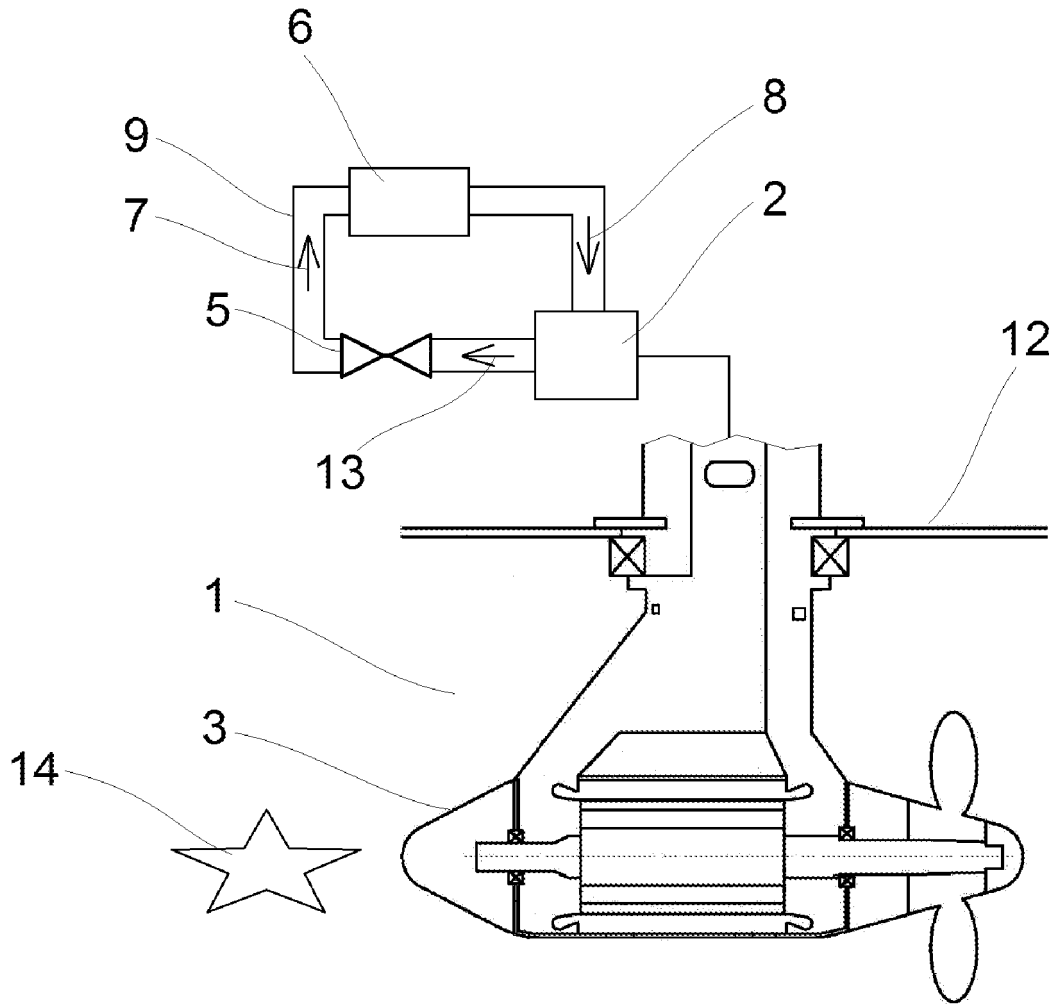


FIG. 1

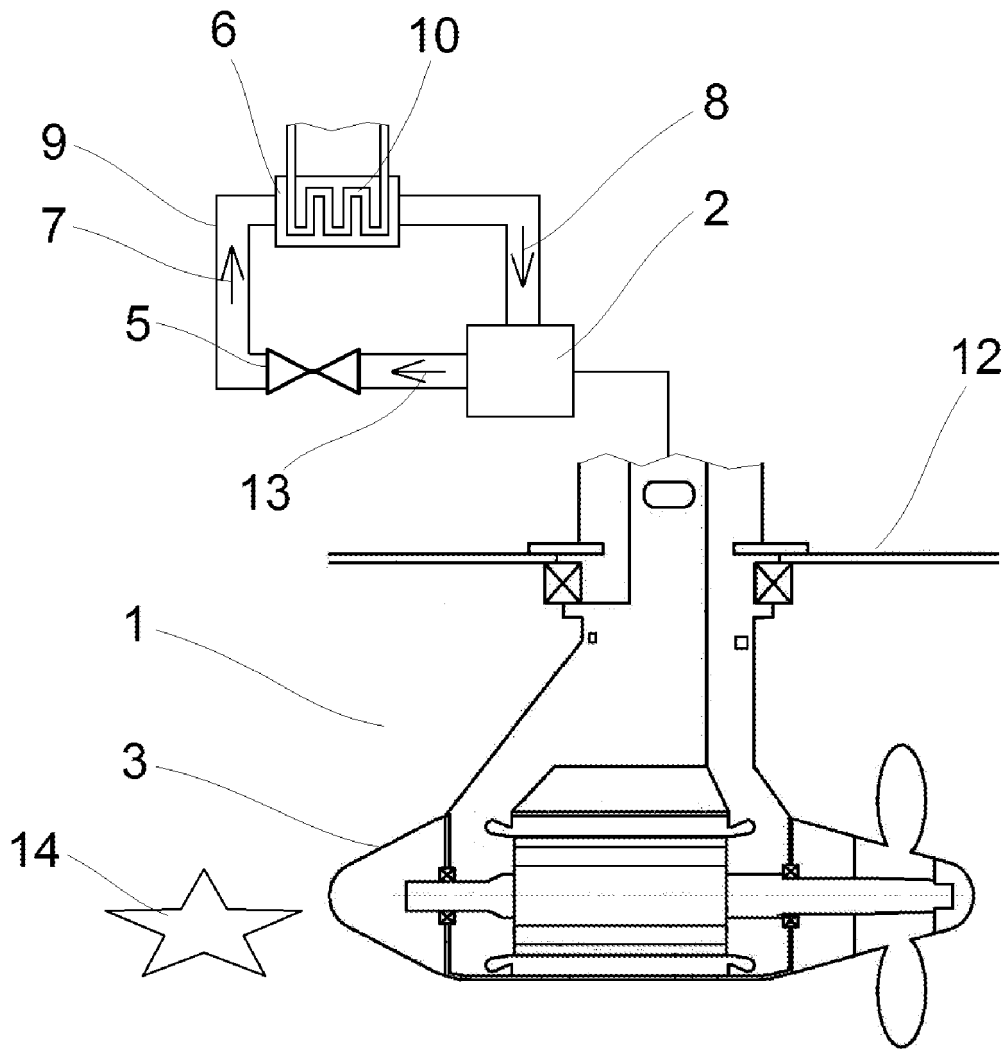


FIG. 2

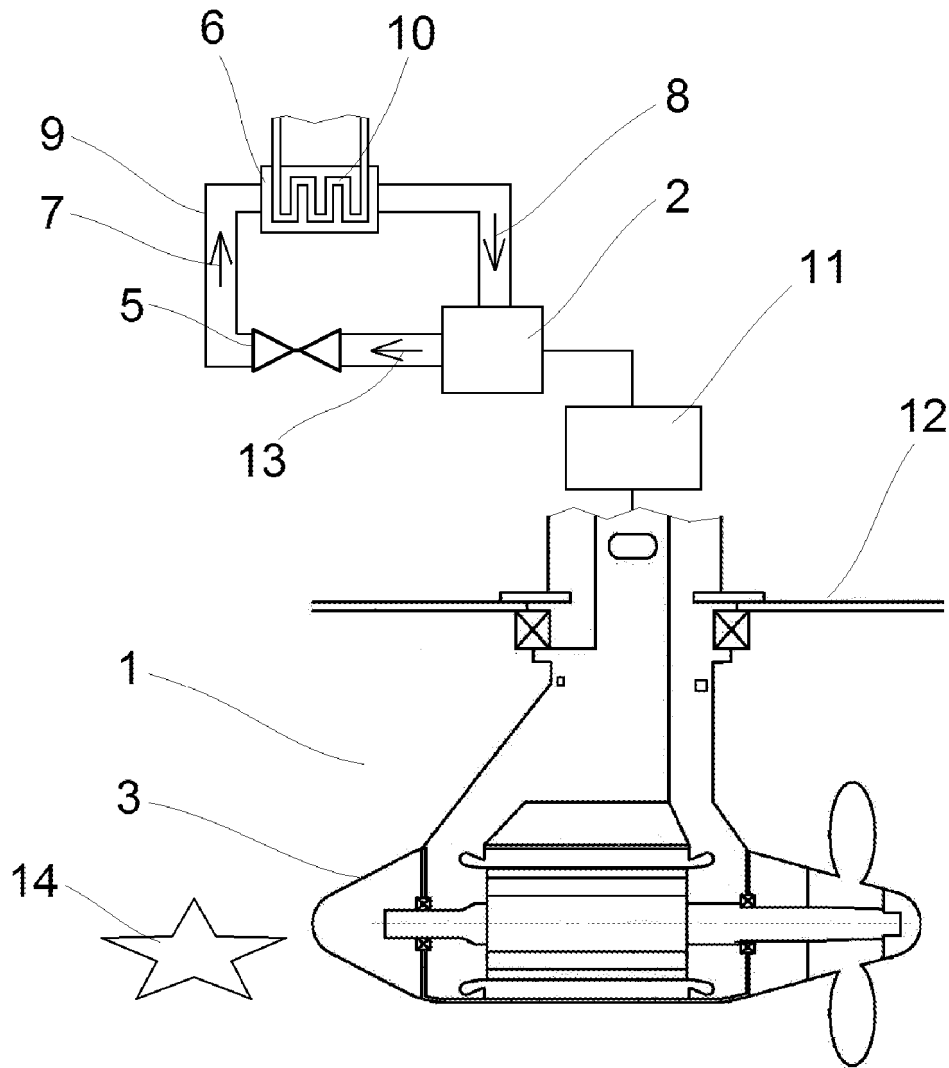


FIG. 3

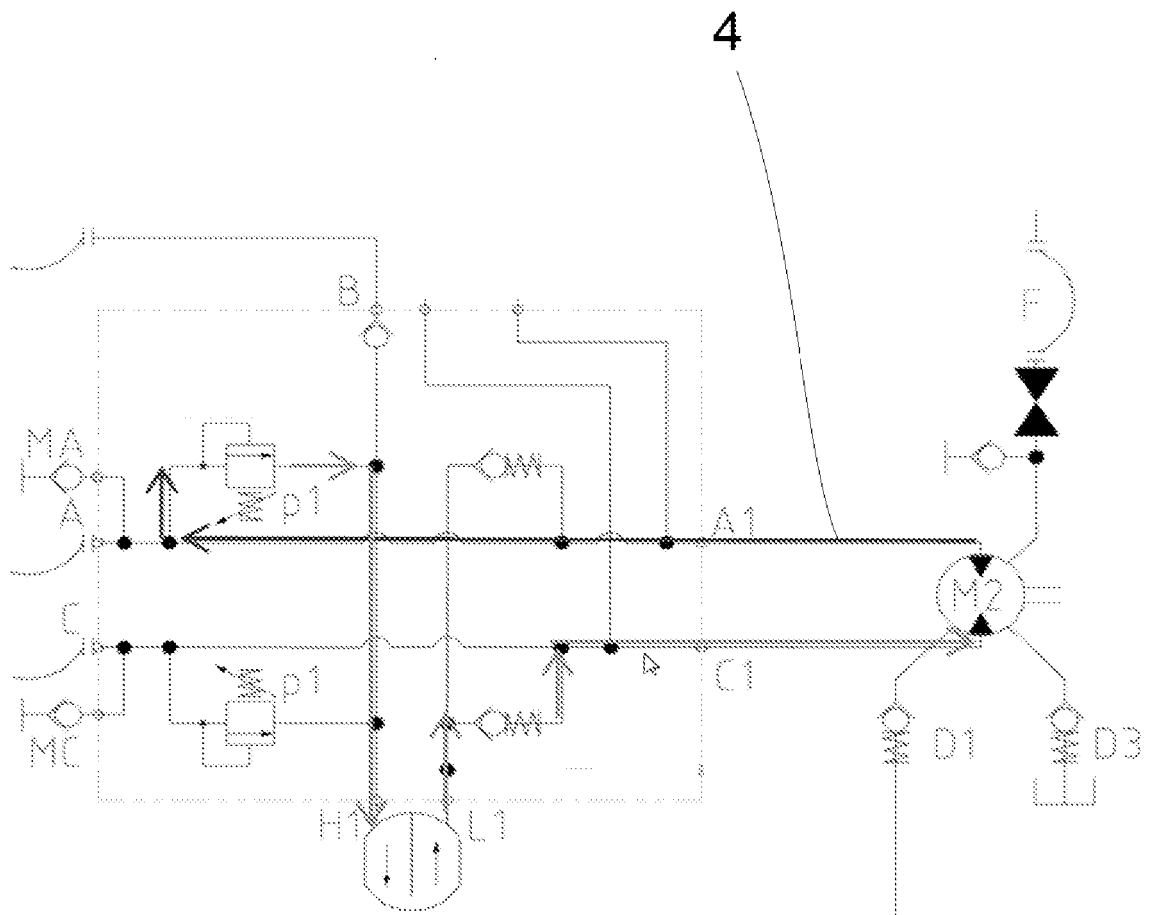


FIG. 4

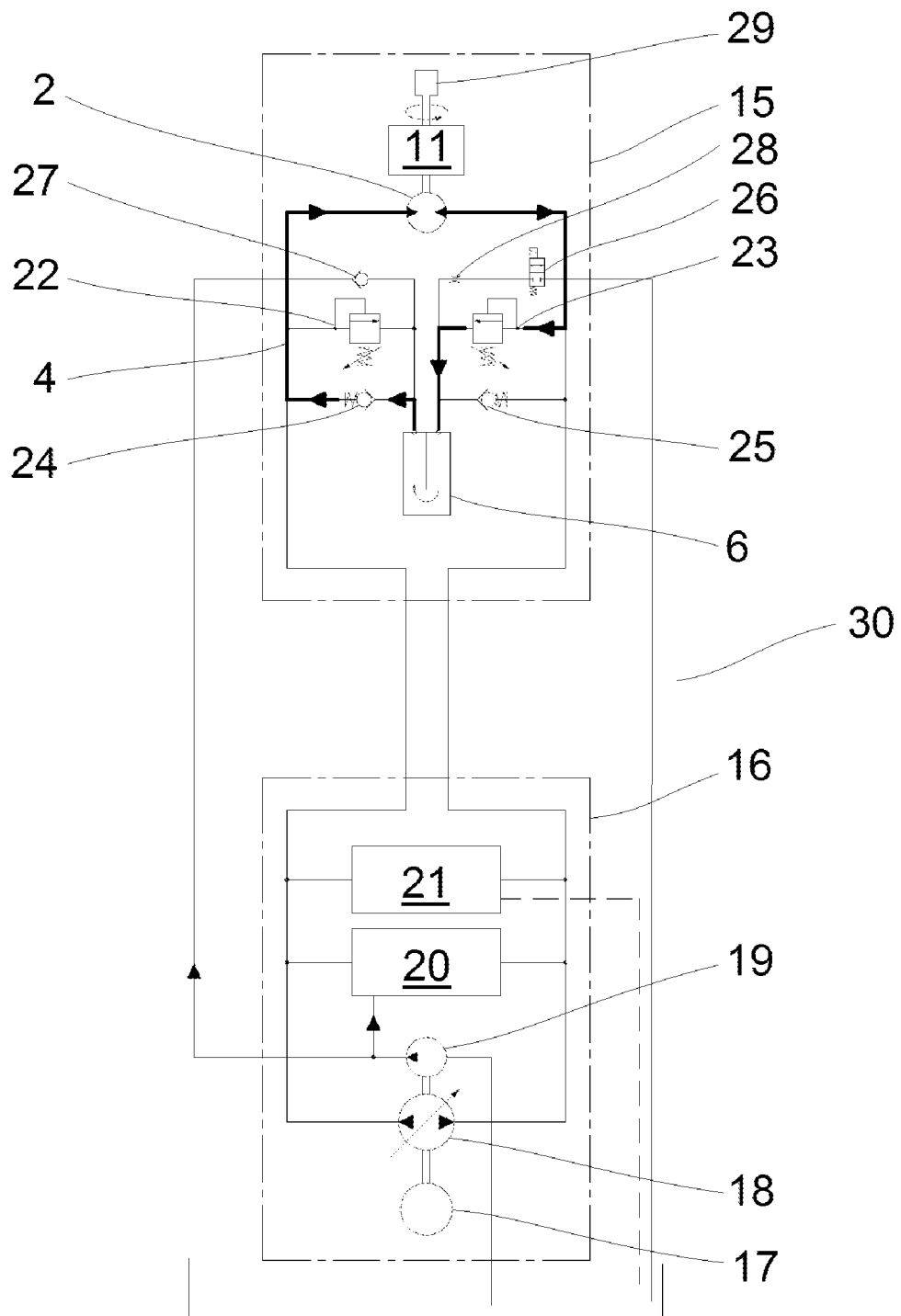


FIG. 5

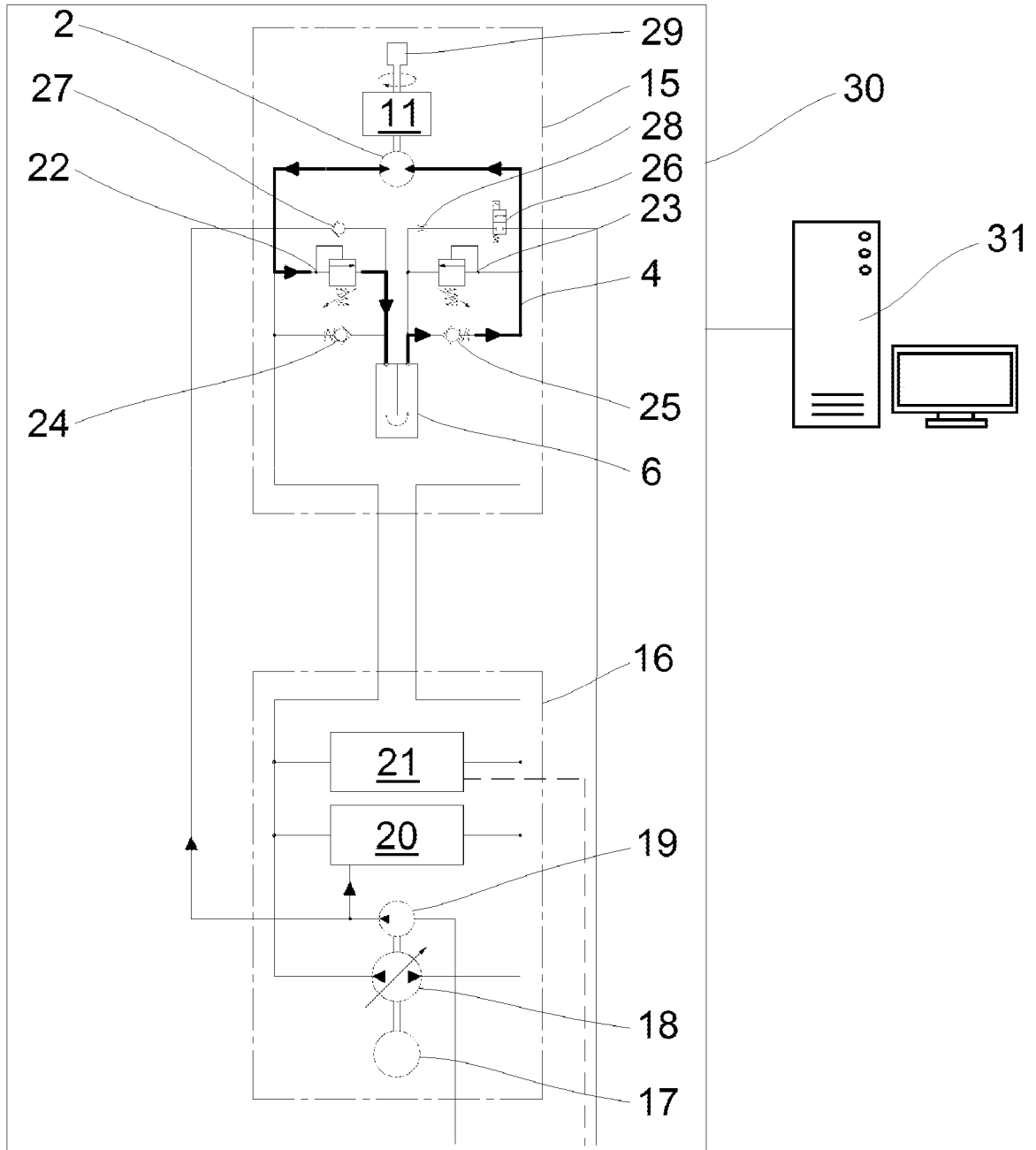


FIG. 6

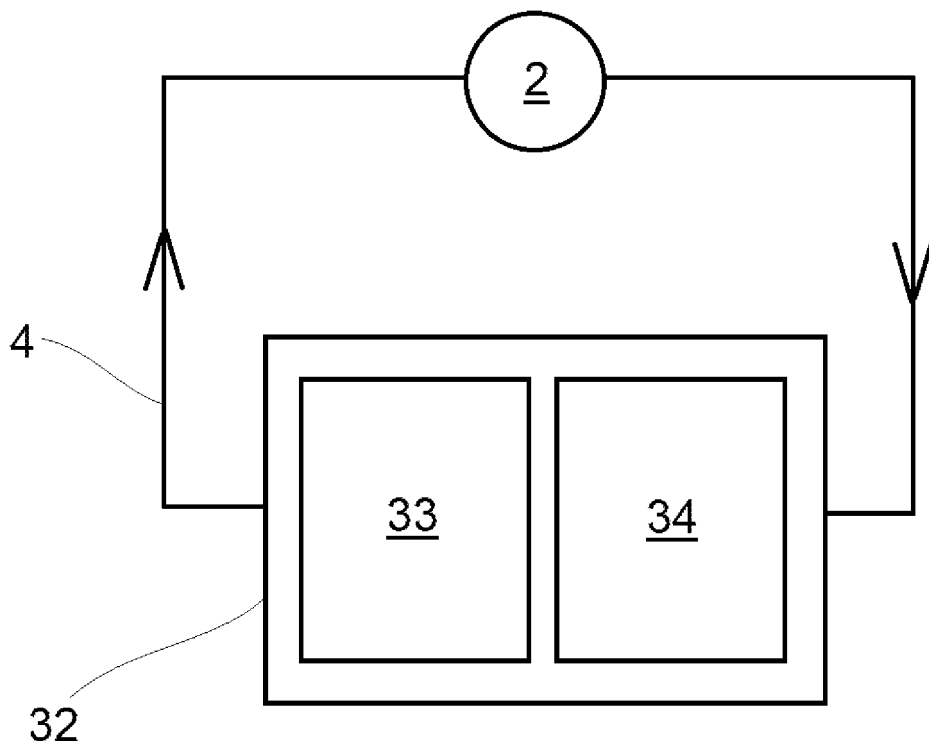


FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 200015495 A1 [0002] [0061]
- WO 2013034797 A1 [0011] [0061]