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(54) **MARINE DRIVE SYSTEM**

(57) A marine drive system (110, 210, 310) for a marine vessel (100) and a marine vessel comprising such marine drive system. The marine drive system comprises an electric motor (220), a motor shaft (230) driven by the electric motor (220), an intermediate shaft (250), a propeller shaft (270) adapted to drive a propeller (280), and a bevel gear mechanism (260) connecting the intermediate shaft (250) to the propeller shaft (270). The marine drive system (110, 210, 310) further comprises a belt transmission (240) connecting the intermediate shaft (250) to the motor shaft (230) with a first gear reduction ratio.

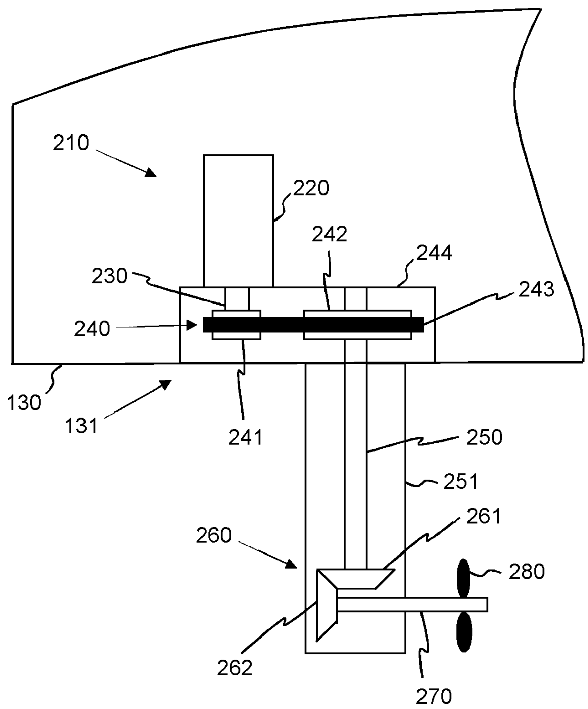

Figure 2

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a marine drive system for a marine vessel. The present disclosure also relates to a marine vessel comprising said marine drive system. The disclosure can be applied in marine vessels, such as boats, ships, and other watercrafts. Although the disclosure may be described with respect to a particular marine vessel, the disclosure is not restricted to any particular marine vessel.

BACKGROUND

[0002] Electric propulsion of vehicles is getting more and more common in order to replace combustible fuels. Slowly, electrical propulsion of marine vehicles are also gaining more interest. Electrical drive systems for slower boats, such as gigs or sailboats, are relatively energy efficient when the boat travels at low speeds. A further advantage for sailboats is that they normally do not need the motor, and that the motor is mostly used in emergencies and when docking. Electric drive systems are therefore particularly suitable for sailboats.

[0003] Smaller sailboats are often provided with an outboard combustion engine used to drive the sailboat when there is no wind or when docking. Larger sailboats often have an inboard combustion engine that is either provided with a straight axle that drives a propeller arranged at the rear of the sailboat, or is provided with a so-called saildrive mounted to the hull of the sailboat. A saildrive normally comprises a motor shaft driven by an inboard engine or motor. The motor shafts is connected to a propeller shaft via one or more gear mechanisms. The propeller shaft drives a fixed propeller or a foldable propeller. The propeller and propeller shaft are normally parts of a lower unit of the saildrive arranged beneath the hull. At least a part of the motor shaft is normally part of an upper unit fastened inside the hull. The saildrive may be steerable. In that case, the lower unit is pivotable around a vertical axis for steering the sailboat. The saildrive is also suitable for smaller sailboats and other types of marine vessels, such as motorboats.

[0004] Saildrives have mostly been used with internal combustion engines. However, some systems using a saildrive with an electric motor have been published recently, such as EP3180242B1. Even if these systems functions well for their intended use, there is room for an improved marine drive system using an electric motor.

SUMMARY

[0005] According to a first aspect of the disclosure, a marine drive system comprises an electric motor, a motor shaft driven by the electric motor, an intermediate shaft, a propeller shaft adapted to drive a propeller, and a bevel gear mechanism connecting the intermediate shaft to the propeller shaft. The marine drive system further comprises a belt transmission connecting the intermediate shaft to the motor shaft with a first gear reduction ratio. The first aspect of the disclosure may seek to provide an improved transmission from the motor to the propeller by the belt transmission. A technical benefit may include providing an improved marine drive system for a marine vessel. In particular, the belt transmission provides gear reduction in a silent manner. The belt transmission may be replaced by interconnected gears and/or a gear mechanism comprising a chain. However, such solutions are less preferred since they are noisier than the belt transmission. In addition, the belt transmission provides high efficiency, requires low maintenance, and does not require lubrication.

[0006] Optionally in some examples, including in at least one preferred example, the bevel gear mechanism is a reduction gear with a second gear reduction ratio.

[0007] Optionally in some examples, including in at least one preferred example, the belt transmission comprises a first pulley attached to the motor shaft, a second pulley attached to the intermediate shaft, and a belt driven connecting the first and the second pulleys. A technical benefit may include that the second pulley typically has a larger dimension than the first pulley to provide the gear reduction from the motor shaft to the intermediate shaft.

[0008] Optionally in some examples, including in at least one preferred example, the belt transmission comprises a toothed belt. A technical benefit may include that a toothed belt offers high efficiency over a wide load range. A toothed belt, however, introduces some additional noise compared to a non-toothed belt.

[0009] Optionally in some examples, including in at least one preferred example, the toothed belt may be helical toothed belt. A technical benefit may include that such shape reduces said additional noise.

[0010] Optionally in some examples, including in at least one preferred example, the first gear reduction ratio is 1.5-10:1, preferably 1.5-5: 1, and more preferably 1.5-3:1.

[0011] Optionally in some examples, including in at least one preferred example, the second gear reduction ratio may e.g. be 2-6:1, and preferably 2-4:1. A technical benefit may include that the first and the second gear reduction ratios advantageously provide a high total reduction ratio, i.e., the product of the first and the second gear reduction ratios, while keeping the respective reduction ratios relatively low. Thus, splitting the gear reduction into two separate mechanisms enables the two mechanisms to be relatively small compared to a single mechanism providing the same total gear reduction. The belt transmission together with the bevel gear mechanism having the second gear reduction ratio therefore provides a compact marine drive system.

[0012] Optionally in some examples, including in at least one preferred example, the electric motor is adapted to drive the motor shaft at up to 6000-12000 revolutions per minute. A technical benefit may include that the range 6000-12000 revolutions per minute may thus be an upper limit of an operation range of the electric motor. In other words, the electric motor may e.g. be adapted to operate from 0 up to 6000-12000 revolutions per minute. Such operational ranges are suitable for marine vessel motors.

[0013] Optionally in some examples, including in at least one preferred example, at least a part of the motor shaft, the belt transmission, and at least a part of the intermediate shaft are arranged in an upper housing, and wherein at least a part of the intermediate shaft, the bevel gear mechanism, and at least a part of the propeller shaft are arranged in a lower housing.

[0014] Optionally in some examples, including in at least one preferred example, the marine drive system is a pulling drive system. A technical benefit may include that such orientation of the marine drive system provides efficient operation.

[0015] Optionally in some examples, including in at least one preferred example, the marine drive system may be steerable. A technical benefit may include that it is desirable for relatively large marine vessels.

[0016] Optionally in some examples, including in at least one preferred example, the marine drive system comprises foldable propellers. A technical benefit may include that this reduces drag when the marine drive system is not needed for propulsion or power generation, which is particularly advantageous if the marine drive system is used on a sailboat.

[0017] Optionally in some examples, including in at least one preferred example, the marine drive system comprises two counter-rotating propellers. A technical benefit may include that this is particularly efficient.

[0018] According to a second aspect of the disclosure, a marine vessel comprises the marine drive system according to the first aspect. The marine vessel is associated with the above-discussed advantages. The marine vessel may e.g. be a sailboat or a motorboat.

[0019] The disclosed aspects, examples (including any preferred examples), and/or accompanying claims may be suitably combined with each other as would be apparent to anyone of ordinary skill in the art. Additional features and advantages are disclosed in the following description, claims, and drawings, and in part will be readily apparent therefrom to those skilled in the art or recognized by practicing the disclosure as described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Examples are described in more detail below with reference to the appended drawings.

Fig. 1 shows a schematic illustration of a marine vessel provided with a marine drive system,

Fig. 2 shows a schematic illustration of a marine drive system, and

Fig. 3 shows a schematic illustration of a steerable marine drive system.

DETAILED DESCRIPTION

[0021] The detailed description set forth below provides information and examples of the disclosed technology with sufficient detail to enable those skilled in the art to practice the disclosure.

[0022] There is disclosed herein a marine drive system and a marine vessel comprising such marine drive system. The disclosed marine drive system resembles a saildrive used in e.g. a sailboat. The disclosed marine drive system can be used in any type of marine vessels, such as boats, ships, and other watercrafts, and particularly sailboats or motorboats. Figure 1 shows a schematic illustration of marine vessel 100 provided with a marine drive system 110 for propelling the marine vessel or for generating electric energy. Figure 2 shows details of a schematic illustration of a marine drive system 210. Figure 3 shows details of a schematic illustration of a steerable marine drive system 310.

[0023] In Figure 1, the marine drive system 110 comprises an upper housing 144 mounted to an opening 131 in the hull 130 of the marine vessel 100. The upper housing is mounted flush with the hull such that the upper housing does not extend out of the hull. The upper housing is provided with an electric motor adapted to drive a propeller. The marine drive system 110 further comprises a lower housing 151 provided with a leg 152 and a hub 153. In the example of Figure 1, the hub is provided with two counter-rotating propellers 180. The marine drive system may alternatively be arranged to drive a single propeller. Any type of propeller may be foldable to reduce drag, which is particularly advantageous if the marine drive system is used on a sailboat. The lower housing is preferably mounted to the upper housing in a watertight manner. The electric motor is powered by a battery 120. One advantage of using an electric drive motor is that the motor can also be used to charge the battery when the marine drive system 110 is installed in a sailboat. The marine drive system may also comprise an electronic control unit (ECU) 111 used to control the electric motor. The ECU may e.g. be configured to control the rotation speed of the propeller or to toggle between a propulsion mode and a recharging mode.

[0024] A marine vessel 100 may be provided with one or more of the disclosed marine drive system, and may be accompanied by other drive systems as well. A smaller regular sailboat may e.g. be provided with a single marine drive system that replaces a regular saildrive installation, where the sailboat is steered with a rudder. Alternatively, the smaller sailboat may be provided with a steerable marine drive system with a pivotable lower unit, which is pivotable around a vertical axis for steering the sailboat. Larger sailboats may be provided with two or more marine drive systems, which are fixed or steerable. Here, steering may be performed by driving propellers of different marine drive systems with different rotational speeds. The disclosed marine drive system is also suitable for motorboats. Such motorboat may comprise one or more fixed or steerable marine drive systems.

[0025] In the example of Figure 1, the marine drive system is a pulling drive system. A pulling drive system means that the propeller is arranged to pull water when the marine vessel is going in a forward direction. For example, in a fixed marine drive system, a pulling drive system may be implemented by arranging the propeller on a propeller shaft extending away from the lower housing and towards a forward direction of the marine vessel. In general, however, the disclosed marine drive system may be pulling or pushing drive system.

[0026] As mentioned, there is a need for an improved marine drive systems using an electric motor. An electric motor for a marine vessel is typically arranged to operate with adjustable speeds, where the maximum speed is relatively high. A propeller, on the other hand, is normally designed for a maximum rotation speed that is relatively low. For example, an electric motor may be configured to rotate up to 9000 revolutions per minute, whereas a propeller may be designed to have a maximum rotation speed of 1500 revolutions per minute. Faster propeller speeds may result in blade loading that produce noise, vibration, and cavitation, which are undesired. To pair said example propeller with said example motor, the propeller should be driven via one or more reduction gears with a reduction ratio of 6:1.

[0027] According to some aspects, the electric motor 220 is be adapted to rotate up to 6000-12000 revolutions per minute. The marine drive system should consequently comprise gear reduction from the motor to the propeller. The range 6000-12000 revolutions per minute is here an upper limit of an operation range of the electric motor. In other words, the electric motor may e.g. be adapted to operate from 0 up to 6000-12000 revolutions per minute. Such operational ranges are suitable for marine vessel motors.

[0028] The disclosed marine drive system therefore comprises improved transmission with gear reduction. Figure 2 shows an example marine drive system 210 where details of the transmission from the electric motor to the propeller are shown. In particular, the disclosed marine drive system comprises an electric motor 220, a motor shaft 230 driven by the electric motor 220, an intermediate shaft 250, a propeller shaft 270 adapted to drive a propeller 280, and a bevel gear mechanism 260 connecting the intermediate shaft 250 to the propeller shaft 270. A shaft is a rotatable machine part, which usually has a circular cross section, used to transmit power from one element to another. The motor shaft is preferably driven directly by the electric motor and is in that case preferably directly attached to the motor. Similarly, the propeller shaft preferably directly drives the propeller and is in that case preferably directly attached to the propeller. The bevel gear mechanism transfers the rotation of the intermediate shaft to the propeller shaft. The intermediate shaft typically has a different extension direction than the propeller shaft. For example, the intermediate shaft may extend in a direction that is perpendicular to the extension direction of the propeller shaft. The motor shaft may extend in a direction that is parallel to the extension direction of the intermediate shaft. In a double propeller installation, the propeller shaft may comprise a concentric shaft.

[0029] The gear reduction is provided by a belt transmission 240 with a first gear reduction ratio. In other words, the belt transmission is type of reduction gear mechanism. The belt transmission 240 is arranged to connect the intermediate shaft 250 to the motor shaft 230 with the first gear reduction ratio. The belt transmission is thus configured such that the rotary speed of the intermediate shaft is reduced relative to the rotary speed of the motor shaft. The first gear reduction ratio may e.g. be 1.5-10:1. In other words, the rotary speed of the motor shaft may be 1-5-10 times larger than the rotary speed of the intermediate shaft.

[0030] The belt transmission provides gear reduction in a silent manner. The bevel gear mechanism is arranged closer to the propeller and does not influence noise levels significantly. The belt transmission may be replaced by interconnected gears and/or a gear mechanism comprising a chain. However, such solutions are less preferred since they are noisier than the belt transmission. In addition, the belt transmission provides high efficiency, requires low maintenance, and does not require lubrication.

[0031] The dimensions of a gear reduction mechanism, such as the belt transmission or the bevel gear mechanism, is typically dependent on its gear reduction ratio. In some cases, the first gear reduction ratio is preferably 1.5-5:1, and more preferably 1.5-3:1, to keep the dimensions of the belt transmission relatively small. It is desired to keep the marine drive system as small as possible since space inside the hull is limited and since the portion of the marine drive system outside the hull introduces drag.

[0032] Figure 2 shows a bevel gear mechanism 260 comprising a first bevel gear 261 directly interconnected with a second bevel gear 262.

[0033] The bevel gear mechanism 260 may be a reduction gear with a second gear reduction ratio. The second gear reduction ratio may e.g. be 2-6:1. The first and the second gear reduction ratios advantageously provide a high total reduction ratio, i.e., the product of the first and the second gear reduction ratios, while keeping the respective reduction ratios relatively low. Thus, splitting the gear reduction into two separate mechanisms enables the two mechanisms to be relatively small compared a single mechanism providing the same total gear reduction.

[0034] As an example, the first and the second gear reduction ratios may be selected such that the total reduction ratio is 6:1. In that case, the first gear reduction ratio may be selected as 1.5-3:1 and the second gear reduction ration may be selected as a corresponding number in the range 2-4:1. If the respective reduction ratios of the belt transmission and the bevel gear mechanism are kept below 4:1, their respective dimensions may be relatively small.

[0035] As is illustrated in the example marine drive system of Figure 2, the belt transmission 240 may comprise a first pulley 241 attached to the motor shaft 230, a second pulley 242 attached to the intermediate shaft 250, and a belt 243 connecting the first and the second pulleys. The motor shaft preferably directly drives the first pulley and is in that case preferably directly attached to the first pulley. Similarly, the second pulley preferably directly drives the intermediate shaft and is in that case preferably directly attached to the intermediate shaft. The second pulley typically has a larger dimension than the first pulley to provide the gear reduction from the motor shaft to the intermediate shaft. Alternatively, the belt transmission 240 may comprise other configurations of belts and pulleys.

[0036] The belt transmission 240 may comprise a toothed belt. A toothed belt can also be called a synchronous, timing, positive-drive, or high-torque drive belt. A toothed belt comprises a plurality of teeth and is typically paired with toothed pulleys or sprockets with corresponding teeth arranged to mate with the teeth of the belt. A toothed belt offers high efficiency over a wide load range. A toothed belt, however, introduces some additional noise compared to a non-toothed belt. The toothed belt may therefore be a helical toothed belt. Such shape reduce said additional noise. The teeth of a helical belt are set at an angle relative to a running direction of the belt. This allows the teeth to mesh gradually with corresponding teeth of a pulley. A double helical belt is a type of helical belt that reduces noise further. An offset double helical belt is a type of helical belt that reduces noise even further. The double helical belt comprises two columns of angled teeth that may be connected to form V-shaped teeth. The offset double helical belt comprises two columns of angled teeth, where the two columns are offset relative to each other in the running direction of the belt. In general, however, the belt transmission may comprise any type of belt, such as a cogged belt or a V-shaped belt.

[0037] As is further illustrated in the example marine drive system 210 of Figure 2, at least a part of the motor shaft 230, the belt transmission 240, and at least a part of the intermediate shaft 250 may be arranged in an upper housing 244. Furthermore, at least a part of the intermediate shaft 250, the bevel gear mechanism 260, and at least a part of the propeller shaft 270 may be arranged in a lower housing 251. As mentioned, the lower housing may comprise a leg housing the at least a part of the intermediate shaft 250, and a hub housing the bevel gear mechanism 260 and at least a part of the propeller shaft. In the example of Figure 2, the upper housing is mounted flush with the hull 130, and the lower housing is mounted to the upper housing in a watertight manner.

[0038] As is illustrated in the example of Figure 3, the steerable marine drive system 310 comprises an intermediate housing 345. The lower housing 251 is pivotable around a vertical axis for steering the marine vessel. The intermediate housing is mounted flush with the hull 130, and the lower housing is mounted to the intermediate housing in a watertight and rotatable manner. In the example of Figure 3, the lower housing 251 is rotated by a steering motor 347 via a worm gear 346. Other gear mechanisms for steering the lower housing are also possible.

[0039] The terminology used herein is for the purpose of describing particular aspects only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. It will be further understood that the terms "comprises," "comprising," "includes," and/or "including" when used herein specify the presence of stated features, integers, actions, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, actions, steps, operations, elements, components, and/or groups thereof.

[0040] It will be understood that, although the terms first, second, etc., may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element without departing from the scope of the present disclosure.

[0041] Relative terms such as "below" or "above" or "upper" or "lower" or "horizontal" or "vertical" may be used herein to describe a relationship of one element to another element as illustrated in the Figures. It will be understood that these terms and those discussed above are intended to encompass different orientations of the device in addition to the orientation depicted in the Figures. It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element, or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present.

[0042] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. It will be further understood that terms used herein should be interpreted as having a meaning consistent with their meaning in the context of this specification and the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0043] It is to be understood that the present disclosure is not limited to the aspects described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the present disclosure and appended claims. In the drawings and specification, there have been disclosed aspects for purposes of illustration only and not for purposes of limitation, the scope of the disclosure being set forth in the following claims.

REFERENCE SIGNS

[0044]

100:	Marine vessel
110:	Marine drive system
111:	Electronic control unit
120:	Battery
130:	Hull
131:	Opening
144:	Upper housing
151:	Lower housing
152:	Leg
153:	Hub
180:	Propeller
210:	Marine drive system
220:	Electric motor
230:	Motor shaft
240:	Belt transmission
241:	First pulley
242:	Second pulley
243:	Belt
244:	Upper housing
250:	Intermediate shaft
251:	Lower housing
260:	Bevel gear mechanism
261:	First bevel gear
262:	Second bevel gear
270:	Propeller shaft
280:	Propeller
310:	Marine drive system
345:	Intermediate housing
346:	Worm gear
347:	Steering motor

Claims

1. A marine drive system (110, 210, 310) for a marine vessel (100), the marine drive system comprising

an electric motor (220),
a motor shaft (230) driven by the electric motor (220),
an intermediate shaft (250),
a propeller shaft (270) adapted to drive a propeller (280), and
a bevel gear mechanism (260) connecting the intermediate shaft (250) to the propeller shaft (270),

characterized in that the marine drive system (110, 210, 310) further comprises a belt transmission (240) connecting the intermediate shaft (250) to the motor shaft (230) with a first gear reduction ratio.

2. The marine drive system (110, 210, 310) according to claim 1, wherein the bevel gear mechanism (260) is a reduction gear with a second gear reduction ratio.

3. The marine drive system (110, 210, 310) according to any previous claim, wherein the belt transmission (240) comprises a first pulley (241) attached to the motor shaft (230), a second pulley (242) attached to the intermediate shaft (250), and a belt (243) connecting the first and the second pulleys.

4. The marine drive system (110, 210, 310) according to any previous claim, wherein the belt transmission (240) comprises a toothed belt.

5. The marine drive system (110, 210, 310) according to claim 4, wherein the toothed belt is a helical toothed belt.

6. The marine drive system (110, 210, 310) according to any previous claim, wherein the first gear reduction ratio is 1.5-10:1, preferably 1.5-5:1, and more preferably 1.5-3:1.

7. The marine drive system (110, 210, 310) according to any previous claim when dependent on claim 2, wherein the second gear reduction ratio is 2-6:1, and preferably 2-4:1.

8. The marine drive system (110, 210, 310) according to any previous claim, wherein the electric motor (220) is adapted to drive the motor shaft (230) up to 6000-12000 revolutions per minute.

9. The marine drive system (110, 210, 310) according to any previous claim, wherein at least a part of the motor shaft (230), the belt transmission (240), and at least a part of the intermediate shaft (250) are arranged in an upper housing (144, 244), and wherein at least a part of the intermediate shaft (250), the bevel gear mechanism (260), and at least a part of the propeller shaft (270) are arranged in a lower housing (151, 251).

10. The marine drive system (110, 210, 310) according to any previous claim, wherein the marine drive system is a pulling drive system.

11. The marine drive system (110, 210, 310) according to any previous claim, wherein the marine drive system is steerable.

12. The marine drive system (110, 210, 310) according to any previous claim, comprising foldable propellers (280).

13. The marine drive system (110, 210, 310) according to any previous claim, comprising two counter-rotating propellers.

14. A marine vessel (100, 310) comprising the marine drive system (110, 210, 310) according to any of claims 1-13.

15. The marine vessel (100, 310) according to claim 14, wherein the marine vessel is a sailboat or a motorboat.

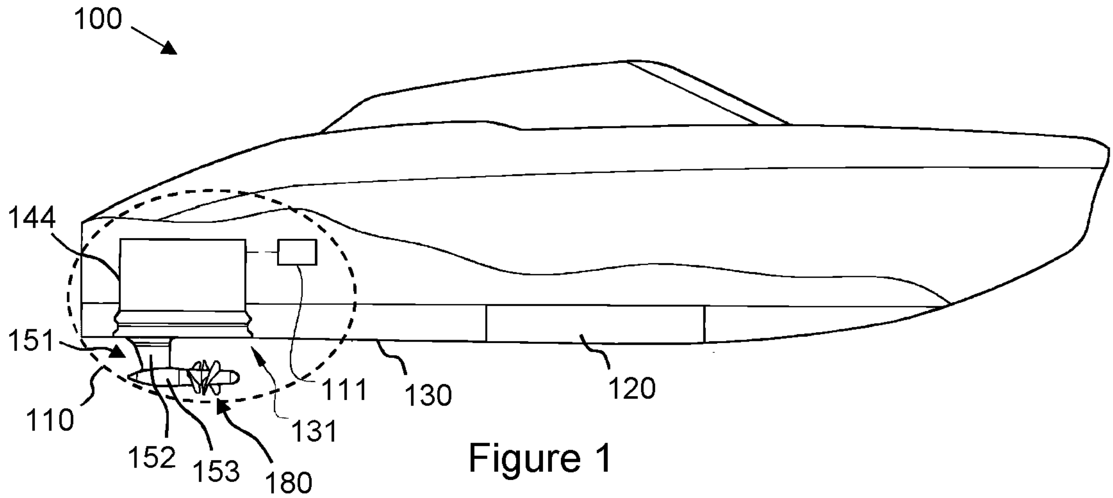

Figure 1

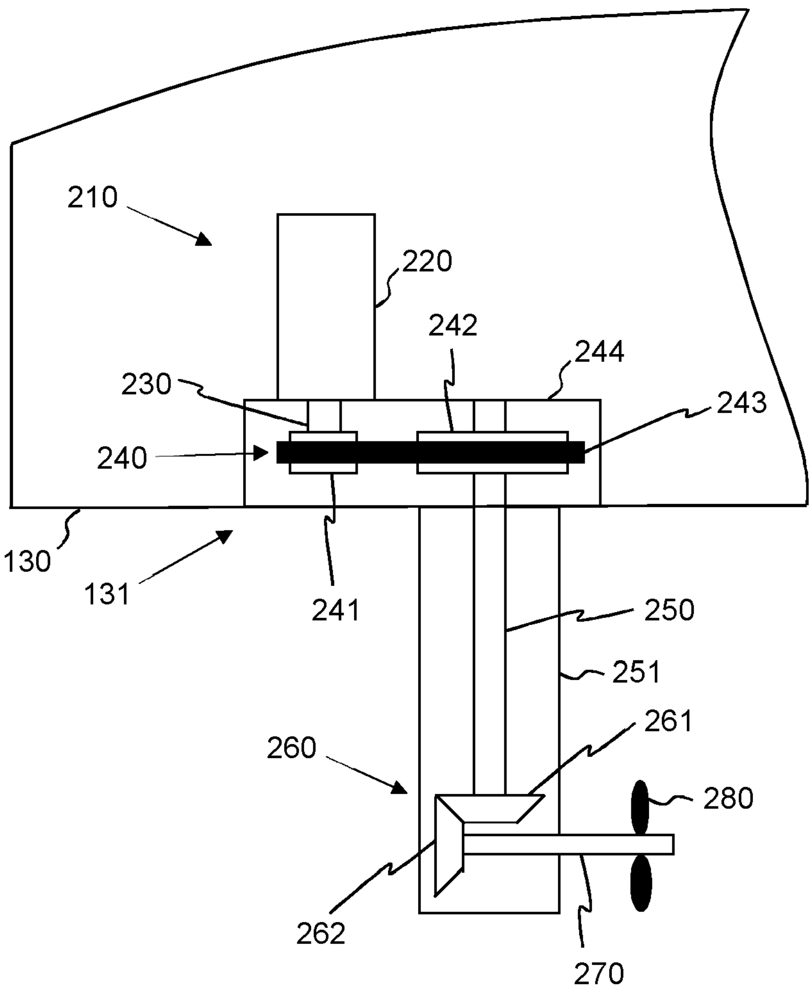

Figure 2

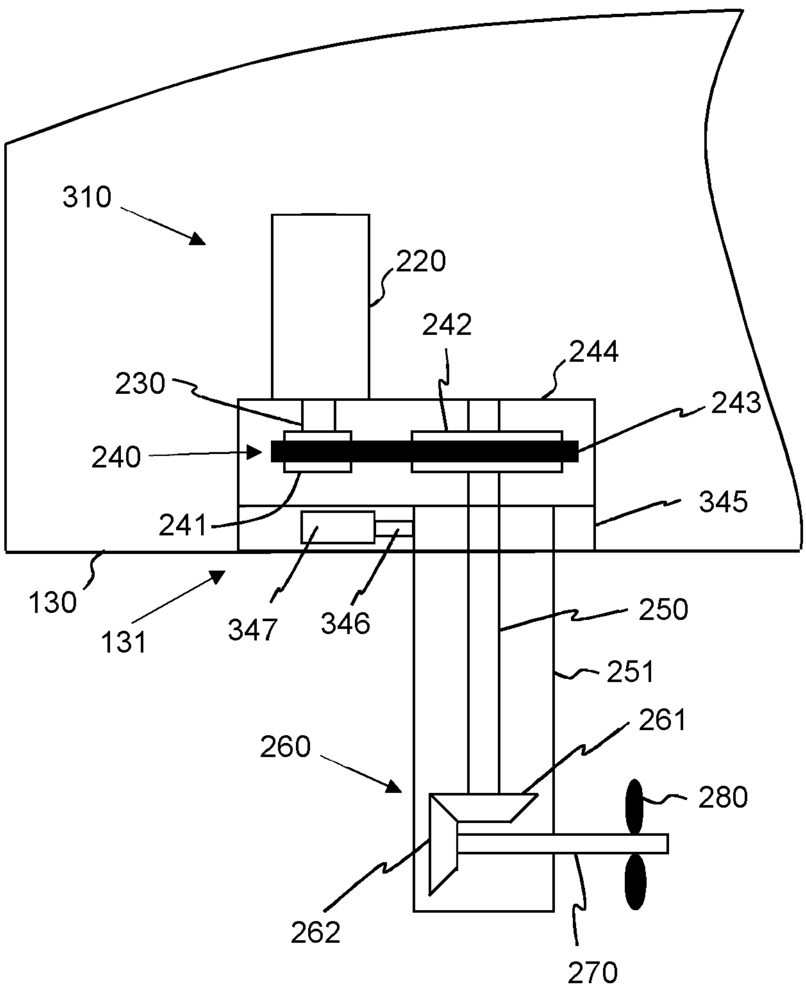
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Figure 3

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EUROPEAN SEARCH REPORT

Application Number
EP 23 16 8523

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 2021/024192 A1 (BLOMDAHL ANDREAS [SE]) 28 January 2021 (2021-01-28) * paragraphs [0002], [0036]; figure 4 * -----	1-15	INV. B63H20/14 B63H21/17 B63H23/02
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			TECHNICAL FIELDS SEARCHED (IPC)
			B63H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	4 October 2023	Harder, Sebastian

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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