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(71) Applicant: **Yanmar Power Technology Co., Ltd.**
Osaka-shi
Osaka 530-0013 (JP)

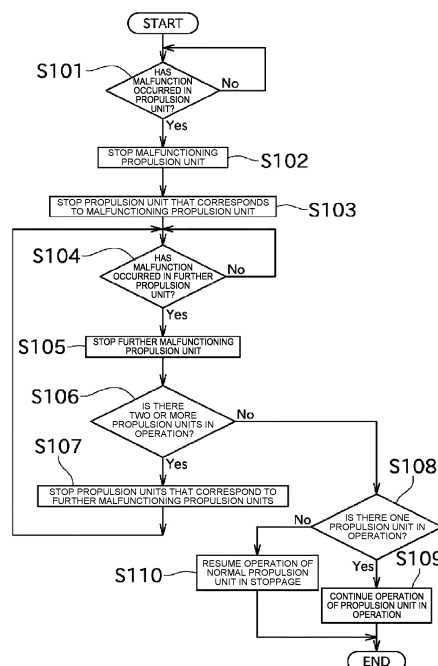
(72) Inventors:
• **KANDA, Shoma**
Osaka-shi, Osaka 530-8311 (JP)
• **TAMURA, Gakuji**
Osaka-shi, Osaka 530-8311 (JP)
• **YAMADA, Yasuhiro**
Osaka-shi, Osaka 530-8311 (JP)

(74) Representative: **Denemeyer & Associates S.A.**
Postfach 70 04 25
81304 München (DE)

(54) **SHIP PROPULSION DEVICE**

(57) A ship propulsion device (1) includes three or more propulsion units (11), a malfunction detection unit (12a), and a control unit (12). The control unit (12) controls the three or more propulsion units (11). The three or more propulsion units (11) are disposed with left-right symmetry. When a malfunction is detected in any one of the three or more propulsion units (11) by the malfunction detection unit (12a) while the three or more propulsion units (11) are operating, the control unit (12) stops the propulsion unit (11) in which the malfunction has been detected, and, on a left side and a right side of a hull, stops at least one propulsion unit (11) of the propulsion units (11) disposed on the side opposite from the side on which the propulsion unit (11) in which the malfunction has been detected is disposed.

FIG. 3



Description**TECHNICAL FIELD**

[0001] The present disclosure relates to a marine vessel propulsion device.

BACKGROUND ART

[0002] Conventionally, there has been known a marine vessel propulsion device having a plurality of propulsion units. Patent Literature 1 discloses a plurality of outboard motors that are the propulsion devices of this type.

[0003] In the configuration of Patent Literature 1, three outboard motors are provided. These outboard motors are mounted side-by-side at the stern of the marine vessel in a manner swingable (turnable) in the left-right direction. Each outboard motor includes an engine and a propeller, and generates propulsive force by rotating the propeller with the driving force of the engine. A turning angle of each outboard motor is controlled by a steering device, so that a direction of the propulsive force is changed, and a travel direction of the marine vessel is changed accordingly.

[0004] The steering device includes a main ECU and a turning ECU. The turning ECU monitors whether a malfunction has occurred in the steering angle control of each outboard motor. If some malfunction occurs in the steering angle control of any of the outboard motors, the steering ECU notifies the main ECU of the matter. This allows the main ECU to detect occurrence of a malfunction in the steering angle control of any of the outboard motors, and to recognize the outboard motor in which a malfunction has occurred in the steering angle control. The main ECU also controls engine speed by using the outboard motor ECU.

[0005] When a malfunction has occurred in the steering angle control of any outboard motor, the main ECU performs, for the outboard motor in which the malfunction has occurred (i.e., the malfunctioning outboard motor), a process to forcibly stop generation of the propulsive force by the particular malfunctioning outboard motor. Specifically, the main ECU fixes the engine speed of the malfunctioning outboard motor to a predetermined idle speed. The main ECU also limits the engine speed of the other normal outboard motors (i.e., outboard motors in which no malfunction occurs in the steering angle control) to less than or equal to a predetermined speed limit.

CITATION LIST**Patent Literature**

[0006] Patent Literature 1 : Japanese Unexamined Patent Publication No. 2014-80082.

DISCLOSURE OF INVENTION**PROBLEMS TO BE SOLVED BY THE INVENTION**

[0007] According to the configuration of the aforementioned Patent Literature 1, when a malfunction occurs in the steering angle control of any outboard motor, generation of the propulsive force by the malfunctioning outboard motor is forcibly stopped, whereas generation of the propulsive forces by the other normal outboard motors is maintained. Therefore, depending on the position of the malfunctioning outboard motor at the stern, navigation may be continued with an imbalance between the left and right propulsive forces generated by the outboard motors. For example, if a malfunction occurs in the propulsion unit mounted on the leftmost side, navigation is performed using the propulsive force by the propulsion unit mounted on the rightmost side and the propulsion unit positioned at the lateral center, which are the other normal outboard motors. Therefore, navigation is likely to become difficult after occurrence of a malfunction in the outboard motors.

[0008] In view of the foregoing circumstances, an object of the disclosure is, for a marine vessel that navigates with a marine vessel propulsion device having three or more propulsion units, to provide a marine vessel propulsion device that facilitates continuation of navigation by increasing ease of balancing between left and right propulsive forces, regarding the propulsive force that is generated by the particular marine vessel propulsion device, when a fault occurs in any of the propulsion units.

MEANS FOR SOLVING THE PROBLEMS

[0009] The problem to be solved by the present disclosure is as described above, and the means for solving this problem and an advantageous effect thereof will be described below.

[0010] According to an aspect of the disclosure, a marine vessel propulsion device having the following configuration is provided. Specifically, this marine vessel propulsion device has three or more propulsion units, a fault detection unit, and a control unit. The three or more propulsion units are mounted to the hull of the marine vessel. The fault detection unit is capable of detecting occurrence of a fault for each of the three or more propulsion units. The control unit controls the three or more propulsion units. The three or more propulsion units are arranged left-right symmetrically. When the fault detection unit detects occurrence of a fault in any of the three or more propulsion units with the three or more propulsion units being operated, the control unit stops the propulsion unit for which occurrence of a fault has been detected, and the control unit stops, among the three or more propulsion units, at least one propulsion unit that is arranged on a side opposite the propulsion unit for which occurrence of a fault has been detected and which is arranged on either of the left side and the right side of the hull.

[0011] In this way, when occurrence of a fault in the propulsion units is detected, the propulsion unit that is arranged on the side laterally opposite the failed propulsion unit is stopped. Therefore, it becomes easier for an operator to continue navigation while balancing the left and right propulsive forces.

[0012] In the marine vessel propulsion device, It is preferable that the at least one propulsion unit to be stopped with the stoppage of the propulsion unit for which occurrence of a fault has been detected includes a propulsion unit that is in a left-right symmetrical relationship with the propulsion unit for which occurrence of a fault has been detected.

[0013] This makes it easier to balance the left and right propulsive forces because the propulsion unit that is arranged left-right symmetrically with the propulsion unit for which occurrence of a fault has been detected is stopped.

[0014] The marine vessel propulsion device described above preferably has the following configuration. Specifically, when the fault detection unit detects, regarding the three or more propulsion units, that a fault has occurred in another propulsion unit in operation different from the propulsion unit for which occurrence of a fault has detected, the control unit stops the another propulsion unit. When the number of the propulsion units in operation is reduced to one as a result of stopping the another propulsion unit, the control unit maintains operation of the propulsion unit in operation and/or resumes the at least one propulsion unit that has been stopped without occurrence of a fault being detected. When there will be no propulsion unit in operation as a result of stopping the central propulsion unit, the control unit resumes operation of the at least one propulsion unit that has been stopped without occurrence of a fault being detected.

[0015] This ensures operation of the propulsion units that generate a propulsive force to continue navigation, even when the number of the propulsion units for which occurrence of a fault has been detected increases.

[0016] The marine vessel propulsion device described above may have the following configuration. Specifically, when the number of the propulsion units in operation is reduced to one as a result of stopping the another propulsion unit, the control unit maintains operation of the propulsion unit in operation and resumes operation of the at least one propulsion unit that has been stopped without occurrence of a fault being detected. The at least one propulsion unit to be resumed includes the propulsion unit that is arranged on the side opposite the propulsion unit in operation that is arranged on either of the left side and right side of the hull.

[0017] This improves the balance between left and right propulsive forces.

[0018] The marine vessel propulsion device described above may have the following configuration. When the number of the propulsion units in operation is reduced to one as a result of stopping the another propulsion unit, the control unit stops operation of the propulsion unit in

operation and resumes operation of the at least one propulsion unit that has been stopped without occurrence of a fault being detected.

[0019] As a result, for example, in place of the remaining one propulsion unit in operation, another propulsion unit that is arranged closer to the lateral center of the hull than the one propulsion unit may be operated. This improves the balance between left and right propulsive forces.

[0020] The marine vessel propulsion device described above preferably has the following configuration. Specifically, this marine vessel propulsion device has an odd number of propulsion units. One of the three or more propulsion units is arranged at the lateral center of the hull. The control unit controls the one propulsion unit that is arranged at the lateral center of the hull independently of other propulsion units among the three or more propulsion units.

[0021] In this way, regarding the other propulsion units, even when both the propulsion unit in which a fault has been detected and the propulsion unit corresponding thereto are stopped, one propulsion unit that is arranged at the lateral center of the hull is controllable. Therefore, it is possible to continue navigation while easily balancing the left and right propulsive forces by the other propulsion units. Furthermore, the strength of the propulsive force may be adjusted by the one propulsion unit arranged at the lateral center of the hull.

[0022] The marine vessel propulsion device described above preferably has the following configuration. Specifically, when the fault detection unit detects that a fault has occurred in the one propulsion unit that is arranged at the lateral center of the hull, the control unit stops the one propulsion unit. When there will be no propulsion unit as a result of stopping the one propulsion unit, the control unit resumes operation of the at least one propulsion unit that has been stopped without occurrence of a fault being detected.

[0023] As a result, even when the propulsion unit arranged at the lateral center of the hull is stopped, it is possible to continue navigation by allowing the at least one propulsion unit to generate the propulsive force.

BRIEF DESCRIPTION OF DRAWINGS

[0024]

FIG. 1 is a schematic plan view illustrating an overall configuration of a marine vessel provided with a marine vessel propulsion device according to a first embodiment of the present disclosure.

FIG. 2 is a block diagram illustrating an electrical configuration of the marine vessel.

FIG. 3 is a flowchart illustrating a process in which a control unit controls propulsion units based on output results from a malfunction detection unit.

FIG. 4 is a schematic plan view illustrating an overall configuration of a marine vessel provided with a ma-

rine vessel propulsion device according to a second embodiment of the present disclosure.

FIG. 5 is a block diagram illustrating an electrical configuration of the marine vessel.

FIG. 6 is a flowchart illustrating a process in which a control unit controls a central propulsion unit based on output results from a malfunction detection unit.

DESCRIPTION OF EMBODIMENTS

[0025] Next, embodiments of the present disclosure will be described with reference to the drawings. First, a description will be made on a marine vessel propulsion device 1 according to a first embodiment of the present disclosure. FIG. 1 is a schematic plan view illustrating an overall configuration of a marine vessel 2 provided with the marine vessel propulsion device 1. FIG. 2 is a block diagram illustrating an electrical configuration of the marine vessel 2.

[0026] As illustrated in FIG. 1, the marine vessel 2 has a hull 3. The marine vessel 2 is provided with the marine vessel propulsion device 1.

[0027] The marine vessel propulsion device 1 includes three or more propulsion units 11 and a control unit 12. In the particular embodiment, there are four (even number) propulsion units 11 provided. The four propulsion units 11 are composed of a first propulsion unit 11A, a second propulsion unit 11B, a third propulsion unit 11C, and a fourth propulsion unit 11D. The number of the propulsion units 11, for example, may be six or eight, but not particularly limited thereto.

[0028] The four propulsion units 11 are provided at the stern of the marine vessel 2. The four propulsion units 11 are each mounted to the hull 3. The four propulsion units 11 are arrayed along the left-right direction. In the particular embodiment, the first propulsion unit 11A, the second propulsion unit 11B, the third propulsion unit 11C, and the fourth propulsion unit 11D are arranged in this order from the left side of the hull 3. The four propulsion units 11 are oppositely arranged on the right and left sides of the hull 3 across a center line 15 passing through the lateral center of the hull 3.

[0029] Two of the four propulsion units 11, specifically the first propulsion unit 11A and the second propulsion unit 11B, are placed on the left side in the hull 3. The other two propulsion units 11, specifically the third propulsion unit 11C and the fourth propulsion unit 11D, are placed on the right side in the hull 3. The four propulsion units 11 are arranged left-right symmetrically in plan with the center line 15 as a symmetry axis. Specifically, the first propulsion unit 11A and the fourth propulsion units 11D are in a left-right symmetric corresponding relationship, while the second propulsion unit 11B and the third propulsion unit 11C are in a left-right symmetric corresponding relationship.

[0030] Each of the four propulsion units 11 has a driving source (engine or electric motor) and a screw. Each propulsion unit 11 may rotate the screw by the driving force

of a driving source. The rotary shaft direction of the screw may be changed around the top-bottom direction axis. The rotary shaft direction, stop/normal rotation/reverse rotation, and rotation speed, of the screw are controlled by the control unit 12. The control unit 12 may change such control parameters independently for each propulsion unit 11. The control unit 12 controls each of the propulsion units 11, whereby various maneuvers of the marine vessel 2, including forward-backward movement, lateral parallel movement, and spin turn, are realized.

[0031] Each propulsion unit 11 may be configured as a stern drive or an outboard motor. However, the configuration of each propulsion unit 11 is not particularly limited. In the particular embodiment, the four propulsion units 11 have substantially the same configuration.

[0032] The control unit 12 is configured as a computer including a CPU, a ROM and a RAM. The ROM stores various programs, etc., including a program for operating each propulsion unit 11. The CPU may read and execute various programs, etc., from the ROM. Cooperation of the hardware and software described above allows the control unit 12 to serve as a malfunction detection unit (fault detection unit) 12a illustrated in FIG. 2.

[0033] The malfunction detection unit 12a detects whether a malfunction (fault) has occurred in each propulsion unit 11. For example, the malfunction detection unit 12a monitors a state of communication between the control unit 12 and a predetermined portion of each propulsion unit 11 connected thereto, and recognizes occurrence of disconnection in a harness that connects the two is recognized based on the state of communication, thereby detecting occurrence of a malfunction (fault) in each propulsion unit 11 when. Although not particularly limited, a configuration of the malfunction detection unit 12a for detecting a malfunction of each propulsion unit 11 may be adapted, for example, to detect a malfunction occurring in each propulsion unit 11 based on the detected values from a group of sensors attached to the driving source of each propulsion unit 11.

[0034] As illustrated in FIG. 2, the control unit 12 is connected to each of four propulsion units 11 composed of the first propulsion unit 11A, the second propulsion unit 11B, the third propulsion unit 11C, and the fourth propulsion unit 11D. The control unit 12 controls each propulsion unit 11 to allow operation or stoppage of the propulsion unit 11.

[0035] The control unit 12 is also connected to a first lever position sensor 21, a steering angle sensor 22, and a second lever position sensor 23.

[0036] The first lever position sensor 21 detects the operating position of a throttle lever provided on the marine vessel 2. The control unit 12 adjusts the operating state of the driving source of the propulsion units 11 to change the rotational speed of the screw according to the operating position of the throttle lever operated by an operator (ship operator). This allows the propulsion units 11 to propel the marine vessel 2.

[0037] The steering angle sensor 22 detects the steer-

ing angle of a steering wheel provided on the marine vessel 2. The second lever position sensor 23 detects the operating position of a steering lever provided on the marine vessel 2. The control unit 12 changes the rotation angle of the propulsion unit 11 (i.e., the rotary shaft direction of the screw) according to a manipulated variable of the steering wheel applied by the operator and/or the operating position of the second lever position sensor 23. This allows the propulsion units 11 to turn the marine vessel 2.

[0038] Next, a detailed description will be given on a process in which the control unit 12 controls the propulsion units 11 based on output results from the malfunction detection unit 12a, with reference to FIG. 3. FIG. 3 is a flowchart illustrating a process in which the control unit 12 controls the propulsion units 11 based on the output results from the malfunction detection unit 12a.

[0039] When each of the four propulsion units 11, composed of the first propulsion unit 11A, the second propulsion unit 11B, the third propulsion unit 11C, and the fourth propulsion unit 11D, is in operation, that is, when the marine vessel 2 is underway, the control unit 12 controls the four propulsion units 11 based on the output results from the malfunction detection unit 12a.

[0040] First, the control unit 12 determines whether a malfunction has occurred in any propulsion unit 11 among the four propulsion units 11 (step S101). This determination is performed based on the detection results from the malfunction detection unit 12a. That is, when the malfunction detection unit 12a detects occurrence of a malfunction in any of the propulsion units 11, the control unit 12 recognizes that the particular propulsion unit 11 malfunctions.

[0041] If it is determined that a malfunction has occurred in any of the four propulsion units 11 (step S101, Yes), the control unit 12 stops the malfunctioning propulsion unit 11 (step S102). On the other hand, if it is determined that no malfunction has occurred in the four propulsion units 11 (step S101, No), the process returns to step S101.

[0042] After stopping the malfunctioning propulsion unit 11, the control unit 12 then stops at least one propulsion unit 11 among the propulsion units 11 that are arranged on the side opposite the malfunctioning propulsion unit 11 that is arranged on either of the left side and right side of the hull 3 (step S103). The propulsion unit 11 to be stopped here is the propulsion unit 11 for which occurrence of a malfunction has not been detected (hereinafter, also referred to as normal propulsion unit 11). For example, when the second propulsion unit 11B on the left side, which is the propulsion unit 11 arranged on one of the left and right side in the hull 3, malfunctions, the control unit 12 stops the second propulsion unit 11B, and then stops at least one of the third propulsion unit 11C and the fourth propulsion unit 11D on the right side, which are the propulsion units 11 arranged on the other of the right and left sides in the hull 3.

[0043] In the particular embodiment, substantially at

the same time as the malfunctioning propulsion unit 11 is stopped, the propulsion unit 11 in a left-right symmetric relationship with the malfunctioning propulsion unit 11 is stopped. As described above, in the example in which the second propulsion unit 11B malfunctions, the control unit 12 stops the second propulsion unit 11B, and also stops the third propulsion unit 11C. As a result, the propulsion units 11 that continue to be operated are the first propulsion unit 11A and the fourth propulsion unit 11D.

[0044] Then, the control unit 12 determines whether a malfunction has occurred in the other propulsion units 11 that maintain operation (step S104).

[0045] If it is determined that a malfunction has occurred in any of the other propulsion units 11 (step S104, Yes), the control unit 12 stops the other propulsion unit 11 (step S105). As in the example described above, if it is determined that a malfunction has newly occurred in the fourth propulsion unit 11D with the second propulsion unit 11B and the third propulsion unit 11C being stopped, the control unit 12 stops operation of the fourth propulsion unit 11D. On the other hand, if it is determined that no malfunction has occurred in any of the other propulsion units 11 (step S104, No), the process returns to step S104.

[0046] After stopping the other propulsion unit 11 that have malfunctioned, the control unit 12 determines whether there are two or more remaining propulsion units in operation 11 or whether there are less than two remaining propulsion units in operation 11 (i.e., normal propulsion units in which no malfunction has occurred) (step S106). In this embodiment, the number of the propulsion units 11 is four. At a time of step S105, the number of the propulsion units 11 to be stopped is three out of four. Since the number of propulsion units 11 in operation is one, the control unit 12 necessarily determines in step S106 that there are less than two remaining propulsion units 11 in operation.

[0047] If it is determined that there are less than two propulsion units 11 in operation (step S106, No), the control unit 12 determines whether there is one propulsion unit 11 in operation (step S108). According to the example described above, at step S108, the number of propulsion units 11 in operation is one. Therefore, decision made in step S108 is Yes.

[0048] If it is determined that there is one propulsion unit 11 in operation, the control unit 12 continues operation of the one propulsion unit 11 in operation (step S109). In other words, it is thought that, in principle, since the fourth propulsion unit 11D has malfunctioned, the first propulsion unit 11A, which is positioned on the side laterally opposite the fourth propulsion unit 11D, should be stopped. However, stopping the only operating first propulsion unit 11A would make it impossible to navigate. Therefore, in this case, operation of the first propulsion unit 11A is controlled not to be stopped.

[0049] When operation of the propulsion unit 11 is continued in step S109, the control unit 12 may resume operation of the normal propulsion unit 11 in stoppage. Ac-

According to the example described above, operation of the first propulsion unit 11A is continued at step S109, while operation of the third propulsion unit 11C, which is normal and which was stopped at step S105, is resumed. The normal propulsion unit 11 to resume operation is preferably one propulsion unit that is arranged on the side opposite the one propulsion unit 11 in operation that is arranged on either of the left side and right side of the hull 3.

[0050] As described above, in the particular embodiment, the number of the propulsion units 11 is four. Since operation of a total of three propulsion units 11 is stopped at S101 through step S105, decision made in step S106 is always No. However, when the number of the propulsion units 11 is five or more, decision made in step S106 may be Yes. In this case, as in step S103, the control unit 12 stops the propulsion unit 11 arranged on the side opposite the malfunctioning propulsion unit 11 (step S107). The process then returns to step S104.

[0051] In the particular embodiment, the number of the propulsion units 11 is an even number (four). Therefore, as a malfunction has occurred in any of the propulsion units 11 and the particular malfunctioning propulsion unit 11 is stopped together with the propulsion unit 11 corresponding thereto, the number of the propulsion units 11 that continue to be operated decreases while maintaining an even number, for example, as from four to two. Consider the case in which there are the last two propulsion units 11 that maintains operation, and a malfunction occurs in one of the two. Since the one remaining propulsion unit 11 is normal, decision made in step S108 is Yes. As a result, the processing of step S109 described above is performed.

[0052] Then, consider the case in which the number of the propulsion units 11 is an odd number, for example, five. When a malfunction has occurred in any of the propulsion units 11 and the particular malfunctioning propulsion unit 11 is stopped together with the propulsion unit 11 corresponding thereto, the number of the propulsion units 11 that continue to be operated decreases while maintaining an odd number, for example, as from five to three, or from three to one. When there is the last one propulsion unit 11 that maintains operation and a malfunction occurs in this only one propulsion unit 11, the particular propulsion unit 11 is stopped in step S105. Since operation of all the propulsion units 11 has been stopped, decision made in step S106 is No and decision made in step S108 is also No. The control unit 12 then resumes operation of at least one normal propulsion unit 11 in stoppage (step S110).

[0053] Thus, after step S108, a state in which at least one normal propulsion unit 11 is operational is realized, and the propulsive force is then secured. This allows the marine vessel 2 to continue sailing.

[0054] As described above, the marine vessel propulsion device 1 of the particular embodiment includes the four propulsion units 11, the malfunction detection unit 12a, and the control unit 12. The four propulsion units 11 are mounted to the hull 3 of the marine vessel 2. The

malfunction detection unit 12a is capable of detecting occurrence of a malfunction for each of the four propulsion units 11. The control unit 12 controls the four propulsion units 11. The four propulsion units 11 are arranged left-right symmetrically. When the malfunction detection unit 12a detects occurrence of a malfunction in any of the four propulsion units 11 with the four propulsion units 11 being operated, the control unit 12 stops the propulsion unit 11 for which occurrence of a malfunction has been detected. In the case described above, the control unit 12 stops, among the four propulsion units 11, at least one propulsion unit 11 that is arranged on the side opposite the propulsion unit 11 for which occurrence of a malfunction has been detected and which is arranged on either of the left side and the right side of the hull 3.

[0055] In this way, when occurrence of a malfunction in any of the propulsion units 11 is detected, the propulsion unit 11 that is arranged on the side laterally opposite the malfunctioning propulsion unit 11 is stopped. Therefore, it becomes easier for an operator to continue navigation while balancing the left and right propulsive forces.

[0056] In the marine vessel propulsion device 1 of the particular embodiment, the at least one propulsion unit to be stopped with the stoppage of the propulsion unit 11 for which occurrence of a malfunction has been detected includes a propulsion unit 11 that is in a left-right symmetrical relationship with the propulsion unit 11 for which occurrence of a malfunction has been detected.

[0057] This makes it easier to balance the left and right propulsive forces because the propulsion unit 11 that is arranged left-right symmetrically with the propulsion unit 11 for which occurrence of a malfunction has been detected is stopped.

[0058] In the marine vessel propulsion device 1 of the particular embodiment, when the malfunction detection unit 12a detects, regarding the four propulsion units 11, occurrence of a malfunction in another propulsion units 11 in operation different from the propulsion unit 11 for which occurrence of a malfunction has been detected, the control unit 12 stops the another propulsion unit 11. When the number of the propulsion unit 11 in operation will be reduced to one as a result of stopping the another propulsion unit 11 in which a malfunction is newly detected, the control unit 12 maintains operation of the propulsion unit 11 in operation. In addition to or in place of maintaining operation of the propulsion units 11 in operation, operation of the at least one propulsion unit 11 has been stopped without occurrence of a malfunction being detected may be resumed. When it is likely that there will be no propulsion unit 11 in operation as a result of stopping the propulsion unit 11 in which a malfunction is newly detected, the control unit 12 resumes operation of the propulsion unit 11 that has been stopped without occurrence of a malfunction being detected.

[0059] This ensures operation of the propulsion units 11 that generate a propulsive force to continue navigation, even when the number of the propulsion units 11

for which occurrence of a malfunction has been detected increases.

[0060] The configuration of the marine vessel propulsion device 1 of the particular embodiment may be modified so that when the number of the propulsion units 11 in operation is reduced to one as a result of stopping the another propulsion unit 11 in which a malfunction have been newly detected, operation of the at least one propulsion unit 11 that has been stopped without occurrence of a malfunction being detected is resumed. It is preferable that the at least one propulsion unit 11 to be resumed includes the propulsion unit 11 that is arranged on the side opposite the propulsion unit 11 in operation that is arranged on either of the left side and right side of the hull 3.

[0061] In this case, the balance between left and right propulsive forces is improved.

[0062] Next, a description will be made on a marine vessel propulsion device 1x according to a second embodiment. FIG. 4 is a schematic plan view illustrating an overall configuration of a marine vessel 2 provided with the marine vessel propulsion device 1x according to the second embodiment. In the description of the second and subsequent embodiments, components that are identical or similar to those of the embodiment described above are designated with the same references in the drawings, and descriptions thereof may be omitted.

[0063] The marine vessel propulsion device 1x illustrated in FIG. 4 is different from the marine vessel propulsion device 1 of the first embodiment, in terms of including an odd number of propulsion units (five propulsion units) 11. One propulsion unit 11 among the odd number of propulsion units 11 is arranged at the lateral center of the hull 3. This propulsion unit 11 arranged at the lateral center is controlled independently of the other propulsion units 11.

[0064] The five propulsion units 11 are composed of a first propulsion unit 11A, a second propulsion unit 11B, a third propulsion unit 11C, a fourth propulsion unit 11D, and a central propulsion unit 11E.

[0065] The five propulsion units 11 are arranged side-by-side along the left-right direction as in the first embodiment. Furthermore, the central propulsion unit 11E is arranged on the center line 15. Among the five propulsion units 11, the four propulsion units 11 except the central propulsion unit 11E are oppositely arranged on the right and left sides of the hull 3 across the central propulsion unit 11E. The first propulsion unit 11A and the second propulsion unit 11B are arranged on the left side in the hull 3. The third propulsion unit 11C and the fourth propulsion unit 11D are arranged on the right side in the hull 3. The first propulsion unit 11A and the fourth propulsion unit 11D are in a left-right symmetric corresponding relationship with respect to the center line 15, while the second propulsion unit 11B and the third propulsion unit 11C are in a left-right symmetric corresponding relationship with respect to the center line 15. Thus, the five propulsion units 11 are left-right symmetrical.

[0066] As illustrated in FIG. 5, the central propulsion unit 11E is connected to the control unit 12 to which the four other propulsion units 11 are connected. The control unit 12 controls the central propulsion unit 11E to allow operation or stoppage of the central propulsion unit 11E. The central propulsion unit 11E is controlled by the control unit 12 independently of the four other propulsion units 11. In other words, the central propulsion unit 11E is controlled regardless of the control status of the four other propulsion units 11.

[0067] Next, a detailed description will be given on a process in which the control unit 12 controls the central propulsion unit 11E, with reference to FIG. 6. FIG. 6 is a flowchart illustrating a process in which the control unit 12 controls the central propulsion unit 11E based on the output results from the malfunction detection unit 12a.

[0068] The control unit 12 controls the four propulsion units 11 except the central propulsion unit 11E among the five propulsion units 11, as in the first embodiment, based on the output results from the malfunction detection unit 12a. The control unit 12 also controls the central propulsion unit 11E while the central propulsion unit 11E is operated, independently of the control of the other propulsion units 11.

[0069] First, the control unit 12 determines whether a malfunction has occurred in the central propulsion unit 11E (step S201). This determination is performed based on the detection results from the malfunction detection unit 12a. That is, when the malfunction detection unit 12a detects occurrence of a malfunction in the central propulsion unit 11E, the control unit 12 recognize that the central propulsion unit 11E malfunctions.

[0070] On the other hand, if it is determined that no malfunction has occurred in the central propulsion unit 11E (step S201, No), the process returns to step S201.

[0071] If it is determined that a malfunction has occurred in the central propulsion units 11E (step S201, Yes), the control unit 12 stops the central propulsion unit 11E (step S202).

[0072] Subsequently, the control unit 12 determines whether there is any propulsion unit 11 in operation (step S203). That is, it is determined, regarding the four other propulsion units 11, that whether there is any propulsion unit 11 that has not been stopped.

[0073] If it is determined that there is some propulsion unit 11 in operation (step S203, Yes), the control unit 12 terminates the process. If it is determined that there is no propulsion unit 11 in operation (step S203, No), the control unit 12 resumes operation of the at least one normal propulsion unit 11 in stoppage (step S204) In this way, the propulsive force concerning the marine vessel 2 is surely ensured.

[0074] As described above, the marine vessel propulsion device 1x of the particular embodiment includes an odd number of propulsion units (five propulsion units) 11. The central propulsion unit 11E, which is one of the five propulsion units 11, is arranged at the lateral center of the hull 3. The control unit 12 controls the central propul-

sion unit 11E independently of the other propulsion units 11 among the five propulsion units 11.

[0075] In this way, regarding the four other propulsion units 11, even when both the propulsion unit 11 in which a malfunction has been detected and the propulsion unit 11 corresponding thereto are stopped, the central propulsion unit 11E is controllable. Therefore, it is possible to continue navigation while easily balancing the left and right propulsive forces by the other propulsion units 11. Furthermore, the strength of the propulsive force may be adjusted by the central propulsion unit 11E.

[0076] In the marine vessel propulsion device 1x of the particular embodiment, the control unit 12 stops the central propulsion unit 11E when the malfunction detection unit 12a detects occurrence of a malfunction in the central propulsion units 11E. When there will be no propulsion unit 11 in operation as a result of stopping the central propulsion unit 11E, the control unit 12 resumes operation of the at least one normal propulsion unit 11 in stoppage.

[0077] As a result, even when the central propulsion unit 11E is stopped, it is possible to continue navigation by allowing the at least one propulsion unit 11 to generate the propulsive force.

[0078] The preferred embodiments of the present disclosure are described above; however, the aforementioned configurations may be modified, for example, as follows.

[0079] The number of the propulsion units 11 may be any number so long as it is three or more, and may be an even number or an odd number.

[0080] When the number of propulsion units 11 is an odd number, the one propulsion unit 11 that is arranged at the lateral center of the hull 3 does not have to be controlled independently of the other propulsion units 11.

[0081] A left-right symmetrical arrangement of three or more propulsion units 11 in the hull 3 includes not only a state in which one propulsion unit 11 is arranged at a position precisely left-right symmetrical with the other propulsion unit 11, but also a state in which one propulsion unit 11 is arranged at a position slightly displaced from the position precisely left-right symmetrical with the other propulsion unit 11.

[0082] Suppose, for example, that the marine vessel propulsion device 1 includes four propulsion units 11, and that the number of propulsion units 11 that continue to be operated is reduced, as in the example described above, from four to two, because a malfunction has occurred in any of the propulsion units 11. Then, consider a case in which a malfunction occurs in one of the two propulsion units 11 in operation, and in which there is only one remaining propulsion unit 11 in operation as a result of stopping the malfunctioning propulsion unit 11. In this case, in place of stopping both the malfunctioning propulsion unit 11 and the propulsion unit 11 in operation, the at least one normal propulsion unit 11 in stoppage may be resumed. In this case, from a view point of making it easier to obtain a balance between the left and right

sides, it is preferable to select, as the propulsion unit 11 of which operation is to be resumed, a propulsion unit 11 that is arranged closer to the lateral center of the hull 3 than the propulsion unit 11 that was normal and in operation.

[0083] The flowchart in Figure 3 is applicable to both a case in which there are an even number of propulsion units 11 and a case in which there are an odd number of the propulsion units 11. This flowchart may be modified to a flowchart specific to a case in which there are an even number of propulsion units 11 or a flowchart specific to a case in which there are an odd number of propulsion units 11.

[0084] Obviously, numerous modifications and variations of the present disclosure are possible in the light of the above teaching. Therefore, it should be understood that the present disclosure may be practiced in a manner other than that described herein within the scope of the appended claims.

DESCRIPTION OF REFERENCE NUMERALS

[0085]

- 1 marine vessel propulsion device
- 2 marine vessel
- 3 hull
- 11 propulsion unit
- 11A first propulsion unit
- 11B second propulsion unit
- 11C third propulsion unit
- 11D fourth propulsion unit
- 11E central propulsion unit
- 12 control unit
- 12a malfunction detection unit (fault detection unit)

Claims

1. A marine vessel propulsion device comprising:

three or more propulsion units mounted to a hull of a marine vessel;
a fault detection unit capable of detecting occurrence of a fault for each of the three or more propulsion units; and
a control unit that controls the three or more propulsion units, wherein
the three or more propulsion units are arranged left-right symmetrically,
when the fault detection unit detects occurrence of a fault in any of the three or more propulsion units with the three or more propulsion units being operated, the control unit stops the propulsion unit for which occurrence of a fault has been detected, and the control unit stops, among the three or more propulsion units, at least one propulsion unit that is arranged on a side opposite

the propulsion unit for which occurrence of a fault has been detected, on either of a left side and a right side of the hull.

2. The marine vessel propulsion device according to claim 1, wherein the at least one propulsion unit to be stopped with the stoppage of the propulsion unit for which occurrence of a fault has been detected includes a propulsion unit that is in a left-right symmetrical relationship with the propulsion unit for which occurrence of a fault has been detected.

3. The marine vessel propulsion device according to claim 1 or 2, wherein

when the fault detection unit detects, regarding the three or more propulsion units, that a fault has occurred in another propulsion unit in operation different from the propulsion unit for which occurrence of a fault has been detected, the control unit stops the another propulsion unit, when a number of the propulsion units in operation will be reduced to one as a result of stopping the another propulsion unit, the control unit maintains operation of the propulsion unit in operation and/or resumes operation of the at least one propulsion unit that has been stopped without occurrence of a fault being detected, and when there will be no propulsion unit in operation, the control unit resumes operation of the at least one propulsion unit that has been stopped without occurrence of a fault being detected.

4. The marine vessel propulsion device according to claim 3, wherein

when a number of the propulsion units in operation is reduced to one as a result of stopping the another propulsion unit, the control unit maintains operation of the propulsion unit in operation and resumes operation of the at least one propulsion unit that has been stopped without occurrence of a fault being detected, and the at least one propulsion unit the operation of which is to be resumed includes the propulsion unit that is arranged on a side opposite the propulsion unit in operation, on either of the left side and right side of the hull.

5. The marine vessel propulsion device according to claim 3, wherein when a number of the propulsion units in operation is reduced to one as a result of stopping the another propulsion unit, the control unit stops operation of the propulsion unit in operation and resumes operation of the at least one propulsion unit that has been stopped without occurrence of a fault being detected.

6. The marine vessel propulsion device according any one of claims 1 to 5, wherein

there are an odd number of the propulsion units, one of the three or more propulsion units is arranged at a lateral center of the hull, the control unit controls the one propulsion unit that is arranged at the lateral center of the hull independently of other propulsion units among the three or more propulsion units.

7. The marine vessel propulsion device according to claim 6, wherein

when the fault detection unit detects occurrence of a fault in the one propulsion unit that is arranged at the lateral center of the hull, the control unit stops the one propulsion unit, and when there will be no propulsion unit in operation as a result of stopping the one propulsion unit, the control unit resumes operation of the at least one propulsion unit that has been stopped without occurrence of a fault being detected.

FIG. 1

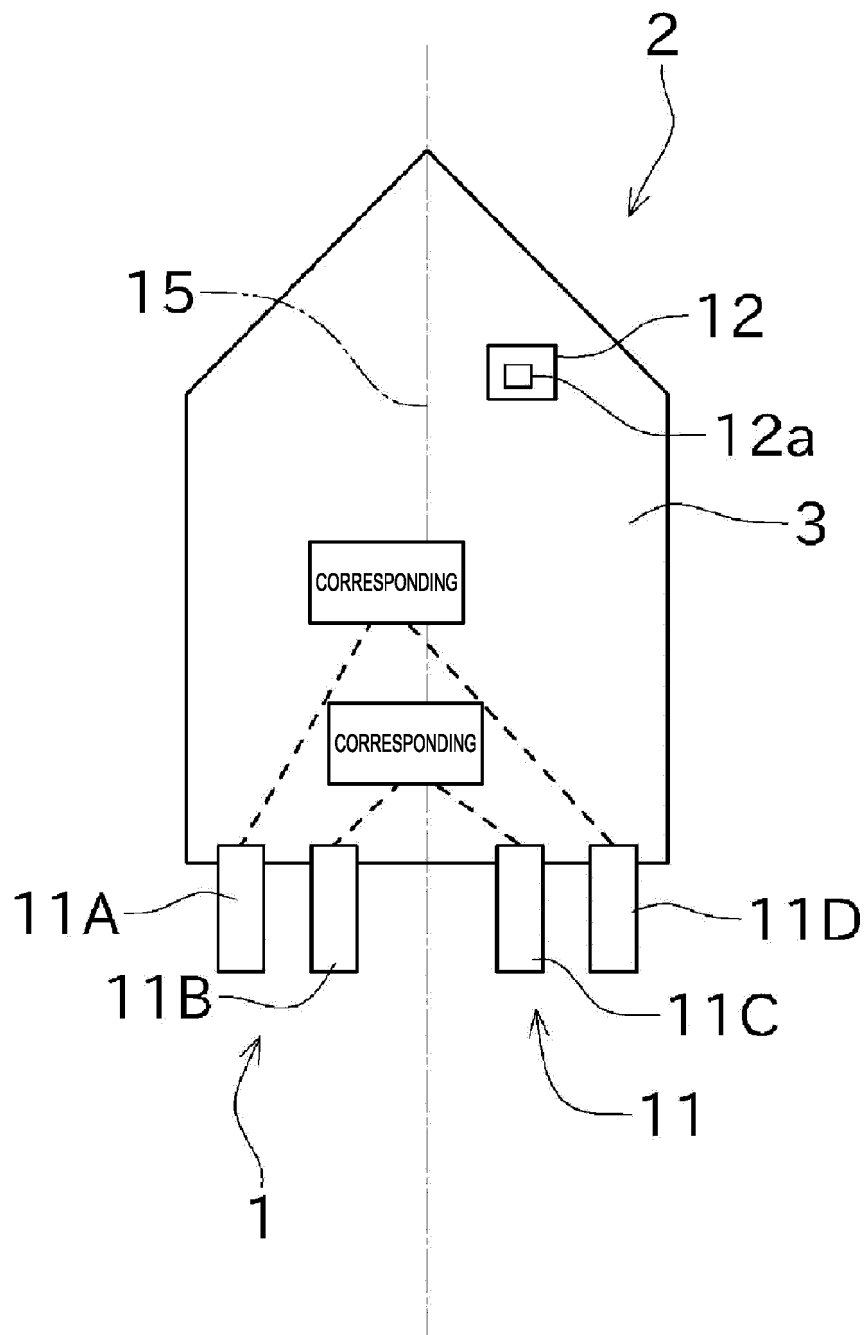


FIG. 2

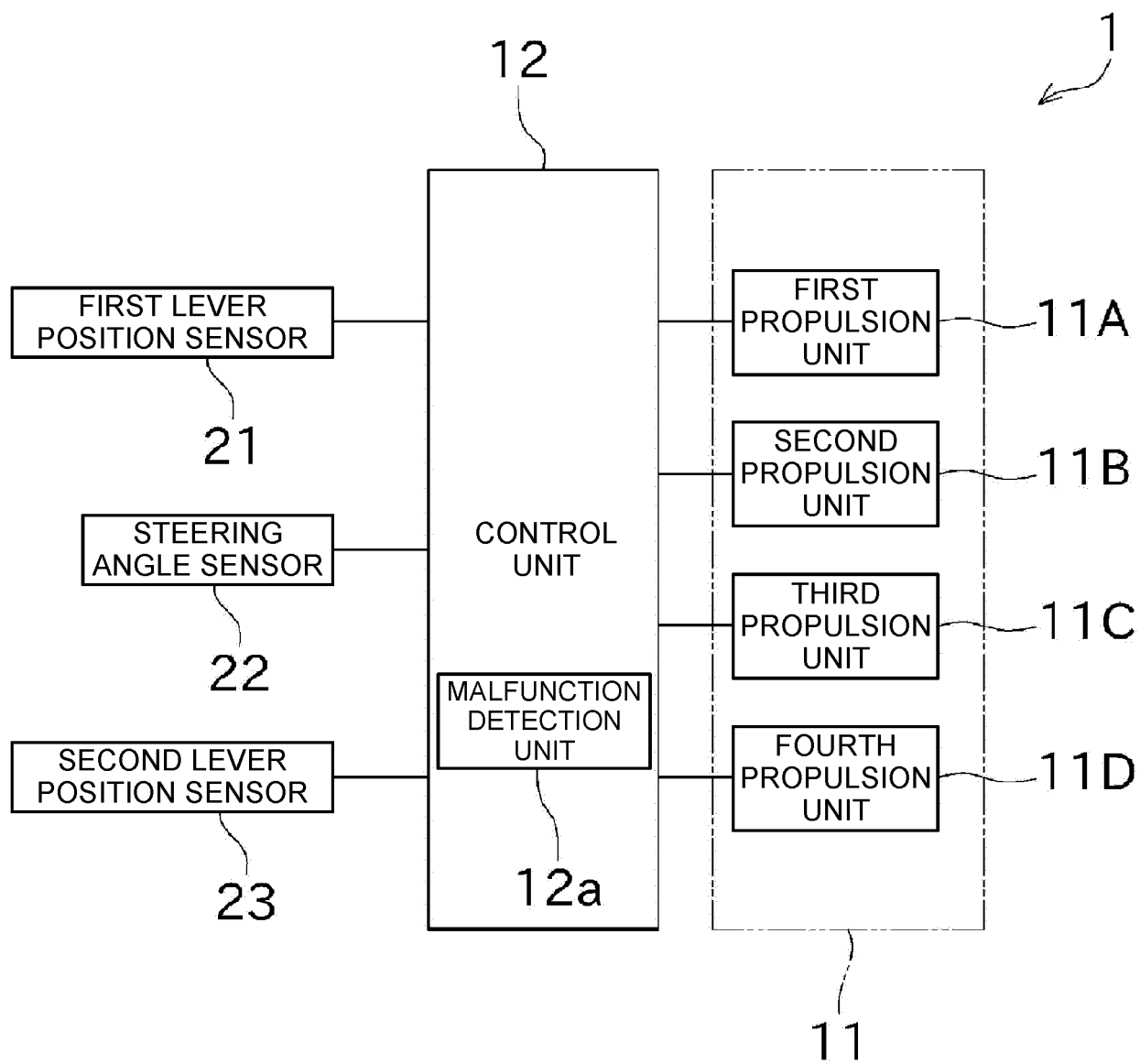


FIG. 3

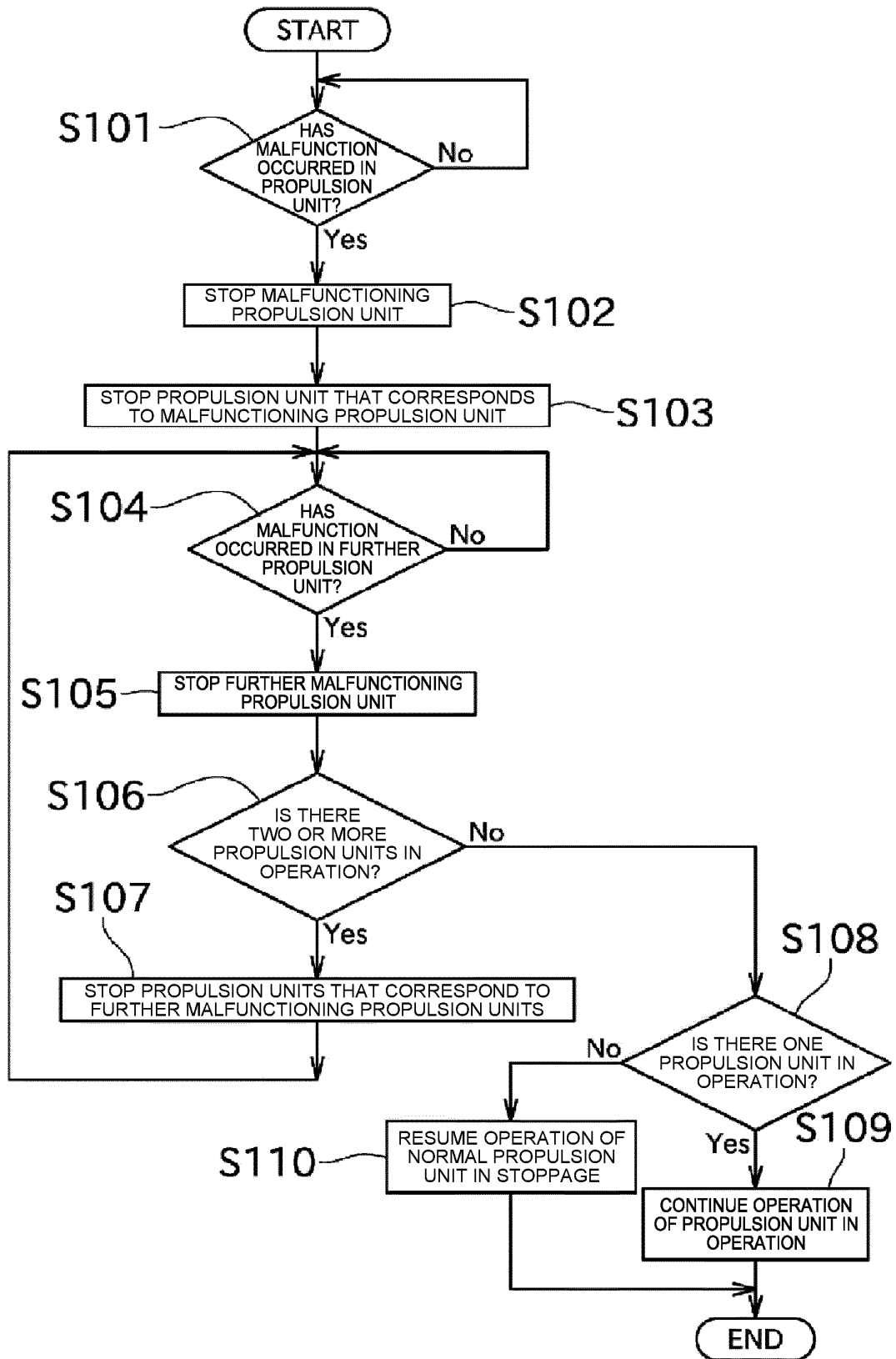


FIG. 4

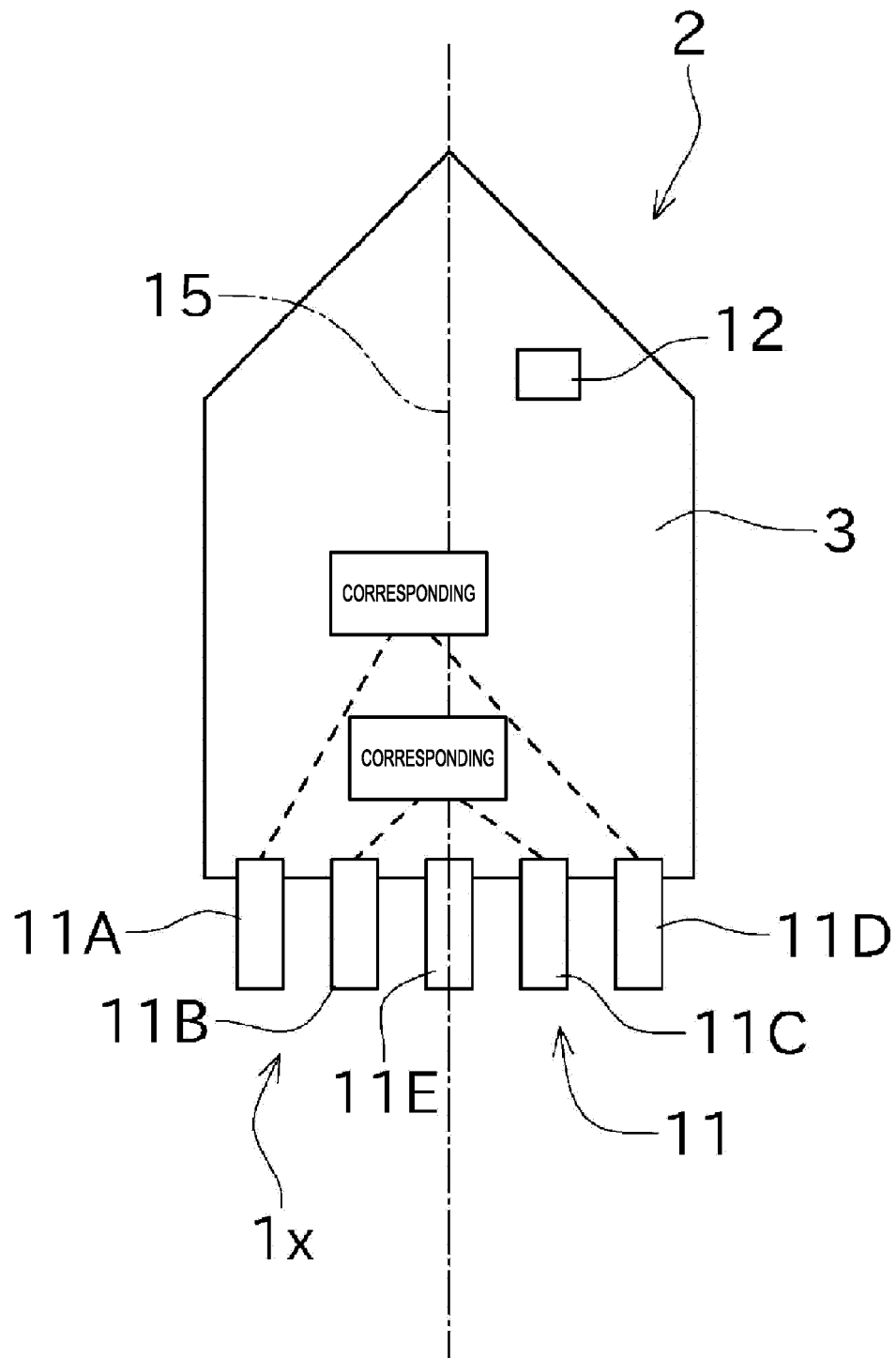


FIG. 5

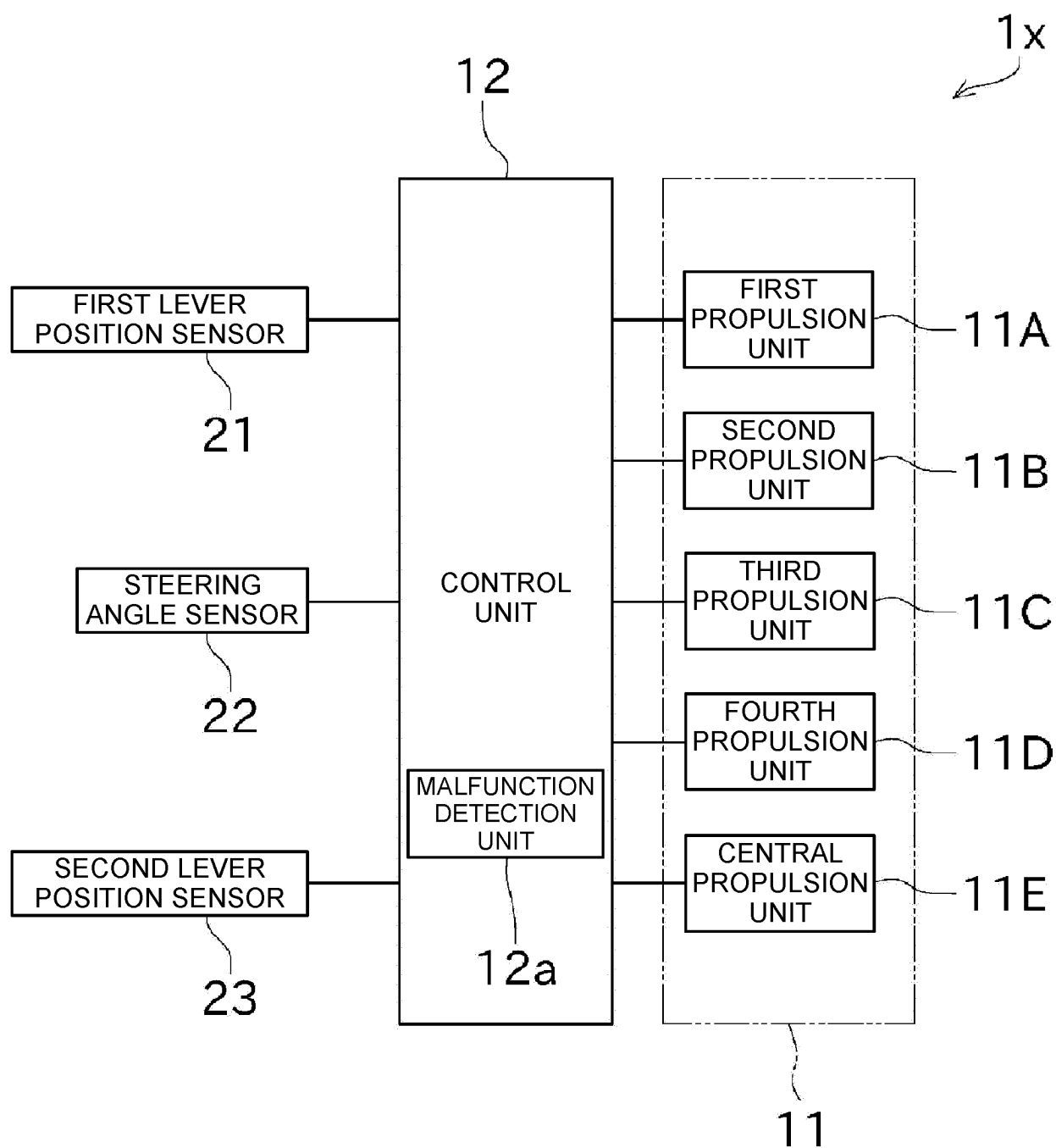
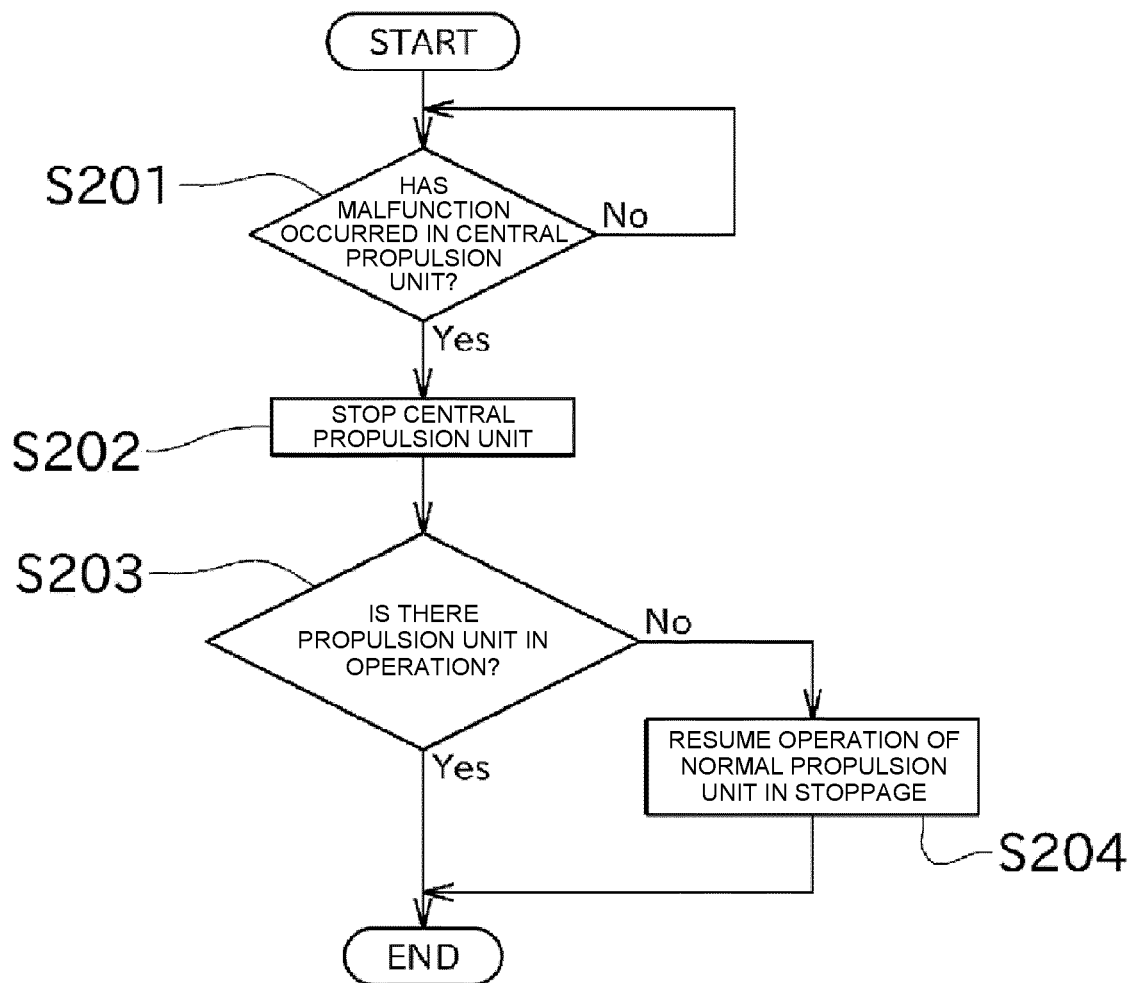


FIG. 6



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/038696

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A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. B63H20/00 (2006.01)i, B63H21/21 (2006.01)i, B63H25/24 (2006.01)i, B63H25/42 (2006.01)i

FI: B63H20/00803, B63H21/21, B63H25/24A, B63H25/42B

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

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. B63H20/00, B63H21/21, B63H25/24, B63H25/42

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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	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 2014-80082 A (YAMAHA MOTOR CO., LTD.) 08 May 2014 (2014-05-08), paragraphs [0030]-[0106], fig. 1-11	1-3, 6-7
Y	JP 2016-68579 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 09 May 2016 (2016-05-09), paragraphs [0032]-[0119], fig. 1-19	1-3, 6-7
Y	JP 62-237034 A (SANSHIN IND CO., LTD.) 17 October 1987 (1987-10-17), page 2, upper right column, lines 1-8	1-3, 6-7

☒ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

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* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	
Date of the actual completion of the international search 22 December 2020	Date of mailing of the international search report 28 December 2020
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/038696

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	JP 2-256879 A (SANSHIN IND CO., LTD.) 17 October 1990 (1990-10-17), page 3, upper left column, line 15 to upper right column, line 3	1-7
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Information on patent family members

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paragraphs [0030], [0031]
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JP 2-256879 A 17 October 1990 (Family: none)

JP 2008-163864 A 17 July 2008 US 2008/0171480 A1
entire text, all drawings

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REFERENCES CITED IN THE DESCRIPTION

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