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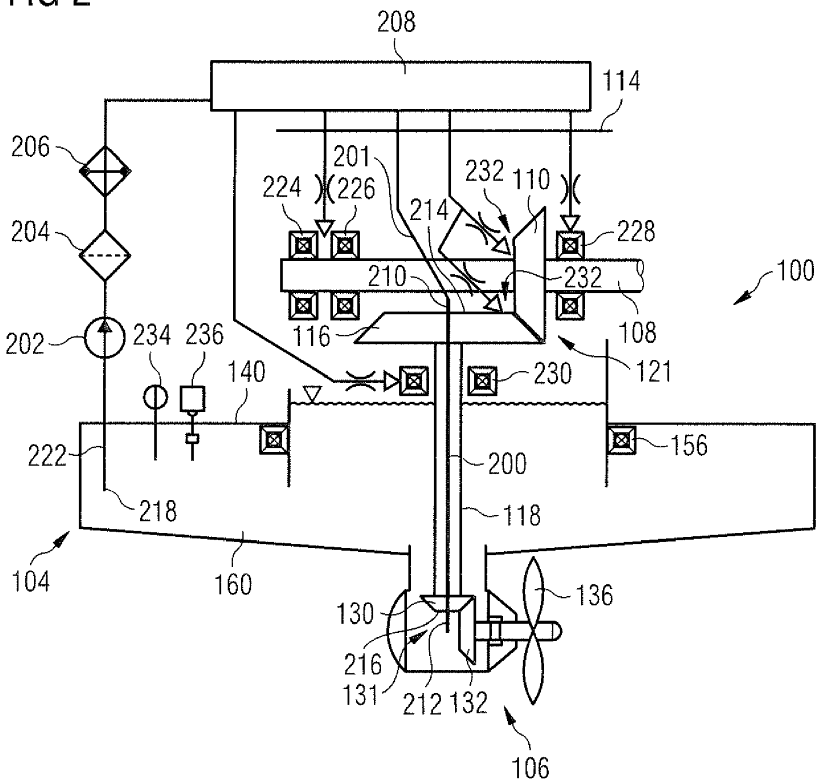
(54) LUBRICATION SYSTEM FOR AZIMUTH THRUSTER

(57) An azimuth thruster (100) for a marine vessel is disclosed. The azimuth thruster (100) comprises an upper gear unit (102), a lower gear unit (106), and an input shaft (118) drivingly connecting the upper gear unit (102) and the lower gear unit (106). The input shaft (118) includes an inner lubricant channel (200) extending in a longitudinal direction of the input shaft (118). The inner lubricant channel (200) may allow for lubrication directly provided to the highly stressed components of the lower gear unit (106) of the azimuth thruster (100) to improve lubrication and heat dissipation.

FIG 2



EP 3 279 079 A1

Description

Technical Field

[0001] The present disclosure relates to an azimuth thruster for a marine vessel, and a method for lubricating an azimuth thruster for a marine vessel.

Background

[0002] Azimuth thrusters are commonly used as propulsion devices for marine vessels. Azimuth thrusters are at least partly arranged beneath a hull of a marine vessel and typically comprise an upper gear unit, an azimuth unit and a lower gear unit. The upper gear unit is connected to a horizontal drive shaft via an upper gear crown wheel and configured to mechanically drive a vertical input shaft of the azimuth thruster. The azimuth unit is connected to the upper gear unit via a slewing bearing. The azimuth unit has an outer azimuth stem and an inner azimuth stem. The slewing bearing allows a relative rotation between the outer azimuth stem and the inner azimuth stem so that the azimuth thruster can be slewed for maneuvering the vessel. The lower gear unit includes one or more propellers connected to the vertical input shaft for providing thrust to the marine vessel.

[0003] Lubrication of the azimuth thruster typically is such that the slewing bearing within the azimuth unit is immersed in lubricant to arrange a full bath lubrication, whereas the upper gear crown wheel within the upper gear unit is splash lubricated. The splash lubrication is arranged to reduce frictional losses due to the upper gear crown wheel churning the lubricant.

[0004] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior systems.

Summary of the Disclosure

[0005] In one aspect, the present disclosure relates to an azimuth thruster for a marine vessel. The azimuth thruster comprises an upper gear unit configured to be connected to a drive source. The azimuth thruster further comprises a lower gear unit configured to be connected to a propeller. The azimuth thruster further comprises an input shaft drivingly connecting the upper gear unit and the lower gear unit. The input shaft includes an inner lubricant channel extending in a longitudinal direction of the input shaft. The azimuth thruster further comprises a lubricant pump fluidly connected to the inner lubricant channel.

[0006] In another aspect, the present disclosure relates to a method for lubricating an azimuth thruster for a marine vessel. The method comprises providing a first lubricant path through an input shaft drivingly connecting an upper gear unit for connecting to a drive source, and a lower gear unit for connecting to a propeller. The first lubricant path receives a lubricant from a lubricant pump and supplies the lubricant to the lower gear unit.

[0007] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0008] The accompanying drawings, which are incorporated herein and constitute a part of the specification, illustrate exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure. In the drawings:

Fig. 1 shows a schematic drawing of an exemplary azimuth thruster for a marine vessel (ship, oil rig, etc.) according to the present disclosure;

Fig. 2 shows a schematic drawing of a lubrication circuit for the azimuth thruster of Fig. 1.

Detailed Description

[0009] The following is a detailed description of exemplary embodiments of the present disclosure. The exemplary embodiments described therein and illustrated in the drawings are intended to teach the principles of the present disclosure, enabling those of ordinary skill in the art to implement and use the present disclosure in many different environments and for many different applications. Therefore, the exemplary embodiments are not intended to be, and should not be considered as, a limiting description of the scope of patent protection. Rather, the scope of patent protection shall be defined by the appended claims.

[0010] The present disclosure is based in part on the realization that a lubricant channel extending vertically through the azimuth thruster can be integrally formed with the input shaft that also vertically extends through the azimuth thruster. Accordingly, a separate lubrication line can be omitted.

[0011] The present disclosure is further based in part on the realization that providing an inner lubricant channel in the input shaft allows for lubrication directly provided to the highly stressed components of the lower gear unit of the azimuth thruster to improve lubrication and heat dissipation.

[0012] The present disclosure is further based in part on the realization that lubricant directly provided to the lower gear unit can be cooled and/or filtered in advance such that the lubricant and heat dissipation effects are particularly improved at those components of the azimuth thrusters, which typically bear the highest loads during operation, particularly bearings supporting the rotating shafts of the lower gear unit.

[0013] The present disclosure is further based in part on the realization that a lubricant channel integrally formed with or included in an outer azimuth stem of the azimuth unit allows cooling of the lubricant in the lubricant channel. The reason is that the outer azimuth stem includes an outer circumferential face that contacts water in the mounted state of the azimuth thruster. The water cools the outer circumferential face and thus the outer azimuth stem. By cooling the outer azimuth stem, lubricant flowing through the lubricant channel integrated in the outer azimuth stem is cooled too.

[0014] Referring now to the drawings. It should be noted that throughout the drawings, like elements are referred to with the same reference signs.

[0015] Fig. 1 shows a schematic drawing of an exemplary azimuth thruster 100 for a marine vessel. The azimuth thruster 100 includes an upper gear unit 102, an azimuth unit 104 and a lower gear unit 106.

[0016] The upper gear unit 102 includes a substantially horizontal drive shaft 108 for connecting to a drive source. The drive shaft 108 terminates to an upper gear pinion wheel 110. The upper gear pinion wheel 110 includes an upper gear pinion wheel extension 112 configured to rotatably support the horizontal drive shaft 108 within an upper gear housing 114. The upper gear pinion wheel 110 is configured to transmit power from the horizontal drive shaft 108 to an upper gear crown wheel 116.

[0017] The upper gear crown wheel 116 is mounted on top of a substantially vertical input shaft 118. The vertical input shaft 118 includes an upper crown wheel shaft 120, an intermediate shaft 122, and a lower pinion shaft 124. The upper crown wheel shaft 120 is drivably connected to the intermediate shaft 122 via a first connection 126. The lower pinion shaft 124 is drivably connected to the intermediate shaft 122 via a second connection 128. The first and second connections 126, 128 may be splined connections, flexible shaft couplings and/or floating shaft couplings.

[0018] The horizontal drive shaft 108, the upper gear pinion wheel 110, the upper gear crown wheel 116 and the upper crown wheel shaft 120 together form part of an upper gear transmission 121.

[0019] The vertical input shaft 118 terminates to a lower gear pinion wheel 130 formed on the lower pinion shaft 124. The lower gear pinion wheel 130 extends into the lower gear unit 106 and transmits the power to a lower gear crown wheel 132. The lower gear crown wheel 132 is connected to a propeller shaft 134. The propeller shaft 134 extends substantially horizontal and is provided with a propeller 136 for providing thrust to the azimuth thruster 100. The propeller 136 may be any type of propeller 136 known to a person skilled in the art, for example a variable or fixed pitch propeller.

[0020] The lower gear pinion wheel 130, the lower gear crown wheel 132 and the propeller shaft 134 together form a lower gear transmission 131 . The lower gear transmission 131 is disposed inside the lower gear unit 106.

[0021] The propeller 136 is surrounded by a nozzle 138. The nozzle 138 is fixedly connected to the lower gear unit 106 and may be any type of nozzle known to a person skilled in the art. The nozzle 138 is configured to increase a thrust of the propeller 136 and to protect the propeller 136 against, for example, debris. In some embodiments, the azimuth thruster 100 may not include the nozzle 138.

[0022] For maneuvering the marine vessel, the lower gear unit 106 including the propeller 136 and the nozzle 138 need to be rotated (slewed) around the vertical input shaft 118. This means that the upper gear unit 102 needs to be stationary, e.g. non-rotatable, whereas the lower gear unit 106 needs to be rotatable. To rotate the lower gear unit 106 relative to the upper gear unit 102 and thus about the vertical input shaft 118, the azimuth thruster 100 includes the azimuth unit 104.

[0023] The azimuth unit 104 is connected to the upper gear unit 102 via a separation plate 140. The separation plate 140 includes an opening 142 configured to at least partially accommodate the upper crown wheel shaft 120. Thus, the separation plate 140 at least partially separates the azimuth unit 104 from the upper gear unit 102. An upper crown wheel shaft housing (not shown) may be connected to the separation plate 140 and may protrude through the opening 142 for rotatably supporting the upper crown wheel shaft 120 via suitable bearings.

[0024] The azimuth unit 104 further includes an azimuth stem 144 with an inner azimuth stem 146 and an outer azimuth stem 148. The outer azimuth stem 148 is connected to the separation plate 140 via an outer ring body 152. The outer ring body 152 is fixedly connected to an annular flange 150 of the outer azimuth stem 148. The outer azimuth stem 148 includes an outer circumferential face 149 which at least partially contacts water in a mounted state of the azimuth thruster 100. The annular flange 150 is fixedly connected to a hull structure (foundation) of the marine vessel. Thus, the outer azimuth stem 148 including the separation plate 140 and the upper gear unit 102 are stationary, e.g. non-rotatable, with respect to the marine vessel.

[0025] A ring-shaped gearwheel 154 is rotatable relative to the outer ring body 152 via a plurality of suitable bearings 153. The ring-shaped gearwheel 154 is fixedly connected to the inner azimuth stem 146. The outer ring body 152 and the ring-shaped gearwheel 154 together form a slewing bearing 156. Specifically, the outer ring body 152 forms an outer race of the slewing bearing 156, and the ring-shaped gearwheel 154 forms an inner race of the slewing bearing 156. The slewing bearing 156 is configured to allow a rotation of the inner azimuth stem 146 relative to the outer azimuth stem 148 (relative rotation between the ring-shaped gearwheel 154 and the outer ring body 152).

[0026] The ring-shaped gearwheel 154 includes teeth on an inner circumferential face. A slewing drive including at least one drive gearwheel (both not shown) is arranged to rotate the ring-shaped gearwheel 154. Specifically, teeth on an outer circumferential face of the at least one drive gearwheel engage with the teeth on the inner circumferential face of the ring-shaped gearwheel 154. Thus, the slewing drive rotates the at least one drive gearwheel which in turn rotates the ring-shaped gearwheel

154 relative to the outer ring body 152.

[0027] The inner azimuth stem 146 is connected at its lower part to a vertical shaft housing 158. The vertical shaft housing 158 surrounds the vertical input shaft 118 and connects the inner azimuth stem 146 with the lower gear unit 106. The vertical shaft housing 158 is fixedly connected to a lower gear housing 159. The lower gear housing 159 surrounds the lower gear transmission of the lower gear unit 106.

[0028] As the outer azimuth stem 148 is non-rotatably connected to the hull structure of the marine vessel, and as the inner azimuth stem 146 is rotatably connected to the outer azimuth stem 148 via the slewing bearing 156, the lower gear unit 106 is rotatable relative to the upper gear unit 102 via the slewing bearing 156.

[0029] Inside the azimuth unit 104 a first lubricant compartment 160 is disposed to accommodate lubricant for bath lubricating the slewing bearing 156. Lubricant may be any type of lubricant known to a person skilled in the art. For example, the lubricant may be oil.

[0030] The first lubricant compartment 160 is formed by an annular space surrounding the vertical input shaft 118. The first lubricant compartment 160 is filled with lubricant such that the slewing bearing 156 is immersed in lubricant for arranging a full bath lubrication of the slewing bearing 156. For keeping the lubricant within the azimuth stem 144, a radial shaft seal 157 is arranged between a lower end of the outer azimuth stem 148 and a lower end of inner azimuth stem 146.

[0031] Typically, the first lubricant compartment 160 accommodates a volume of lubricant in a range between about 0.5 m^3 and about 3 m^3, depending on the type and size of the azimuth thruster 100 and the inner azimuth stem 146.

[0032] Inside the upper gear unit 102 a second lubricant compartment 162 is disposed. The second lubricant compartment 162 is configured to accommodate lubricant for splash lubricating the upper gear pinion wheel 110 and the upper gear crown wheel 116. For this, lubricant spray nozzles (not shown) may be disposed inside the upper gear unit 102. The lubricant spray nozzles are configured to spray lubricant onto the upper gear transmission, thereby providing a splash lubrication of the upper gear pinion wheel 110 and the upper gear crown wheel 116. In some embodiments, for example, pinched lubricant pipes may be used instead of lubricant spray nozzles.

[0033] The first lubricant compartment 160 disposed inside the azimuth unit 104 and the second lubricant compartment 162 disposed inside the upper gear unit 102 are fluidly connected via the opening 142. Thus, lubricant sprayed onto the upper gear pinion wheel 110 and the upper gear crown wheel 116 drains from the second lubricant compartment 162 to the first lubricant compartment 160 via the opening 142. On the other hand, lubricant accommodated in the first lubricant compartment 160 may enter the second lubricant compartment 162 via the opening 142. Lubricant may enter the second lubricant compartment 162, for example, during operation of the azimuth thruster 100, because during operation of the azimuth thruster 100 lubricant expands and the space provided in the first lubricant compartment 160 for accommodating lubricant may not be sufficient to accommodate the expanded lubricant. Lubricant expansion is caused by heat and aeration. Thus, during normal operation of the azimuth thruster 100 lubricant may enter the second lubricant compartment 162 and reach at least partially the upper gear transmission, such as the upper gear crown wheel 116.

[0034] Referring to Fig. 2, an exemplary lubricant circuit for circulating lubricant in the azimuth thruster 100 is depicted. It should be noted that the shown lubricant circuit is simplified for the purpose of the present disclosure.

[0035] The lubricant circuit includes a plurality of elements including an inner lubricant channel 200, the first lubricant compartment 160, a lubricant pump 202, a lubricant filter 204, a lubricant cooler 206, and a manifold unit 208.

[0036] The inner lubricant channel 200 extends along a longitudinal axis of the input shaft 118, particularly along an entire length of the input shaft 118. The inner lubricant channel 200 includes an inlet 210 at an upper gear side of the input shaft 118. The inner lubricant channel 200 includes an outlet 212 at a lower gear side of the input shaft 118. The upper gear side of the input shaft 118 is oppositely directed to the lower gear side of the input shaft 118. Particularly, the inlet 210 may be provided in an end face 214 of the crown wheel 116 meshing with the upper gear pinion wheel 110 of the upper gear unit 102. The outlet 212 may be provided in an end face 216 of the gear pinion wheel 130 meshing with the lower gear crown wheel 132 of the of lower gear unit 106.

[0037] The lubricant pump 202 is fluidly connected to the inlet 210 of the inner lubricant channel 200 via a lubricant line 201. The lubricant pump 202 is connected to supply a lubricant to the inlet 210 to flow through the inner lubricant channel 200 to the outlet 212.

[0038] In some embodiments, the inlet 210 is configured as a swivel joint (pivot joint) including an inner lubricant channel. Particularly, the inlet 210 includes two bodies. The two bodies are connected to allow a swivel (pivot) motion between each other. The first body is attached at an end of the lubrication line connected to the lubricant pump 202. The first body is stationary (does not rotate) during operation. The second body is attached at the upper gear crown wheel 116 and/or the input shaft 118. The second body rotates together with the input shaft 118 during operation. Both the first and the second bodies include at least one lubricant channel that together form an inner lubricant channel through the first and second bodies of the inlet 210 to the inner lubricant channel 200. For example, the lubricant channels may be radial lubricant channels. An annular lubricant channel may be formed between the two bodies at an interface region to facilitate a transition between the two bodies. Additionally, the first and second bodies are designed such that the interface region between both bodies is lubricated with a lubricant film at the same time as it is functioning as a channel to direct lubricant to the inner lubricant channel 200.

[0039] Lubricant exiting the outlet 212 bathes the lower gear unit 106 (flows around the elements of the lower gear unit 106). Here, a good lubrication is particularly required, because the bearings and gears of the lower gear unit 106 are particularly highly stressed during operation. The inner lubricant channel 200 allows for the supply of filtered and/or cooled lubricant to those highly stressed components for improving the lubrication at those components and improving heat dissipation from those components. As a result, wear may be reduced.

[0040] The lubricant further flows through the first lubricant compartment 160, and reaches a lubricant suction port 218. The lubricant suction port 218 is fluidly connected to the lubricant pump 202 via a lubricant line 222. The lubricant pump 202 is configured to draw lubricant from the first lubricant compartment 160 to circulate the lubricant to the inlet 210 of the inner lubricant channel 200. The lubricant suction port 218 is disposed in the azimuth unit 104.

[0041] In some embodiments, the lubricant suction port 218 is disposed at an inner circumferential face 220 (see Fig. 1) of the inner azimuth stem 146. The lubricant line 222 connected to the lubricant suction port 218 may at least partially extend through the outer azimuth stem 148. Since the outer circumferential face 149 of the outer azimuth stem 148 contacts (relatively cold) water in the mounted state of the azimuth thruster 100, lubricant flowing through the lubricant line 222 is cooled by heat exchange with the water.

[0042] The lubricant filter 204 is fluidly connected to the lubricant pump 202. Particularly, the lubricant filter 204 is fluidly interconnected between the lubricant pump 202 and the inlet 210. The lubricant filter 204 is configured to clean the lubricant flowing therethrough, for example by filtering particles to purify the lubricant. The lubricant filter 204 may include one or more (replaceable) filter units arranged in series and/or in parallel.

[0043] In some embodiments, the lubricant filter 204 may be omitted. For example, in those embodiments, worn lubricant may be replaced by new lubricant according to a predefined service interval.

[0044] The lubricant cooler 206 is fluidly connected to the lubricant pump 202. Particularly, the lubricant cooler 206 is fluidly interconnected between the lubricant pump 202 and the inlet 210. More particularly, the lubricant cooler 206 is fluidly interconnected between the lubricant filter 204 and the manifold unit 208. The lubricant filter 204 is configured to cool the lubricant flowing therethrough. Cooling of the lubricant may be necessary due to a significant heating of the lubricant, for example, in the lower gear unit 106. The lubricant cooler 206 may include one or more (replaceable) cooler units arranged in series and/or in parallel.

[0045] In some embodiments, the lubricant cooler 206 may be omitted. For example, in those embodiments, the cooling effect obtained by the lubricant line 222 extending through the outer azimuth stem 148 may provide a sufficient cooling amount.

[0046] Lubricant pumped by the lubricant pump 202 passes the lubricant filter 204 and the lubricant cooler 206, and reaches the manifold unit 208. The manifold unit 208 is configured to distribute the lubricant to various lubrication targets. The manifold unit 208 may include a plurality of components for controllably distributing the lubricant to desired target regions. Those components include, for example, control valves, orifices, lubricant lines etc. not shown in further detail herein.

[0047] The manifold unit 208 distributes lubricant to regions of the azimuth thruster 100 in which point lubrication is used to lubricate the components. Said point lubrication is used for components which require lubrication and which are not bath lubricated in the first lubrication compartment 160. Those components are particularly included in the upper gear unit 102. For example, components being lubricated by point lubrication are bearings 224 to 226 rotatably supporting the drive shaft 108. Additionally, in some embodiments, bearing 230 rotatably supporting the input shaft 180 at the upper gear side thereof may be point lubricated. Additionally, in some embodiments, a meshing region 232 of the upper gear pinion wheel 110 and the upper gear crown wheel 116 may be point lubricated. As used herein, point lubrication may include spray lubrication.

[0048] The manifold unit 208 also distributes lubricant to the inlet 210. The lubricant flows through the inner lubricant channel 200, reaches the lower gear unit 106, and contributes to the bath lubrication of the lower gear unit 106 and the azimuth unit 104. It should be noted that Fig. 2 indicates a lubricant level to be below the bearing 230 of the upper gear side end of the input shaft 118, and to be above the slewing bearing 156 of the azimuth unit 104.

[0049] The azimuth thruster 100 may further include a temperature sensor 234 for measuring a temperature of the lubricant in the first lubricant compartment 160. A lubricant level measuring device 236 may be disposed for measuring a lubricant level of the lubricant in the first lubricant compartment 160. The azimuth thruster 100 may further include service ports for draining lubricant from the first lubricant compartment 160, and further separate lubricant lines not discussed in detail herein.

Industrial Applicability

[0050] The azimuth thruster as disclosed herein provides for a method for lubricating the azimuth thruster. A corresponding exemplary method is described in the following with reference to Figs. 1 and 2.

[0051] The method includes providing a first lubricant path. The first lubricant path extends through the input shaft 118. In the embodiment described with reference to Figs. 1 and 2, the first lubricant path is formed by the inner lubricant channel 200. The first lubricant path receives a lubricant from the lubricant pump 202 and supplies the lubricant to the lower gear unit 106.

[0052] In a further method step, a second lubricant path may be provided. The second lubricant path may pass from the lower gear unit 106 through the shaft housing 158. In other words, the second lubricant path may be formed by the first lubricant compartment 160. The second lubricant path receives lubricant from the first lubricant path.

[0053] In another method step, a third lubricant path may be provided. The third lubricant path may pass through the azimuth unit 104, particularly the inner and outer azimuth stems 146 and 148. For example, the third lubricant path may be cooled by providing the third lubricant path in heat exchange relationship to an environment of the azimuth unit 104. Particularly, the heat from the first lubricant path, particularly lubricant flowing through the third lubricant path, may be dissipated by water flowing around the outer azimuth stem 148.

[0054] As explained with reference to Fig. 2, the lubricant may be further cooled and/or cleaned by the lubricant cooler 206 and the lubricant filter 204, respectively, before circulating the cooled and/or cleaned lubricant back to the first lubricant path.

[0055] The method may further comprise the method step of distributing the lubricant to the first lubricant path, and a fourth lubricant path. The fourth lubricant path may pass at least one region to be point lubricated, for example, bearings 224-230 and meshing regions 232. From the regions to be point lubricated, lubricant may flow along the fourth lubricant path to the second lubricant path to join the lubricant from the first lubricant path. Stated differently, lubricant provided to the upper gear unit 102 (second lubricant compartment 162) may flow and fall into the first lubricant compartment 160 due to gravity.

[0056] Terms such as "about", "around", "approximately", or "substantially" as used herein when referring to a measurable value such as a parameter, an amount, a temporal duration, and the like, is meant to encompass variations of $\pm 10\%$ or less, preferably $\pm 5\%$ or less, more preferably $\pm 1\%$ or less, and still more preferably $\pm 0.1\%$ or less of and from the specified value, insofar as such variations are appropriate to perform in the disclosed invention. It is to be understood that the value to which the modifier "about" refers is itself also specifically, and preferably, disclosed. The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within the respective ranges, as well as the recited endpoints.

[0057] Although the preferred embodiments of this invention have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

Claims

1. An azimuth thruster (100) for a marine vessel, comprising:

an upper gear unit (102) configured to be connected to a drive source;
a lower gear unit (106) configured to be connected to a propeller (136);
an input shaft (118) drivingly connecting the upper gear unit (102) and the lower gear unit (106), the input shaft (118) including an inner lubricant channel (200) extending in a longitudinal direction of the input shaft (118); and
a lubricant pump (202) fluidly connected to the inner lubricant channel (200).

2. The azimuth thruster (100) of claim 1, wherein the lubricant pump (202) is arranged to provide a lubricant to the inner lubricant channel (200) such that the lubricant flows through the inner lubricant channel (200) to the lower gear unit (106).

3. The azimuth thruster (100) of claim 1 or claim 2, wherein the inner lubricant channel (200) includes:

an inlet (210) at an upper gear side of the input shaft (118), and/or
an outlet (212) at a lower gear side of the input shaft (118).

4. The azimuth thruster (100) of any one of the preceding claims, wherein the input shaft (118) includes a crown wheel (116) meshing with the upper gear unit (102), and an inlet (210) of the inner lubricant channel (200) is disposed in an end face (214) of the crown wheel (116).

5. The azimuth thruster (100) of any one of the preceding claims, wherein the input shaft (118) includes a gear pinion wheel (130) meshing with the lower gear unit (106), and an outlet (212) of the inner lubricant channel (200) is disposed in an end face (216) of the gear pinion wheel (130).

6. The azimuth thruster (100) of any one of the preceding claims, further comprising an azimuth unit (104) for slewing the azimuth thruster (100), the azimuth unit (104) including a lubricant suction port (218) fluidly connected to the lubricant pump (202).

7. The azimuth thruster (100) of claim 6, wherein the azimuth unit (104) includes an inner azimuth stem (146) and an outer azimuth stem (148), and a lubricant line (222) fluidly connected between the lubricant suction port (218) and the lubricant pump (202) at least partially extends through the outer azimuth stem (148).

8. The azimuth thruster (100) of claim 7, wherein the outer azimuth stem (148) includes an outer circumferential face (149) being arranged to contact water in a mounted state of the azimuth thruster (100).

9. The azimuth thruster (100) of any one of the preceding claims, further comprising:

a lubricant filter (204) fluidly connected to the lubricant pump (202), particularly fluidly connected between the lubricant pump (202) and an inlet (210) of the inner lubricant channel (200), and/or
a lubricant cooler (206) fluidly connected to the lubricant pump (202), particularly fluidly connected between the lubricant pump (202) and an inlet (210) of the inner lubricant channel (200).

10. The azimuth thruster (100) of any one of the preceding claims, wherein the inlet (210) is configured as a swivel joint including a lubricant channel extending therethrough.

11. A method for lubricating an azimuth thruster (100) for a marine vessel, the method comprising:

providing a first lubricant path through an input shaft (118) drivingly connecting an upper gear unit (102) for connecting to a drive source, and a lower gear unit (106) for connecting to a propeller (136), the first lubricant path receiving a lubricant from a lubricant pump (202) and supplying the lubricant to the lower gear unit (106).

12. The method of claim 11, further comprising:

providing a second lubricant path from the lower gear unit (106) through a shaft housing (158) surrounding the input shaft (118), the second lubricant path receiving lubricant from the first lubricant path.

13. The method of claim 11 or claim 12, further comprising:

providing a third lubricant extending through an azimuth unit (104) of the azimuth thruster (100) to the lubricant pump (202), the third lubricant path supplying the lubricant to the lubricant pump (202).

14. The method of any one of claims 13, further comprising:

cooling the third lubricant path by providing the third lubricant path in heat exchange relationship to an environment of the azimuth unit (104).

15. The method of any one of claims 11 to 14, further comprising:

cleaning and/or cooling lubricant before providing the lubricant to the first lubricant path.

FIG 1

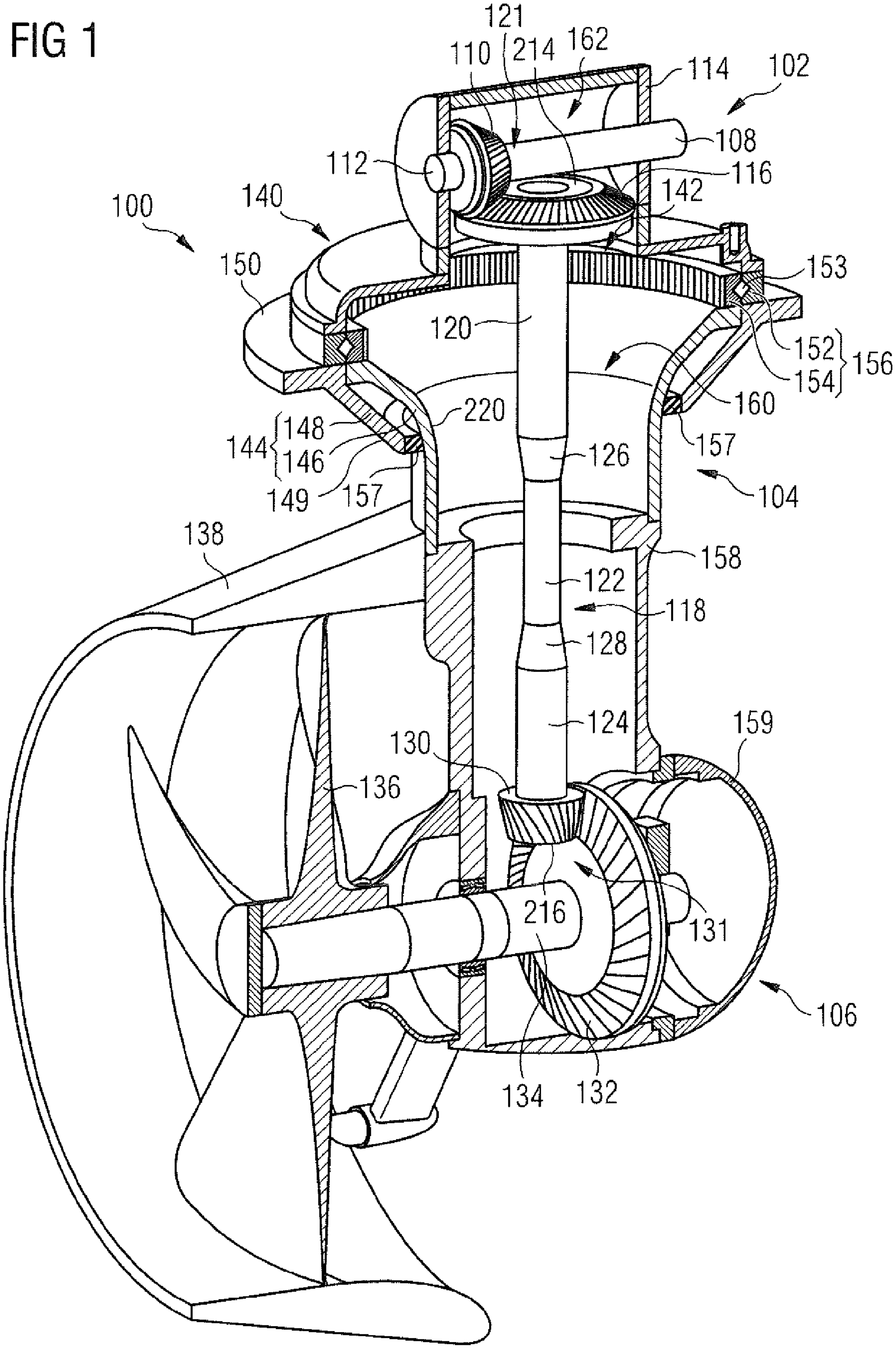

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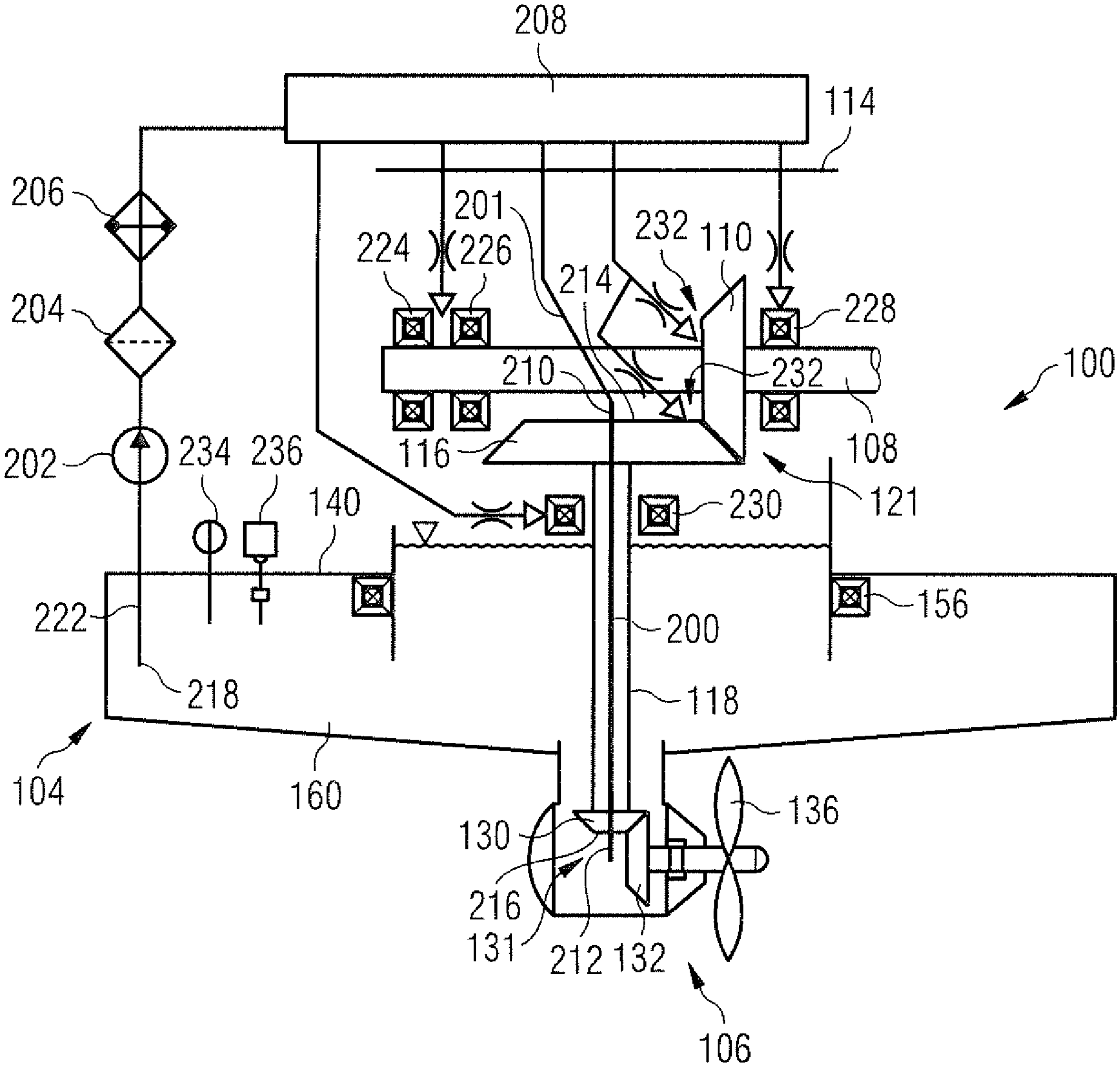
FIG 2



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EUROPEAN SEARCH REPORT

Application Number
EP 16 18 2843

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2014/318898 A1 (DE KRUIJF ARNOUD [NL] ET AL) 30 October 2014 (2014-10-30) * paragraphs [0021] - [0041]; figures 2, 3 *	1-9, 11-15	INV. B63H21/38 B63H5/125
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 January 2017	Brumer, Alexandre

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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