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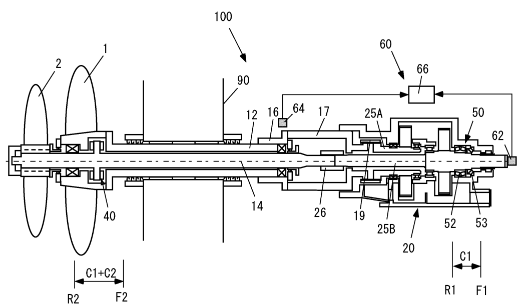
(54) THRUST CLEARANCE MEASURING DEVICE, THRUST CLEARANCE MEASURING METHOD, AND MARINE VESSEL

(57) A marine contra-rotating propeller apparatus (100) comprises: an outer shaft (12) to which the front propeller (1) is attached, an inner shaft (14) to which a rear propeller (2) is attached, a contra-rotating thrust bearing (40) configured to transmit a thrust force acting on the front propeller to the inner shaft, and a contra-rotating gear device (20) configured to rotate the outer shaft and the inner shaft in directions opposite to each other. The contra-rotating gear device (20) has an inner shaft thrust bearing (50) configured to support a thrust force of the inner shaft and hold an axial position of the inner shaft. The thrust clearance measuring device (60) has: an inner shaft position sensor (62) configured to measure a forward-traveling-time inner-shaft position F1 and a backward-traveling-time inner-shaft position R1 in an axial direction during an operation of a marine vessel; and a thrust clearance calculation device (66) configured to calculate a first thrust clearance(C1) of the inner shaft thrust bearing.

Fig. 3



EP 4 316 974 A1

Description

Technical Field

[0001] The present invention relates to a thrust clearance measuring device of a marine contra-rotating propeller apparatus, a thrust clearance measuring method, and a marine vessel.

Background Art

[0002] A marine contra-rotating propeller apparatus can be roughly classified into a two-axis drive system and a uni-axis drive system. In the two-axis drive system, a front propeller and a rear propeller are driven by two concentric shafts, respectively. In the uni-axis drive system, an inversion mechanism is provided between a front propeller and a rear propeller, and both propellers are driven by one shaft.

[0003] Usually, the front propeller is attached to a rear end of an outer shaft, and the rear propeller is attached to a rear end of an inner shaft. A device that rotates the inner shaft and the outer shaft in opposite directions is referred to as a "contra-rotating gear device". In both the two-axis drive system and the uni-axis drive system, the contra-rotating gear device is usually installed inside a vessel hull.

[0004] A marine contra-rotating propeller apparatus is provided with a contra-rotating thrust bearing and an inner shaft thrust bearing.

[0005] The contra-rotating thrust bearing is provided between the outer shaft and the inner shaft and transmits a thrust force of the outer shaft to the inner shaft. The inner shaft thrust bearing is provided in the contra-rotating gear device and supports a thrust force of the inner shaft to hold an axial position of the inner shaft.

[0006] The contra-rotating thrust bearing and the inner shaft thrust bearing are disclosed in, for example, PTLs 1 and 2.

Citation List

Patent Literatures

[0007]

PTL 1: Japanese Patent No. 5266542
PTL 2: Japanese Patent No. 6532927

Summary of Invention

Technical Problem

[0008] A contra-rotating thrust bearing and an inner shaft thrust bearing need to be inspected and repaired periodically to maintain the respective functions.

[0009] In the related art, the inspection of the contra-rotating thrust bearing has been performed as follows.

(1) As means of grasping a state of a contra-rotating thrust bearing in a marine contra-rotating propeller apparatus by a non-open inspection, by measuring a thrust clearance and observing a change of the thrust clearance over time while capturing and grasping components of foreign matters in a lubricating oil, an abnormality such as damage or abnormal wear of the bearing is detected.

(2) The measurement of the thrust clearance is performed by pressing shafts in a forward thrust direction and a backward thrust direction using a hydraulic jack or the like in Dock construction and measuring a distance (or distance between front and rear propellers) between an inner shaft and outer shaft in each case to calculate the difference.

[0010] However, the above-described inspection of the related art has the following problems.

(1) Even when an abnormality occurs during an operation of a marine vessel, in a case where a minute progress is accumulated, the abnormality cannot be detected by capture of foreign matters or component analysis in the lubricating oil.

(2) In the Dock construction every few years, when an abnormality in the thrust clearance is detected by measurement in a dry Dock, open maintenance will be carried out from that point, an unexpected construction period will be extended, and there will be a huge negative impact, such as reviewing operation plans.

(3) Particularly in the case of a marine contra-rotating propeller apparatus for a large marine vessel, the forward/backward movement of the shaft in the dry Dock increases a shaft weight, and the hydraulic jack to be used is also increased in size and weight, resulting in very poor workability.

[0011] Meanwhile, in the related art, a thrust bearing (inner shaft thrust bearing) built in a contra-rotating gear device is regularly maintained open.

[0012] However, the above-described inspection has the following problems.

(1) In the case of a small marine vessel, since a section in which the contra-rotating gear device is disposed is narrow, workability at the time of open maintenance is poor, which is a factor of an increase in construction period and cost.

(2) In the case of a large marine vessel, the contra-rotating gear device also becomes larger and heavier, and workability at the time of open maintenance is poor, which is a factor of increasing the construction period and cost as in the small marine vessel.

[0013] The present invention is invented to solve the above-described problems. That is, an object of the present invention is to provide a thrust clearance measuring device, a thrust clearance measuring method, and a marine vessel capable of measuring a thrust clearance during an operation of the marine vessel without opening and maintaining a marine contra-rotating propeller apparatus.

Solution to Problem

[0014] According to the present invention, there is provided a thrust clearance measuring device of a marine contra-rotating propeller apparatus in which a front propeller and a rear propeller are coaxially arranged and which rotates the front propeller and the rear propeller in directions opposite to each other,

the marine contra-rotating propeller apparatus including a hollow outer shaft to which the front propeller is attached to a rear end portion and which is rotatably supported about an axial center,
an inner shaft to which the rear propeller is attached to a rear end portion and which is rotatably supported about the axial center,
a contra-rotating thrust bearing configured to transmit a thrust force acting on the front propeller to the inner shaft, and
a contra-rotating gear device configured to rotate the outer shaft and the inner shaft in directions opposite to each other,
the contra-rotating gear device having an inner shaft thrust bearing configured to support a thrust force of the inner shaft and hold an axial position of the inner shaft,
the thrust clearance measuring device including:

an inner shaft position sensor configured to measure a forward-traveling-time inner-shaft position F1 when the inner shaft moves forward and a backward-traveling-time inner-shaft position R1 when the inner shaft moves backward in an axial direction during an operation of a marine vessel; and
a thrust clearance calculation device configured to calculate a first thrust clearance of the inner shaft thrust bearing.

[0015] Further, according to the present invention, there is provided a thrust clearance measuring method including: using the thrust clearance measuring device;

measuring a forward-traveling-time inner-shaft position F1 when moving forward and a backward-traveling-time inner-shaft position R1 when moving backward during an operation of a marine vessel; and
calculating a first thrust clearance of the inner shaft thrust bearing from the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1.

Advantageous Effects of Invention

[0016] According to the configuration of the present invention described above, the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1 during the operation of the marine vessel are measured by the inner shaft position sensor. In addition, the first thrust clearance of the inner shaft thrust bearing from the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1 is calculated by the thrust clearance calculation device.

[0017] Therefore, the thrust clearance can be measured during the operation of the marine vessel without opening and maintaining the marine contra-rotating propeller apparatus.

Brief Description of Drawings

[0018]

Fig. 1 is a schematic plan view of a marine contra-rotating propeller apparatus.
Fig. 2 is a side sectional view of a contra-rotating gear device of Fig. 1.
Fig. 3 is an explanatory diagram of a thrust clearance measuring method according to the present invention.
Fig. 4 is a schematic diagram illustrating detection data of an inner shaft position sensor and an outer shaft position sensor.

Description of Embodiments

[0019] Hereinafter, an embodiment of the present invention will be described with reference to the drawings. In addition, the same reference numerals are given to common parts in each drawing, and duplicate description will be omitted.

[0020] A marine vessel according to the present invention includes a thrust clearance measuring device 60 and a marine contra-rotating propeller apparatus 100 according to the present invention.

[0021] Fig. 1 is a schematic plan view of the marine contra-rotating propeller apparatus 100.

[0022] In Fig. 1, the marine contra-rotating propeller apparatus 100 is a device in which the front propeller 1 and the rear propeller 2 are coaxially arranged and which rotates the front propeller 1 and the rear propeller 2 in directions opposite to each other.

[0023] The marine contra-rotating propeller apparatus 100 includes an outer propeller shaft (hereinafter, "outer shaft 12"), an inner propeller shaft (hereinafter, "inner shaft 14"), a contra-rotating gear device 20, a drive device 30, and a contra-rotating thrust bearing 40.

[0024] The outer shaft 12 has a hollow shape, the front propeller 1 is attached to a rear end portion thereof, and the outer shaft 12 is rotatably supported about an axial center.

[0025] The rear propeller 2 attached to a rear end portion of the inner shaft 14 and the inner shaft 14 is rotatably supported about an axial center.

[0026] The contra-rotating gear device 20 rotates the outer shaft 12 and the inner shaft 14 in directions opposite to each other.

[0027] The contra-rotating gear device 20 has an inner shaft thrust bearing 50 which supports a thrust force of the inner shaft 14 and holds an axial position of the inner shaft 14.

[0028] The drive device 30 is a rotation drive source for the outer shaft 12 and the inner shaft 14.

[0029] The contra-rotating thrust bearing 40 transmits a thrust force acting on the front propeller 1 to the inner shaft 14.

[0030] The outer shaft 12 is a hollow component and is installed to penetrate a stern pipe 3 provided on a vessel hull 90. A front bush 5 and a rear bush 6 are provided between the stern pipe 3 and the outer shaft 12 so that the outer shaft 12 is rotatably supported by the vessel hull 90. In order to prevent a lubricating oil in the stern pipe 3 from leaking to an engine room side, a bow-side stern pipe sealing device 7 is provided on a bow-side end surface of the stern pipe 3. In order to prevent the lubricating oil in the stern pipe 3 from leaking to a seawater side, a stern-side stern pipe sealing device 8 is provided on a stern-side end surface of the stern pipe 3.

[0031] The front propeller 1 has a boss 13 at a center portion, and a bow-side end surface of the boss 13 and a stern-side end surface of the outer shaft 12 are connected and fixed by connecting means such as bolts. An outer shaft sleeve coupling 16 is connected and fixed to a bow-side end portion of the outer shaft 12.

[0032] A hollow outer shaft intermediate shaft 17 is connected and fixed to a bow-side end portion of the outer shaft sleeve coupling 16. The outer shaft intermediate shaft 17 has a configuration that can be divided into a plurality of (two or more) portions in a radial direction so that maintenance of an incidental component (such as contra-rotating front sealing device 37) of the inner shaft 14 is possible.

[0033] The inner shaft 14 is rotatably supported inside the outer shaft 12. The rear propeller 2 has a boss 15 at a center portion, is fitted to a rear end portion of the inner shaft 14 at the boss 15, and is fixed to the inner shaft 14 by a propeller nut 39.

[0034] In the marine contra-rotating propeller apparatus 100, a front-side radial bearing 35 and a rear-side radial bearing 36 are installed to rotatably support the inner shaft 14 by the outer shaft 12. In a configuration example of Fig. 1, the front-side radial bearing 35 is disposed between the outer shaft sleeve coupling 16 and the inner shaft 14, and the rear-side radial bearing 36 is disposed between the boss of the front propeller 1 and the inner shaft 14. The disposition positions of the front-side radial bearing 35 and the rear-side radial bearing 36 are not limited to the above-described positions, and may be, for example, between a tip end portion and a rear end portion of the outer shaft 12 and the inner shaft 14.

[0035] In Fig. 1, the contra-rotating thrust bearing 40 is provided inside the boss 13 of the front propeller 1. More specifically, an annular recessed portion 13a is formed between the boss 13 of the front propeller 1 and the outer shaft 12, and the contra-rotating thrust bearing 40 is provided in the annular recessed portion 13a. The contra-rotating thrust bearing 40 is preferably a tilting pad type thrust bearing, for example.

[0036] In order to lubricate the front-side radial bearing 35, the rear-side radial bearing 36, and the contra-rotating thrust bearing 40, a contra-rotating lubricating oil is supplied between the outer shaft 12 and the boss 13 of the front propeller 1 and the inner shaft 14 from a contra-rotating lubricating oil supply device (not illustrated). In order to prevent the contra-rotating lubricating oil from leaking, the contra-rotating front sealing device 37 is disposed on the bow-side end surface of the outer shaft sleeve coupling 16, and a contra-rotating rear sealing device 38 is disposed on the stern-side end surface of the boss 13 of the front propeller 1.

[0037] The contra-rotating lubricating oil passes through a clearance between a seal liner of the contra-rotating rear sealing device 38 and the inner shaft 14 after lubricating the rear-side radial bearing 36, and passes through an oil passage hole 44 provided inside the boss 15 of the rear propeller 2. Further, this lubricating oil enters the hollow portion of the inner shaft 14 through the inside of a propeller cap 45 attached to the rear end portion of the boss 15, passes through a sealing device (not illustrated) provided at a bow-side end portion of a shaft of an inner shaft output gear 29, and returns to a lubricating oil tank (not illustrated) installed in the engine room. An opening at a tip of the shaft of the inner shaft output gear 29 is closed by a stop flange 46.

[0038] In Fig. 1, the drive device 30 includes a first drive device 31 that is a rotation drive source of the outer shaft 12 and a second drive device 32 that is a rotation drive source of the inner shaft 14. The first drive device 31 and the second drive device 32 may be a main engine of a gas turbine engine, a diesel engine, or the like, or may be an electric motor. In the case of the electric motor, for example, one or a plurality of gas turbine generators, diesel generators, and the like can be mounted in an engine room, and used as a power source.

[0039] The contra-rotating gear device 20 of Fig. 1 is configured to independently transmit rotational driving forces of the first drive device 31 and the second drive device 32 to the outer shaft 12 and the inner shaft 14 respectively. More specifically, the contra-rotating gear device 20 has a housing 21 and includes an outer shaft transmission mechanism 18A and an inner shaft transmission mechanism 18B inside the housing 21.

[0040] The outer shaft transmission mechanism 18A includes an outer shaft input gear 22 which is disposed coaxially with an output shaft 31a of the first drive device 31 and to which a driving force from the first drive device

31 is input. The outer shaft transmission mechanism 18A further includes a hollow outer shaft output gear 24 which is disposed coaxially with the outer shaft 12 and transmits a rotational driving force to the outer shaft 12, and an outer shaft intermediate gear 23 disposed between the outer shaft input gear 22 and the outer shaft output gear 24. The output shaft 31a of the first drive device 31 and the outer shaft input gear 22 are connected to each other via a gear coupling 33a. Although the number of the outer shaft intermediate gear 23 is one in Fig. 1, there may be a plurality of the outer shaft intermediate gears 23.

[0041] The inner shaft transmission mechanism 18B has an inner shaft input gear 27 that is disposed coaxially with the output shaft 32a of the second drive device 32 and to which a driving force from the second drive device 32 is input. The inner shaft transmission mechanism 18B further includes the inner shaft output gear 29 which penetrates the hollow portion of the outer shaft output gear 24, is disposed coaxially with the inner shaft 14, and transmits the rotational driving force to the inner shaft 14, and an inner shaft intermediate gear 28 disposed between the inner shaft input gear 27 and the inner shaft output gear 29. The output shaft 32a of the second drive device 32 and the inner shaft input gear 27 are connected to each other via a gear coupling 33b. Although the number of the inner shaft intermediate gear 28 is one in Fig. 1, there may be a plurality of inner shaft intermediate gears 28. The inner shaft output gear 29 and the inner shaft 14 are connected and fixed by an inner shaft sleeve coupling 26.

[0042] In the marine contra-rotating propeller apparatus 100, the inner shaft thrust bearing 50 receives a thrust load (a load obtained by combining a thrust load of only the inner shaft 14 and a thrust load of only the outer shaft 12) from the inner shaft 14 and transmits the load to the vessel hull 90. In Fig. 1, the inner shaft thrust bearing 50 is provided on a bow-side part of the housing 21 of the contra-rotating gear device 20. Therefore, the thrust load from the inner shaft 14 is supported by the vessel hull 90 via the housing 21.

[0043] The disposition position of the inner shaft thrust bearing 50 is not limited to the above-described position as long as the thrust load from the inner shaft 14 can be transmitted to the vessel hull 90. Therefore, the inner shaft thrust bearing 50 may be disposed inside the housing 21 or outside the housing 21 as long as the inner shaft thrust bearing 50 is on the bow side of the outer shaft output gear 24.

[0044] In the configuration example of Fig. 1, both the outer shaft transmission mechanism 18A and the inner shaft transmission mechanism 18B are gear transmission mechanisms, but may be planetary gears.

[0045] Fig. 2 is a side sectional view of the contra-rotating gear device 20 of Fig. 1.

[0046] In Fig. 2, the inner shaft thrust bearing 50 includes a self-aligning radial bearing 52 and a self-aligning thrust bearing 53. Further, reference numerals 54 and 55 are radial roller bearings, and reference numeral 56 is a self-aligning radial bearing.

[0047] A hollow central shaft 25A of the outer shaft output gear 24 is supported by the radial roller bearing 55 and the self-aligning radial bearing 56 to be rotatable about an axial center. Further, a tip end portion (left end portion in Fig. 2) of the hollow central shaft 25A is connected to the outer shaft intermediate shaft 17 via a gear coupling 19. Further, in Fig. 1, the outer shaft intermediate shaft 17 is connected to the outer shaft 12 via the outer shaft sleeve coupling 16. The connection between the outer shaft 12 and the outer shaft sleeve coupling 16 and the outer shaft intermediate shaft 17 is strong so that the clearance in the axial direction does not occur.

[0048] A central shaft 25B of the inner shaft output gear 29 is rotatably supported by the inner shaft thrust bearing 50 and the radial roller bearing 54 about an axial center. Further, in Fig. 1, a tip end portion (left end portion in Fig. 1) of the central shaft 25B is connected to the inner shaft 14 via the inner shaft sleeve coupling 26. The connection by the inner shaft sleeve coupling 26 is strong so that the clearance in the axial direction does not occur.

[0049] In Fig. 2, the thrust clearance measuring device 60 according to the present invention includes an inner shaft position sensor 62, an outer shaft position sensor 64, and a thrust clearance calculation device 66.

[0050] The inner shaft position sensor 62 and the outer shaft position sensor 64 are preferably non-contact distance sensors fixed to a fixed part in the vessel hull.

[0051] The distance sensor preferably has a measurement range of 10 mm to 100 mm with a detection accuracy of 10 um or less. As the distance sensor, it is possible to use, for example, a laser displacement meter, an ultrasonic sensor, or the like.

[0052] The thrust clearance calculation device 66 is preferably, for example, a computer (PC) having a storage device, a computing device, an input device, and an output device.

[0053] The inner shaft position sensor 62 measures a forward-traveling-time inner-shaft position F1 when the inner shaft 14 moves forward and a backward-traveling-time inner-shaft position R1 when the inner shaft 14 moves backward in the axial direction during the operation of the marine vessel.

[0054] The thrust clearance calculation device 66 calculates a first thrust clearance C1 of the inner shaft thrust bearing 50 from the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1.

[0055] In addition, the outer shaft position sensor 64 measures a forward-traveling-time outer-shaft position F2 when the outer shaft 12 moves forward and a backward-traveling-time outer-shaft position R2 when the outer shaft 12 moves backward in the axial direction during the operation of the marine vessel.

[0056] The thrust clearance calculation device 66 calculates a second thrust clearance C2 of the contra-rotating thrust bearing 40 from the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1.

[0057] The first thrust clearance C1 is an overall clearance of the inner shaft thrust bearing 50 in the axial direction, that is, an overall clearance between the self-aligning radial bearing 52 and the self-aligning thrust bearing 53 in the axial direction. The first thrust clearance C1 is, for example, 0.2 to 0.3 mm in a normal state.

[0058] The second thrust clearance C2 is an overall clearance of the contra-rotating thrust bearing 40 in the axial direction. The second thrust clearance C2 is, for example, 2.0 to 2.6 mm in a normal state.

[0059] Fig. 3 is an explanatory diagram of the thrust clearance measuring method according to the present invention.

(Measurement of First Thrust Clearance C1)

[0060] As described above, the inner shaft 14 and the central shaft 25B are connected via the inner shaft sleeve coupling 26 so that a clearance in the axial direction does not occur.

[0061] Therefore, during the operation of the marine vessel, when the marine vessel moves forward, a thrust force of the rear propeller 2 acts forward (in right direction in Fig. 3), the central shaft 25B is pressed axially forward integrally with the inner shaft 14 and the inner shaft sleeve coupling 26, and a front clearance of the inner shaft thrust bearing 50 becomes 0.

[0062] Similarly, during operation of the marine vessel when the marine vessel moves backward, the thrust force of the rear propeller 2 acts backward (in left direction in Fig. 3), the central shaft 25B is pressed axially backward integrally with the inner shaft 14 and the inner shaft sleeve coupling 26, and a rear clearance of the inner shaft thrust bearing 50 becomes 0.

[0063] The first thrust clearance C1 of the inner shaft thrust bearing 50 is the sum of the front clearance and the rear clearance.

[0064] Therefore, a difference ($\Delta 1$ = F1 - R1) in a front-rear direction between the forward-traveling-time inner-shaft position F1 measured when moving forward and the backward-traveling-time inner-shaft position R1 measured when moving backward corresponds to the first thrust clearance C1 of the inner shaft thrust bearing 50.

[0065] The inner shaft position sensor 62 is fixed to a fixed part in the vessel hull, and detects, for example, a front end surface of the central shaft 25B or an end surface of the stop flange 46.

[0066] In this case, a reference position (measurement origin) of the inner shaft position sensor 62 is set to, for example, the front end surface of the central shaft 25B. However, the position of the front end surface of the central shaft 25B in the front-rear direction changes depending on an operating state of the marine vessel, for example, temperatures of the inner shaft 14 and the central shaft 25B and a load in the axial direction.

[0067] Therefore, it is preferable to measure the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1 when the marine vessel is in operation, for example, when switching between forward and backward movements. As a result, it is possible to make the operating states of the marine vessel substantially the same and to reduce a measurement error due to the operating state.

(Measurement of Second Thrust Clearance C2)

[0068] As described above, the outer shaft 12 and the outer shaft intermediate shaft 17 are connected via the outer shaft sleeve coupling 16 so that a clearance in the axial direction does not occur.

[0069] Therefore, during the operation of the marine vessel, when the marine vessel moves forward, a thrust force of the front propeller 1 acts forward (in right direction in Fig. 3). Therefore, the outer shaft 12 is pressed forward (to the right in Fig. 3) in the axial direction and moves until the rear clearance of the contra-rotating thrust bearing 40 and the front clearance of the inner shaft thrust bearing 50 become 0.

[0070] Similarly, during operation of the marine vessel, when the marine vessel moves backward, the thrust force of the front propeller 1 acts backward (in left direction in Fig. 3). Therefore, the outer shaft 12 is pressed backward (to the left in Fig. 3) in the axial direction and moves until the front clearance of the contra-rotating thrust bearing 40 and the rear clearance of the inner shaft thrust bearing 50 become 0.

[0071] Both the first thrust clearance C1 and the second thrust clearance C2 change when moving forward and when moving backward.

[0072] Therefore, a difference in the front-rear direction between the forward-traveling-time outer-shaft position F2 measured when moving forward and the backward-traveling-time outer-shaft position R2 measured when moving backward corresponds to the sum of the first thrust clearance C1 and the second thrust clearance C2.

[0073] Therefore, a value obtained by subtracting ($\Delta 1$ = F1 - R1) corresponding to the first thrust clearance C1 from a difference ($\Delta 2$ = F2 - R2) between the forward-traveling-time outer-shaft position F2 and the backward-traveling-time outer-shaft position R2 corresponds to the second thrust clearance C2.

[0074] The outer shaft position sensor 64 is fixed to a fixed part in the vessel hull and, for example, detects the end surface of the outer shaft intermediate shaft 17.

[0075] In this case, a reference position (measurement origin) of the outer shaft position sensor 64 is set, for example, to the rear end surface of the outer shaft intermediate shaft 17. However, the position of the rear end surface of the outer shaft intermediate shaft 17 in the front-rear direction changes according to the operating state of the marine vessel, for example, temperatures of the outer shaft 12 and the outer shaft intermediate shaft 17 and a load in the axial direction.

[0076] Therefore, it is preferable to measure the forward-traveling-time outer-shaft position F2 and the backward-traveling-time outer-shaft position R2 when the marine vessel is in operation, for example, when switching between forward and backward movements. Further, at the same time as this measurement, it is preferable to also measure the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1.

[0077] As a result, it is possible to make the operating states of the marine vessel substantially the same and to reduce a measurement error due to the operating state.

[0078] Fig. 4 is a schematic diagram illustrating detection data of the inner shaft position sensor 62 and the outer shaft position sensor 64.

[0079] As illustrated in Fig. 4, the detection data of the inner shaft position sensor 62 and the outer shaft position sensor 64 usually fluctuates in a cycle corresponding to the rotational speed due to the rotation of the outer shaft 12 and the inner shaft 14. This fluctuation is also caused by, for example, a deviation in the axial direction of a measurement unit or a vibration of the vessel hull 90.

[0080] Therefore, in the measurement of the forward-traveling-time outer-shaft position F2, the backward-traveling-time outer-shaft position R2, the forward-traveling-time inner-shaft position F1, and the backward-traveling-time inner-shaft position R1, it is preferable to use an average value in consideration of the fluctuation range.

[0081] Further, as described above, since the measured values fluctuate according to the operating state of the marine vessel, during the operation of the marine vessel which can be regarded as the same, it is preferable to measure the forward-traveling-time outer-shaft position F2, the backward-traveling-time outer-shaft position R2, the forward-traveling-time inner-shaft position F1, and the backward-traveling-time inner-shaft position R1 described above.

[0082] Further, in order to grasp and match the operating state of the marine vessel, it is also preferable to measure and record a shaft rotation speed, a rotation direction, a shaft output (or shaft torque, shaft thrust), a marine vessel speed, a handle position, a vibration in a casing, and the like.

[0083] According to the above-described embodiment of the present invention, the inner shaft position sensor 62 measures the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1 during the operation of the marine vessel. In addition, the thrust clearance calculation device 66 calculates the first thrust clearance C1 of the inner shaft thrust bearing 50 from the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1.

[0084] Therefore, the thrust clearance can be measured during the operation of the marine vessel without opening and maintaining the marine contra-rotating propeller apparatus 100.

[0085] In addition, the following accompanying effects are also obtained.

(1) Since the thrust clearance can be measured during the operation, it is possible to determine whether maintenance is necessary or not before entering a Dock.
(2) For the measurement in a dry Dock, the movement in the axial direction by a hydraulic jack is necessary, which requires a high degree of proficiency in the work. However, since the measurement can be automatically performed during the operation, any person can perform the measurement.
(3) It is possible to avoid regular open maintenance and reduce system downtime and costs.
(4) It is possible to automate the system for responding to unmanned vessels.

[0086] The present invention is not limited to the above-described embodiment, and it is needless to say that various modifications may be made without departing from the gist of the present invention.

Reference Signs List

[0087]

C1 first thrust clearance
C2 second thrust clearance
F1 forward-traveling-time inner-shaft position
F2 forward-traveling-time outer-shaft position
R1 backward-traveling-time inner-shaft position
R2 backward-traveling-time outer-shaft position
1 front propeller
2 rear propeller
3 stern pipe
5 front bush
6 rear bush
7 bow-side stern pipe sealing device
8 stern-side stern pipe sealing device
12 outer shaft (outer propeller shaft)
13 boss
13a annular recessed portion
14 inner shaft (inner propeller shaft)
15 boss
16 outer shaft sleeve coupling
17 outer shaft intermediate shaft
18A outer shaft transmission mechanism
18B inner shaft transmission mechanism
19 gear coupling
20 contra-rotating gear device
21 housing
22 outer shaft input gear
23 outer shaft intermediate gear
24 outer shaft output gear
25A hollow central shaft
25B central shaft
26 inner shaft sleeve coupling

27 inner shaft input gear
28 inner shaft intermediate gear
29 inner shaft output gear
30 drive device
31 first drive device
31a output shaft
32 second drive device
32a output shaft
33a, 33b gear coupling
35 front-side radial bearing
36 rear-side radial bearing
37 contra-rotating front sealing device
38 contra-rotating rear sealing device
39 propeller nut
40 contra-rotating thrust bearing
44 oil passage hole
45 propeller cap
46 stop flange
50 inner shaft thrust bearing
52 self-aligning radial bearing
53 self-aligning thrust bearing
54, 55 radial roller bearing
56 self-aligning radial bearing
60 thrust clearance measuring device
62 inner shaft position sensor
64 outer shaft position sensor
66 thrust clearance calculation device
90 vessel hull
100 marine contra-rotating propeller apparatus

Claims

1. A thrust clearance measuring device of a marine contra-rotating propeller apparatus to which a front propeller and a rear propeller are coaxially arranged and which rotates the front propeller and the rear propeller in directions opposite to each other, the marine contra-rotating propeller apparatus including

a hollow outer shaft to which the front propeller is attached to a rear end portion and which is rotatably supported about an axial center,
an inner shaft to which the rear propeller is attached to a rear end portion and which is rotatably supported about the axial center,
a contra-rotating thrust bearing configured to transmit a thrust force acting on the front propeller to the inner shaft, and
a contra-rotating gear device configured to rotate the outer shaft and the inner shaft in directions opposite to each other,
the contra-rotating gear device having an inner shaft thrust bearing configured to support a thrust force of the inner shaft and hold an axial position of the inner shaft,
the thrust clearance measuring device comprising:
an inner shaft position sensor configured to measure a forward-traveling-time inner-shaft position F1 when the inner shaft moves forward and a backward-traveling-time inner-shaft position R1 when the inner shaft moves backward in an axial direction during an operation of a marine vessel; and
a thrust clearance calculation device configured to calculate a first thrust clearance of the inner shaft thrust bearing.

2. The thrust clearance measuring device according to claim 1, further comprising an outer shaft position sensor configured to measure a forward-traveling-time outer-shaft position F2 when the outer shaft moves forward and a backward-traveling-time outer-shaft position R2 when the outer shaft moves backward in an axial direction during the operation of the marine vessel,
wherein the thrust clearance calculation device calculates a second thrust clearance of the contra-rotating thrust bearing.

3. The thrust clearance measuring device according to claim 2, wherein the inner shaft position sensor or the outer shaft position sensor is a non-contact distance sensor fixed to a fixed part in a vessel hull.

4. A thrust clearance measuring method comprising:

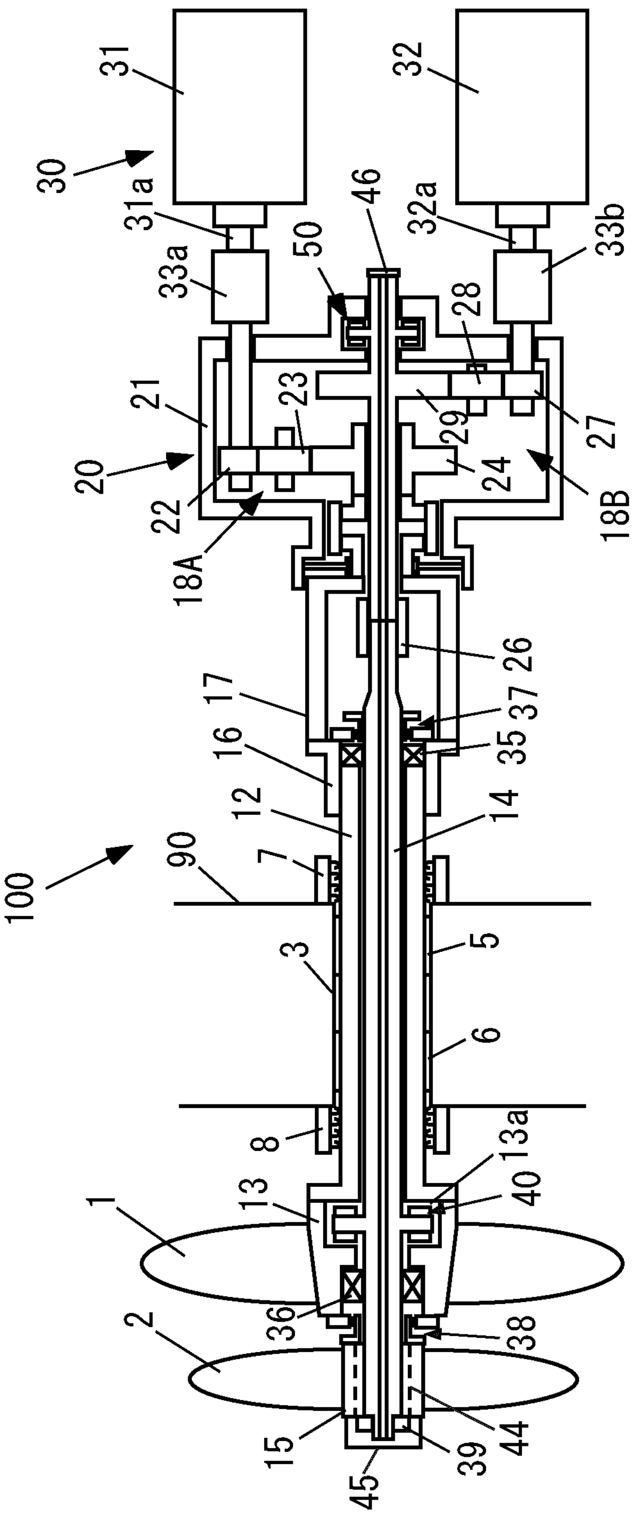
using the thrust clearance measuring device according to claim 1;
measuring a forward-traveling-time inner-shaft position F1 when moving forward and a backward-traveling-time inner-shaft position R1 when moving backward during an operation of a marine vessel; and
calculating a first thrust clearance of the inner shaft thrust bearing from the forward-traveling-time inner-shaft position F1 and the backward-traveling-time inner-shaft position R1.

5. The thrust clearance measuring method according to claim 4, further comprising:

measuring a forward-traveling-time outer-shaft position F2 when moving forward and a backward-traveling-time outer-shaft position R2 when moving backward during the operation of the marine vessel; and
calculating a second thrust clearance of the contra-rotating thrust bearing from the forward-traveling-time inner-shaft position F1, the backward-traveling-time inner-shaft position R1, the forward-traveling-time outer-shaft position F2, and the backward-traveling-time outer-shaft position R2.

6. A marine vessel comprising the thrust clearance measuring device according to claim 1.

Fig. 1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31a
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Fig. 2

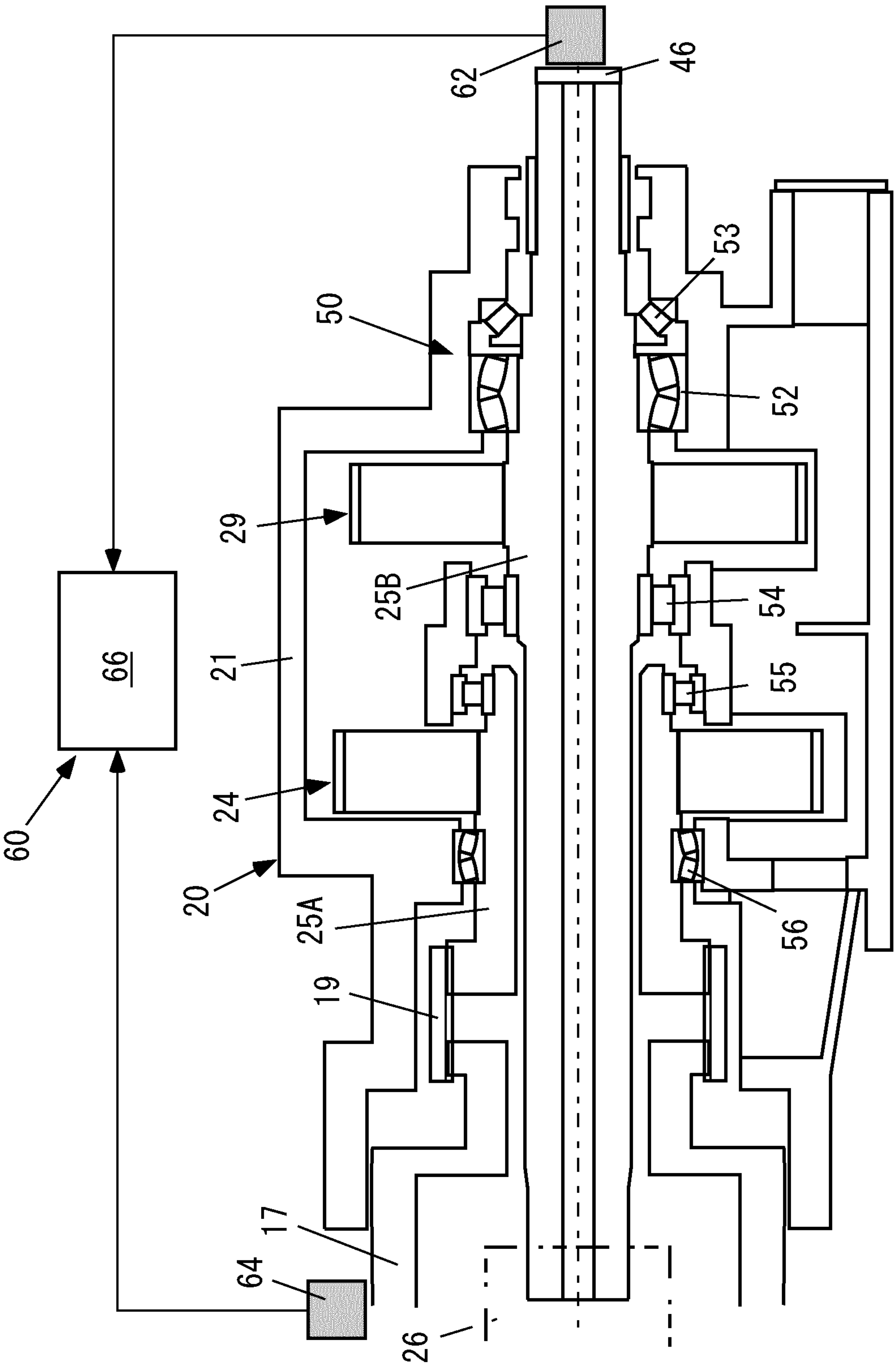
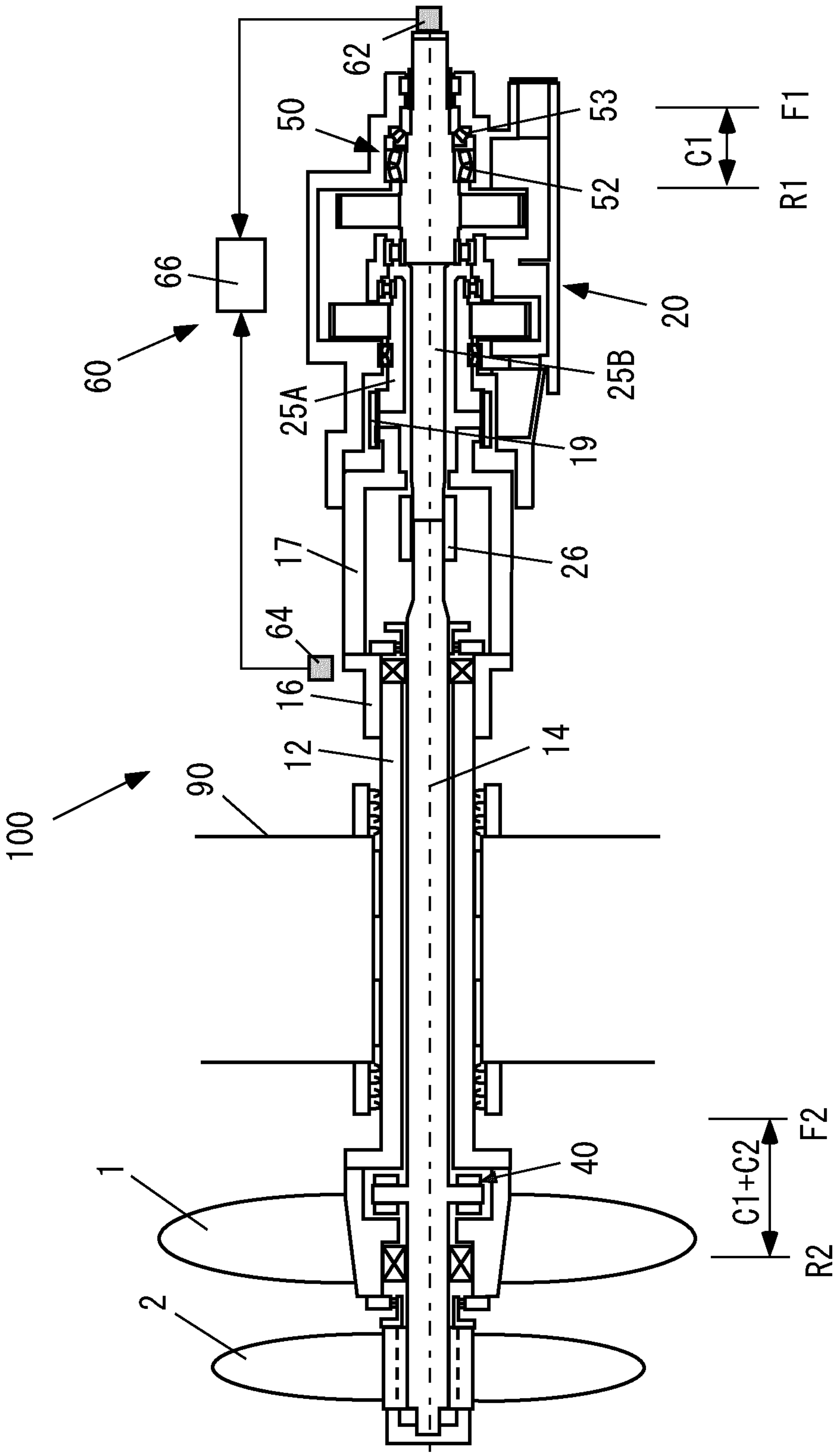


Fig. 3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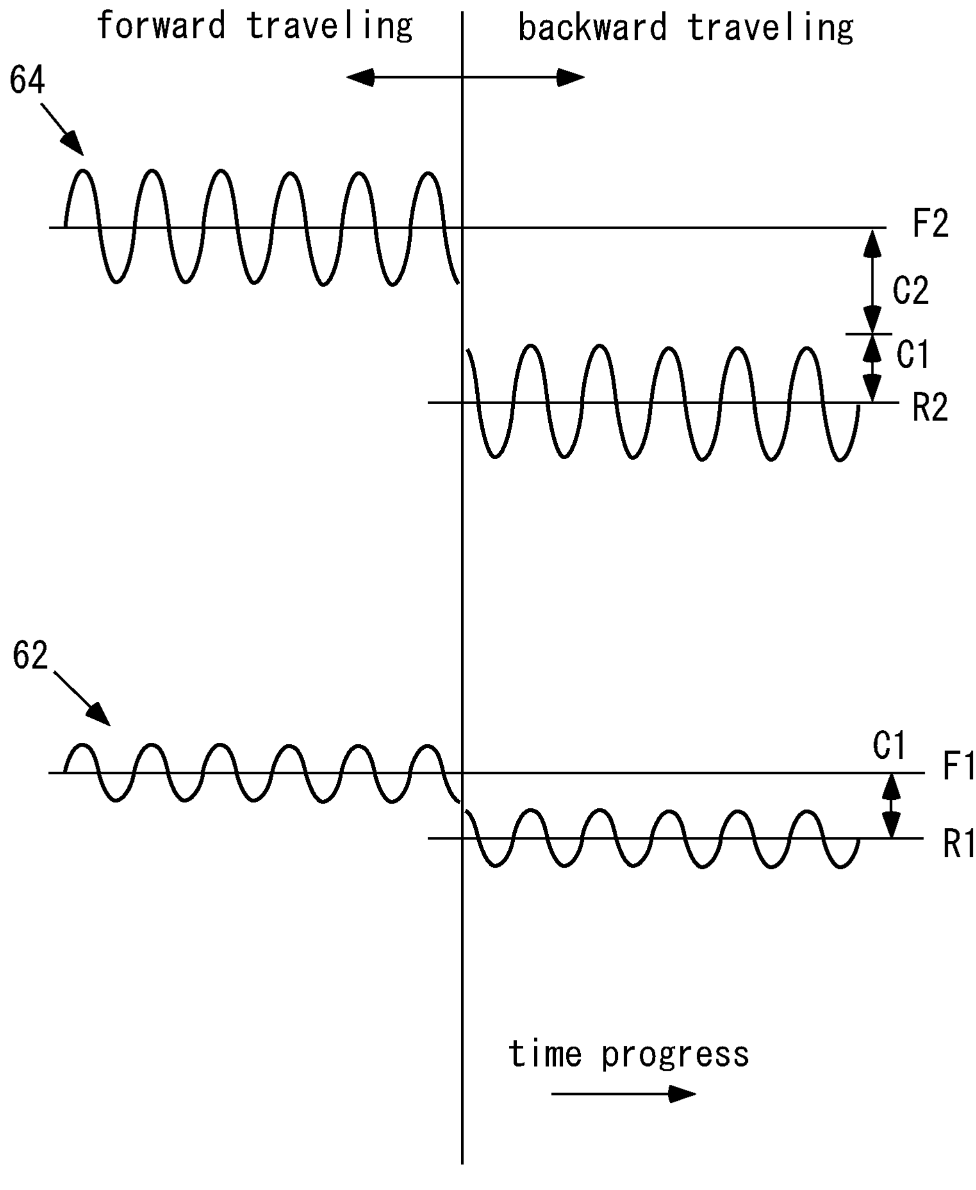
50
53
F1
C1
52
R1
66
60
20
25B
25A
19
17
26
64
16
12
14
100
90
1
40
F2
C1+C2
R2
2

Fig. 4


forward traveling
backward traveling
64
F2
C2
C1
R2
62
C1
F1
R1
time progress

INTERNATIONAL SEARCH REPORT

International application No. **PCT/JP2022/014076**

A. CLASSIFICATION OF SUBJECT MATTER

B63B 79/10(2020.01)i; ***B63B 81/00***(2020.01)i; ***B63H 5/10***(2006.01)i; ***B63H 23/32***(2006.01)i
FI: B63H23/32 A; B63H5/10; B63B79/10; B63B81/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B63B79/10; B63B81/00; B63H5/10; B63H23/32

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2013-0125868 A (SAMSUNG HEAVY INDUSTRIES CO., LTD.) 20 November 2013 (2013-11-20) paragraphs [0026]-[0103], fig. 1-14	1, 4, 6
A	paragraphs [0026]-[0103], fig. 1-14	2-3, 5
A	KR 10-2012-0135795 A (SAMSUNG HEAVY INDUSTRIES CO., LTD.) 17 December 2012 (2012-12-17)	1-6
A	JP 2015-523931 A (SAMSUNG HEAVY INDUSTRIES CO., LTD.) 20 August 2015 (2015-08-20)	1-6
A	JP 2020-147278 A (BECKER MARINE SYSTEMS GMBH) 17 September 2020 (2020-09-17)	1-6

☐ Further documents are listed in the continuation of Box C.

☑ See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 May 2022	**17 May 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/014076

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KR 10-2012-0135795 A	17 December 2012	(Family: none)	
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Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 5266542 B **[0007]**
- JP 6532927 B **[0007]**