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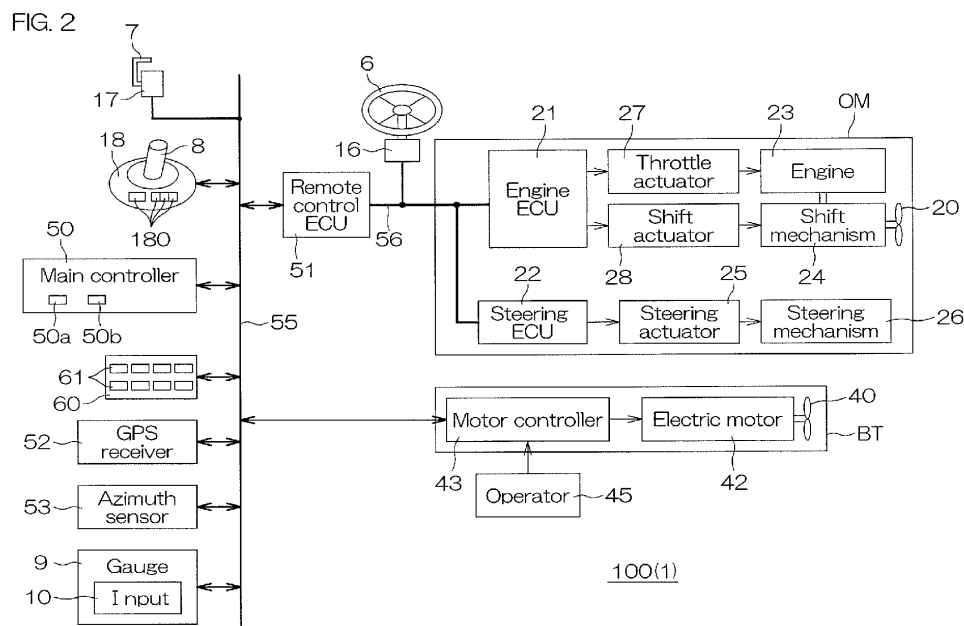
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(54) **WATERCRAFT PROPULSION SYSTEM AND WATERCRAFT**

(57) A watercraft propulsion system includes a propulsion unit (BT, OM, 25, 26) to apply a propulsive force to a hull (2), and a controller (50) configured or programmed to control the propulsion unit (BT, OM, 25, 26) in response to a lateral movement command to cause the hull (2) to move in a zig-zag pattern in a direction indicated by the lateral movement command between two parallel reference lines (R1, R2) extending laterally of the hull (2) and

spaced apart from each other anteroposteriorly of the hull (2) while maintaining an azimuth of the hull (2). The propulsion unit may include a bow thruster (BT) at the bow of the hull (2) to generate a propulsive force laterally of the hull (2), a propulsion device (OM) on the hull (2) to generate a propulsive force anteroposteriorly of the hull (2), and a steering (25, 26) to change the course of the hull (2).



Description

[0001] The present invention relates to watercraft propulsion systems, and watercraft including the watercraft propulsion systems.

[0002] US 2014/0046515 A1 discloses a watercraft propulsion control system for a watercraft including a bow thruster and a single outboard motor. In the watercraft propulsion control system, a watercraft maneuvering pattern is preliminarily selected and defined for an operation state of a lever (joystick) provided on a joystick unit. Specifically, watercraft maneuvering patterns for bow turning with arcuate movement, diagonally forward translation, diagonally rearward translation, fixed-point bow turning, and lateral translation are selectable for lateral tilt operation of the joystick. A watercraft maneuvering pattern for anteroposterior movement is solely selected for anteroposterior tilt operation of the joystick.

[0003] In the lateral translation of a hull, the outboard motor is controlled to generate a propulsive force alternately in a diagonally forward direction and in a diagonally rearward direction, while the bow thruster is controlled to generate a propulsive force laterally. Thus, a diagonally forward movement and a diagonally rearward movement are alternately repeated such that the hull is laterally moved.

[0004] The inventor of example embodiments of the present invention described and claimed in the present application conducted an extensive study and research regarding a watercraft propulsion system, such as the one described above, and in doing so, discovered and first recognized new unique challenges and previously unrecognized possibilities for improvements as described in greater detail below.

[0005] In US 2014/0046515 A1, the lateral translation is described, but no detailed description is given to a specific control operation and the like for the lateral translation. Therefore, consideration is still needed for the lateral translation of the hull.

[0006] Example embodiments of the present invention provide watercraft propulsion systems each including a specific arrangement for the lateral translation of a hull, and watercraft including the watercraft propulsion systems.

[0007] In order to overcome the previously unrecognized and unsolved challenges described above, an example embodiment of the present invention provides a watercraft propulsion system including a bow thruster at a bow of a hull to generate a propulsive force laterally of the hull, a propulsion device on the hull to generate a propulsive force anteroposteriorly of the hull, and a steering to change the course of the hull. The watercraft propulsion system further includes a controller configured or programmed to, in response to a lateral movement command, set two parallel reference lines extending laterally of the hull and spaced a distance apart from each other anteroposteriorly of the hull, and to control the bow thruster, the propulsion device, and the steering to

cause the hull to move in a zig-zag pattern in a direction indicated by the lateral movement command between the two reference lines while maintaining the azimuth of the hull.

[0008] With this arrangement, the two parallel reference lines spaced apart from each other anteroposteriorly of the hull are set in response to the lateral movement command. These reference lines extend laterally of the hull. The controller controls the bow thruster, the propulsion device, and the steering so as to cause the hull to move (preferably translate) in a zig-zag pattern in a lateral direction (a rightward or leftward direction) indicated by the lateral movement command between the two reference lines. Therefore, the hull is moved in the lateral direction indicated by the lateral movement command by the zig-zag movement between the two reference lines. The watercraft propulsion system is specifically arranged to achieve the lateral movement of the hull.

[0009] The reference lines are preferably ground-based reference lines set to extend laterally of the hull as observed when the lateral movement command is issued. Thus, the ground-based lateral movement is achieved even if the azimuth of the hull is changed.

[0010] In an example embodiment of the present invention, the zig-zag pattern of the hull includes a first movement which is a diagonal movement including a lateral movement component indicated by the lateral movement command and one of forward and rearward movement components, and a second movement including the other of the forward and rearward movement components, the first movement and the second movement being each carried out at least once.

[0011] Typically, the first movement and the second movement are alternately repeated. More specifically, when the hull reaches one of the two reference lines by the first movement, the hull is switched to the second movement. When the hull reaches the other of the two reference lines by the second movement, the hull is switched to the first movement. Either the first movement or the second movement may come first.

[0012] The second movement may include a lateral movement component or may not include the lateral movement component. Where the second movement does not include the lateral movement component, the hull moves along a serration path. The hull movement along the serration path is an example of the zig-zag hull movement. The second movement preferably includes a lateral movement component indicated by the lateral movement command. Thus, the hull moves in the lateral direction indicated by the lateral movement command in both the first movement and the second movement, so that the lateral movement is smoothly achieved. The second movement may include a lateral movement component having a lateral direction opposite to that indicated by the lateral movement command, but the opposite-direction lateral movement component should be smaller in magnitude than the lateral movement component of the first movement.

[0013] In an example embodiment of the present invention, the controller is configured or programmed to control the bow thruster, the propulsion device, and the steering to cause the hull to alternately repeat a first movement and a second movement between the two reference lines, the first movement being a diagonally forward movement (preferably a diagonally forward translation) including a lateral movement component indicated by the lateral movement command, the second movement being a diagonally rearward movement (preferably a diagonally rearward translation) including a lateral movement component indicated by the lateral movement command.

[0014] With this arrangement, the hull is moved in the lateral direction indicated by the lateral movement command in both the first movement and the second movement, so that the lateral movement is smoothly achieved by alternately repeating the first movement and the second movement. Either the first movement or the second movement may come first.

[0015] The first movement and the second movement are each preferably a parallel movement (translation) without the bow turning of the hull. That is, the controller preferably controls the bow thruster, the propulsion device, and the steering so that the first movement and the second movement are each the parallel movement (translation) without the bow turning of the hull. Even if such a control operation is performed, however, the hull often suffers from bow turning due to external disturbance such as tidal current and wind. In this case, a user (a watercraft operator) may perform a manual operation to reduce the bow turning. Further, the controller may perform an azimuth assist control operation to automatically reduce the bow turning of the hull occurring due to the external disturbance in the first movement and the second movement.

[0016] In an example embodiment of the present invention, the controller is configured or programmed to perform an azimuth holding control operation to maintain the azimuth of the hull during a switching period in which switching between the first movement and the second movement occurs. This arrangement reduces a change in the azimuth of the hull during the switching between the first movement and the second movement, making it possible to achieve the lateral movement of the hull while maintaining the azimuth of the hull.

[0017] In an example embodiment of the present invention, the two reference lines are located forward and rearward, respectively, of the gravity center of the hull. This arrangement makes it possible to laterally move the hull while moving the hull back and forth with respect to a position of the gravity center of the hull observed when the lateral movement command is issued.

[0018] In an example embodiment of the present invention, the two reference lines are both located forward or rearward (preferably forward) of the gravity center of the hull. This arrangement makes it possible to laterally move the hull while moving the hull back and forth with

respect to a position forward or rearward of the position of the gravity center of the hull observed when the lateral movement command is issued.

[0019] In an example embodiment of the present invention, the propulsion device includes only a single propulsion device on the stern of the hull, or a plurality of propulsion devices on the stern of the hull and steerable at a same steering angle.

[0020] A combination of the plurality of propulsion devices steerable at the same steering angle is equivalent to the single propulsion device in that the propulsive forces of the respective propulsion devices are applied in the same direction to the hull but are not simultaneously applied in different directions to the hull. With the use of the watercraft propulsion system including the bow thruster provided at the bow of the hull and the propulsion devices provided on the stern of the hull and incapable of simultaneously applying their propulsive forces in different directions to the hull, the hull is moved in a zig-zag pattern in the lateral direction indicated by the lateral movement command.

[0021] In an example embodiment of the present invention, the watercraft propulsion system further includes a lateral movement operator operable by a user to input the lateral movement command to the controller.

[0022] One non-limiting example of the lateral movement operator is a joystick unit including a joystick tiltable in all directions. In this case, the joystick unit inputs the lateral movement command to the controller, if the joystick is tilted laterally (rightward and leftward). Another non-limiting example of the lateral movement operator is a lever unit including a laterally tiltable lever. Another further non-limiting example of the lateral movement operator is a lateral operator unit including left and right individual operators. The left and right individual operators may be paddle levers that are pivotable together with a steering wheel. The lateral movement operator is preferably configured so as to change the lateral movement command according to the operation amount thereof.

[0023] In an example embodiment of the present invention, the controller is configured or programmed to control the bow thruster, the propulsion device, and the steering to change a propulsive force to be generated in the lateral direction indicated by the lateral movement command according to the operation amount of the lateral movement operator.

[0024] With this arrangement, the user is able to adjust a lateral movement speed according to the operation amount of the lateral movement operator. For example, the lateral propulsive force may be reduced as the operation amount decreases, and may be increased as the operation amount increases. In this case, for example, the user increases the operation amount of the lateral movement operator to speedily move the hull laterally when a distance to a target berthing position is great, and reduces the operation amount of the lateral movement operator to slowly move the hull laterally when the hull comes closer to the target berthing position.

[0025] In an example embodiment of the present invention, the controller is configured or programmed to change the distance between the two reference lines according to the operation amount of the lateral movement operator.

[0026] Specifically, the distance between the two reference lines may be reduced as the operation amount decreases, and may be increased as the operation amount increases. In this case, for example, the user is able to accurately move the hull toward the target berthing position by reducing the operation amount of the lateral movement operator as the hull approaches the target berthing position.

[0027] In an example embodiment of the present invention, the controller is configured or programmed to control the bow thruster, the propulsion device, and the steering so as to prioritize the maintaining of the azimuth of the hull over the lateral movement at a beginning of an operation of the lateral movement operator.

[0028] With this arrangement, the deviation of the hull azimuth is reduced which is otherwise liable to occur when the lateral movement is started. The prioritization of the maintaining of the hull azimuth may be achieved, for example, by gradually changing at least one of the propulsive force of the bow thruster, the propulsive force of the propulsion device, and the steering angle of the steering to gradually increase the lateral propulsive force. Thus, the bow turning of the hull is reduced, which may otherwise occur, for example, due to a delay in the movement of the bow or the stern of the hull during a transition period in which the propulsive force of the bow thruster or the propulsion device increases.

[0029] In an example embodiment of the present invention, the lateral movement command is generated by performing a position/azimuth holding control operation to maintain the position and the azimuth of the hull.

[0030] In the position/azimuth holding control operation, typically, if the position of the hull is offset, the hull is moved to correct the hull position and, if the azimuth of the hull is offset, the bow of the hull is turned to correct the hull azimuth. Therefore, the hull position is corrected with the hull azimuth maintained by providing a position correction command as the lateral movement command.

[0031] In an example embodiment of the present invention, the bow thruster is fixed to the hull in an unsteerable manner.

[0032] Another example embodiment of the present invention provides a watercraft propulsion system including a propulsion unit (a bow thruster, an outboard motor, a trolling motor or the like) to apply a propulsive force to a hull, and a controller configured or programmed to control the propulsion unit in response to a lateral movement command to cause the hull to move (preferably, translate) in a zig-zag pattern in a direction indicated by the lateral movement command between two parallel reference lines (preferably, ground-based reference lines) extending laterally of the hull and spaced apart from each other anteroposteriorly of the hull while maintaining the azi-

imuth of the hull.

[0033] With this arrangement, the two parallel reference lines spaced apart from each other anteroposteriorly of the hull are set in response to the lateral movement command. These reference lines extend laterally of the hull. The controller controls the propulsion unit (the bow thruster and the propulsion device) and a steering to cause the hull to move (preferably translate) in a zig-zag pattern in a lateral direction (a rightward or leftward direction) indicated by the lateral movement command between the two reference lines. Therefore, the hull is moved in the lateral direction indicated by the lateral movement command by the zig-zag pattern between the two reference lines. The watercraft propulsion system is specifically arranged to achieve the lateral movement of the hull.

[0034] The reference lines are preferably ground-based reference lines extend laterally of the hull as observed when the lateral movement command is issued. Thus, the lateral movement is achieved on a ground basis even if the azimuth of the hull is changed.

[0035] Another further example embodiment of the present invention provides a watercraft, which includes a hull, and a watercraft propulsion system including any of the features described above.

[0036] The above and other elements, features, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of the example embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037]

FIG. 1 is a plan view showing an exemplary construction of a watercraft mounted with a watercraft propulsion system according to an example embodiment of the present invention.

FIG. 2 is a block diagram showing a configuration of the watercraft propulsion system by way of example.

FIG. 3 is a perspective view showing the structure of a joystick unit by way of example.

FIG. 4 is a diagram for describing a neutral mode and an anteroposterior mode, which are sub-modes of a first joystick mode.

FIG. 5 is a diagram for describing the neutral mode and a bow turning mode, which are sub-modes of the first joystick mode.

FIG. 6 is a diagram showing an anteroposterior insensitive zone and a lateral insensitive zone of a joystick.

FIG. 7 is a diagram for describing a second joystick mode, showing the operation states of the joystick and the corresponding hull behaviors.

FIG. 8 is a flowchart showing an exemplary process to be performed by a main controller for diagonal translation calibration.

FIG. 9 is a flowchart showing an exemplary control process to be performed according to a translation command and a bow turning command in a calibration mode.

FIGS. 10A to 10D show an exemplary operation to be performed when a bow turning promotion command is issued in the calibration mode.

FIGS. 11A to 11D show an exemplary operation to be performed when a bow turning reduction command is issued in the calibration mode.

FIGS. 12A and 12B show exemplary operations to be performed when a lateral movement command is issued.

FIG. 13 is a flowchart showing an exemplary process to be performed by the main controller in response to the lateral movement command.

FIG. 14 is a diagram showing an arrangement of a watercraft propulsion system according to another example embodiment of the present invention.

FIGS. 15A and 15B show some other exemplary operations to be performed when the lateral movement command is issued.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

[0038] FIG. 1 is a plan view showing an exemplary construction of a watercraft 1 mounted with a watercraft propulsion system 100 according to an example embodiment of the present invention. The watercraft 1 includes a hull 2, a bow thruster BT provided at the bow of the hull 2 to generate a lateral propulsive force, and an outboard motor OM (an example of the propulsion device) provided on the stern 3 of the hull 2 and having a variable steering angle. In the present example embodiment, the single outboard motor OM is provided on a center line 2a extending anteroposteriorly of the hull 2 by way of example, but a plurality of outboard motors OM, more specifically, two or more outboard motors OM, may be provided on the stern 3.

[0039] The outboard motor OM includes a propeller 20 located underwater, and is configured to generate a propulsive force by the rotation of the propeller 20 and apply the propulsive force to the hull 2. The outboard motor OM is attached to the stern 3 pivotably leftward and rightward such that the direction of the propulsive force generated by the propeller 20 is changed leftward and rightward. The steering angle is defined, for example, as an angle between the direction of the propulsive force generated by the propeller 20 and an anteroposterior reference direction parallel to the center line 2a. The outboard motor OM is configured to be pivoted leftward and rightward by a steering mechanism 26 thereof (see FIG. 2) to change the steering angle. When the propulsive force direction is parallel to the anteroposterior direction, the steering angle is zero. When the rear end of the outboard motor OM is directed rightward, the steering angle may be expressed with a positive sign. When the

rear end of the outboard motor OM is directed leftward, the steering angle may be expressed with a negative sign.

[0040] The bow thruster BT includes a propeller 40 disposed in a tubular tunnel 41 extending through the bow portion of the hull 2 transversely of the hull 2. The propeller 40 may include, for example, two propellers connected to the opposite ends of its rotation shaft. The propeller 40 is rotatable in a forward rotation direction and a reverse rotation direction, i.e., is bidirectionally rotatable such that the bow thruster BT is able to apply a rightward or leftward propulsive force to the hull 2. In the present example embodiment, the direction of the propulsive force to be generated by the bow thruster BT is not setttable to a direction other than the rightward direction and the leftward direction. That is, the bow thruster BT is fixed to the hull 2 in an unsteerable manner in the present example embodiment.

[0041] A usable space 4 for passengers is provided inside the hull 2. A helm seat 5 is provided in the usable space 4. A steering wheel 6, a remote control lever 7, a joystick 8, a gauge 9 (display panel) and the like are provided in association with the helm seat 5. The steering wheel 6 is an operator to be operated by a user to change the course of the watercraft 1. The remote control lever 7 is an operator to be operated by the user to change the magnitude (output) and the direction (a forward or reverse direction) of the propulsive force of the outboard motor OM, and corresponds to an acceleration operator. The joystick 8 is an operator to be operated instead of the steering wheel 6 and the remote control lever 7 by the user for watercraft maneuvering. An operator 45 (see FIG. 2) dedicated for the operation of the bow thruster BT may be provided in addition to the aforementioned operators.

[0042] FIG. 2 is a block diagram showing the configuration of the watercraft propulsion system 100 provided in the watercraft 1 by way of example. The watercraft propulsion system 100 includes the outboard motor OM and the bow thruster BT. The outboard motor OM may be an engine outboard motor or an electric outboard motor. In FIG. 2, the engine outboard motor is illustrated as the outboard motor OM by way of example.

[0043] The outboard motor OM includes an engine ECU (Electronic Control Unit) 21, a steering ECU 22, an engine 23, a shift mechanism 24, the propeller 20, the steering mechanism 26 and the like. Power generated by the engine 23 is transmitted to the propeller 20 via the shift mechanism 24. The steering mechanism 26 is configured to pivot the body of the outboard motor OM leftward and rightward with respect to the hull 2 (see FIG. 1) to change the direction of the propulsive force generated by the outboard motor OM leftward and rightward. The shift mechanism 24 is configured to select a shift position from a forward shift position, a reverse shift position, and a neutral shift position. With the shift position set to the forward shift position, the propeller 20 is rotated in a forward rotation direction by the transmission

of the rotation of the engine 23 such that the outboard motor OM is brought into a forward drive state to generate a forward propulsive force. With the shift position set to the reverse shift position, the propeller 20 is rotated in a reverse rotation direction by the transmission of the rotation of the engine 23 such that the outboard motor OM is brought into a reverse drive state to generate a reverse propulsive force. With the shift position set to the neutral shift position, the power transmission between the engine 23 and the propeller 20 is interrupted such that the outboard motor OM is brought into an idling state.

[0044] The outboard motor OM further includes a throttle actuator 27 and a shift actuator 28, which are controlled by the engine ECU 21. The throttle actuator 27 is an electric actuator (typically including an electric motor) that actuates the throttle valve (not shown) of the engine 23. The shift actuator 28 is an actuator that actuates the shift mechanism 24. The outboard motor OM further includes a steering actuator 25 to be controlled by the steering ECU 22. The steering actuator 25 is the drive source of the steering mechanism 26, and typically includes an electric motor. The steering actuator 25 may include a hydraulic device of an electric pump type. The steering actuator 25 and the steering mechanism 26 are a non-limiting example of the steering that changes the course of the hull 2.

[0045] The bow thruster BT includes the propeller 40, an electric motor 42 that drives the propeller 40, and a motor controller 43 that controls the electric motor 42.

[0046] The watercraft propulsion system 100 further includes a main controller 50. The main controller 50 includes a processor 50a and a memory 50b, and is configured so that the processor 50a executes a program stored in the memory 50b to perform a plurality of functions. The main controller 50 is connected to an onboard network 55 (CAN: Control Area Network) provided in the hull 2. A remote control unit 17, a remote control ECU 51, a joystick unit 18, a GPS (Global Positioning System) receiver 52, an azimuth sensor 53 and the like are connected to the onboard network 55.

[0047] The remote control ECU 51 for the outboard motor OM is connected to the onboard network 55. The engine ECU 21 and the steering ECU 22 of the outboard motor OM are connected to the remote control ECU 51 via an outboard motor control network 56. The main controller 50 transmits and receives signals to/from various units connected to the onboard network 55 to control the outboard motor OM and the bow thruster BT, and further controls other units. The main controller 50 includes a plurality of control modes, and controls the units in predetermined manners according to the respective control modes.

[0048] A steering wheel unit 16 is connected to the outboard motor control network 56. The steering wheel unit 16 outputs an operation angle signal indicating the operation angle of the steering wheel 6 to the outboard motor control network 56. The operation angle signal is received by the remote control ECU 51 and the steering

ECU 22. In response to the operation angle signal generated by the steering wheel unit 16 or a steering angle command generated by the remote control ECU 51, the steering ECU 22 correspondingly controls the steering actuator 25 to control the steering angle of the outboard motor OM.

[0049] The remote control unit 17 generates an operation position signal indicating the operation position of the remote control lever 7.

[0050] The joystick unit 18 generates an operation position signal indicating the operation position of the joystick 8, and generates an operation signal indicating the operation of any of operation buttons 180 provided in the joystick unit 18.

[0051] The remote control ECU 51 outputs a propulsive force command to the engine ECU 21 via the outboard motor control network 56. The propulsive force command includes a shift command indicating the shift position, and an output command indicating an engine output (specifically, an engine speed). Further, the remote control ECU 51 outputs the steering angle command to the steering ECU 22 via the outboard motor control network 56. The steering ECU 22 receives the detection signal of a steering angle sensor (not shown) that detects the steering angle of the steering mechanism 26. The steering ECU 22 controls the steering actuator 25 so that the actual steering angle detected by the steering angle sensor matches with the steering angle command issued from the remote control ECU 51. The actual steering angle detected by the steering angle sensor is transmitted to the remote control ECU 51 from the steering ECU 22, and further transmitted to the main controller 50 from the remote control ECU 51.

[0052] The remote control ECU 51 performs different control operations according to different control modes of the main controller 50. In a control mode for watercraft maneuvering with the use of the steering wheel 6 and the remote control lever 7, for example, the remote control ECU 51 generates the propulsive force command (the shift command and the output command) according to the operation position signal generated by the remote control unit 17, and issues the propulsive force command (the shift command and the output command) to the engine ECU 21. Further, the remote control ECU 51 commands the steering ECU 22 to conform to the operation angle signal generated by the steering wheel unit 16. In a control mode for watercraft maneuvering without the use of the steering wheel 6 and the remote control lever 7, on the other hand, the remote control ECU 51 conforms to commands issued by the main controller 50. That is, the main controller 50 generates the propulsive force command (the shift command and the output command) and the steering angle command, and the remote control ECU 51 outputs the propulsive force command (the shift command and the output command) and the steering angle command to the engine ECU 21 and the steering ECU 22, respectively. In a control mode for watercraft maneuvering with the use of the joystick 8 (joystick

mode), for example, the main controller 50 generates the propulsive force command (the shift command and the output command) and the steering angle command according to the signals generated by the joystick unit 18. The magnitude and the direction (the forward direction or the reverse direction) of the propulsive force and the steering angle of the outboard motor OM are controlled according to the propulsive force command (the shift command and the output command) and the steering angle command thus generated.

[0053] The engine ECU 21 drives the shift actuator 28 according to the shift command to control the shift position, and drives the throttle actuator 27 according to the output command to control the throttle opening degree of the engine 23. The steering ECU 22 controls the steering actuator 25 according to the steering angle command to control the steering angle of the outboard motor OM.

[0054] The motor controller 43 of the bow thruster BT is connected to the onboard network 55, and is configured to actuate the electric motor 42 in response to a command issued from the main controller 50. The motor controller 43 may be connected to the onboard network 55 via a gateway (not shown). The main controller 50 issues a propulsive force command to the motor controller 43. The propulsive force command includes a shift command (rotation direction command) and an output command (rotation speed command). The shift command is a rotation direction command that causes the stop, the forward rotation or the reverse rotation of the propeller 40. The output command is a rotation speed command that causes a propulsive force to be generated, specifically, a target rotation speed value. The motor controller 43 controls the rotation direction and the rotation speed of the electric motor 42 according to the shift command (rotation direction command) and the output command.

[0055] In this example, the operator 45 dedicated for the bow thruster BT is connected to the motor controller 43. The user is able to adjust the rotation direction and the rotation speed of the bow thruster BT by operating the operator 45.

[0056] The GPS receiver 52 is an exemplary position detection device. The GPS receiver 52 detects the position of the watercraft 1 by receiving radio waves from an artificial satellite orbiting the earth, and outputs position data indicating the position of the watercraft 1 and speed data indicating the moving speed of the watercraft 1. The main controller 50 acquires the position data and the speed data, which are used to control and display the position and/or the azimuth of the watercraft 1. GPS is a specific example of GNSS (Global Navigation Satellite System).

[0057] The azimuth sensor 53 detects the azimuth of the watercraft 1 to generate azimuth data, which is used by the main controller 50.

[0058] The gauge 9 is connected to the onboard network 55. The gauge 9 is a display device that displays various information for the watercraft maneuvering. The

gauge 9 is able to communicate, for example, with the main controller 50, the remote control ECU 51 and the motor controller 43. Thus, the gauge 9 is able to display the operation state of the outboard motor OM, the operation state of the bow thruster BT, the position and/or the azimuth of the watercraft 1, and other information. The gauge 9 may include an input device 10 such as touch panel and buttons. The input device 10 may be operated by the user to set various settings and give various commands such that operation signals are outputted to the onboard network 55. An additional network other than the onboard network 55 may be provided to transmit display control signals related to the gauge 9.

[0059] Further, an application switch panel 60 is connected to the onboard network 55. The application switch panel 60 includes a plurality of function switches 61 to be operated to apply predefined function commands. For example, the function switches 61 may include switches for automatic watercraft maneuvering commands. More specifically, a command for a bow holding mode (Heading Hold) in which an automatic steering operation is performed to maintain the bow azimuth during forward sailing may be assigned to one of the function switches 61, and a command for a straight sailing holding mode (Course Hold) in which an automatic steering operation is performed to maintain the bow azimuth and a straight course during forward sailing may be assigned to another of the function switches 61. Further, a command for a checkpoint following mode (Track Point™) in which an automatic steering operation is performed to follow a course (route) passing through specified checkpoints may be assigned to further another of the function switches 61, and a command for a pattern sailing mode (Pattern Steer) in which an automatic steering operation is performed to follow a predetermined sailing pattern (zig-zag pattern, spiral pattern or the like) may be assigned to still another of the function switches 61.

[0060] FIG. 3 is a perspective view showing the structure of the joystick unit 18 by way of example. The joystick unit 18 includes the joystick 8, which is tiltable forward, backward, leftward, and rightward (i.e., in all 360-degree directions) from its neutral tilt position, and is pivotable or twistable leftward and rightward from its neutral twist position about its axis. In this example, the joystick unit 18 further includes the operation buttons 180. The operation buttons 180 include a joystick button 181 and holding mode setting buttons 182 to 184.

[0061] The joystick button 181 is an operator to be operated by a user (a watercraft operator) to select a control mode (watercraft maneuvering mode) utilizing the joystick 8, i.e., the joystick mode.

[0062] The holding mode setting buttons 182, 183, 184 are operation buttons to be operated by the user to select position/azimuth holding control modes (examples of an automatic watercraft maneuvering mode). More specifically, the holding mode setting button 182 is operated to select a fixed-point holding mode (Stay Point™) in which the position and the bow azimuth (or the stern azimuth) of

the watercraft 1 are maintained. The holding mode setting button 183 is operated to select a position holding mode (Fish Point™) in which the position of the watercraft 1 is maintained but the bow azimuth (or the stern azimuth) of the watercraft 1 is not maintained. The holding mode setting button 184 is operated to select an azimuth holding mode (Drift Point™) in which the bow azimuth (or the stern azimuth) of the watercraft 1 is maintained but the position of the watercraft 1 is not maintained.

[0063] The control mode of the main controller 50 can be classified into an ordinary mode, the joystick mode or the automatic watercraft maneuvering mode in terms of the operation system.

[0064] In the ordinary mode, a steering control operation is performed according to the operation angle signal generated by the steering wheel unit 16, and a propulsive force control operation is performed according to the operation signal (operation position signal) of the remote control lever 7. In the present example embodiment, the ordinary mode is a default control mode of the main controller 50. In the steering control operation, specifically, the steering ECU 22 drives the steering actuator 25 according to the operation angle signal generated by the steering wheel unit 16 or the steering angle command generated by the remote control ECU 51. Thus, the body of the outboard motor OM is steered leftward and rightward such that the propulsive force direction is changed leftward and rightward with respect to the hull 2. In the propulsive force control operation, specifically, the engine ECU 21 drives the shift actuator 28 and the throttle actuator 27 according to the propulsive force command (the shift command and the output command) issued from the remote control ECU 51 to the engine ECU 21. Thus, the shift position of the outboard motor OM is set to the forward shift position, the reverse shift position or the neutral shift position, and the engine output (specifically, the engine speed) of the outboard motor OM is changed.

[0065] In the joystick mode, the steering control operation and the propulsive force control operation are performed according to the operation signal of the joystick 8 of the joystick unit 18.

[0066] In the joystick mode, the steering control operation and the propulsive force control operation are performed on the outboard motor OM. That is, the main controller 50 issues the steering angle command and the propulsive force command to the remote control ECU 51, and the remote control ECU 51 issues the steering angle command and the propulsive force command to the steering ECU 22 and the engine ECU 21, respectively.

[0067] In the automatic watercraft maneuvering mode, the steering control operation and/or the propulsive force control operation are automatically performed by the functions of the main controller 50 and the like without the operation of the steering wheel 6, the remote control lever 7 and the joystick 8. That is, an automatic watercraft maneuvering operation is performed. The automatic watercraft maneuvering operation includes an automatic

watercraft maneuvering operation to be performed on a sailing basis during sailing, and an automatic watercraft maneuvering operation on a position/azimuth holding basis to maintain one or both of the position and the azimuth. Examples of the automatic watercraft maneuvering operation on the sailing basis include the automatic steering operations to be selected by operating the function switches 61. Examples of the automatic watercraft maneuvering operation on the position/azimuth holding basis include watercraft maneuvering operations to be performed in the fixed-point holding mode, the position holding mode and the azimuth holding mode, which are respectively selected by operating the holding mode setting buttons 182, 183 and 184.

[0068] In the present example embodiment, a cooperative mode in which the outboard motor OM and the bow thruster BT cooperate to achieve an intended hull behavior or a non-cooperative mode in which the outboard motor OM and the bow thruster BT do not cooperate is selectable in the joystick mode and the automatic watercraft maneuvering mode. A selection operator operable by the user to select the cooperative mode or the non-cooperative mode, for example, may be assigned to any of the function switches 61 provided on the application switch panel 60. Alternatively, the selection of the cooperative mode or the non-cooperative mode may be achieved by operating the input device 10 of the gauge 9. In the cooperative mode, the main controller 50 performs the steering control operation and the propulsive force control operation on the outboard motor OM and, in addition, performs the propulsive force control operation on the bow thruster BT.

[0069] FIGS. 4 and 5 are diagrams for describing a first joystick mode in the cooperative mode, showing the operation states of the joystick 8 and the corresponding behaviors of the hull 2. In the first joystick mode, the main controller 50 includes a plurality of sub-modes (control modes) including a neutral mode in which no propulsive force is applied to the hull 2, a bow turning mode in which the bow of the hull 2 is turned, and an anteroposterior mode in which the hull 2 is anteroposteriorly moved. When the joystick 8 is in the neutral tilt position and the neutral twist position, the main controller 50 is in the neutral mode. In the neutral mode, the main controller 50 controls the propulsive force of the bow thruster BT to zero, sets the shift position of the outboard motor OM to the neutral shift position N, and controls the steering angle of the outboard motor OM to zero. When the joystick 8 is tilted from the neutral tilt position in the neutral twist position, the main controller 50 is switched from the neutral mode to the anteroposterior mode. This operation is shown in FIG. 4. Further, when the joystick 8 is twisted from the neutral twist position in the neutral tilt position, the main controller 50 is switched from the neutral mode to the bow turning mode. This operation is shown in FIG. 5.

[0070] Referring to FIG. 4, the main controller 50 is switched into the anteroposterior mode when the joystick

8 is operated anteroposteriorly in the neutral mode. The main controller 50 determines that the joystick 8 is operated anteroposteriorly, if the anteroposterior component of the tilt amount of the joystick 8 from the neutral tilt position 80 (see FIG. 6) (hereinafter referred to simply as "tilt amount") falls outside a predetermined anteroposterior insensitive zone 81 (see FIG. 6). The main controller 50 determines that the joystick 8 is operated laterally if the lateral component of the tilt amount of the joystick 8 falls outside a lateral insensitive zone 82 (see FIG. 6).

[0071] In the anteroposterior mode, the main controller 50 causes the bow thruster BT to generate the propulsive force according to the lateral component of the tilt amount of the joystick 8. Further, the main controller 50 causes the outboard motor OM to generate the propulsive force according to the anteroposterior component of the tilt amount of the joystick 8. Further, the main controller 50 controls the steering angle of the outboard motor OM by controlling the steering actuator 25 according to the twisting of the joystick 8 to drive the steering mechanism 26.

[0072] More specifically, if the joystick 8 is tilted straight forward from the neutral tilt position, the main controller 50 controls the propulsive force of the bow thruster BT to zero, sets the shift position of the outboard motor OM to the forward shift position F, controls the magnitude of the propulsive force of the outboard motor OM according to the tilt amount of the joystick 8, and controls the steering angle of the outboard motor OM to zero. If the joystick 8 is thereafter twisted, the main controller 50 steers the outboard motor OM so as to promote the bow turning of the hull 2 in a direction corresponding to the twisting direction (twist direction) of the joystick 8. That is, the steering direction of the outboard motor OM corresponds to the twisting direction of the joystick 8, and the steering amount of the outboard motor OM corresponds to the twisting amount (twist amount) of the joystick 8. The twisting amount is a twisting amount from the neutral twist position of the joystick 8 (this definition also applies to the following description). The propulsive force of the bow thruster BT is kept at zero. Therefore, the user is able to adjust the steering of the outboard motor OM by the twisting of the joystick 8, while adjusting the propulsive force of the outboard motor OM by the forward tilt amount of the joystick 8.

[0073] If the joystick 8 is tilted in a diagonally forward-right direction, the main controller 50 causes the bow thruster BT to generate a rightward propulsive force, and controls the magnitude of the rightward propulsive force according to the lateral component of the tilt amount of the joystick 8. Further, the main controller 50 sets the shift position of the outboard motor OM to the forward shift position F, controls the magnitude of the propulsive force of the outboard motor OM according to the anteroposterior component of the tilt amount of the joystick 8, and controls the steering angle of the outboard motor OM to zero. If the joystick 8 is thereafter twisted, the main controller 50 steers the outboard motor OM so as to

promote the bow turning of the hull 2 in a direction corresponding to the twisting direction of the joystick 8. That is, the steering direction of the outboard motor OM corresponds to the twisting direction of the joystick 8, and the steering amount of the outboard motor OM corresponds to the twisting amount of the joystick 8. The rightward propulsive force generated by the bow thruster BT applies a clockwise bow turning moment to the hull 2. Therefore, if the joystick 8 is twisted counterclockwise, the outboard motor OM is steered leftward with respect to its neutral steering position (a position at which the steering angle is zero), and the propulsive force of the outboard motor OM applies a counterclockwise bow turning moment to the hull 2. Therefore, the clockwise bow turning moment applied by the propulsive force of the bow thruster BT is reduced. Further, if the joystick 8 is twisted clockwise, the outboard motor OM is steered rightward with respect to the neutral steering position, and the propulsive force of the outboard motor OM applies a clockwise bow turning moment to the hull 2. Therefore, the clockwise bow turning moment is added to the clockwise bow turning moment applied by the propulsive force of the bow thruster BT. Thus, the user is able to move the hull 2 in the diagonally forward-right direction by the tilting of the joystick 8, and is able to adjust the bow turning of the hull 2 by the twisting of the joystick 8. For example, the user is able to find a twist position of the joystick 8 at which the hull 2 is free from the bow turning, while operating the joystick 8, to cause the hull 2 to translate in the diagonally forward-right direction.

[0074] If the joystick 8 is tilted in a diagonally forward-left direction, the main controller 50 causes the bow thruster BT to generate a leftward propulsive force, and controls the magnitude of the leftward propulsive force according to the lateral component of the tilt amount of the joystick 8.

[0075] Further, the main controller 50 sets the shift position of the outboard motor OM to the forward shift position F, controls the magnitude of the propulsive force of the outboard motor OM according to the anteroposterior component of the tilt amount of the joystick 8, and controls the steering angle of the outboard motor OM to zero. If the joystick 8 is thereafter twisted, the main controller 50 steers the outboard motor OM so as to promote the bow turning of the hull 2 in a direction corresponding to the twisting direction of the joystick 8. That is, the steering direction of the outboard motor OM corresponds to the twisting direction of the joystick 8, and the steering amount of the outboard motor OM corresponds to the twisting amount of the joystick 8. The leftward propulsive force generated by the bow thruster BT applies a counterclockwise bow turning moment to the hull 2. Therefore, if the joystick 8 is twisted clockwise, the outboard motor OM is steered rightward with respect to the neutral steering position, and the propulsive force of the outboard motor OM applies a clockwise bow turning moment to the hull 2. Therefore, the counterclockwise bow turning moment applied by the propulsive force of

the bow thruster BT is reduced. Further, if the joystick 8 is twisted counterclockwise, the outboard motor OM is steered leftward with respect to the neutral steering position, and the propulsive force of the outboard motor OM applies a counterclockwise bow turning moment to the hull 2. Therefore, the counterclockwise bow turning moment is added to the counterclockwise bow turning moment applied by the propulsive force of the bow thruster BT. Thus, the user is able to move the hull 2 in the diagonally forward-left direction by the tilting of the joystick 8, and is able to adjust the bow turning of the hull 2 by the twisting of the joystick 8. For example, the user is able to find a twist position of the joystick 8 at which the hull 2 is free from the bow turning, while operating the joystick 8, to cause the hull 2 to translate in the diagonally forward-left direction.

[0076] If the joystick 8 is tilted straight rearward from the neutral tilt position, the main controller 50 controls the propulsive force of the bow thruster BT to zero, sets the shift position of the outboard motor OM to the reverse shift position R, controls the magnitude of the propulsive force of the outboard motor OM according to the tilt amount of the joystick 8, and controls the steering angle of the outboard motor OM to zero. If the joystick 8 is thereafter twisted, the main controller 50 steers the outboard motor OM so as to promote the bow turning of the hull 2 in a direction corresponding to the twisting direction of the joystick 8. That is, the steering direction of the outboard motor OM corresponds to a direction opposite to the twisting direction of the joystick 8, and the steering amount of the outboard motor OM corresponds to the twisting amount of the joystick 8. The propulsive force of the bow thruster BT is kept at zero. Thus, the user is able to adjust the steering of the outboard motor OM by the twisting of the joystick 8 while adjusting the propulsive force of the outboard motor OM by the rearward tilt amount of the joystick 8.

[0077] If the joystick 8 is tilted in a diagonally rearward-right direction, the main controller 50 causes the bow thruster BT to generate a rightward propulsive force, and controls the magnitude of the rightward propulsive force according to the lateral component of the tilt amount of the joystick 8. Further, the main controller 50 sets the shift position of the outboard motor OM to the reverse shift position R, controls the magnitude of the propulsive force of the outboard motor OM according to the anteroposterior component of the tilt amount of the joystick 8, and controls the steering angle of the outboard motor OM to zero. If the joystick 8 is thereafter twisted, the main controller 50 steers the outboard motor OM so as to promote the bow turning of the hull 2 in a direction corresponding to the twisting direction of the joystick 8. That is, the steering direction of the outboard motor OM corresponds to a direction opposite to the twisting direction of the joystick 8, and the steering amount of the outboard motor OM corresponds to the twisting amount of the joystick 8. The rightward propulsive force generated by the bow thruster BT applies a clockwise bow

turning moment to the hull 2. Therefore, if the joystick 8 is twisted counterclockwise, the outboard motor OM is steered rightward with respect to the neutral steering position, and the propulsive force of the outboard motor OM applies a counterclockwise bow turning moment to the hull 2. Therefore, the clockwise bow turning moment applied by the propulsive force of the bow thruster BT is reduced. Further, if the joystick 8 is twisted clockwise, the outboard motor OM is steered leftward, and the propulsive force of the outboard motor OM applies a clockwise bow turning moment to the hull 2. Therefore, the clockwise bow turning moment is added to the clockwise bow turning moment applied by the propulsive force of the bow thruster BT. Thus, the user is able to move the hull 2 in the diagonally rearward-right direction by the tilting of the joystick 8, and is able to adjust the bow turning of the hull 2 by the twisting of the joystick 8. For example, the user is able to find a twist position of the joystick 8 at which the hull 2 is free from the bow turning, while operating the joystick 8, to cause the hull 2 to translate in the diagonally rearward-right direction.

[0078] If the joystick 8 is tilted in a diagonally rearward-left direction, the main controller 50 causes the bow thruster BT to generate a leftward propulsive force, and controls the magnitude of the leftward propulsive force according to the lateral component of the tilt amount of the joystick 8. Further, the main controller 50 sets the shift position of the outboard motor OM to the reverse shift position R, controls the magnitude of the propulsive force of the outboard motor OM according to the anteroposterior component of the tilt amount of the joystick 8, and controls the steering angle of the outboard motor OM to zero. If the joystick 8 is thereafter twisted, the main controller 50 steers the outboard motor OM so as to promote the bow turning of the hull 2 in a direction corresponding to the twisting direction of the joystick 8. That is, the steering direction of the outboard motor OM corresponds to a direction opposite to the twisting direction of the joystick 8, and the steering amount of the outboard motor OM corresponds to the twisting amount of the joystick 8. The leftward propulsive force generated by the bow thruster BT applies a counterclockwise bow turning moment to the hull 2. Therefore, if the joystick 8 is twisted clockwise, the outboard motor OM is steered leftward with respect to the neutral steering position, and the propulsive force of the outboard motor OM applies a clockwise bow turning moment to the hull 2. Therefore, the counterclockwise bow turning moment applied by the propulsive force of the bow thruster BT is reduced. Further, if the joystick 8 is twisted counterclockwise, the outboard motor OM is steered rightward with respect to the neutral steering position, and the propulsive force of the outboard motor OM applies a counterclockwise bow turning moment to the hull 2. Therefore, the counterclockwise bow turning moment is added to the counterclockwise bow turning moment applied by the propulsive force of the bow thruster BT. Thus, the user is able to move the hull 2 in the diagonally

rearward-left direction by the tilting of the joystick 8, and is able to adjust the bow turning of the hull 2 by the twisting of the joystick 8. For example, the user is able to find a twist position of the joystick 8 at which the hull 2 is free from the bow turning, while operating the joystick 8, to cause the hull 2 to translate in the diagonally rearward-left direction.

[0079] It is noted that, even if the anteroposterior component of the tilt amount of the joystick 8 falls within the anteroposterior insensitive zone 81 (see FIG. 6) when the lateral component of the tilt amount of the joystick 8 falls outside the lateral insensitive zone 82 (see FIG. 6) in the anteroposterior mode, the main controller 50 is maintained in the anteroposterior mode. This feature is not illustrated in FIG. 4 to avoid complication.

[0080] Even if the lateral component of the tilt amount of the joystick 8 falls outside the lateral insensitive zone 82 (see FIG. 6) when the anteroposterior component of the tilt amount of the joystick 8 falls within the anteroposterior insensitive zone 81 (see FIG. 6), the main controller 50 is maintained in the neutral mode, and controls the propulsive forces of the bow thruster BT and the outboard motor OM to zero. That is, the bow thruster BT is not driven, and the shift position of the outboard motor OM is set to the neutral shift position N.

[0081] When the anteroposterior component of the tilt amount of the joystick 8 falls within the anteroposterior insensitive zone 81 (see FIG. 6) and the lateral component of the tilt amount of the joystick 8 falls within the lateral insensitive zone 82 (see FIG. 6), the main controller 50 determines that the joystick 8 is in the neutral tilt position. When the twisting amount of the joystick 8 falls within a predetermined twist insensitive zone, the main controller 50 determines that the joystick 8 is in the neutral twist position. When the joystick 8 is in the neutral tilt position and the neutral twist position, the main controller 50 is in the neutral mode. Even if the joystick 8 is tilted laterally from the neutral tilt position over the lateral insensitive zone 82 (see FIG. 6) when the anteroposterior component of the tilt amount of the joystick 8 falls within the anteroposterior insensitive zone 81 (see FIG. 6) in the neutral mode, the main controller 50 is maintained in the neutral mode.

[0082] Referring next to FIG. 5, the main controller 50 is switched to the bow turning mode when the joystick 8 is twisted in the neutral mode.

[0083] In the bow turning mode, the main controller 50 causes the bow thruster BT to generate a propulsive force according to the twisting of the joystick 8. Further, the main controller 50 steers the outboard motor OM according to the twisting of the joystick 8, and causes the outboard motor OM to generate a propulsive force according to the anteroposterior component of the tilt amount of the joystick 8.

[0084] More specifically, if the joystick 8 is twisted from the neutral twist position, the main controller 50 drives the bow thruster BT so as to promote the bow turning of the hull 2 in a direction corresponding to the twisting direction

of the joystick 8. That is, if the joystick 8 is twisted clockwise from the neutral twist position, the main controller 50 causes the bow thruster BT to generate a rightward propulsive force, and controls the magnitude of the rightward propulsive force according to the twisting amount of the joystick 8 from the neutral twist position. Thus, a clockwise bow turning moment is applied to the hull 2. Further, if the joystick 8 is twisted counterclockwise from the neutral twist position, the main controller 50 causes the bow thruster BT to generate a leftward propulsive force, and controls the magnitude of the leftward propulsive force according to the twisting amount of the joystick 8 from the neutral twist position. Thus, a counterclockwise bow turning moment is applied to the hull 2. As long as the anteroposterior component of the tilt amount of the joystick 8 falls within the anteroposterior insensitive zone 81 (see FIG. 6), the main controller 50 sets the shift position of the outboard motor OM to the neutral shift position N so as to prevent the outboard motor OM from generating the propulsive force. Thus, a fixed-point bow turning behavior is achieved by utilizing the propulsive force of the bow thruster BT alone. In the bow turning mode, however, the main controller 50 may control the steering angle of the outboard motor OM according to the twisting of the joystick 8. This steering angle control may be performed in substantially the same manner as when the joystick 8 is tilted forward in the anteroposterior mode.

[0085] If the joystick 8 is twisted clockwise from the neutral twist position and, in this state, the joystick 8 is tilted straight forward, the main controller 50 sets the shift position of the outboard motor OM to the forward shift position F, and causes the outboard motor OM to generate a propulsive force having a magnitude corresponding to the anteroposterior component of the tilt amount of the joystick 8. At this time, the main controller 50 steers the outboard motor OM in a direction corresponding to the twisting of the joystick 8, i.e., steers the outboard motor OM rightward with respect to the neutral steering position. The steering amount of the outboard motor OM corresponds to the twisting amount of the joystick 8 from the neutral twist position. Thus, the propulsive force of the outboard motor OM, as well as the propulsive force of the bow thruster BT, applies a clockwise bow turning moment to the hull 2.

[0086] If the joystick 8 is twisted clockwise from the neutral twist position and, in this state, the joystick 8 is tilted straight rearward, on the other hand, the main controller 50 sets the shift position of the outboard motor OM to the reverse shift position R, and causes the outboard motor OM to generate a propulsive force having a magnitude corresponding to the anteroposterior component of the tilt amount of the joystick 8. At this time, the main controller 50 steers the outboard motor OM in a direction opposite to the twisting direction of the joystick 8, i.e., steers the outboard motor OM leftward with respect to the neutral steering position. The steering amount of the outboard motor OM corresponds to the twisting amount of the joystick 8 from the neutral twist

position. Thus, the propulsive force of the outboard motor OM, as well as the propulsive force of the bow thruster BT, applies a clockwise bow turning moment to the hull 2.

[0087] If the joystick 8 is twisted counterclockwise from the neutral twist position and, in this state, the joystick 8 is tilted straight forward, the main controller 50 sets the shift position of the outboard motor OM to the forward shift position F, and causes the outboard motor OM to generate a propulsive force having a magnitude corresponding to the anteroposterior component of the tilt amount of the joystick 8. At this time, the main controller 50 steers the outboard motor OM in a direction corresponding to the twisting of the joystick 8, i.e., steers the outboard motor OM leftward with respect to the neutral steering position. The steering amount of the outboard motor OM corresponds to the twisting amount of the joystick 8 from the neutral twist position. Thus, the propulsive force of the outboard motor OM, as well as the propulsive force of the bow thruster BT, applies a counterclockwise bow turning moment to the hull 2.

[0088] If the joystick 8 is twisted counterclockwise from the neutral twist position and, in this state, the joystick 8 is tilted straight rearward, on the other hand, the main controller 50 sets the shift position of the outboard motor OM to the reverse shift position R, and causes the outboard motor OM to generate a propulsive force having a magnitude corresponding to the anteroposterior component of the tilt amount of the joystick 8. At this time, the main controller 50 steers the outboard motor OM in a direction opposite to the twisting direction of the joystick 8, i.e., steers the outboard motor OM rightward with respect to the neutral steering position. The steering amount of the outboard motor OM corresponds to the twisting amount of the joystick 8 from the neutral twist position. Thus, the propulsive force of the outboard motor OM, as well as the propulsive force of the bow thruster BT, applies a counterclockwise bow turning moment to the hull 2.

[0089] If the joystick 8 is tilted in any of the diagonal directions (i.e., in the forward-right direction, the rearward-right direction, the forward-left direction or the rearward-left direction) in the bow turning mode, the main controller 50 is switched into the anteroposterior mode. In the bow turning mode, the steering control operation is performed on the outboard motor OM according to the twisting of the joystick 8 as in the anteroposterior mode. Therefore, even if the main controller 50 is switched into the anteroposterior mode from the bow turning mode, the continuity of the watercraft maneuvering feeling is not impaired.

[0090] FIG. 7 is a diagram for describing a second joystick mode in the cooperative mode, showing the operation states of the joystick 8 and the corresponding behaviors of the hull 2. Either the first joystick mode described above or the second joystick mode to be described below is selectable, for example, by operating the input device 10. When the joystick mode is selected by operating the joystick button 181, the main controller

50 performs a process according to the first joystick mode or the second joystick mode selected by the operation of the input device 10.

[0091] In the second joystick mode, the main controller 50 regards the tilting of the joystick 8 as a translation command. Specifically, the main controller 50 regards the tilt direction of the joystick 8 as a traveling direction command indicating the traveling direction of the hull 2, and regards the tilt amount of the joystick 8 as a propulsive force magnitude command indicating the magnitude of the propulsive force to be applied in the traveling direction. Further, the main controller 50 regards the twisting of the joystick 8 about its axis as a bow turning command. Specifically, the main controller 50 regards the twisting direction of the joystick 8 about its axis (with respect to the neutral twist position) as a bow turning direction command, and regards the twisting amount of the joystick 8 (with respect to the neutral twist position) as a bow turning speed command. In order to follow these commands, the main controller 50 inputs a steering angle command and a propulsive force command to the remote control ECU 51, and inputs a propulsive force command to the motor controller 43 of the bow thruster BT.

[0092] The remote control ECU 51 transmits the steering angle command and the propulsive force command to the steering ECU 22 and the engine ECU 21, respectively, of the outboard motor OM. Thus, the outboard motor OM is steered to a steering angle indicated by the steering angle command, and the shift position and the engine speed of the outboard motor OM are controlled so as to generate a propulsive force indicated by the propulsive force command. Further, the motor controller 43 controls the rotation direction and the rotation speed of the electric motor 42 so as to generate a propulsive force having a direction and a magnitude indicated by the propulsive force command inputted thereto.

[0093] In the present example embodiment, the joystick 8 is an exemplary translation/bow turning operator to be operated by the user to give commands for the translation and the bow turning of the hull 2.

[0094] When the joystick 8 is tilted without being twisted in the second joystick mode, the hull 2 is moved in a direction corresponding to the tilt direction of the joystick 8 without the bow turning, i.e., with its azimuth maintained. That is, the hull 2 is in a hull behavior of translation movement. Examples of the translation movement are shown in FIG. 7. A control mode of the main controller 50 in which the translation movement is achieved according to the operation (tilting) of the joystick 8 as shown in FIG. 7 is a so-called translation watercraft maneuvering mode.

[0095] The translation movement is achieved by moving the hull 2 in a state such that the bow turning moment applied to the hull 2 by the bow thruster BT and the bow turning moment applied to the hull 2 by the outboard motor OM cancel each other out (with the total bow turning moment kept at zero).

[0096] When the joystick 8 is tilted straight forward, the main controller 50 sets the shift position of the outboard motor OM to the forward shift position F, and controls the propulsive force of the bow thruster BT to zero. When the joystick 8 is tilted straight rearward, the main controller 50 sets the shift position of the outboard motor OM to the reverse shift position R, and controls the propulsive force of the bow thruster BT to zero. The propulsive force to be generated by the outboard motor OM is determined based on the tilt amount of the joystick 8. Thus, the hull 2 is caused to translate forward or rearward according to the operation of the joystick 8.

[0097] When the joystick 8 is tilted in the diagonally forward-right direction, the main controller 50 causes the bow thruster BT to generate a rightward propulsive force, and sets the shift position of the outboard motor OM to the forward shift position F. Further, the main controller 50 controls the steering angle of the outboard motor OM to steer the outboard motor OM leftward with respect to the neutral steering position (the position at which the steering angle is zero). Then, the propulsive force of the bow thruster BT applies a clockwise bow turning moment to the hull 2, and the propulsive force of the outboard motor OM applies a counterclockwise bow turning moment to the hull 2. Therefore, the clockwise bow turning moment and the counterclockwise bow turning moment cancel each other out, thus causing the hull 2 to translate in the diagonally forward-right direction. The propulsive force of the outboard motor OM is determined based on the tilt amount of the joystick 8, and the output of the bow thruster BT is determined by multiplying the lateral component of the propulsive force of the outboard motor OM by a predetermined ratio.

[0098] When the joystick 8 is tilted in the diagonally forward-left direction, the main controller 50 causes the bow thruster BT to generate a leftward propulsive force, and sets the shift position of the outboard motor OM to the forward shift position F. Further, the main controller 50 controls the steering angle of the outboard motor OM to steer the outboard motor OM rightward with respect to the neutral steering position (the position at which the steering angle is zero). Then, the propulsive force of the bow thruster BT applies a counterclockwise bow turning moment to the hull 2, and the propulsive force of the outboard motor OM applies a clockwise bow turning moment to the hull 2. Therefore, the counterclockwise bow turning moment and the clockwise bow turning moment cancel each other out, thus causing the hull 2 to translate in the diagonally forward-left direction. The propulsive force of the outboard motor OM is determined based on the tilt amount of the joystick 8, and the output of the bow thruster BT is determined by multiplying the lateral component of the propulsive force of the outboard motor OM by a predetermined ratio.

[0099] When the joystick 8 is tilted in the diagonally rearward-right direction, the main controller 50 causes the bow thruster BT to generate a rightward propulsive force, and sets the shift position of the outboard motor

OM to the reverse shift position R. Further, the main controller 50 controls the steering angle of the outboard motor OM to steer the outboard motor OM rightward with respect to the neutral steering position (the position at which the steering angle is zero). Then, the propulsive force of the bow thruster BT applies a clockwise bow turning moment to the hull 2, and the propulsive force of the outboard motor OM applies a counterclockwise bow turning moment to the hull 2. Therefore, the clockwise bow turning moment and the counterclockwise bow turning moment cancel each other out, thus causing the hull 2 to translate in the diagonally rearward-right direction. The propulsive force of the outboard motor OM is determined based on the tilt amount of the joystick 8, and the output of the bow thruster BT is determined by multiplying the lateral component of the propulsive force of the outboard motor OM by a predetermined ratio.

[0100] When the joystick 8 is tilted in the diagonally rearward-left direction, the main controller 50 causes the bow thruster BT to generate a leftward propulsive force, and sets the shift position of the outboard motor OM to the reverse shift position R. Further, the main controller 50 controls the steering angle of the outboard motor OM to steer the outboard motor OM leftward with respect to the neutral steering position (the position at which the steering angle is zero). Then, the propulsive force of the bow thruster BT applies a counterclockwise bow turning moment to the hull 2, and the propulsive force of the outboard motor OM applies a clockwise bow turning moment to the hull 2. Therefore, the counterclockwise bow turning moment and the clockwise bow turning moment cancel each other out, thus causing the hull 2 to translate in the diagonally rearward-left direction. The propulsive force of the outboard motor OM is determined based on the tilt amount of the joystick 8, and the output of the bow thruster BT is determined by multiplying the lateral component of the propulsive force of the outboard motor OM by a predetermined ratio.

[0101] Since the steering angle of the outboard motor OM is less than 90 degrees (e.g., about 30 degrees) leftward and rightward, it is impossible to direct the resultant propulsive force of the single outboard motor OM and the bow thruster BT exactly laterally of the hull 2 (in a horizontal direction orthogonal to the center line 2a of the hull 2, or rightward or leftward of the hull 2). In the present example embodiment, therefore, the main controller 50 is designed so as to alternately repeat a diagonally forward movement and a diagonally rearward movement if the joystick 8 is tilted exactly laterally (rightward or leftward). If the joystick 8 is tilted rightward within the anteroposterior insensitive zone, specifically, the hull 2 is moved laterally rightward in a zig-zag traveling pattern by alternately repeating the translation movement in the diagonally forward-right direction and the translation movement in the diagonally rearward-right direction. Likewise, if the joystick 8 is tilted leftward within the anteroposterior insensitive zone, the hull 2 is moved laterally leftward in a zig-zag traveling pattern by alternately repeating the

translation movement in the diagonally forward-left direction and the translation movement in the diagonally rearward-left direction. These operations will be described later in detail.

[0102] The following control parameters are preliminarily stored in the memory 50b of the main controller 50 for proper thrust allocation for the translation movement.

[0103] Control parameters for diagonally forward-right translation

- A ratio between an outboard motor lateral thrust and a bow thruster output for the diagonally forward-right translation
- A maximum outboard motor thrust value for the diagonally forward-right translation
- A steering angle for the diagonally forward-right translation Control parameters for diagonally forward-left translation
- A ratio between an outboard motor lateral thrust and a bow thruster output for the diagonally forward-left translation
- A maximum outboard motor thrust value for the diagonally forward-left translation
- A steering angle for the diagonally forward-left translation Control parameters for diagonally rearward-right translation
- A ratio between an outboard motor lateral thrust and a bow thruster output for the diagonally rearward-right translation
- A maximum outboard motor thrust value for the diagonally rearward-right translation
- A steering angle for the diagonally rearward-right translation

[0104] Control parameters for diagonally rearward-left translation

- A ratio between an outboard motor lateral thrust and a bow thruster output for the diagonally rearward-left translation
- A maximum outboard motor thrust value for the diagonally rearward-left translation
- A steering angle for the diagonally rearward-left translation

[0105] The main controller 50 determines the target propulsive force of the outboard motor OM according to the tilt amount of the joystick 8. Then, the main controller 50 determines the output (target output value) of the bow thruster BT by multiplying the lateral component of the target propulsive force (the outboard motor lateral thrust, corresponding to the lateral component of the tilt amount of the joystick 8) by the control parameter value of the ratio between the outboard motor lateral thrust and the bow thruster output. The control parameter "maximum outboard motor thrust value" indicates the upper limit value of the absolute value of a propulsive force permitted to be generated by the outboard motor OM, and the

control parameter value of the maximum outboard motor thrust value is set so that the bow turning moment applied to the hull 2 by the outboard motor OM is cancelled out by the bow turning moment applied to the hull 2 by the bow thruster BT. The control parameter "steering angle" indicates the steering angle (target steering angle) of the outboard motor OM in the translation movement.

[0106] The control parameters may be each set to a default value (initial value) when the main controller 50 is shipped from a factory. However, the conditions for the translation movement vary depending on the individual watercraft 1, i.e., depending on the shape and the size of the hull 2, the type and the attachment position of the bow thruster BT, the type (model) and the attachment position of the outboard motor OM, the layout of other watercraft devices, loads and the like. Therefore, control parameter values (calibration values) are properly determined by performing calibration on the individual watercraft 1, and stored in the memory 50b.

[0107] Specifically, the calibration is herein performed to find control parameter values that make it possible to properly achieve the diagonally forward-right translation, the diagonally forward-left translation, the diagonally rearward-right translation, and the diagonally rearward-left translation of the hull 2, i.e., the diagonal translation movements of the hull 2 without the bow turning, and store the control parameter values as the calibration values in the memory 50b. The calibration thus performed makes it possible to achieve a translation movement as intended by the user according to the operation of the joystick 8. Typically, the diagonally forward-right translation, the diagonally forward-left translation, the diagonally rearward-right translation, and the diagonally rearward-left translation are individually calibrated such that the calibration values for the respective diagonal translations are generated and then stored in the memory 50b (see FIG. 2).

[0108] A calibration procedure and a calibration process to be performed by the main controller 50 will be described below by way of specific example. The diagonally forward-right translation, the diagonally forward-left translation, the diagonally rearward-right translation, and the diagonally rearward-left translation may be calibrated in any order. A procedure and a process to be performed to calibrate the diagonally forward-right translation, the diagonally forward-left translation, the diagonally rearward-right translation, and the diagonally rearward-left translation in this order will be described below.

[0109] FIG. 8 is a flowchart showing an exemplary process to be performed for the diagonal translation calibration by the main controller 50.

[0110] The calibration is started when a calibrating person performs a predetermined calibration start operation to give a calibration mode command to the main controller 50. In this case, the calibrating person may be the user, or may be a worker of a boat builder, a dealer or the like. The calibration start operation may be, for example, the long-pressing of the joystick button 181. If the

calibration start operation is performed (YES in Step S1), the control mode of the main controller 50 is switched into the calibration mode (Step S2). The calibrating person may be notified of the calibration mode by an indicator such as an LED lamp (not shown) provided in the joystick unit 18.

[0111] Upon the switching to the calibration mode, the main controller 50 reads out previously stored control parameter values (previous calibration values) from the memory 50b and, when the calibrating person operates the joystick 8, the main controller 50 generates a propulsive force command and a steering angle command by using the control parameter values thus read out (Step S3). If the calibration is performed for the first time, the control parameter values are default values preliminarily written in the memory 50b. Where the calibration is previously performed, the control parameter values are those set by the previous calibration. However, the control parameter values (calibration values) set by the previous calibration may be reset to the default values by a reset operation to be described later.

[0112] In the calibration mode, the calibrating person performs a diagonal translation operation for the calibration. Here, the calibrating person performs a diagonally forward-right translation operation, i.e., tilts the joystick 8 in the diagonally forward-right direction, by way of example. The calibrating person observes the behavior of the hull 2. If the bow of the hull 2 is turned counterclockwise, the calibrating person twists the joystick 8 clockwise for counteroperation in order to correct the counterclockwise bow turning. If the bow of the hull 2 is turned clockwise, the calibrating person twists the joystick 8 counterclockwise for counteroperation in order to correct the clockwise bow turning.

[0113] According to the operation of the joystick 8, a joystick operation signal is inputted to the main controller 50 from the joystick unit 18. According to the operation signal, the main controller 50 changes the propulsive force command for the bow thruster BT and the propulsive force command and the steering angle command for the outboard motor OM (Step S4). If the behavior of the hull 2 translating in the diagonally forward-right direction is achieved by the operation state of the joystick 8, the calibrating person performs a decision operation (YES in Step S5). The decision operation may be, for example, the pressing of the joystick button 181. In this case, the joystick button 181 is an exemplary calibration ending operator.

[0114] In response to the decision operation, the main controller 50 determines whether or not the joystick 8 is in the neutral tilt position (Step S6). If the joystick 8 is not in the neutral tilt position, calibration values (proper control parameter values) for the diagonally forward-right translation are written and set in the memory 50b (Step S7). The calibration values written in the memory 50b are used when the main controller 50 thereafter computes the propulsive force command and the steering angle command according to the operation of the joystick 8 for

the watercraft maneuvering with the use of the joystick 8. The calibration values for the diagonally forward-right translation are used for the computation of the propulsive force command and the steering angle command when the joystick 8 is tilted in the diagonally forward-right direction in the second joystick mode.

[0115] The main controller 50 computes the calibration values based on the control states of the bow thruster BT and the outboard motor OM observed when the decision operation is performed (Step S5), and writes the calibration values in the memory 50b. Specifically, a steering angle observed when the decision operation is performed is stored on an as-is basis as a calibration value in the memory 50b. Further, the main controller 50 computes a ratio between an outboard motor lateral thrust and a bow thruster output observed when the decision operation is performed, and stores the ratio as a calibration value in the memory 50b. Further, the main controller 50 computes a maximum outboard motor thrust value based on the ratio and the steering angle (stored as the calibration values) and the upper limit value of the output of the bow thruster BT, and stores the maximum outboard motor thrust value as a calibration value in the memory 50b. This calibration value corresponds to a propulsive force to be generated by the outboard motor OM to generate a bow turning moment to prevent the bow turning of the hull 2 against the bow turning moment generated by the propulsive force of the bow thruster BT when the output of the bow thruster BT is its upper limit value. Thereafter, the control mode is switched into the joystick mode (second joystick mode) (Step S8).

[0116] If the joystick 8 is in the neutral tilt position (YES in Step S6) when the decision operation (Step S5) is performed, the main controller 50 determines that the reset operation is performed so as to reset the calibration values to the default values. In this case, the main controller 50 resets the calibration values to the default values (Step S9). Subsequently, the control mode is switched into the joystick mode (second joystick mode) (Step S8).

[0117] Thereafter, the diagonally forward-left translation, the diagonally rearward-right translation, and the diagonally rearward-left translation may be calibrated in substantially the same manner, and calibration values for the diagonally forward-left translation, calibration values for the diagonally rearward-right translation, and calibration values for the diagonally rearward-left translation may be stored in the memory 50b.

[0118] The main controller 50 may write calibration status data in the memory 50b. The calibration status data indicates calibration statuses respectively indicating whether or not the diagonally forward-right translation is calibrated, whether or not the diagonally forward-left translation is calibrated, whether or not the diagonally rearward-right translation is calibrated, and whether or not the diagonally rearward-left translation is calibrated.

[0119] If any one of the diagonally forward-right translation, the diagonally forward-left translation, the diagonally

ally rearward-right translation, and the diagonally rearward-left translation is calibrated, the main controller 50 sets the calibration status of the calibrated diagonal translation to a value indicating "calibrated."

[0120] The main controller 50 may estimate calibration values of the control parameters for the other uncalibrated diagonal translations (each having a calibration status "uncalibrated") based on the calibration values for the calibrated diagonal translation (having the calibration status "calibrated").

[0121] If the calibration values computed by the calibration of the diagonally forward-right translation are stored in the memory 50b, for example, the main controller 50 may estimate the calibration values for the diagonally forward-left translation, for the diagonally rearward-right translation, and for the diagonally rearward-left translation, and store the estimated calibration values in the memory 50b. In this case, the calibration statuses of the other diagonal translations for which the calibration values are estimated are each set to "uncalibrated." By calibrating at least one diagonal translation selected from the diagonally forward-right translation, the diagonally forward-left translation, the diagonally rearward-right translation, and the diagonally rearward-left translation, therefore, somewhat reasonable calibration values may be estimated for the other uncalibrated diagonal translations and stored in the memory 50b. Of course, the calibration values may be more accurately computed and stored in the memory 50b by calibrating two or more of the four diagonal translations (preferably by calibrating all four diagonal translations).

[0122] Typically, the estimation of the calibration values may be achieved based on lateral symmetry and anteroposterior symmetry. Specifically, it may be assumed that the calibration value of the ratio between the outboard motor lateral thrust and the bow thruster output for the diagonally forward-right translation is equal to that for the diagonally forward-left translation. Further, it may be assumed that calibration values obtained by inverting the positive/negative signs of the calibration values for the diagonally forward-right translation and for the diagonally forward-left translation are equal to those for the diagonally rearward-right translation and for the diagonally rearward-left translation, respectively. It may be assumed that the calibration value of the maximum outboard motor thrust value for the diagonally forward-right translation is equal to those for the diagonally forward-left translation, for the diagonally rearward-right translation, and for the diagonally rearward-left translation. It may be assumed that the calibration value of the steering angle for the diagonally forward-right translation is equal to that for the diagonally rearward-left translation. Further, it may be assumed that calibration values obtained by inverting the positive/negative signs of the calibration values for the diagonally forward-right translation and for the diagonally rearward-left translation are equal to those for the diagonally forward-left translation and for the diagonally rearward-right

translation, respectively. Of course, the calibration values may be each estimated by correction with a proper correction factor.

[0123] FIG. 9 is a flowchart showing an exemplary control process to be performed according to the translation command and the bow turning command in the calibration mode, and showing an exemplary operation to be performed in Step S4 of FIG. 8.

[0124] When the calibration mode is started, the calibrating person tilts the joystick 8 diagonally forward or diagonally rearward. Accordingly, the translation command is issued from the joystick unit 18 to the main controller 50. Then, the main controller 50 reads out the control parameter values (the previous calibration values or the default values) from the memory 50b according to the operation direction of the joystick 8 (the diagonally forward-right direction, the diagonally forward-left direction, the diagonally rearward-right direction or the diagonally rearward-left direction), and controls the steering actuator 25 based on the control parameter value of the steering angle to steer the outboard motor OM (Step S41).

[0125] Further, the main controller 50 computes a target propulsive force to be generated by the outboard motor OM based on the tilt amount of the joystick 8 (Step S42). Further, the main controller 50 issues a propulsive force command indicating the shift position and the output of the outboard motor OM based on the target propulsive force to the outboard motor OM (Step S45). Further, the main controller 50 computes the lateral component of the target propulsive force based on the target propulsive force and the steering angle (Step S43). The main controller 50 computes the output of the bow thruster BT by multiplying the lateral component of the target propulsive force by the control parameter value of the ratio between the outboard motor lateral thrust and the bow thruster output (Step S44), and issues a propulsive force command indicating the bow thruster output to the bow thruster BT (Step S46).

[0126] If the bow of the hull 2 is turned, the calibrating person twists the joystick 8 to reduce the bow turning. When the bow turning command issued by the twisting of the joystick 8 is a bow turning promotion command (a command that promotes or causes the bow turning of the hull 2 in the translation direction) indicating the bow turning of the hull 2 in a hull movement direction indicated by the translation command (Step S47), the main controller 50 increases the output of the bow thruster BT (Step S48). Specifically, if the bow of the hull 2 is turned counterclockwise as shown in FIG. 10A when a diagonally forward-right translation command is issued, the calibrating person twists the joystick 8 clockwise. Thus, as shown in FIG. 10B, the output of the bow thruster BT is increased to increase a rightward propulsive force to promote the clockwise bow turning of the hull 2. This correspondingly reduces the counterclockwise bow turning of the hull 2. During this period, the steering angle of the outboard motor OM is not changed.

[0127] Even if the output of the bow thruster BT reaches its upper limit when the bow turning promotion command is issued (YES in Step S49), the main controller 50 reduces the propulsive force of the outboard motor OM while maintaining the steering angle of the outboard motor OM (Step S50, see FIG. 10C). Thus, the bow turning moment applied to the hull 2 by the outboard motor OM is reduced. Even if the propulsive force of the outboard motor OM reaches a predetermined lower limit value when the bow turning promotion command is issued (YES in Step S51), the main controller 50 reduces the absolute value of the steering angle of the outboard motor OM (Step S52). That is, the steering angle of the outboard motor OM is changed so that the propulsive force direction of the outboard motor OM is moved toward the turning center 2c of the hull 2 (see FIG. 10D). During this period, the output of the bow thruster BT is maintained at its upper limit value, and the propulsive force of the outboard motor OM is maintained at its lower limit value.

[0128] When the bow turning command issued by the twisting of the joystick 8 is a bow turning reduction command (a command that reduces the bow turning of the hull 2 in the translation direction) indicating the bow turning of the hull 2 in a direction opposite to the hull movement direction indicated by the translation command (Step S47), on the other hand, the main controller 50 increases the absolute value of the steering angle of the outboard motor OM (Step S53). Specifically, if the bow of the hull 2 is turned clockwise as shown in FIG. 11A when the diagonally forward-right translation command is issued, the calibrating person twists the joystick 8 counterclockwise. Thus, as shown in FIG. 11B, the main controller 50 changes the steering angle of the outboard motor OM so that the propulsive force direction of the outboard motor OM is moved away from the turning center 2c. This correspondingly increases the counterclockwise bow turning moment applied to the hull 2 by the outboard motor OM. Therefore, the counterclockwise bow turning of the hull 2 is promoted, and the clockwise bow turning of the hull 2 is correspondingly reduced. During this period, the output of the bow thruster BT and the propulsive force of the outboard motor OM are not changed.

[0129] Even if the absolute value of the steering angle reaches its upper limit when the bow turning reduction command is issued (YES in Step S54), the main controller 50 increases the propulsive force of the outboard motor OM while maintaining the steering angle of the outboard motor OM (Step S55, see FIG. 11C). Thus, the bow turning moment applied to the hull 2 by the outboard motor OM is increased. Even if the propulsive force of the outboard motor OM reaches a predetermined upper limit value when the bow turning reduction command is issued (YES in Step S56), the main controller 50 reduces the output of the bow thruster BT (Step S57, see FIG. 11D). Thus, the bow turning moment applied to the hull 2 by the bow thruster BT is reduced. During this period, the ab-

solute value of the steering angle of the outboard motor OM is maintained at its upper limit value, and the propulsive force of the outboard motor OM is maintained at its upper limit value.

[0130] For the bow turning promotion command issued by the twisting of the joystick 8, the output of the bow thruster BT, the propulsive force of the outboard motor OM, and the steering angle of the outboard motor OM are changed in this order. For the bow turning reduction command issued by the twisting of the joystick 8, the steering angle of the outboard motor OM, the propulsive force of the outboard motor OM, and the output of the bow thruster BT are changed in this order. Thus, a hull behavior such that the hull 2 is free from the bow turning is achieved. If a hull behavior intended by the calibrating person is not satisfactorily achieved by performing the calibration process once, the calibration process is repeatedly performed in the same manner such that the intended hull behavior can be substantially achieved. Further, by placing importance on the adjustment of the output of the bow thruster BT for the bow turning promotion command and placing importance on the adjustment of the steering angle of the outboard motor OM for the bow turning reduction command, the absolute value of the steering angle of the outboard motor OM is increased as much as possible. Thus, the steering angle of the outboard motor OM for the diagonal translation is calibrated so as to efficiently utilize the lateral component of the propulsive force generated by the outboard motor OM, making it possible to promote the hull behavior during the diagonal translation.

[0131] In the second joystick mode, the main controller 50 controls the output of the bow thruster BT and the propulsive force and the steering angle of the outboard motor OM based on the calibration values if the translation command is issued from the joystick unit 18. When the bow turning command is issued from the joystick unit 18 by the twisting of the joystick 8, the main controller 50 changes one or both of the steering angle of the outboard motor OM and the output of the bow thruster BT to promote the bow turning of the hull 2 in a direction indicated by the bow turning command. This makes it possible to turn the bow of the hull 2 at a fixed point or to turn the bow of the hull 2 while moving the hull 2 diagonally.

[0132] FIGS. 12A and 12B show exemplary operations to be performed when a translation command indicating a lateral movement (rightward or leftward movement) (hereinafter referred to as "lateral movement command") is issued from the joystick unit 18 by operating the joystick 8 exactly laterally.

[0133] In response to the lateral movement command, the main controller 50 sets two parallel reference lines R1, R2 extending laterally of the hull 2 and spaced apart from each other anteroposteriorly of the hull 2. These reference lines R1, R2 are ground-based reference lines. That is, the main controller 50 acquires a hull position (typically the position of the gravity center of the hull 2)

and a hull azimuth from the GPS receiver 52 and the azimuth sensor 53, respectively, when the lateral movement command is issued. Then, the main controller 50 sets a horizontal line extending through the acquired hull position orthogonally to the acquired hull azimuth as a target line OL. Further, the main controller 50 sets two parallel reference lines R1, R2 extending parallel to the target line OL and spaced apart from each other anteroposteriorly of the hull 2.

[0134] In an example shown in FIG. 12A, the two reference lines R1, R2 are set on the front side and the rear side, respectively, of the target line OL and, therefore, are located forward of the gravity center of the hull 2 and rearward of the gravity center of the hull 2, respectively. In an example shown in FIG. 12B, the two reference lines R1, R2 are both set on the front side of the target line OL and, therefore, are both located forward of the gravity center of the hull 2. Though not shown, the two reference lines R1, R2 may be both set on the rear side of the target line OL and, therefore, may be both located rearward of the gravity center of the hull 2. Further, one of the two reference lines R1, R2 may coincide with the target line OL.

[0135] When the lateral movement command is issued, the main controller 50 controls the output of the bow thruster BT and the propulsive force and the steering angle of the outboard motor OM so as to cause the hull 2 to move in a zig-zag in a direction indicated by the lateral movement command between the two reference lines R1, R2 while maintaining the azimuth of the hull 2. Specifically, the control of the steering angle of the outboard motor OM is the control of the steering actuator 25.

[0136] The zig-zag hull movement includes a first movement M1 toward one of the two reference lines R1, R2 and a second movement M2 toward the other of the two reference lines R1, R2. The first movement M1 is a diagonal movement including a lateral movement component (a rightward movement component in FIGS. 12A and 12B) indicated by the lateral movement command and one of forward and rearward movement components (a forward movement component in FIGS. 12A and 12B). The second movement M2 includes the other of the forward and rearward movement components (a rearward movement component in FIGS. 12A and 12B).

[0137] In the specific examples shown in FIGS. 12A and 12B, the first movement M1 is a diagonally forward movement (a diagonally forward-right translation in these examples) including a lateral movement component (a rightward movement component in these examples) indicated by the lateral movement command between the two reference lines R1, R2. Further, the second movement M2 is a diagonally rearward movement (a diagonally rearward-right translation in these examples) including a lateral movement component (a rightward movement component in these examples) indicated by the lateral movement command. The main controller 50 controls the output of the bow thruster BT and the propulsive force and the steering angle of the outboard motor OM so

as to alternately repeat the first movement M1 and the second movement M2. That is, when the hull 2 reaches one of the two reference lines R1, R2 by the first movement M1, the hull 2 is switched to the second movement M2. When the hull 2 reaches the other of the two reference lines R1, R2 by the second movement M2, the hull 2 is switched to the first movement M1. In FIGS. 12A and 12B, the first movement M1 comes first by way of example, but either of the first movement M1 and the second movement M2 may come first.

[0138] Thus, the hull 2 moves laterally along the target line OL while translating in a zig-zag between the two reference lines R1, R2.

[0139] FIG. 13 is a flowchart showing an exemplary process to be performed by the main controller 50 in response to the lateral movement command. If the lateral movement command is inputted (YES in Step S61), the main controller 50 acquires a hull position and a hull azimuth from the GPS receiver 52 and the azimuth sensor 53, respectively (Step S62). Then, the main controller 50 sets a horizontal line extending through the acquired hull position orthogonally to the acquired hull azimuth as a target line OL (Step S63).

[0140] Further, the main controller 50 sets two parallel reference lines R1, R2 extending parallel to the target line OL and spaced a distance from each other anteroposteriorly of the hull 2 (Step S64). At this time, the main controller 50 sets the distance between the two reference lines R1, R2 according to the lateral component of the lateral movement command. Specifically, the main controller 50 sets the two reference lines R1, R2 so that the distance is reduced as the lateral component of the lateral movement command decreases, and the distance is increased as the lateral component of the lateral movement command increases. Where the lateral movement command is issued from the joystick unit 18, the lateral component of the lateral movement command corresponds to the lateral component of the tilt amount of the joystick 8.

[0141] Based on the two reference lines R1, R2 thus set, the main controller 50 performs a control operation for the zig-zag lateral movement. Specifically, the main controller 50 controls the output of the bow thruster BT and the propulsive force and the steering angle of the outboard motor OM for the first movement M1 (e.g., for a diagonally forward translation) including a lateral movement component (a rightward or leftward movement component) indicated by the lateral movement command (Step S65). Then, when the hull 2 reaches one of the two reference lines R1, R2 (e.g., a forward reference line R1) (Step S66), the main controller 50 controls the output of the bow thruster BT and the propulsive force and the steering angle of the outboard motor OM for the second movement M2 (e.g., for a diagonally rearward translation) including a lateral movement component (a rightward or leftward movement component) indicated by the lateral movement command (Step S69). Then, when the hull 2 reaches the other of the two reference lines R1, R2

(e.g., a rearward reference line R2) (Step S70), the main controller 50 performs the control operation for the first movement M1 again (Step S65). By repeating the control operation for the first movement M1 and the control operation for the second movement M2, the zig-zag lateral movement along the target line OL is achieved (see FIGS. 12A and 12B).

[0142] The hull 2 reaching the reference line R1, R2 is detected based on the current position of the hull 2 acquired from the GPS receiver 52. If the hull 2 does not reach the reference line R1, R2 yet (NO in Step S66 or Step S70) and the lateral movement command is continuously issued (YES in Step S67 or Step S71), the control operation for the first movement M1 or the second movement M2 is continuously performed.

[0143] In this example, the first movement M1 and the second movement M2 are the diagonally forward translation and the diagonally rearward translation, respectively, and the control operations for the first movement M1 and the second movement M2 are substantially the same as those for the diagonally forward translation and the diagonally rearward translation in the second joystick mode. Therefore, if the calibration process described above is preliminarily performed, the hull 2 translates diagonally without the bow turning.

[0144] In the switching between the first movement M1 and the second movement M2, an azimuth holding control operation is performed to maintain the hull azimuth acquired in Step S62 (Step S68 or Step S72). Thus, the deviation of the hull azimuth is reduced when the switching between the diagonally forward translation (first movement M1) and the diagonally rearward translation (second movement M2) occurs. The azimuth holding control operation may be performed by feedback-controlling the bow thruster BT so that the hull azimuth outputted by the azimuth sensor 53 coincides with the hull azimuth acquired in Step S62. In the switching between the diagonally forward translation and the diagonally rearward translation, as will be understood from FIG. 7, the shift position of the outboard motor OM is switched between the forward shift position and the reverse shift position, and the outboard motor OM is steered to the opposite side with respect to the neutral steering position. Therefore, a switching period is present mainly according to a standby period for the steering of the outboard motor OM. During this switching period, the lateral movement of the hull 2 is continued by utilizing the propulsive force of the bow thruster BT to maintain the hull azimuth without performing a bow turning operation for the correction of the hull azimuth.

[0145] During the first movement M1 and the second movement M2, the main controller 50 adjusts the lateral component of the propulsive force to be applied to the hull 2 according to the lateral component of the lateral movement command. Thus, the lateral movement speed of the hull 2 is increased as the lateral component of the lateral movement command increases. Correspondingly, the lateral movement components of the first movement

M1 and the second movement M2 indicated by the lateral movement command are changed. Further, the main controller 50 changes the distance between the two reference lines R1, R2 according to the magnitude of the lateral component of the lateral movement command during the first movement M1 and the second movement M2. Specifically, the distance is increased as the magnitude of the lateral component of the movement command increases, and the distance is reduced as the magnitude of the lateral component of the movement command decreases. When the magnitude of the lateral component of the movement command is smaller, therefore, the hull 2 is moved little by little in the diagonally forward and rearward directions to achieve the zig-zag lateral movement along the target line OL. This makes it easier to guide the hull 2 to the target position.

[0146] At the beginning of the first movement M1, the main controller 50 preferably prioritizes the maintaining of the azimuth of the hull 2 over the lateral movement (first movement M1) of the hull 2. Likewise, at the beginning of the second movement M2, the main controller 50 preferably prioritizes the maintaining of the azimuth of the hull 2 over the lateral movement (second movement M2) of the hull 2. Specifically, the prioritization of the maintaining of the azimuth of the hull 2 may be achieved by gradually increasing the output of the bow thruster BT and the propulsive force of the outboard motor OM and gradually increasing the absolute value of the steering angle of the outboard motor OM to gradually increase the lateral propulsive force. Thus, the bow turning of the hull 2 is reduced which may otherwise occur due to a delay in the movement of the bow or the stern of the hull 2 at the beginning of the first movement M1 and the second movement M2 (particularly, during a transition period in which the output of the bow thruster BT and the propulsive force of the outboard motor OM rise).

[0147] The hull 2 often suffers from the bow turning due to the influence of external disturbance such as tidal current and wind during the first movement M1 and the second movement M2. In this case, the user is able to reduce the bow turning of the hull 2 by twisting the joystick 8 as required to give the bow turning command. Then, the main controller 50 changes the output of the bow thruster BT, the propulsive force of the outboard motor OM, and the steering angle of the outboard motor OM according to the bow turning command. The main controller 50 may perform an azimuth assist control operation to automatically reduce the bow turning of the hull 2 occurring due to the external disturbance. Specifically, if the change amount or the change rate of the hull azimuth detected by the azimuth sensor 53 exceeds a predetermined threshold, the main controller 50 may determine that the bow of the hull 2 is turned, and internally generate the bow turning command to reduce or eliminate the bow turning. Based on the internally generated bow turning command, the main controller 50 changes the output of the bow thruster BT, the propulsive force of the outboard motor OM, and the steering angle of the outboard motor

OM. Thus, the bow turning of the hull 2 occurring due to the external disturbance is automatically reduced.

[0148] During a period in which the lateral movement command is issued, the azimuth holding control operation (Step S68 or Step S72) may be constantly performed mainly by utilizing the propulsive force of the bow thruster BT. An allowable error in the azimuth holding control operation is not necessarily required to be constant, but the main controller 50 may change the allowable error in the azimuth holding control operation according to the situation. The maintaining of the hull azimuth is prioritized by reducing the allowable error. The maintaining of the hull azimuth is prioritized by reducing the allowable error at the beginning of the first movement M1 and the second movement M2. Further, if the magnitude of the lateral movement command is smaller, for example, the main controller 50 may prioritize the maintaining of the hull azimuth by reducing the allowable error. If the magnitude of the lateral movement command is greater, the main controller 50 may prioritize the movement of the hull 2 over the maintaining of the hull azimuth by increasing the allowable error.

[0149] The process to be performed by the main controller 50 as described with reference to FIG. 13 may be utilized in the automatic watercraft maneuvering control for the fixed-point holding mode (Stay Point™) in which the position and the bow azimuth (or the stern azimuth) of the hull 2 are maintained. In this case, if the hull position (current hull position) acquired from the GPS receiver 52 deviates from the target position, the main controller 50 internally generates a movement command to eliminate the deviation of the hull position from the target position (positional deviation). Where the movement command is the lateral movement command indicating the exactly lateral movement of the hull 2, the main controller 50 performs the process shown in FIG. 13. Thus, the hull 2 is guided to the target position by the zig-zag lateral movement with its azimuth maintained.

[0150] In the present example embodiment, as described above, the main controller 50 sets the two parallel reference lines R1, R2 spaced apart from each other anteroposteriorly of the hull 2 in response to the lateral movement command. These reference lines R1, R2 extend laterally of the hull 2. The main controller 50 controls the output of the bow thruster BT, the propulsive force of the outboard motor OM, and the steering actuator 25 so as to cause the hull 2 to move (translate in the present example embodiment) in a zig-zag in the lateral direction (the rightward or leftward direction) indicated by the lateral movement command between the two reference lines R1, R2. Therefore, the hull 2 is moved in the lateral direction indicated by the lateral movement command by the zig-zag movement between the two reference lines R1, R2. Thus, the watercraft propulsion system includes a specific arrangement for the lateral movement of the hull 2.

[0151] In the present example embodiment, the first movement M1 which is the diagonally forward movement

(translation in the present example embodiment) and the second movement M2 which is the diagonally rearward movement (translation in the present example embodiment) are alternately repeated for the zig-zag lateral movement. The first movement M1 and the second movement M2 each include the lateral movement component indicated by the lateral movement command. Thus, the hull 2 moves in the lateral direction indicated by the lateral movement command in both the first movement M1 and the second movement M2 and, therefore, the lateral movement is smoothly achieved by alternately repeating the first movement M1 and the second movement M2.

[0152] In the present example embodiment, the main controller 50 performs the azimuth holding control operation to maintain the azimuth of the hull 2 during the switching between the first movement M1 and the second movement M2. This reduces the change in the azimuth of the hull 2 during the switching between the first movement M1 and the second movement M2, thus making it possible to laterally move the hull 2 while maintaining the azimuth of the hull 2.

[0153] In the example of FIG. 12A, the two reference lines R1, R2 are set so as to be located forward and rearward, respectively, of the gravity center of the hull 2. This makes it possible to laterally move the hull 2 while moving the hull 2 back and forth with respect to a position of the gravity center of the hull 2 observed when the lateral movement command is issued.

[0154] As shown in FIG. 12B, both the two reference lines R1, R2 may be set so as to be located forward or rearward of the gravity center of the hull 2 (forward of the gravity center of the hull 2 in the example of FIG. 12B). In this case, it is possible to laterally move the hull 2 while moving the hull 2 back and forth with respect to a position forward or rearward of the gravity center of the hull 2 observed when the lateral movement command is issued.

[0155] In the present example embodiment, the joystick unit 18 having the joystick 8 to be operated by the user is an example of the lateral movement operation device that inputs the lateral movement command to the main controller 50.

[0156] The lateral movement command to be generated by the joystick unit 18 is changed according to the lateral component of the tilt amount of the joystick 8, and the main controller 50 correspondingly changes the lateral component of the propulsive force to be applied to the hull 2. Thus, the user is able to adjust the lateral movement speed by the lateral tilt amount of the joystick 8. The main controller 50 reduces the lateral component of the propulsive force to be applied to the hull 2, as the lateral component of the tilt amount of the hull 2 decreases. The main controller 50 increases the lateral component of the propulsive force to be applied to the hull 2, as the lateral component of the tilt amount of the hull 2 increases. Thus, the lateral movement components of the first movement M1 and the second movement M2

are increased. When a distance to a target berthing position is great, for example, the user is able to speedily move the hull 2 laterally by increasing the lateral tilt amount of the joystick 8. When the hull 2 comes closer to the target berthing position, the user is able to slowly move the hull 2 laterally by reducing the tilt amount of the joystick 8.

[0157] Further, the lateral movement command to be generated by the joystick unit 18 is changed according to the lateral component of the tilt amount of the joystick 8, and the main controller 50 correspondingly changes the distance between the two reference lines R1, R2. Specifically, the main controller 50 reduces the distance between the two reference lines R1, R2, as the lateral tilt amount of the joystick 8 decreases. The main controller 50 increases the distance between the two reference lines R1, R2, as the lateral tilt amount of the joystick 8 increases. Therefore, the user is able to accurately move the hull 2 toward the target berthing position, for example, by reducing the lateral tilt amount of the joystick 8 as the hull 2 approaches the target berthing position.

[0158] FIG. 14 is a diagram showing an arrangement of a watercraft propulsion system according to another example embodiment of the present invention. In the example embodiments described above, the single propulsion device (single outboard motor OM) is provided on the stern of the hull 2 by way of example. Alternatively, the example embodiments described above may be applied to an arrangement which includes a plurality of propulsion devices provided on the stern of the hull 2 and configured to be steered at the same steering angle. In the example shown in FIG. 14, the steering levers 90 of the respective outboard motors OM provided on the stern are mechanically connected together by a link 91, and the outboard motors OM (in this example, two outboard motors OM) are steered in synchronism (i.e., at the same steering angle) by a single steering. In this example, the steering includes a steering actuator 25 and a steering mechanism 26 to be driven by the steering actuator 25.

[0159] The plurality of propulsion devices configured to be steered in synchronism at the same steering angle applies their propulsive forces in the same direction to the hull 2, but are not able to apply the propulsive forces simultaneously in different directions to the hull 2. In this aspect, a combination of the plurality of propulsion devices is equivalent to the single propulsion device. Therefore, the example embodiments described above are applicable to a watercraft propulsion system which includes a plurality of propulsion devices provided on the stern of a hull 2 and incapable of applying their propulsive forces simultaneously in different directions to the hull 2, and a bow thruster BT provided at the bow of the hull 2. This makes it possible to move the hull 2 laterally according to a lateral movement command while moving the hull 2 in a zig-zag.

[0160] While the example embodiments of the present invention have thus been described, the present invention may be embodied in some other ways.

[0161] In the example embodiments described above, the first movement M1 and the second movement M2 for the zig-zag lateral movement each include the lateral movement component indicated by the lateral movement command (see FIGS. 12A and 12B) by way of example. However, the zig-zag movement of the hull 2 is merely required to include the first movement M1 which is the diagonal movement including the lateral movement component indicated by the lateral movement command and one of the forward and rearward movement components, and the second movement M2 including the other of the forward and rearward movement components. That is, the second movement M2 may include the lateral movement component, or may not include the lateral movement component. Where the second movement M2 does not include the lateral movement component, the hull 2 moves along a serration path as shown in FIGS. 15A and 15B. In an example shown in FIG. 15A, the first movement M1 is a diagonally forward translation, and the second movement M2 is a straight rearward translation. In an example shown in FIG. 15B, the first movement M1 is a diagonally rearward translation, and the second movement M2 is a straight forward translation. The hull movement along the serration path is also an example of the zig-zag hull movement. The second movement M2 may include a lateral movement component having a direction opposite to that indicated by the lateral movement command, but the opposite-direction lateral movement component should be smaller in magnitude than the lateral movement component of the first movement M1.

[0162] In the example embodiments described above, the joystick unit 18 including the joystick 8 tiltable in all directions is used as an example of the lateral movement operation device. However, the lateral movement operation device may be other than the joystick. For example, the lateral movement operation device may be a lever unit having a laterally tiltable lever. Further, the lateral movement operation device may be a lateral operator unit including left and right individual operators. More specifically, left and right paddle levers that are pivotable together with the steering wheel may be used as the lateral movement operation device. The lateral movement operation device is preferably configured so as to change the lateral movement command according to the operation amount thereof. Thus, the lateral movement speed and the distance between the reference lines R1, R2 may be changed according to the operation amount of the lateral movement operation device.

[0163] In the example embodiments described above, the bow thruster BT is fixed to the hull 2 in the unsteerable manner. Alternatively, a steerable propulsion unit such as a trolling motor may be used as the bow thruster. The example embodiments described above are applicable even in this case.

[0164] In the example embodiments described above, the outboard motor OM is used as the propulsion device by way of example, but the propulsion device may be in any of various forms such as inboard motor, inboard/out-

board motor and waterjet propulsion device. The propulsion device may be provided on a proper portion of the hull other than the stern.

[0165] The bow thruster and the propulsion device are exemplary propulsion units each adapted to apply a propulsive force to the hull. The example embodiments described above are applicable to a watercraft propulsion system including any forms of propulsion units in any combination such that the hull is laterally moved by the zig-zag lateral movement.

[0166] While example embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art. The scope of the present invention, therefore, is to be determined solely by the following claims.

Claims

1. A watercraft propulsion system (100) comprising:

a propulsion unit (BT, OM, 25, 26) to apply a propulsive force to a hull (2); and
a controller (50) configured or programmed to control the propulsion unit (BT, OM, 25, 26) in response to a lateral movement command to cause the hull (2) to move in a zig-zag pattern in a direction indicated by the lateral movement command between two parallel reference lines (R1, R2) extending laterally of the hull (2) and spaced apart from each other anteroposteriorly of the hull (2) while maintaining an azimuth of the hull (2).

2. The watercraft propulsion system (100) according to claim 1, wherein

the propulsion unit includes a bow thruster (BT) at a bow of the hull (2) to generate a propulsive force laterally of the hull (2), a propulsion device (OM) on the hull (2) to generate a propulsive force anteroposteriorly of the hull (2), a steering (25, 26) to change a course of the hull (2); and the controller (50) is configured or programmed, in response to the lateral movement command, to set the two parallel reference lines (R1, R2), and to control the bow thruster (BT), the propulsion device (OM), and the steering (25, 26) to cause the hull (2) to move in a zig-zag pattern in a direction indicated by the lateral movement command between the two reference lines (R1, R2) while maintaining the azimuth of the hull (2).

3. The watercraft propulsion system (100) according to claim 2, wherein the propulsion device includes only one single propulsion device (OM) on a stern (3) of the hull (2), or a plurality of propulsion devices (OM)

on the stern (3) of the hull (2) and steerable at a same steering angle.

4. The watercraft propulsion system (100) according to claim 2 or 3, wherein the bow thruster (BT) is fixed to the hull (2) in an unsteerable manner.

5. The watercraft propulsion system (100) according to any one of claims 1-4, wherein the zig-zag pattern of the hull (2) includes a first movement (M1) which is a diagonal movement including a lateral movement component indicated by the lateral movement command and one of forward and rearward movement components, and a second movement (M2) including the other of the forward and rearward movement components, the first movement (M1) and the second movement (M2) being each carried out at least once.

6. The watercraft propulsion system (100) according to any one of claims 1-4, wherein the controller (50) is configured or programmed to control the propulsion unit (BT, OM, 25, 26) to cause the hull (2) to alternately repeat a first movement (M1) and a second movement (M2) between the two reference lines (R1, R2), the first movement (M1) being a diagonally forward movement including a lateral movement component indicated by the lateral movement command, the second movement (M2) being a diagonally rearward movement including a lateral movement component indicated by the lateral movement command.

7. The watercraft propulsion system (100) according to claim 5 or 6, wherein the controller (50) is configured or programmed to perform an azimuth holding control operation to maintain the azimuth of the hull (2) during a switching period in which switching between the first movement (M1) and the second movement (M2) occurs.

8. The watercraft propulsion system (100) according to any one of claims 1-7, wherein the two reference lines (R1, R2) are located forward and rearward, respectively, of a gravity center of the hull (2).

9. The watercraft propulsion system (100) according to any one of claims 1-7, wherein the two reference lines (R1, R2) are both located forward or rearward of a gravity center of the hull (2).

10. The watercraft propulsion system (100) according to any one of claims 1-9, further comprising a lateral movement operator (18) operable by a user to input the lateral movement command to the controller (50).

11. The watercraft propulsion system (100) according to

claim 10, wherein the controller (50) is configured or programmed to control the propulsion unit (BT, OM, 25, 26) to change a propulsive force to be generated in a lateral direction indicated by the lateral movement command according to an operation amount of the lateral movement operator (18). 5

12. The watercraft propulsion system (100) according to claim 10 or 11, wherein the controller (50) is configured or programmed to change the distance between the two reference lines (R1, R2) according to an operation amount of the lateral movement operator (18). 10

13. The watercraft propulsion system (100) according to any one of claims 10-12, wherein the controller (50) is configured or programmed to control the propulsion unit (BT, OM, 25, 26) so as to prioritize the maintaining of the azimuth of the hull (2) over the lateral movement at a beginning of an operation of the lateral movement operator (18). 15 20

14. The watercraft propulsion system (100) according to any one of claims 1-13, wherein the lateral movement command is generated by performing a position/azimuth holding control operation to maintain the azimuth and a position of the hull (2) . 25

15. A watercraft (1) comprising: 30
a hull (2); and
the watercraft propulsion system (100) according to any one of claims 1-14.

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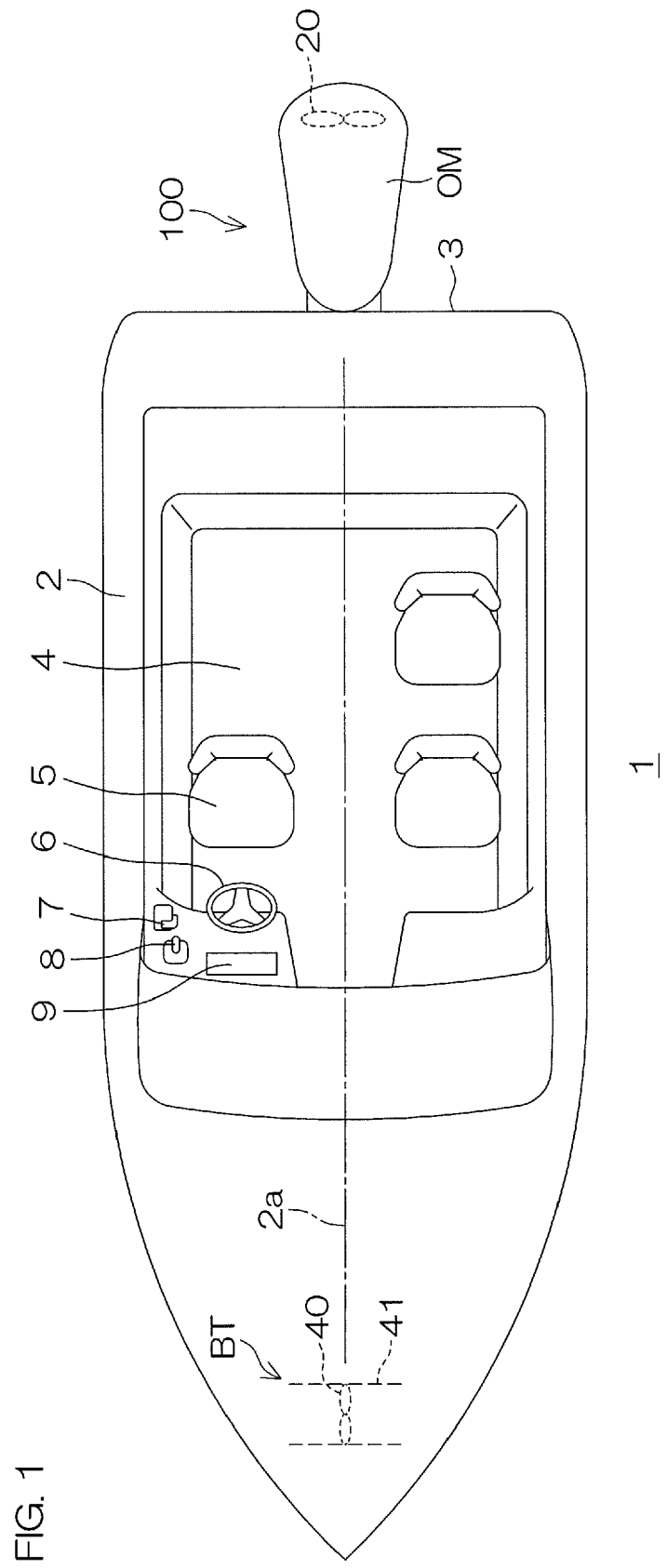


FIG. 2

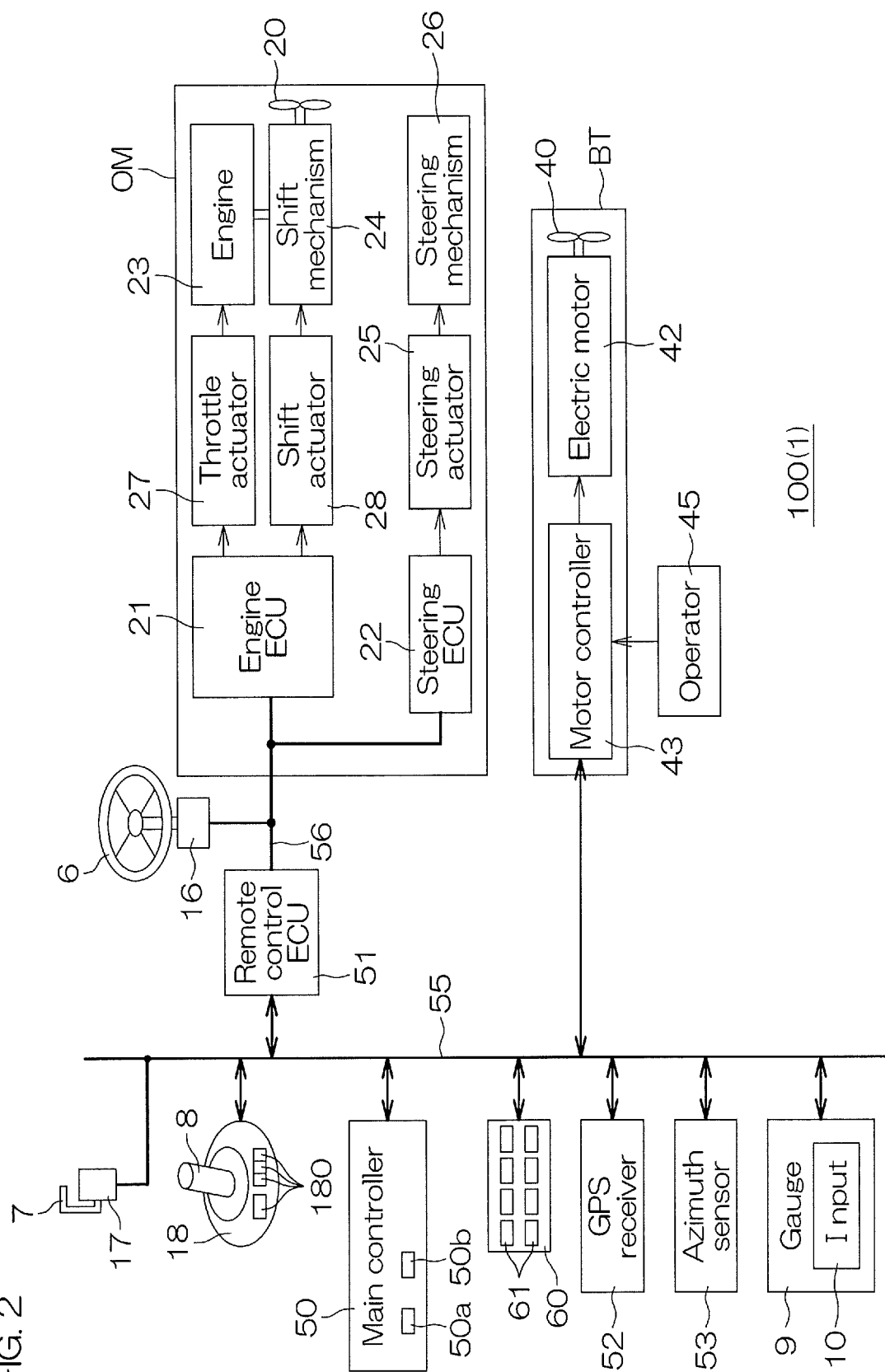


FIG. 3

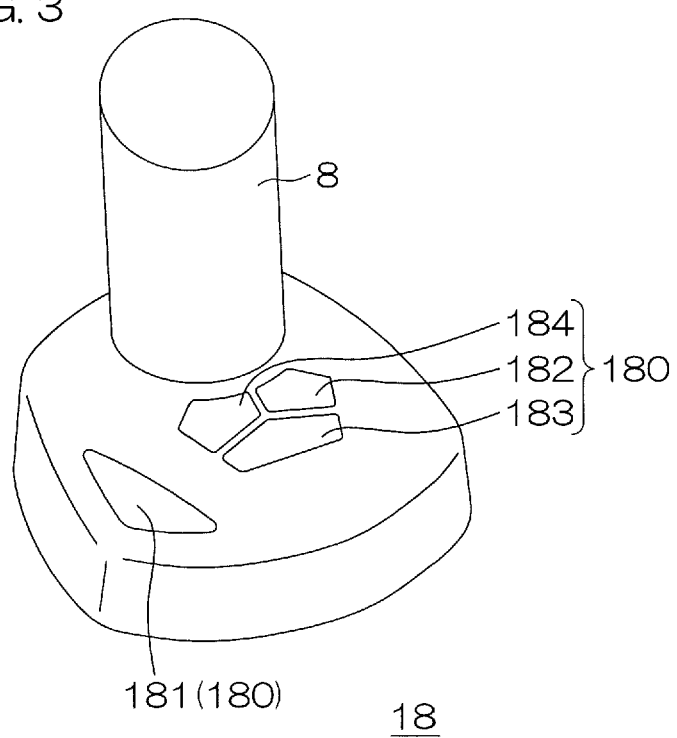
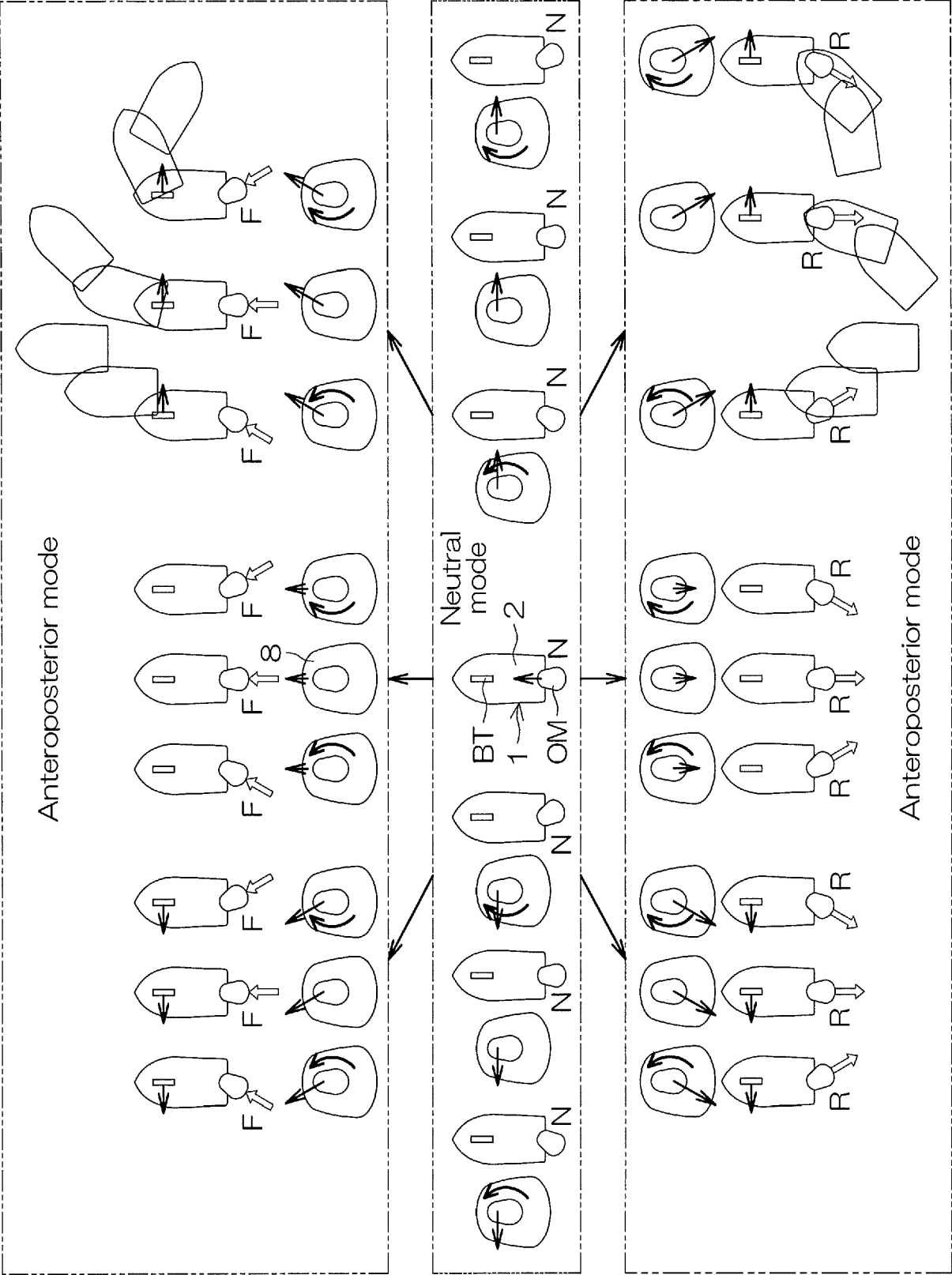


FIG. 4



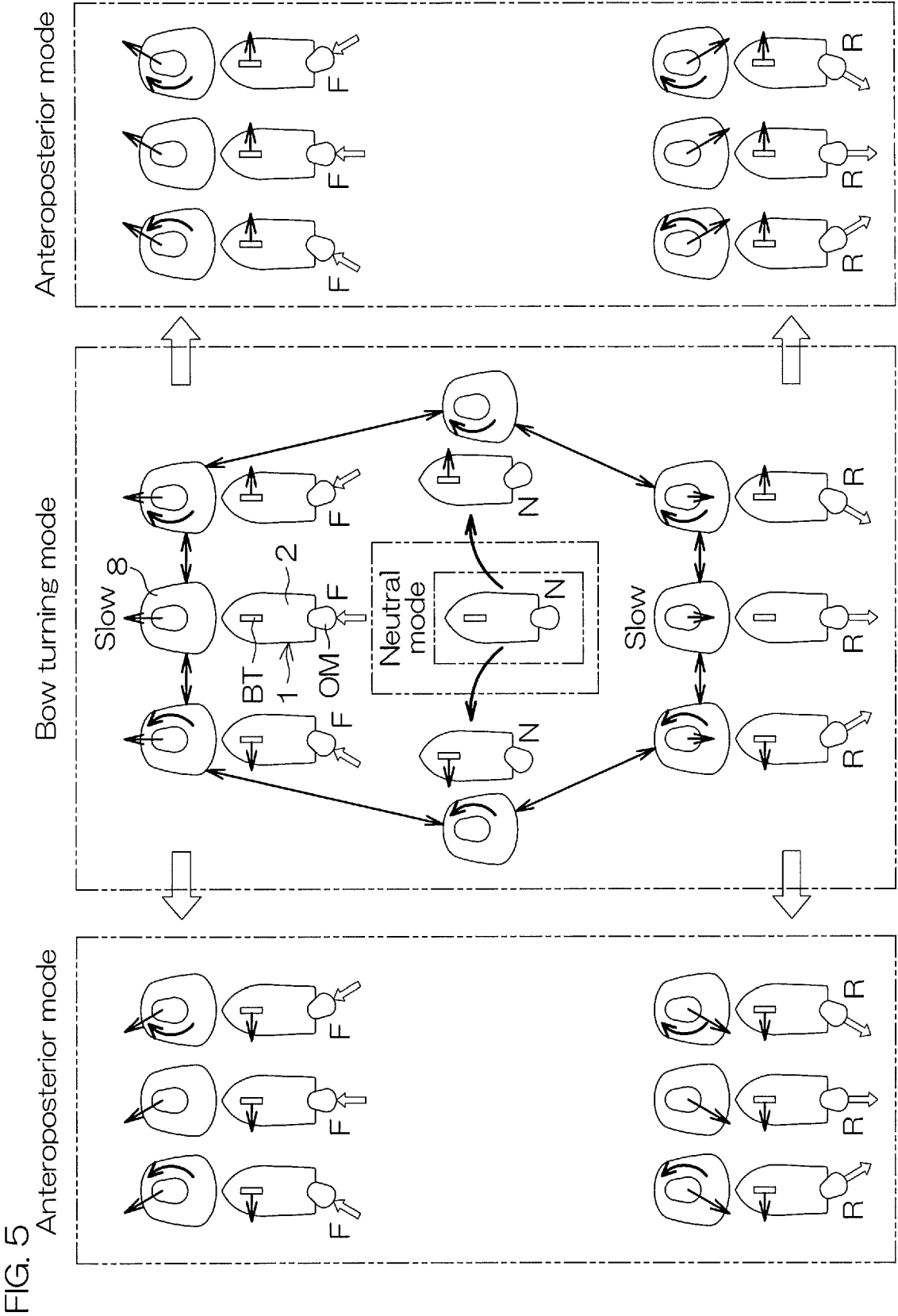


FIG. 6

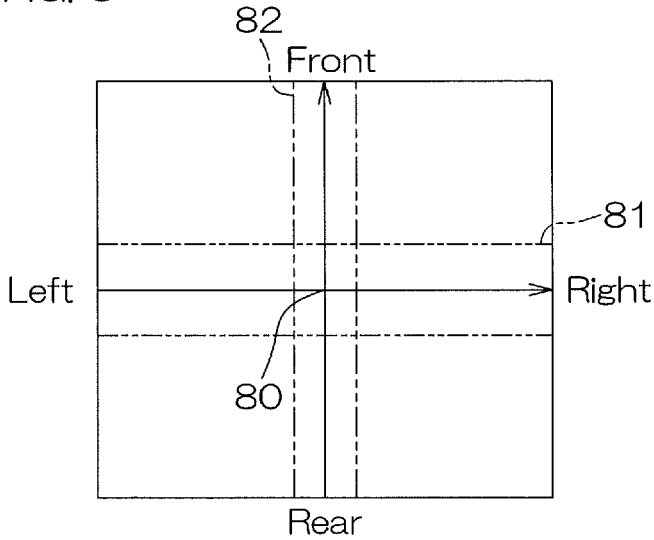


FIG. 7

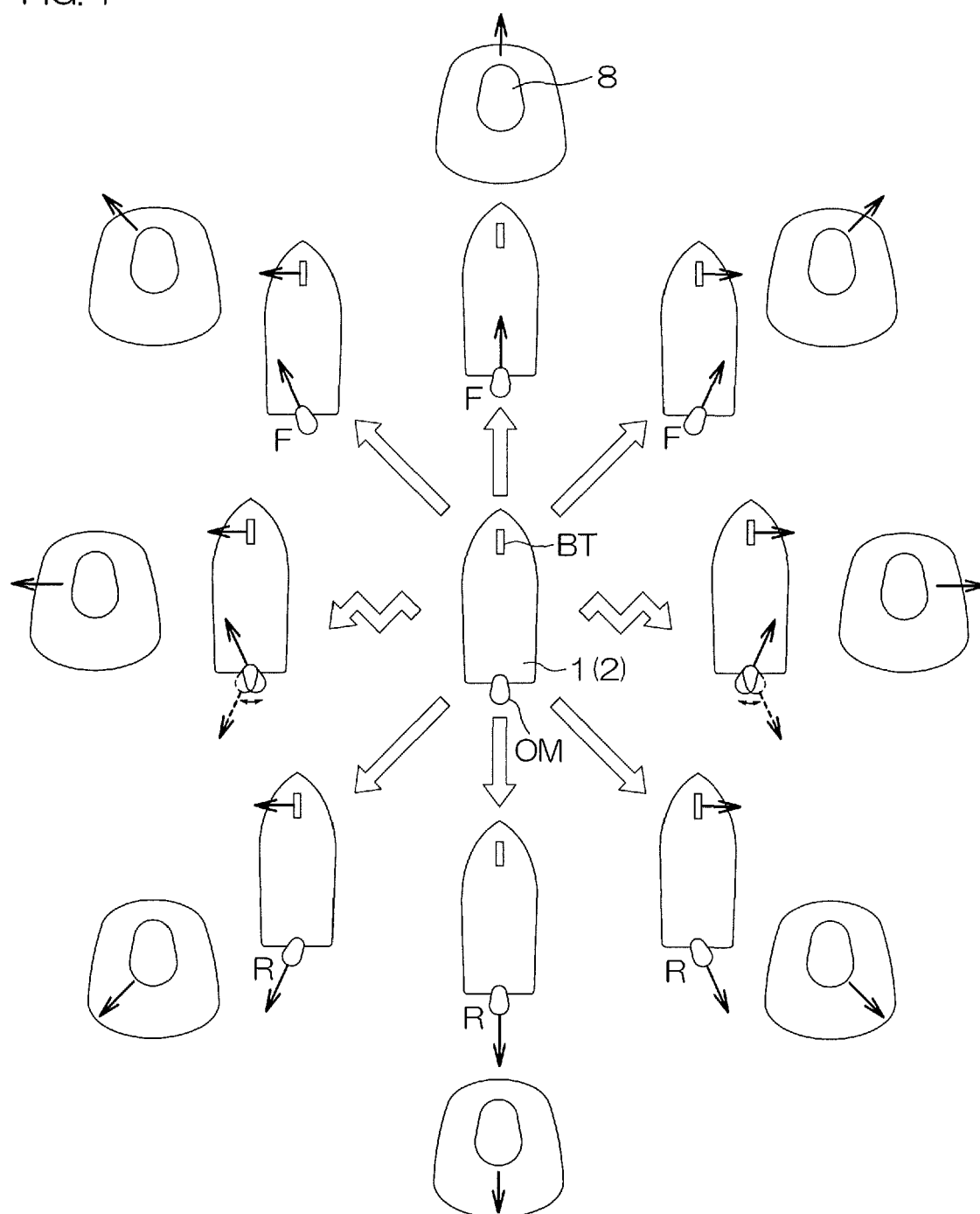


FIG. 8

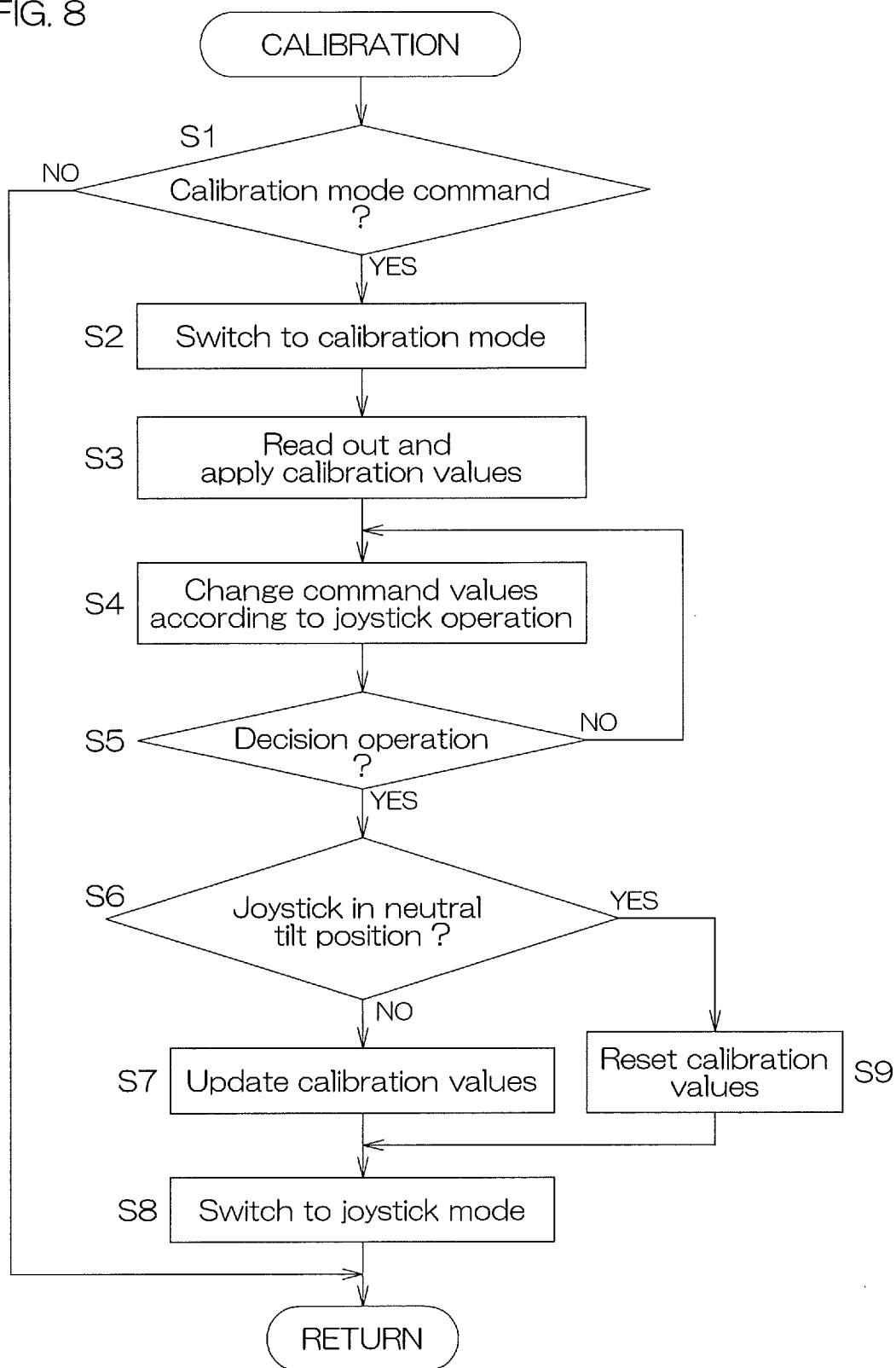
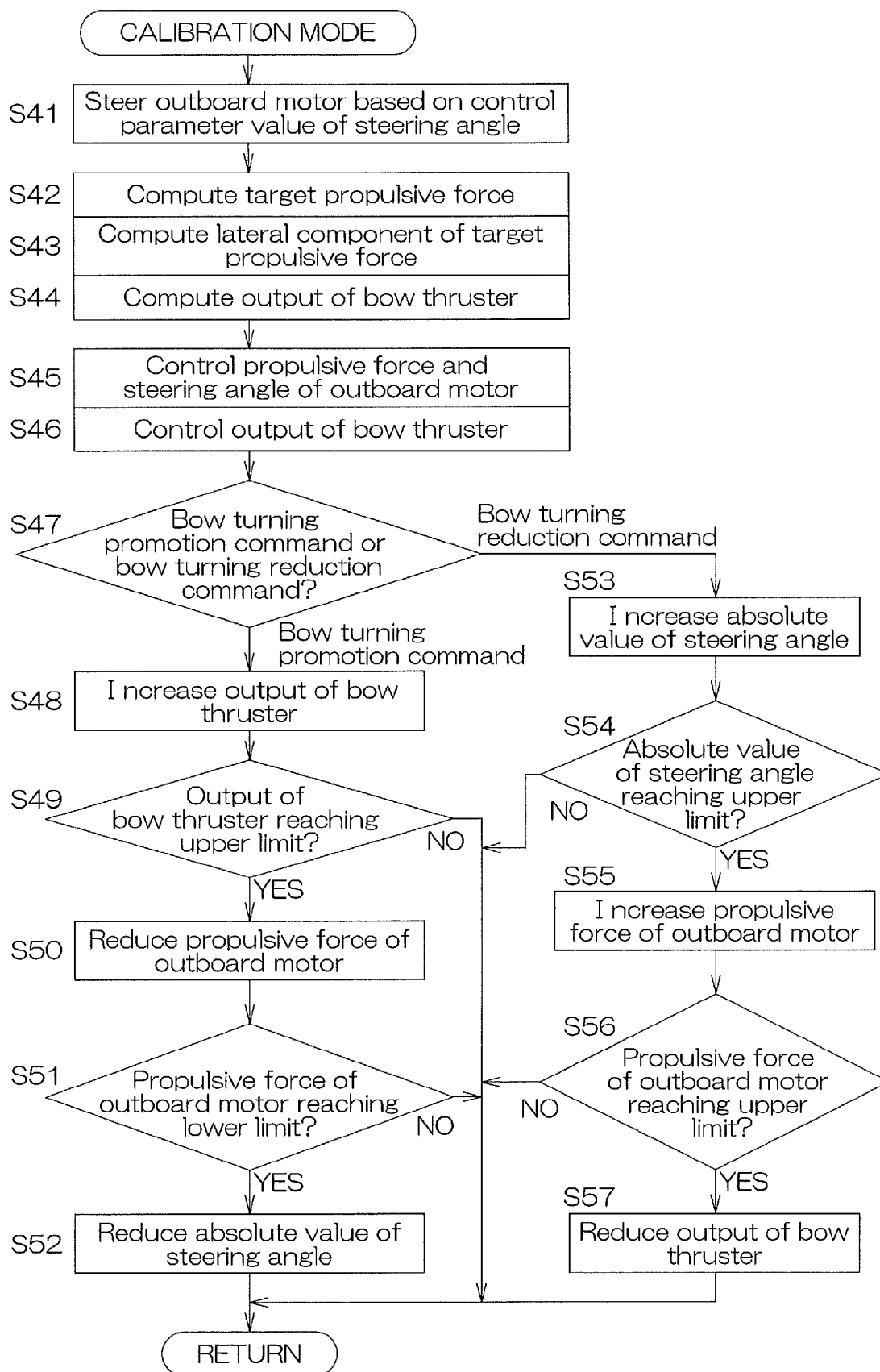


FIG. 9



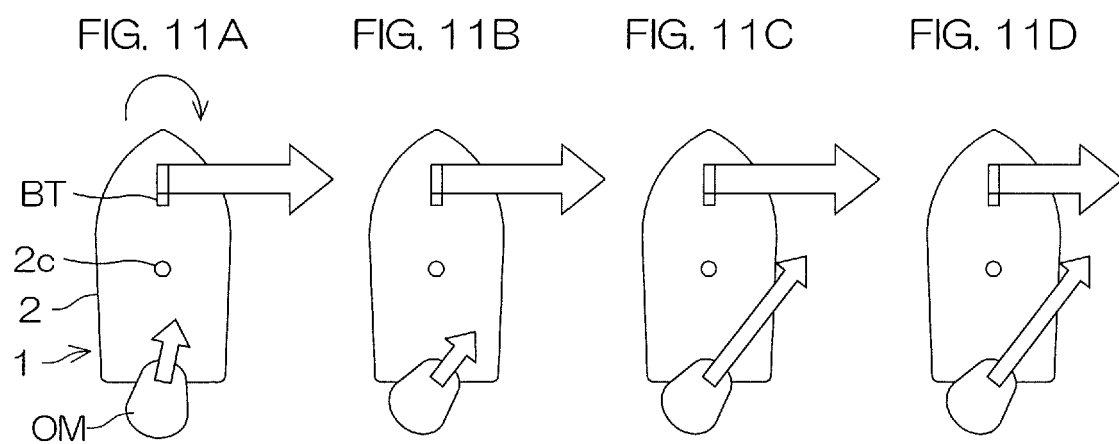
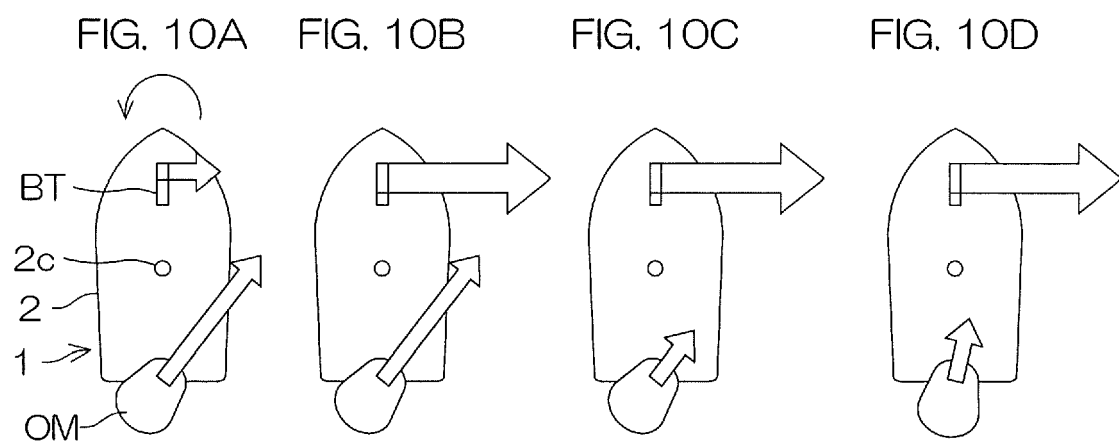


FIG. 12A

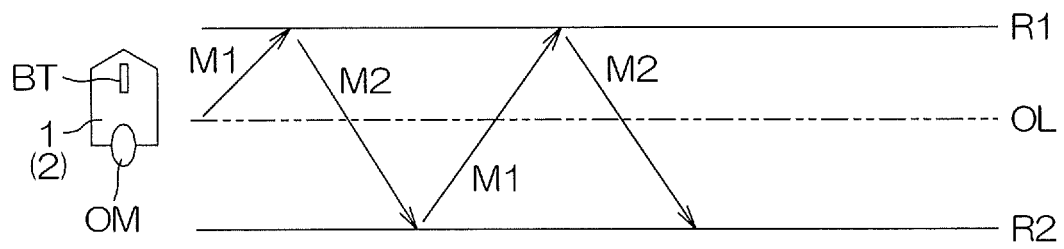


FIG. 12B

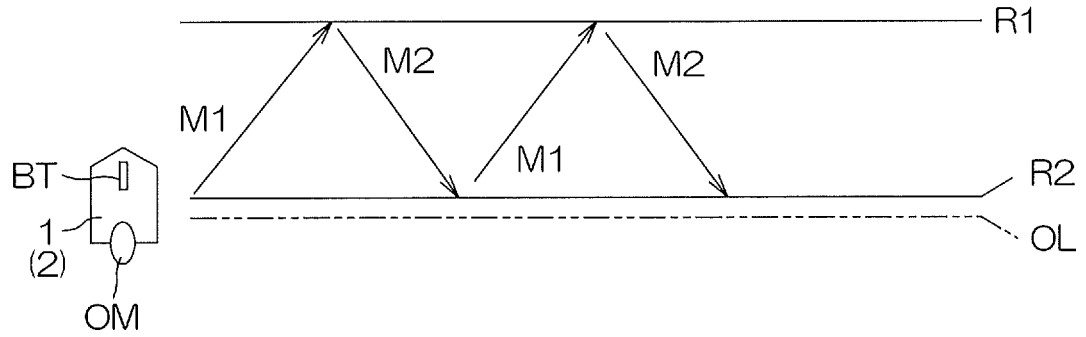


FIG. 13

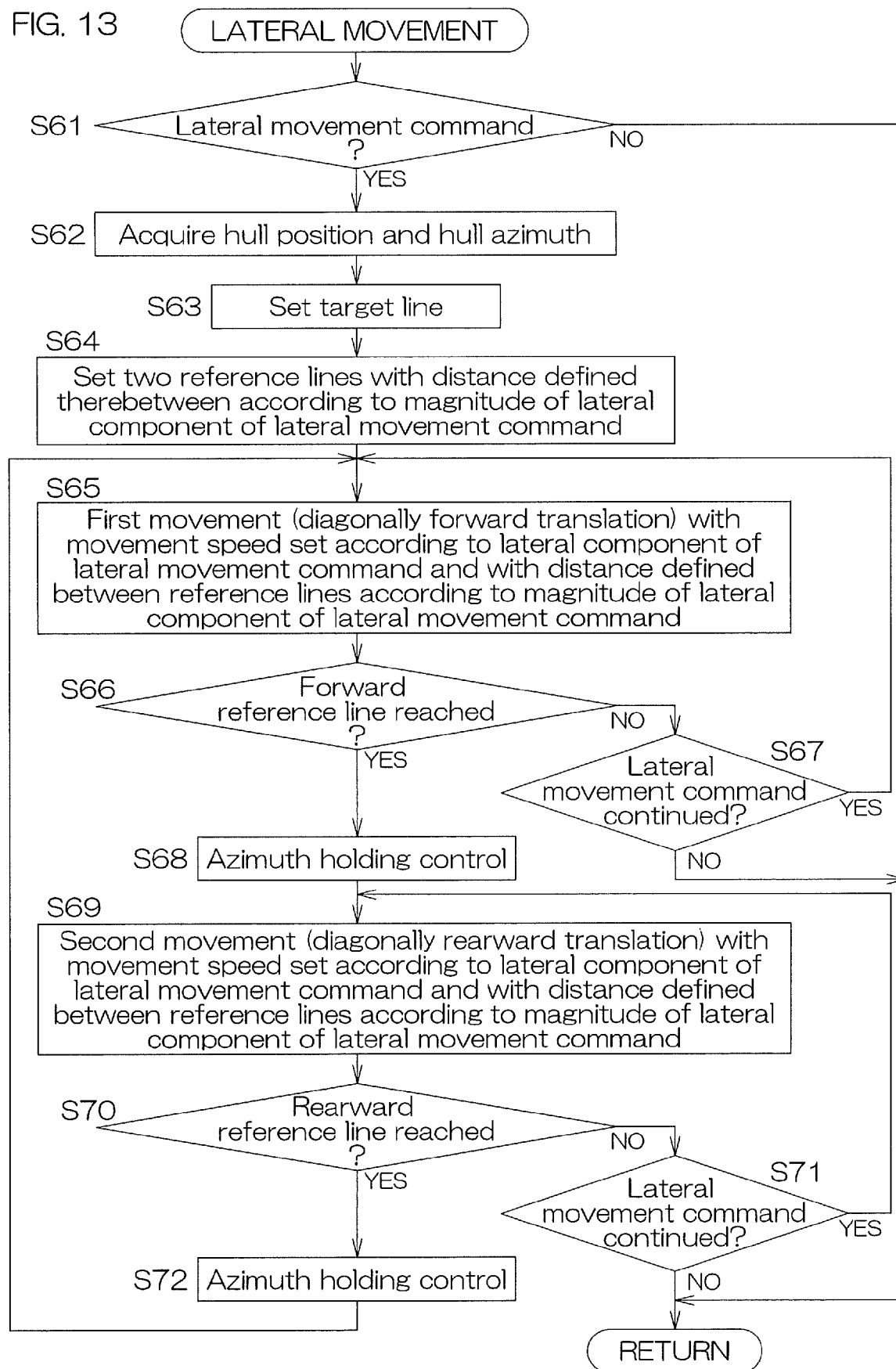


FIG. 14

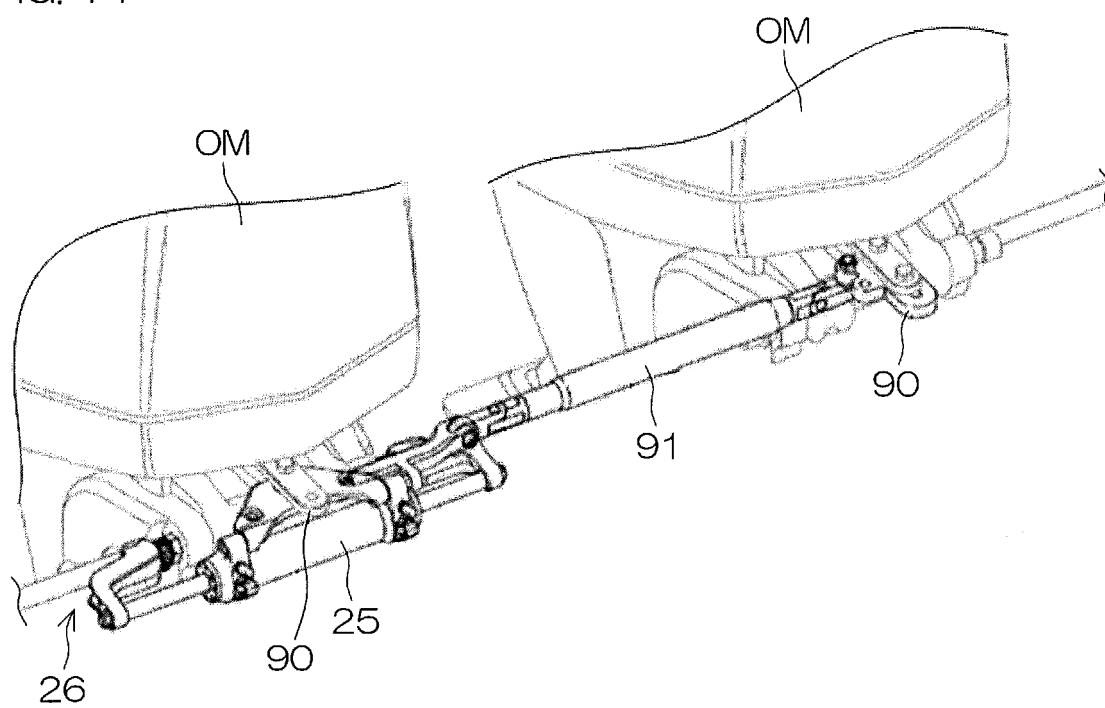


FIG. 15A

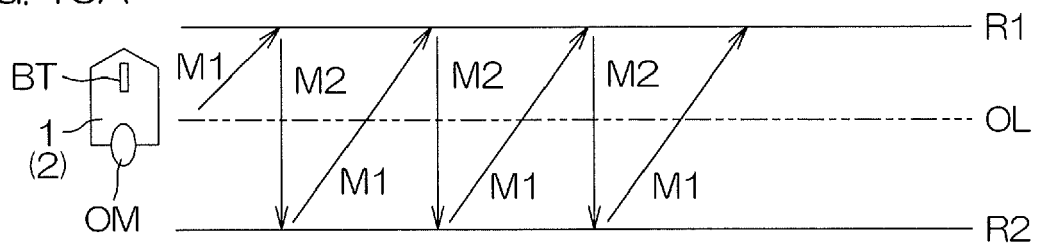
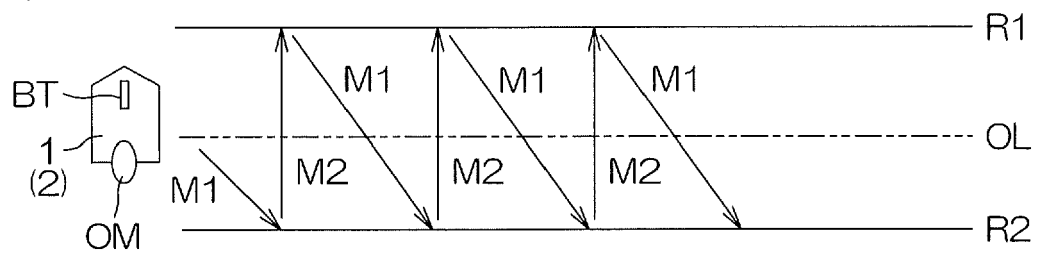


FIG. 15B





EUROPEAN SEARCH REPORT

Application Number

EP 24 19 2326

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X	JP 5 932362 B2 (MAROL LTD) 8 June 2016 (2016-06-08) * figures 11-13 * * paragraph [0122] *	1-15	
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X	US 2022/299998 A1 (MORIMOTO YUKI [JP]) 22 September 2022 (2022-09-22) * figure 5A *	1-15	
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 24 January 2025	Examiner Freire Gomez, Jon
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24 - 01 - 2025

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