



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
02.03.2016 Bulletin 2016/09

(51) Int Cl.:
B63H 3/00 (2006.01) **B64C 11/38 (2006.01)**
B64D 45/00 (2006.01)

(21) Application number: **14182701.4**

(22) Date of filing: **28.08.2014**

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

(72) Inventors:
• **Thyberg, Conny**
47532 Öckerö (SE)
• **Gibson, Johannes**
41468 Göteborg (SE)

(71) Applicant: **Caterpillar Propulsion Production AB**
475 22 Öckerö (SE)

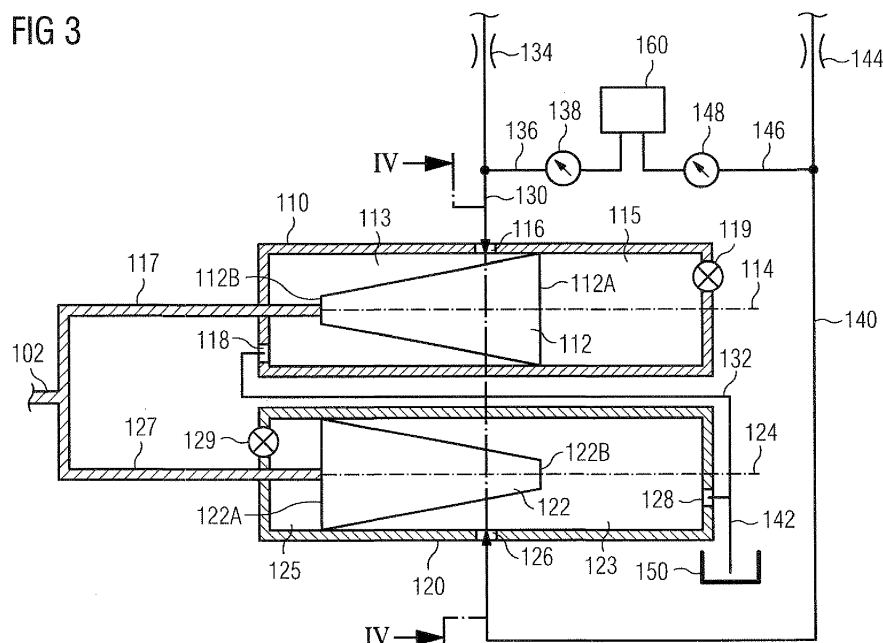
(74) Representative: **Kramer Barske Schmidtchen**
Patentanwälte PartG mbB
European Patent Attorneys
Landsberger Strasse 300
80687 München (DE)

(54) **System and method for indicating a pitch angle of a variable marine propeller**

(57) The present disclosure relates to a system and method for indicating a pitch angle of a variable marine propeller of a vessel. The pitch angle indication system (100) may comprise a first hydraulic cylinder (110) having a first inlet (116) configured to receive hydraulic fluid and a first outlet (118) configured to direct the hydraulic fluid out of the first hydraulic cylinder (110), a first piston (112) coupled to the at least one marine propeller blade and movable disposed within the first hydraulic cylinder (110),

a first pressure detection device (138) configured to detect a first pressure upstream of the first inlet (116) and output a first pressure signal indicative of the first pressure, and a processing unit (160) connected to the first pressure detection device (138) and configured to, at least partially based on the first pressure signal, indicate the pitch angle of the at least one marine propeller blade (18, 22).

FIG 3



Description

Technical Field

[0001] The present disclosure generally relates to a system and method for indicating a pitch angle of a variable marine propeller having at least one adjustable marine propeller blade and, particularly, to a system and method for accurately indicating a zero pitch angle position of the at least one adjustable blade. The present disclosure further relates to an adjustable marine propeller arrangement used in, for example, a vessel.

Background

[0002] Floating vessels, in particular cargo vessels and supply vessels, are generally furnished with a propulsion system including an adjustable marine propeller arrangement. The marine propeller arrangement includes a marine propeller with at least one marine propeller blade, but often a plurality of marine propeller blades, wherein the pitch of each one of the marine propeller blades is controlled by a servo arrangement. The servo arrangement generally is a hydraulic arrangement with fluid chambers and a piston located in the boss of the marine propeller. For changing the pitch of the marine propeller blades, hydraulic fluid is supplied to the servo arrangement for displacing the piston, which in turn changes the pitch of the marine propeller blades.

[0003] At present, for detecting the zero pitch angle position of an marine propeller blade of a marine propeller of a vessel, an operator may visually look into the water for identifying the current water jet of the marine propeller. In dependency of the direction of the water jet output by the marine propeller, the operator may adjust the pitch angle of the at least one marine propeller blade until the water jet is substantially zero which may indicate that the at least one marine propeller blade is in the zero pitch angle position and and, therefore, the marine propeller may output substantially zero thrust.

[0004] For example, WO 2010/033060 A1 discloses an adjustable marine propeller arrangement and a method for distributing fluid to and/or from such an adjustable marine propeller arrangement. The adjustable marine propeller arrangement disclosed therein includes a measuring arrangement having a pin. The measuring arrangement is operatively coupled to the piston, which is configured to axially displace for changing the pitch of the marine propeller blades. When being axially displaced, the pin may indicate on a scale the current pitch angle of the marine propeller blades.

[0005] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior systems.

Summary of the Disclosure

[0006] According to an aspect of the present disclosure,

a pitch angle indication system for indicating a pitch angle of at least one marine propeller blade of an adjustable marine propeller arrangement used in, for example, a vessel, is disclosed. The pitch angle indication system may comprise a first hydraulic cylinder defining a first longitudinal axis and having a first inlet configured to receive hydraulic fluid and a first outlet configured to direct the hydraulic fluid out of the first hydraulic cylinder. The pitch angle indication system may further comprise a first piston disposed within the first hydraulic cylinder and movable along the first longitudinal axis. The position of the first piston relative to the first inlet may be associated with the pitch angle of the at least one marine propeller blade. The first piston may be shaped such that a position change of the first piston relative to the first inlet changes a first flow resistance between the first inlet to the first outlet. The pitch angle indication system may further comprise a first pressure detection device configured to detect a first pressure upstream of the first inlet and output a first pressure signal indicative of the first pressure. The pitch angle indication system may further comprise a processing unit connected to the first pressure detection device. The processing unit may be configured to receive the first pressure signal and, at least partially based on the first pressure signal, indicate the pitch angle of the at least one marine propeller blade.

[0007] According to another aspect of the present disclosure, an adjustable marine propeller arrangement used in, for example, a vessel, is disclosed. The adjustable marine propeller arrangement may comprise an adjustable marine propeller configured to be connected to a drive shaft and having at least one marine propeller blade rotatable connected to the adjustable marine propeller, and a piston connected to the at least one marine propeller blade. The piston may be configured to control the pitch angle of the at least one marine propeller blade. The adjustable marine propeller arrangement may further comprise at least one pitch angle indication system according to the present disclosure, wherein the first and/or second pistons may be operatively coupled to the at least one marine propeller blade.

[0008] According to another aspect of the present disclosure, a method for indicating a pitch angle of at least one marine propeller blade of an adjustable marine propeller arrangement used in, for example, a vessel, is disclosed. The method may comprise adjusting the pitch angle of the at least one marine propeller blade, thereby changing a first flow resistance between a first inlet of a first hydraulic cylinder and a first outlet of the first hydraulic cylinder. The method may further comprise directing hydraulic fluid into the first hydraulic cylinder through the first inlet and out of the first hydraulic cylinder through the first outlet, detecting a first pressure upstream of the first inlet, and indicating the pitch angle of the at least one marine propeller blade at least partially based on the detected first pressure.

[0009] Other features and aspects of this disclosure will be apparent from the following description and the

accompanying drawings.

Brief Description of the Drawings

[0010]

Fig. 1 shows a schematic side view of a vessel provided with an adjustable marine propeller arrangement;

Fig. 2 shows a schematic side view of a partial cross-section of an adjustable marine propeller arrangement;

Fig. 3 shows a schematic illustration of an exemplary disclosed pitch angle indication system of the marine propeller arrangement of Fig. 2; and

Fig. 4 shows a sectional view of first and second hydraulic cylinders of the pitch angle indication system of Fig. 3 taken along line IV - IV of Fig. 3.

Detailed Description

[0011] 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.

[0012] The present disclosure may be based at least in part on the realization that movably providing a piston within a hydraulic cylinder such that a flow resistance may be changed by the position of the piston relative to an inlet of the hydraulic cylinder may support in determining a current pitch angle of at least one marine propeller blade based at least partially on a pressure detected upstream of the inlet. The detected pressure may be associated with the current pitch angle of the at least one marine propeller blade. Particularly, the piston may be shaped such that the flow resistance is changed in accordance with the position of the piston relative to the inlet. For example, the piston may have a tapered shape, preferably a conical shape, such that the pressure upstream of the inlet is a function of a flow region within the hydraulic cylinder at the inlet.

[0013] The present disclosure may be further based at least in part on the realization that providing two hydraulic cylinders with respective pistons movably disposed therein may support in accurately determining the current pitch angle, particularly in determining a zero pitch angle position of the at least one marine propeller blade. Specifically, the two pistons may be oppositely arranged with respect to one another and may be movable in dependency of the current pitch blade. With such arrangement,

the current pitch angle may be determined without the influence of hydraulic medium properties, such as, for example, the type of hydraulic medium, the temperature of the hydraulic medium, and the pressure of the hydraulic medium, which may affect the viscosity of the hydraulic medium and, hence, may distort the determination of the current pitch angle. Thus, the environmental influence to the hydraulic medium may be compensated such that the determination of the current pitch angle may be more accurate.

[0014] For example, the at least one marine propeller blade may be in the zero pitch angle position when the vessel is in a stationary state, that is when the vessel is not moving. However, in such stationary state of the vessel, the marine propeller may still be operating. Hence, the thrust of the marine propeller should be zero, which may be achieved by rotating the at least one marine propeller blade into the zero pitch angle position.

[0015] Fig. 1 illustrates a schematic side view of a vessel 10 comprising an adjustable marine propeller arrangement 12. As may be gleaned from Fig. 1, the arrangement 12 comprises a drive shaft 14 extending in a longitudinal direction 13 and an adjustable marine propeller 16 connected to the drive shaft 14. The adjustable marine propeller comprises at least one marine propeller blade, in the embodiment of the adjustable marine propeller illustrated in Fig. 1, the marine propeller includes four marine propeller blades three of which 18, 20, 22 are visible in Fig. 1. However, other implementations of marine propellers with more or fewer marine propeller blades may also be used with the marine propeller arrangement. Furthermore, the vessel 10 may in some applications be provided with two or more adjustable marine propeller arrangements 12.

[0016] Moreover, Fig. 1 illustrates that the vessel 10 includes an engine 24 which generally is connected to the drive shaft 14 through a gear device 26. Additionally, a part of a hydraulic fluid distribution system is illustrated in Fig. 1, which part in the Fig. 1 embodiment of the hydraulic fluid distribution system is schematically illustrated by a housing 28 partly enclosing the drive shaft 14. In Fig. 1, the housing 28 is located in a preferred location in the marine propeller arrangement 12, namely around the drive shaft 14 and between the gear device 26 and the marine propeller 16. However, in other embodiments, the housing 28 may be located at other locations in the marine propeller arrangement 12. For instance, the housing 28 may be located on an extension of the drive shaft 14 extending through the gear device 26, such that the housing 28 is located on the opposite side of the gear 26 than the marine propeller 16. This alternative location is indicated by dotted lines in Fig. 1.

[0017] It should be noted that the drive shaft 14 does not necessarily have to be made in one piece. In practice, the drive shaft 14 may in fact often be constituted by a plurality of shaft parts which are fixedly attached to one another to form the complete drive shaft 14.

[0018] Fig. 2 illustrates a partial cross-section of the

adjustable marine propeller arrangement 12 used in, for example, a vessel of Fig. 1. As shown in Fig. 2, the adjustable marine propeller 16 includes a marine propeller boss 32 which in turn comprises a hydraulic servo 34 including a forward pitch chamber 36, a backward pitch chamber 38 and a piston 40. Depending on the fluid pressure in the forward pitch chamber 36 and the backward pitch chamber 38, respectively, the piston 40 may be imparted a displacement either along the longitudinal direction 13 (in Fig. 2 to the left) or counter the longitudinal direction 13 (in Fig. 2 to the right). Such a displacement will in turn impart a change in the pitch of each one of the marine propeller blades 18, 22.

[0019] The piston 40 is fixedly attached to a fluid conveying member 43 accommodating, in the embodiment shown in Fig. 2, two conduits, namely a forward pitch chamber conduit 55 for feeding the forward pitch chamber 36 with hydraulic fluid and a backward pitch chamber conduit 56 for feeding the backward pitch chamber 38 with hydraulic fluid. In the embodiment of the marine propeller arrangement 12 illustrated in Fig. 2, the forward pitch chamber conduit 54 and the backward pitch chamber conduit 56 are connected to a hydraulic fluid distribution system 28 configured to provide hydraulic fluid to the forward and backward pitch chambers 36, 38, respectively, for changing the pitch of the marine propeller blades 18, 22.

[0020] In the embodiment shown in Fig. 2, the fluid conveying member 43 has a substantially L-shape extending through the circumferential wall of the drive shaft 14 through a slit 64 in the drive shaft 14. An inner sleeve 72 is fixedly attached to an end of the fluid conveying member 43 which is opposite to the end of the fluid conveying member 43 to which the hydraulic servo 34 is connected. The inner sleeve 72 provides conduits fluidly connecting to the forward pitch chamber conduit 55 and the backward pitch chamber conduit 56, respectively. An outer sleeve 74 is rotatable connected to the inner sleeve 72 via a thrust bearing 96 adapted to not transmit a rotation of the inner sleeve 72 to the outer sleeve 74. Also the outer sleeve 74 provides conduits fluidly connecting to the forward pitch chamber conduit 55 and the backward pitch chamber conduit 56, respectively. The conduits of the outer sleeve 74 are fluidly connected to the hydraulic fluid distribution system 28.

[0021] As further shown in Fig. 2, three sealing devices 88, 89, 90 are interposed between the inner sleeve 72 and the outer sleeve 74 for sealingly separating the environment, the forward pitch chamber conduit 55, the backward pitch chamber conduit 56, and the thrust bearing 96 from one another.

[0022] When the drive shaft 14 rotates around its longitudinal axis, which is parallel to the longitudinal direction 13, the fluid conveying member 43 and the inner sleeve 72 also rotate whereas the outer sleeve 74 and the sealing devices 88, 89, 90 remain stationary in relation to the vessel. If the pitch of the marine propeller blades 18, 22 is altered by a change in the longitudinal

position of the piston 40, that is a longitudinal displacement. Such longitudinal displacement is transmitted to the fluid conveying member 43 and subsequently to the inner sleeve 72 and the outer sleeve 74.

[0023] As further indicated in Fig. 2, a pitch angle indication system 100 is provided in the drive shaft 14 and rigidly attached to the fluid conveying member 43 via a transmission device 102, for example, a rigid rod assembly. In some embodiments, the transmission device 102 may be any device capable of transmitting the longitudinal displacement of the fluid conveying member 43 to the pitch angle indication system 100. In some further embodiments, the transmission device 102 may be configured to transmit the longitudinal displacement of the fluid conveying member 43 to the pitch angle indication system 100 with a predetermined transformation ratio. Such transformation ratio may be configured to, for instance, increase the longitudinal displacement of the pitch angle indication system 100.

[0024] The pitch angle indication system 100 is configured to detect and indicate the current pitch angle of the marine propeller blades 18, 22. The current pitch angle of one of the marine propeller blades 18, 22 may be defined as the angle between a plane spanned by one of the marine propeller blades 18, 22 and a longitudinal axis of the drive shaft 14. In Fig. 2, the pitch angle indication system 100 is indicated with a box in dash-dot lines and will be described in more detail with respect to Figs. 3 and 4.

[0025] The marine propeller blades 18, 22 may be configured to have its default (standard) position at a pitch angle of 0° (which will in the following be referred to as "zero pitch angle position"). When being in the zero pitch angle position, the marine propeller blades 18, 22 may be substantially perpendicular to the longitudinal direction 13 and, thus, substantially perpendicular to the drive shaft 14. When supplying hydraulic fluid to, for example, the forward pitch chamber 36, the marine propeller blades 18, 22 may rotate relatively to the marine propeller boss 32 in a first direction, thereby ensuing a positive pitch angle. To the contrary, when supplying hydraulic fluid to the backward pitch chamber 38, the marine propeller blades 18, 22 may rotate relatively to the marine propeller boss 32 in a second direction counter to the first, thereby ensuing a negative pitch angle.

[0026] With respect to Fig. 3, the pitch angle indication system 100 of Fig. 2 is illustrated in greater detail. In the exemplary embodiment shown in Fig. 3, the pitch angle indication system 100 includes a first hydraulic cylinder 110 extending along a first longitudinal axis 114 and a second hydraulic cylinder 120 extending along a second longitudinal axis 124. A first piston 112 is movable disposed within the first hydraulic cylinder 110, and a second piston 122 is movable disposed within the second hydraulic cylinder 120. Both the first and second pistons 112, 122 are movable along the first and second longitudinal axes 114, 124, respectively, which are parallel to one another. In another embodiment, the first and second

longitudinal axis 114, 124 may be angled to one another, such that the first and second cylinders 110, 120 are not parallel to one another. For example, the first and second cylinders 110, 120 may have inner diameters of about 100 mm to about 200 mm or more.

[0027] Although shown with two hydraulic cylinders 110, 120, in some embodiments, the pitch angle indication system 100 according to the present disclosure may include only one hydraulic cylinder 110 for indicating the current pitch angle. In such embodiment, the current pitch angle may be determined at least partially based on the first pressure detected upstream of the first inlet 116.

[0028] The first hydraulic cylinder 110 includes a first inlet 116 and a first outlet 118. As depicted in Fig. 3, the first inlet 116 is disposed in a circumferential wall of the first hydraulic cylinder 110 and the first outlet 118 is disposed at an end side of the first hydraulic cylinder 110. The first inlet 116 is configured to receive hydraulic fluid from a first hydraulic supply line 130. The first outlet 118 is configured to direct the hydraulic fluid out of the first hydraulic cylinder 110 via a first hydraulic drain line 132 into a fluid reservoir 150.

[0029] The second hydraulic cylinder 120 includes a second inlet 126 and a second outlet 128. As depicted in Fig. 3, the second inlet 126 is disposed in a circumferential wall of the second hydraulic cylinder 120 and the second outlet 128 is disposed at an end side of the second hydraulic cylinder 120. The second inlet 126 is configured to receive hydraulic fluid from a second hydraulic supply line 140. The second outlet 128 is configured to direct the hydraulic fluid out of the second hydraulic cylinder 120 via a second hydraulic drain line 142 into the fluid reservoir 150.

[0030] The first and second hydraulic supply lines 130, 140 may be connected to the hydraulic fluid distribution system 28 for receiving hydraulic fluid. Hence, fluid conveying member 43 may be provided with respective fluid channels (not shown in the drawings) for providing the hydraulic fluid from the hydraulic fluid distribution system 28 to the first and second cylinders 110, 120. The additional fluid channels may also extend through the inner and outer sleeves 72, 74 similarly as described above.

[0031] In some embodiments, for example, the first and/or second outlets 118, 128 may have a size substantially corresponding to the diameter of the first and/or second cylinders 118, 128. In such case, the hydraulic fluid may freely stream out of the first and/or second cylinders 118, 128, as only the pressures detected upstream of the first and second inlets 116, 126 may be relevant for indicating the current pitch angle of the marine propeller blades 18, 22. The first and second outlets 118, 128 are configured to substantially not affect the flow resistance of the hydraulic fluid flowing from the first and second inlets 116, 128 to the first and second outlets 118, 128, respectively.

[0032] The first piston 112 has a substantially tapered shape. In Fig. 3, the first piston 112 has a conical shape with a first piston end 112A sealingly contacting the inner

circumferential wall of the first hydraulic cylinder 110 and a second piston end 112B opposite to the first piston end 112A. The first piston end 112A divides the first hydraulic cylinder 110 into a first fluid chamber 113 and a first non-fluid chamber 115. The second piston end 112B has a diameter smaller than the diameter of the first piston end 112A. The tapered first piston 112 substantially extends along the first longitudinal axis 114.

[0033] The second piston 122 has a substantially tapered shape. In Fig. 3, the second piston 122 has a conical shape with a first piston end 122A sealingly contacting the inner circumferential wall of the second hydraulic cylinder 120 and a second piston end 122B opposite to the first piston end 122A. The first piston end 122A divides the second hydraulic cylinder 120 into a second fluid chamber 123 and a second non-fluid chamber 125. The second piston end 122B has a diameter smaller than the diameter of the first piston end 122A. The tapered second piston 122 extends along the second longitudinal axis 124.

[0034] In some embodiments, the first and/or second pistons 112, 122 may have any tapered shape, such as, for example, a stepped like shape. In such embodiments, the first piston ends 112A, 122A may be substantially cylindrical with a first diameter and the second piston ends 112B, 122B may be substantially cylindrical with a second diameter smaller than the first diameter. In such case, the first and/or second pistons 112, 122 may have at least one further cylindrical portion between the first ends 112A, 122A and the second ends 112B, 122B with a third diameter smaller than the first diameter and greater than the second diameter.

[0035] As indicated in Fig. 3, the first piston 112 is tapered in a first direction, and the second piston 122 is tapered in a second direction opposite to the first direction. Thus, the tapered first and second pistons 112, 122 are disposed in the first and second hydraulic cylinders 110, 120, such that the tapered first piston 112 is oppositely arranged with respect to the tapered second piston 122. In the embodiment shown in Fig. 3, the first and second pistons 112, 122 are identical in shape, but oppositely arranged to one another.

[0036] The second piston end 112B of the first piston 112 is connected to the transmission device 102 via a first rod 117 sealingly extending through the first hydraulic cylinder 110. Similarly, the second piston end 122B of the second piston 122 is connected to the transmission device 102 via a second rod 127 sealingly extending through the second hydraulic cylinder 120. Therefore, when the marine propeller blades 18, 22 experience a pitch angle change, the fluid conveying member 43 is also displaced (see Fig. 2). The displacement of the fluid conveying member 43 is transferred to the first and second pistons 112, 122 via the transmission device 102 and the first and second rods 117, 127, respectively.

[0037] In the embodiment shown in the drawings, the amount of displacement of the piston 40, the fluid conveying member 43 and the first and second pistons 112,

122 are substantially equal. However, in some embodiments, the transmission device 102 may transmit the amount of displacement of the fluid conveying member 43 to the first and second pistons 112, 122 with a predetermined transmission ratio.

[0038] In some embodiments, the first and/or second rods 117, 127 may be connected to the first piston ends 112A, 122A of the first and second pistons 112, 122 respectively. In some further embodiments, the first and second rods 117, 127 may be each directly connected to the fluid conveying member 43.

[0039] A hydraulic pump (not shown in the drawings) may be connected to the first and second hydraulic supply lines 130, 140 for supplying hydraulic fluid to the first and second hydraulic cylinders 110, 120, respectively. In some embodiments, there may be two hydraulic pumps configured to provide hydraulic fluid to the first and second hydraulic cylinders 110, 120, respectively. The engine 24 may be configured to drive the hydraulic pump(s).

[0040] For ensuring that the amount of hydraulic fluid supplied to the first hydraulic cylinder 110 is substantially equal to the amount of hydraulic fluid supplied to the second hydraulic cylinder 120, a first hydraulic throttle 134 is disposed in the first hydraulic supply line 130 and a second hydraulic throttle 144 is disposed in the second hydraulic supply line 140. The first and second hydraulic throttles 134, 144 may, for example, be variable throttles for adapting the amount of hydraulic fluid supplied to the first and second hydraulic cylinders 110, 120 via the first and second hydraulic supply lines 130, 140, respectively.

[0041] The first hydraulic cylinder 110 further includes a first venting valve 119 configured to vent the first non-fluid chamber 115. For example, during movement of the first piston 112 towards the first venting valve 119, the air within the first non-fluid chamber 115 may freely exit the first non-fluid chamber 115, such that the first piston 112 can freely and smoothly move within the first hydraulic cylinder 110.

[0042] The second hydraulic cylinder 120 further includes a second venting valve 129 configured to vent the second non-fluid chamber 125. For example, during movement of the second piston 122 towards the second venting valve 129, the air within the second non-fluid chamber 125 may freely exit the second non-fluid chamber 125, such that the second piston 122 can freely and smoothly move within the second hydraulic cylinder 120.

[0043] In some embodiments, the first and/or second pistons 112, 122 may allow fluid from the first and/or second fluid chambers 113, 123 to stream into the chambers 115, 125, respectively. In such embodiments, the first and/or second venting valves 119, 129 may not be necessary.

[0044] The pitch angle indication system 100 further includes a first pressure detection device 138 configured to be fluidly connected to the first hydraulic supply line 130 via a first detection line 136. The first detection line 136 fluidly connects to a portion of the first hydraulic sup-

ply line 130 upstream of the first inlet 116 and downstream of the first hydraulic throttle 134.

[0045] The pitch angle indication system 100 further includes a second pressure detection device 148 configured to be fluidly connected to the second hydraulic supply line 140 via a second detection line 146. The second detection line 146 fluidly connects to a portion of the second hydraulic supply line 140 upstream of the second inlet 126 and downstream of the second hydraulic throttle 144.

[0046] The first and second pressure detection devices 138, 148 are configured to detect a first pressure in the first hydraulic supply line 130 upstream of the first inlet 116, and a second pressure in the second hydraulic supply line 140 upstream of the second inlet 126, respectively. The first and second pressure detection devices 138, 148 are further configured to generate and output a first and second pressure signal indicative of the first and second pressures, respectively.

[0047] The first and second pressure detection devices 138, 148 are in communication with a processing unit 160 configured to receive the first and second pressure signals. The processing unit 160 is further configured to determine a pressure difference between the first pressure and the second pressures and, at least partially based on the pressure difference, output a signal indicative of the current pitch angle of the marine propeller blades 18, 22.

[0048] The processing unit 160 may output the pitch angle signal as, for instance, an electric signal provided to a control unit for further processing. However, in some embodiments, the processing unit 160 may output the pitch angle signal as, for example, a mechanical signal indicating the pitch angle on, for instance, a pointer-scale-apparatus.

[0049] In some embodiments, instead of providing first and second pressure detection devices 136, 138, there may be a differential pressure gauge fluidly connected to the first and second hydraulic supply lines 130, 140 via the first and second detection lines 136, 146, respectively. The differential pressure gauge may be configured to directly detect the pressure difference between the first pressure and the second pressure and output a signal to the processing unit 160 indicative of the pressure difference. In some embodiments, the differential pressure gauge may visually indicate the detected pressure difference on a scale, such that an operator may check the differential pressure for associating the differential pressure with the current pitch angle.

[0050] Referring to Fig. 4, a sectional view of the first and second hydraulic cylinders 110, 120 taken along line IV - IV of Fig. 3 through the first and second inlets 116, 126, respectively, is shown. As can be seen in Fig. 4, the first hydraulic cylinder 110 and the first piston 112 define a first annular flow region 170 extending about the first piston 112. The first annular flow region 170 is further defined by the width of the first inlet 116, which extends along the first longitudinal axis 114 (see Fig. 3). Thus,

the first annular flow region 170 includes a first volume at the first inlet 116.

[0051] The second hydraulic cylinder 120 and the second piston 122 define a second annular flow region 180 extending about the second piston 122. The second annular flow region 180 is further defined by the width of the second inlet 126, which extends along the second longitudinal direction 124 (see Fig. 3). Thus, the second annular flow region 180 includes a second volume at the second inlet 126.

[0052] In Figs. 3 and 4, the positions of the first and second pistons 112, 122 relative to the first and second inlets 116, 126, respectively, are off-center. That is, the first and second pistons 112, 122 are displaced from respective center positions to the left. The center positions of the first and second pistons 112, 122 relative to the first and second outlets 118, 128 may be defined by positions at which the first and second flow regions 170, 180 at the first and second inlets 116, 126 are substantially equal. With the first and second pistons 112, 122 in the center positions relative to the first and second inlet 116, 126, respectively, the marine propeller blades 18, 22 may be in the zero pitch angle positions.

[0053] The first and second pistons 112, 122 are configured to have a length in the first and second longitudinal directions 114, 124, respectively, which is at least greater than half the length of the first and second hydraulic cylinders 110, 120, respectively. Due to this configuration, it may be ensured that the first and second pistons 112, 122 affect first and second flow resistances between the first and second inlets 116, 126 and the first and second outlets 118, 128, respectively, irrespective of the position of the first and second pistons 112, 122 relative to the first and second inlets 116, 126.

[0054] The first and second flow resistances are a function of the current pitch blade. Particularly, the first and second flow regions 170, 180 at the first and second inlets 116, 126 may be a function of the current pitch blade, respectively. Moreover, the first and second flow resistances, the first and second flow regions 170, 180, the first and second pressures, and the current pitch angle may at least partially depend on one another.

[0055] In some embodiments, the first and second cylinders 110, 120 may have open longitudinal ends. In such case, the hydraulic fluid supplied into the first and second cylinders 110, 120, respectively, may exit the first and second cylinders 110, 120 at both longitudinal ends and may flow into the fluid reservoir 150, as it is only the pressure(s) upstream of the first and second inlets 116, 126 that indicate the current pitch angle.

Industrial Applicability

[0056] In the following, the exemplary disclosed pitch angle indication system 100 during operation of the marine propeller arrangement 12 is disclosed with respect to the drawings.

[0057] When supplying hydraulic fluid to, for example,

the backward pitch chamber 38 via the backward pitch chamber conduit 56, the piston 40 is displaced in the longitudinal direction 13, that is to the left in Fig. 2. Displacement of the piston 40 causes the marine propeller blades 18, 22 to rotate relatively to the marine propeller boss 32, thereby changing its pitch angle. Moreover, displacement of the piston 40 causes the fluid conveying member 43 to displace in the longitudinal direction 13, that is to the left in Fig. 2.

[0058] Due to the transmission device 102 connected to the fluid conveying member 43 and coupled to the first and second pistons 112, 122 via the first and second rods 117, 127, also the first and second pistons 112, 122 are longitudinally displaced relative to the first and second inlets 116, 126 along the first and second longitudinal axes 114, 124 (see Fig. 3). Particularly, with the transmission device 102 and the first and second rods 117, 127 as shown in Figs. 2 and 3, the first and second pistons 112, 122 are also displaced to the left.

[0059] As already described above, the first piston 112 is oppositely arranged with respect to the second piston 122. Therefore, referring particularly to Fig. 4, the first flow region 170 is smaller than the second flow region 180 and, hence, the first flow resistance between the first inlet 116 and the first outlet 118 is higher than the second flow resistance between the second inlet 126 and the second outlet 128. Specifically, as the distance from the first inlet 116 to the first piston 112 is smaller than the distance from the second inlet 126 to the second piston 122 (see Fig. 4), the hydraulic backlog in the first hydraulic supply line 130 is greater than the hydraulic backlog in the second hydraulic supply line 140. The different first and second backlogs lead to different first and second pressures upstream of the first and second inlets 116, 126, which can be detected by the first and second pressure detection devices 138, 148, respectively.

[0060] The first and second pressure detection devices 138, 148 each generate a first and second pressure signal indicative of the detected first and second pressures, respectively. The first and second pressure signals are then provided to the processing unit 160 for further processing. For example, the processing unit 160 may determine a pressure difference based on the first and second pressure signals. The processing unit 160 may subsequently determine the current pitch angle at least partially based on the determined pressure difference.

[0061] For example, the processing unit 160 may include a look-up table pre-stored in a memory. The look-up table may associate the pressure difference with the pitch angle. In some embodiments, the processing unit 160 may determine the current pitch angle based on the first and second pressure signals using, for instance, a pre-stored algorithm.

[0062] For pitching the marine propeller blades 18, 22 to the zero pitch angle, hydraulic fluid is supplied to the forward pitch chamber 36 via the forward pitch chamber conduit 55. This causes the piston 40 to be displaced in a direction opposite the longitudinal direction 13, that is

to the right in Fig. 2. Displacement of the piston 40 causes the marine propeller blades 18, 22 to rotate relatively to the marine propeller boss 32, thereby changing its pitch angle. Moreover, displacement of the piston 40 causes the inner and outer sleeves 72, 74 to displace in a direction opposite the longitudinal direction 13, that is to the right in Fig. 2.

[0063] Due to the transmission device 102 connected to the outer sleeve 74 and coupled to the first and second pistons 112, 122 via the first and second rods 117, 127, also the first and second pistons 112, 122 are longitudinally displaced relative to the first and second inlets 116, 126 along the first and second longitudinal axes 114, 124 (see Fig. 3). Particularly, with the transmission device 102 and the first and second rods 117, 127 as shown in Figs. 1 and 2, the first and second pistons 112, 122 are displaced to the right.

[0064] During displacement of the first and second pistons 112, 122, the first and second pressure detection devices 138, 148 continuously detect the first and second pressures, respectively, and provide corresponding first and second pressure signals to the processing unit 160 for further processing. When the processing unit 160 determines a pressure difference of zero, the processing unit 160 may output a signal indicative of the zero pitch angle. The zero pitch angle signal may then be provided to, for instance, a control unit of the vessel for further processing. For example, the zero pitch angle signal may indicate that the marine propeller blades 18, 22 are in a position perpendicular to the drive shaft 14. In this position, the marine propeller 16 has not thrust and the vessel 10 may be stationary.

[0065] 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. For example, in some embodiments, the pitch angle indication system may further comprise a second hydraulic cylinder defining a second longitudinal axis and having a second inlet configured to receive hydraulic fluid and a second outlet configured to direct the hydraulic fluid out of the second hydraulic cylinder. In such embodiments, the pitch angle indication system may further comprise a second piston disposed within the second hydraulic cylinder and movable along the second longitudinal axis. The position of the second piston relative to the second inlet may be associated with the pitch angle of the at least one marine propeller blade. The second piston may be shaped such that a second flow resistance between the second inlet to the second outlet may correspond to the position of the second piston relative to the second inlet. The first pressure detection device may be further configured to detect a second pressure upstream of the second inlet and output a second pressure signal indicative of the second pressure. The processing unit may be further configured to receive the second pressure signal and, at least partially based on the first and/or second pressure signals, determine the pitch angle of the at least one ma-

rine propeller blade.

[0066] In some embodiments, the first pressure detection device may be a differential pressure gauge configured to detect a differential pressure between the first pressure and the second pressure. In such embodiments, the differential pressure gauge may be configured to output a differential pressure signal indicative of the differential pressure between the first pressure and the second pressure.

[0067] In some embodiments, the first flow resistance may be a function of a first flow region delimited by the first hydraulic cylinder and the first piston at the first inlet. The second flow resistance may be a function of a second flow region delimited by the second hydraulic cylinder and the second piston at the second inlet.

[0068] Within the meaning of the present disclosure, the zero pitch angle position of the at least one marine propeller blade may be defined as an orientation of the at least one marine propeller blade in which the marine propeller does not provide any thrust. For example, the zero pitch angle position of the at least one marine propeller blade may be defined as the orientation of the at least one marine propeller blade in which the at least one marine propeller blade is substantially perpendicular to a drive shaft of the marine propeller.

[0069] Within the meaning of the present disclosure, a flow resistance may be defined as the capability of hydraulic medium to stream along a predefined flow path. The more or greater obstacles within the flow path, the higher the hydraulic resistance and, therefore, the higher a pressure upstream of the obstacles. Particularly, the flow resistance within the meaning of the present disclosure may be defined as the capability of hydraulic medium to enter a hydraulic cylinder through an inlet of the hydraulic cylinder and to flow out of the hydraulic cylinder through an outlet of the hydraulic cylinder. Due to the specific shape of the piston disposed within the hydraulic cylinder, the flow resistance between the inlet and the outlet may depend on the position of the piston relative to the inlet, which may lead to a change of pressure upstream of the inlet.

Claims

1. A pitch angle indication system (100) for indicating a pitch angle of at least one marine propeller blade (18, 22) of an adjustable marine propeller arrangement (12) used in, for example, a vessel (10), the pitch angle indication system (100) comprising:

a first hydraulic cylinder (110) defining a first longitudinal axis (114) and having a first inlet (116) configured to receive hydraulic fluid and a first outlet (118) configured to direct the hydraulic fluid out of the first hydraulic cylinder (110);
a first piston (112) disposed within the first hydraulic cylinder (110) and movable along the first

- longitudinal axis (114), wherein the position of the first piston (112) relative to the first inlet (116) is associated with the pitch angle of the at least one marine propeller blade (18, 22), the first piston (112) being shaped such that a position change of the first piston (112) relative to the first inlet (116) changes a first flow resistance between the first inlet (116) to the first outlet (118);
a first pressure detection device (138) configured to detect a first pressure upstream of the first inlet (116) and output a first pressure signal indicative of the first pressure; and
a processing unit (160) connected to the first pressure detection device (138), the processing unit (160) being configured to receive the first pressure signal and, at least partially based on the first pressure signal, determine the pitch angle of the at least one marine propeller blade (18, 22).
2. The pitch angle indication system (100) of claim 1, further comprising:
- a second hydraulic cylinder (120) defining a second longitudinal axis (124) and having a second inlet (126) configured to receive hydraulic fluid and a second outlet (128) configured to direct the hydraulic fluid out of the second hydraulic cylinder (120); and
a second piston (122) disposed within the second hydraulic cylinder (120) and movable along the second longitudinal axis (124), wherein the position of the second piston (122) relative to the second inlet (126) is associated with the pitch angle of the at least one marine propeller blade (18, 22), the second piston (122) being shaped such that a second flow resistance between the second inlet (126) to the second outlet (128) corresponds to the position of the second piston (122) relative to the second inlet (126),
a second pressure detection device (148) configured to detect a second pressure upstream of the second inlet (126) and output a second pressure signal indicative of the second pressure; and
wherein the processing unit (160) is further configured to receive the second pressure signal and, at least partially based on the first and/or second pressure signals, determine the pitch angle of the at least one marine propeller blade (18, 22).
3. The pitch angle indication system (100) of any one of the preceding claims, wherein
the first flow resistance is a function of a first flow region (170) delimited by the first hydraulic cylinder (110) and the first piston (112) related to the first inlet (116), and/or
the second flow resistance is a function of a second flow region (180) delimited by the second hydraulic cylinder (120) and the second piston (122) related to the second inlet (126).
4. The pitch angle indication system (100) of any one of the preceding claims, wherein the at least one of first piston (112) and the second piston (122) has a substantially tapered shape, preferably a conical shape.
5. The pitch angle indication system (100) of claim 4, wherein
the first piston (112) is substantially tapered along the first longitudinal axis (114) in a first direction, and the second piston (122) is substantially tapered along the second longitudinal axis (124) in a second direction, the second direction being opposite to the first direction.
6. The pitch angle indication system (100) of any one of the claims 2 to 5, wherein the first piston (112) and the second piston (122) are substantially identical in shape.
7. The pitch angle indication system (100) of any one of claims 2 to 6, wherein the processing unit (160) is further configured to, at least partially based on the first and second pressure signals, determine a pressure difference and, at least partially based on the determined pressure difference, indicate the pitch angle of the at least one marine propeller blade (18, 22).
8. The pitch angle indication system (100) of any one of the preceding claims, wherein the first pressure detection device is a differential pressure gauge (138, 148) configured to detect a pressure difference between the first pressure and the second pressure and to output a signal indicative of the pressure difference.
9. The pitch angle indication system (100) of any one of the preceding claims, further comprising a transmission device (102) configured to transmit a rotational pitch movement of the at least one marine propeller blade (18, 22) into a translational movement of the first and/or second pistons (112, 122).
10. An adjustable marine propeller arrangement (12) used in, for example, a vessel (10), comprising:
an adjustable marine propeller (16) configured to be connected to a drive shaft (14) and having at least one marine propeller blade (18, 22) rotatable connected to the adjustable marine propeller (16), and a piston (40) connected to the

at least one marine propeller blade (18, 22), the piston (40) being configured to control the pitch angle of the at least one marine propeller blade (18, 22); and

at least one pitch angle indication system (100) according to any one of the preceding claims, wherein the first and/or second pistons (112, 122) are operatively coupled to the at least one marine propeller blade (18, 22).

- 11.** A method for indicating a pitch angle of at least one marine propeller blade (18, 22) of an adjustable marine propeller arrangement (12) used in, for example, a vessel (10), the method comprising:

adjusting the pitch angle of the at least one marine propeller blade (18, 22), thereby changing a first flow resistance between a first inlet (116) of a first hydraulic cylinder (110) and a first outlet (118) of the first hydraulic cylinder (110);

directing hydraulic fluid into the first hydraulic cylinder (110) through the first inlet (116) and out of the first hydraulic cylinder (110) through the first outlet (118);

detecting a first pressure upstream of the first inlet (116); and

indicating the pitch angle of the at least one marine propeller blade (18, 22) at least partially based on the detected first pressure.

- 12.** The method of claim 11, wherein adjusting the pitch angle of the at least one marine propeller blade (18, 22) includes changing a second flow resistance between a second inlet (126) of a second hydraulic cylinder (120) and a second outlet (128) of the second hydraulic cylinder (120); the method further comprising:

directing hydraulic fluid into the second hydraulic cylinder (120) through the second inlet (126) and out of the second hydraulic cylinder (120) through the second outlet (128);

detecting a second pressure upstream of the second inlet (126); and

indicating the pitch angle of the at least one marine propeller blade (18, 22) at least partially based on the detected first and/or second pressures.

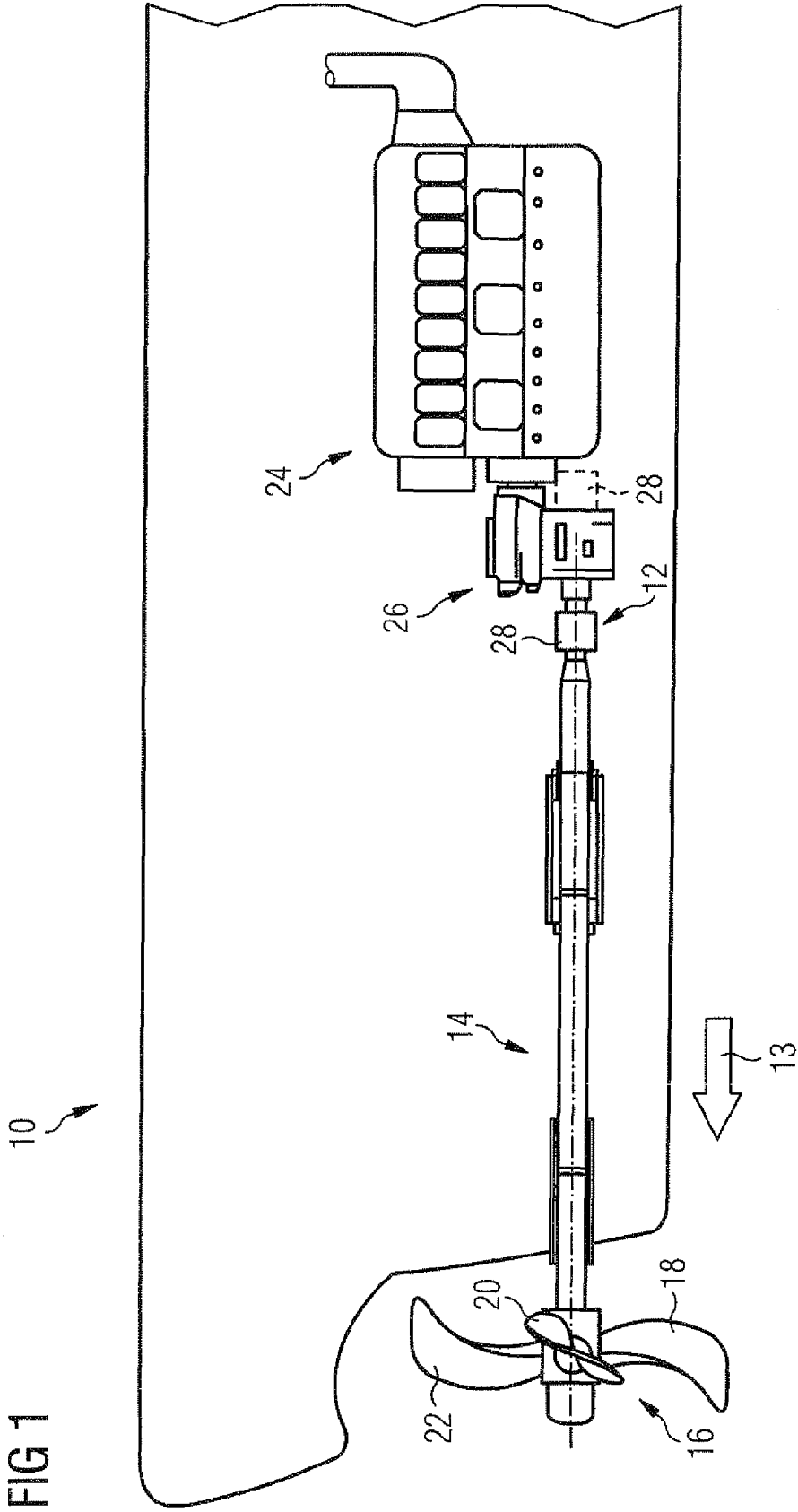
- 13.** The method of any one of claims 11 and 12, wherein adjusting the pitch angle of the at least one marine propeller blade (18, 22) includes positioning a first piston (112) movable disposed within the first hydraulic cylinder (110) relative to the first inlet (116), thereby changing the first flow resistance; and/or adjusting the pitch angle of the at least one marine propeller blade (18, 22) includes positioning a second piston (122) movable disposed within the sec-

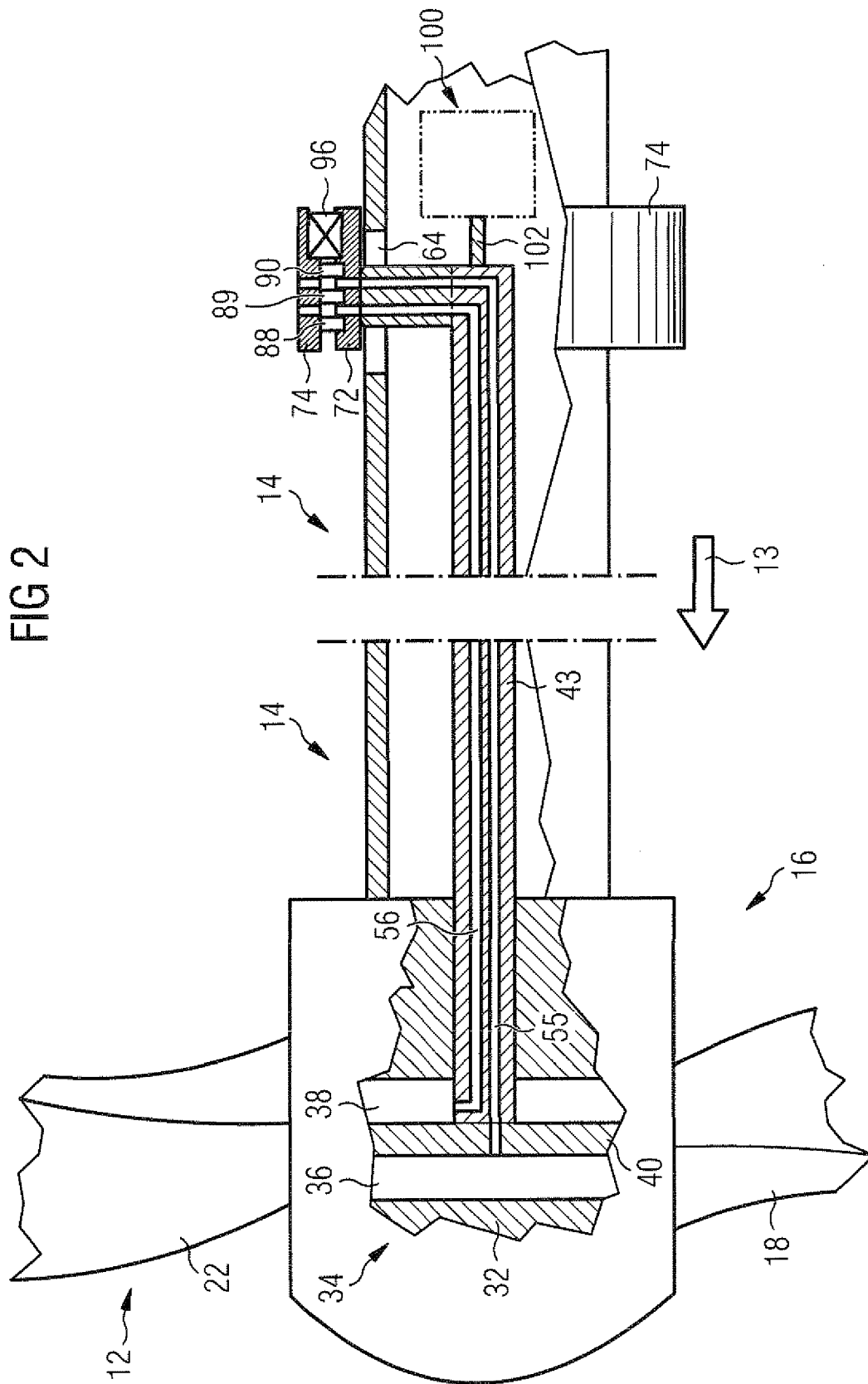
ond hydraulic cylinder (120) relative to the second inlet (126), thereby changing the second flow resistance.

- 14.** The method of any one of claims 12 and 13, further comprising determining a pressure difference between the detected first and second pressures, wherein indicating the pitch angle of the at least one marine propeller blade (18, 22) is at least partially based on the determined pressure difference.

- 15.** The method of claim 14, wherein a pressure difference of zero is indicative of a zero pitch angle of the at least one marine propeller blade (18,22).

FIG 1





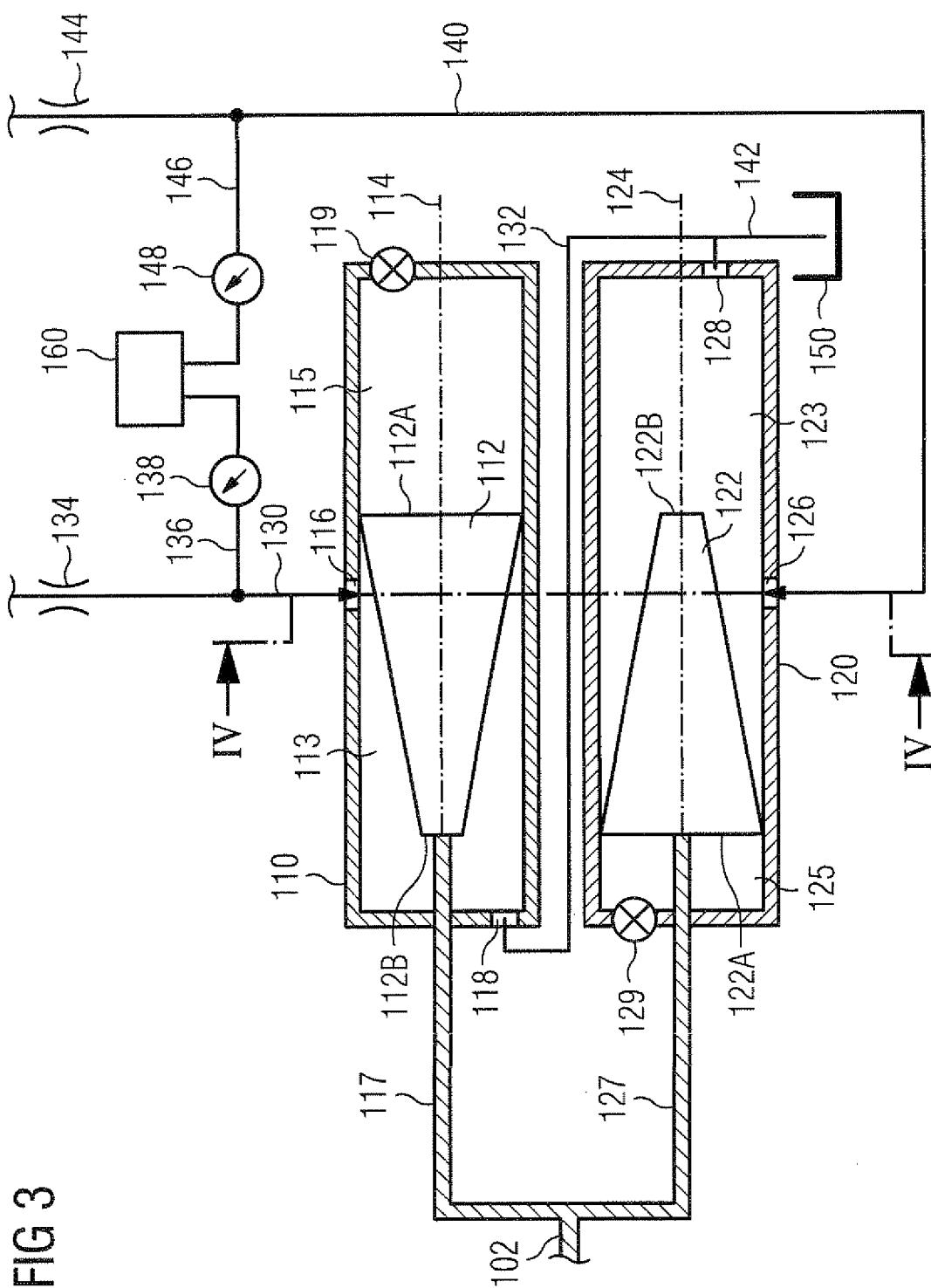
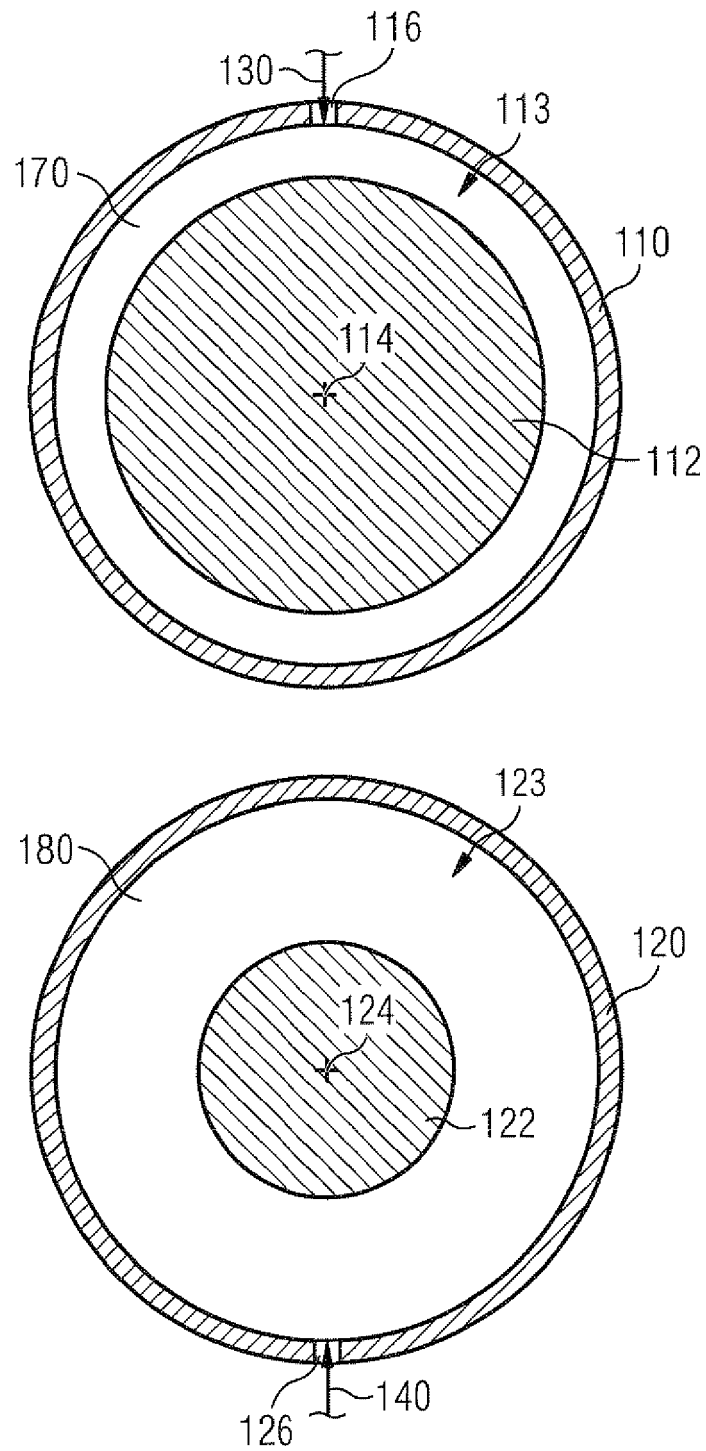


FIG 4





EUROPEAN SEARCH REPORT

Application Number
EP 14 18 2701

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2010/033060 A1 (BERG PROPULSION TECHNOLOGY AB [SE]; THYBERG CONNY [SE]) 25 March 2010 (2010-03-25) * page 13, lines 5-13; figure 2A *	1-15	INV. B63H3/00 B64C11/38 B64D45/00
A	US 3 895 883 A (PEDERSEN JAMES MILLER) 22 July 1975 (1975-07-22) * column 3, line 50 - column 4, line 16; figures 1, 2 *	1-15	
A	US 4 872 811 A (CAVALLARO JOSEPH L [US] ET AL) 10 October 1989 (1989-10-10)	1-15	
A	CH 217 669 A (ESCHER WYSS MASCHF AG [CH]) 31 October 1941 (1941-10-31) * page 2, line 10 - page 3, line 79; figure 1 *	1-15	
A	GB 560 207 A (DEHAVILLAND AIRCRAFT; ERIC STANLEY MOULT; KENNETH BRYAN GILLMORE; ROBE) 24 March 1944 (1944-03-24) * page 2, lines 109-128; figure 1 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63H B64C B64D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 30 January 2015	Examiner Brumer, Alexandre
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 18 2701

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

30-01-2015

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010033060 A1	25-03-2010	CN 102224069 A	19-10-2011
		EP 2331398 A1	15-06-2011
		KR 20110059779 A	03-06-2011
		US 2011189909 A1	04-08-2011
		WO 2010033060 A1	25-03-2010

US 3895883 A	22-07-1975	NONE	

US 4872811 A	10-10-1989	NONE	

CH 217669 A	31-10-1941	NONE	

GB 560207 A	24-03-1944	NONE	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2010033060 A1 **[0004]**