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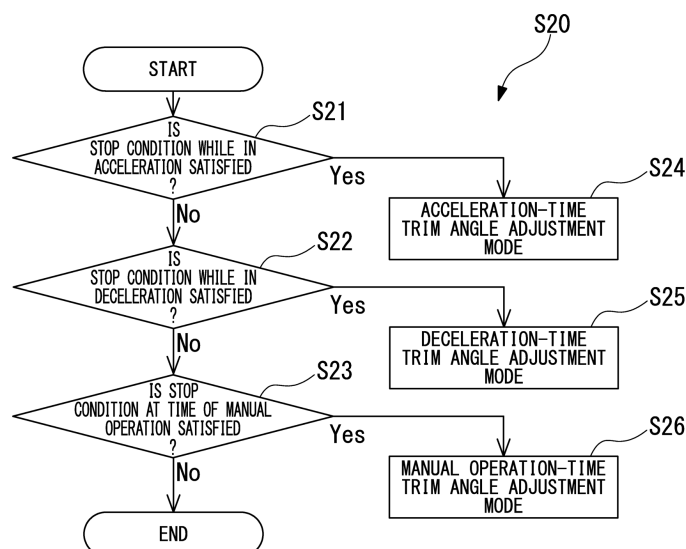
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(54) **PROPULSION SYSTEM OF BOAT**

(57) A propulsion system of a boat, includes: a propulsion machine provided on a hull; a trim angle adjuster configured to adjust a trim angle of the propulsion machine; and a controller configured to control the trim angle adjuster, in which the controller is capable of conducting hump control of causing the trim angle adjuster to adjust the trim angle of the propulsion machine with a preset trim

angle lower limit value as a lower limit to suppress an inclination in a pitch direction of the hull, and in stopping conducting the hump control from a state of conducting the hump control, the controller causes the trim angle adjuster to adjust the trim angle of the propulsion machine in accordance with a state of the hull.

FIG. 12



Description

BACKGROUND OF THE INVENTION

[0001] Priority is claimed on Japanese Patent Application No. 2025-057513, filed March 31, 2025, the content of which is incorporated herein by reference.

Field of the Invention

[0002] The present invention relates to a propulsion system of a boat.

Description of Related Art

[0003] Various techniques for automatically controlling a propulsion system of a boat have been conventionally proposed in order to improve stability, acceleration, a maximum speed, energy efficiency, and the like, in navigating the boat. For example, when the bow is largely lifted with respect to the stern and the pitch angle of the hull with respect to a horizontal plane increases, a so-called hump state occurs, and the forward visibility of the boat may be impaired.

[0004] For example, Japanese Unexamined Patent Application, First Publication No. H02-237893 discloses that in a case where a pitch angle of the hull with respect to the horizontal plane exceeds a set value, a trim angle of a propulsion machine is decreased to suppress a hump state of the hull.

SUMMARY OF THE INVENTION

[0005] In the boat, by the way, not only the hump control but also another type of control may be conducted in accordance with a navigation state of the boat. For example, different types of control may be conducted when the boat is in a straight advancing state and when the boat is in a turning state. In addition, when the boat operator manually performs the operation, each part may be in a different state from the control that has been automatically conducted.

[0006] In this manner, in transitioning from the state of conducting the hump control to another state, there is a demand for smoothly transitioning the state so as not to impair the stability of the boat or the like, and so as not to make a boat operator feel uneasy.

[0007] The present invention has been made in view of the above circumstances, and it is an object of the present invention to provide a propulsion system of a boat capable of smoothly transitioning a state, in transitioning from a state of conducting hump control to another state.

(1) A propulsion system of a boat according to one aspect of the present disclosure, includes:

a propulsion machine including a drive source, and a propulsor configured to generate thrust

with power transmitted from the drive source, the propulsion machine being provided on a hull; a trim angle adjuster configured to adjust a trim angle of the propulsion machine with respect to the hull; and

a controller configured to control the trim angle adjuster, wherein

the controller is capable of conducting hump control of causing the trim angle adjuster to adjust the trim angle of the propulsion machine with a preset trim angle lower limit value as a lower limit to suppress an inclination in a pitch direction of the hull, and

in stopping conducting the hump control from a state of conducting the hump control, the controller causes the trim angle adjuster to adjust the trim angle of the propulsion machine in accordance with a state of the hull.

(2) In the propulsion system of the boat according to the above aspect (1), the controller may include:

an acceleration-time trim angle adjustment mode of adjusting the trim angle in stopping conducting the hump control from the state of conducting the hump control while the hull is accelerating; and

a deceleration-time trim angle adjustment mode of adjusting the trim angle in stopping conducting the hump control from the state of conducting the hump control while the hull is decelerating.

(3) In the propulsion system of the boat according to the above aspect (2), in the acceleration-time trim angle adjustment mode, in a case where the trim angle of the propulsion machine at a time of stopping conducting the hump control is smaller than a trim angle reference value set to be larger than the trim angle lower limit value in a direction in which the propulsion machine is upright forward in a propulsion direction of the hull, the controller may cause the trim angle of the propulsion machine to be adjusted to the trim angle reference value.

(4) In the propulsion system of the boat according to the above aspect (3),

the controller may be capable of conducting trim support control of causing the trim angle adjuster to adjust the trim angle to a trim support angle set in accordance with either a preset boat speed or a rotation speed of the propulsion machine, and

in stopping conducting the hump control from a state of conducting the trim support control and the hump control while the hull is accelerating, the controller may disable control of decreasing the trim angle of the propulsion machine by the trim support control, in the acceleration-time trim

angle adjustment mode.

(5) In the propulsion system of the boat according to one of the above aspects (2) to (4), in the deceleration-time trim angle adjustment mode, in a case where the trim angle of the propulsion machine at a time of stopping conducting the hump control is smaller than a trim angle reference value set to be larger than the trim angle lower limit value in a direction in which the propulsion machine is upright forward in a propulsion direction of the hull, the controller may cause the trim angle of the propulsion machine to be adjusted to the trim angle reference value.

(6) In the propulsion system of the boat according to the above aspect (5),

the controller may be capable of conducting trim support control of causing the trim angle adjuster to adjust the trim angle to a trim support angle set in accordance with either a preset boat speed or a rotation speed of the propulsion machine, and

in stopping conducting the hump control from a state of conducting the trim support control and the hump control while the hull is decelerating, the controller may enable conducting control of decreasing the trim angle of the propulsion machine by the trim support control, in the deceleration-time trim angle adjustment mode.

(7) The propulsion system of the boat according to one of the above aspects (1) to (6), may further include a trim angle operation unit configured to operate the trim angle adjuster in accordance with an external input, in which

the controller may include a manual operation-time trim angle adjustment mode to be conducted in stopping conducting the hump control upon receipt of an operation input from the trim angle operation unit, while conducting the hump control, and

in the manual operation-time trim angle adjustment mode, in a case where the trim angle of the propulsion machine at a time of stopping conducting the hump control is smaller than a trim angle reference value set to be larger than the trim angle lower limit value in a direction in which the propulsion machine is upright forward in a propulsion direction of the hull, the controller may cause the trim angle of the propulsion machine to be adjusted to the trim angle reference value.

[0008] According to the aspect (1), in stopping conducting the hump control from the state of conducting the hump control, the trim angle adjuster adjusts the trim

angle of the propulsion machine in accordance with the state of the hull. This enables smooth transition of the state, in transitioning from the state of conducting the hump control to another state.

[0009] According to the aspect (2), since the acceleration-time trim angle adjustment mode and the deceleration-time trim angle adjustment mode are provided, it becomes possible to make a suitable transition for a case of stopping conducting the hump control from the state of conducting the hump control while the hull is accelerating and a case of stopping conducting the hump control from the state of conducting the hump control while the hull is decelerating.

[0010] According to the aspect (3), in the acceleration-time trim angle adjustment mode, the trim angle of the propulsion machine is adjusted so that the trim angle becomes the trim angle reference value in a case where the trim angle of the propulsion machine at the time of stopping conducting the hump control is smaller than the trim angle reference value. In this manner, in the case where the trim angle of the propulsion machine at the time of stopping conducting the hump control is smaller than the trim angle reference value, the trim angle is increased to the trim angle reference value, so that the efficiency of navigation can be improved.

[0011] According to the aspect (4), in stopping conducting the hump control from the state of conducting the trim support control and the hump control while the hull is accelerating, the control of decreasing the trim angle of the propulsion machine by the trim support control is disabled. Thus, in subsequent trim support control, the trim angle of the propulsion machine is equal to or larger than the angle at the time of conducting the hump control. That is, it becomes possible to suppress a decrease in efficiency of navigation due to an excessive decrease in the trim angle of the propulsion machine.

[0012] According to the aspect (5), in the deceleration-time trim angle adjustment mode, in a case where the trim angle of the propulsion machine at the time of stopping conducting the hump control is smaller than the trim angle reference value, the trim angle of the propulsion machine is adjusted so that the trim angle becomes the trim angle reference value. In this manner, in the case where the trim angle of the propulsion machine at the time of stopping conducting the hump control is smaller than the trim angle reference value, the trim angle is increased to the trim angle reference value, so that the efficiency of navigation can be improved.

[0013] According to the aspect (6), in stopping conducting the hump control from the state of conducting the trim support control and the hump control while in deceleration, control of decreasing the trim angle of the propulsion machine in the trim support control is enabled. While in deceleration, the trim angle is smaller than that while in acceleration. Therefore, it becomes possible to conduct the trim support control effectively while suppressing a decrease in efficiency of navigation.

[0014] According to the aspect (7), while conducting

the hump control, upon receipt of the operation input from the trim angle operation unit, in a case where the trim angle of the propulsion machine at the time of stopping conducting the hump control is smaller than the trim angle reference value, the trim angle of the propulsion machine is adjusted so that the trim angle becomes the trim angle reference value. In this manner, in the case where the trim angle of the propulsion machine at the time of stopping conducting the hump control is smaller than the trim angle reference value, the trim angle is increased to the trim angle reference value, so that the efficiency of navigation can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a plan view of a boat according to an embodiment;

FIG. 2 is a functional block diagram of a propulsion system of the above boat;

FIG. 3 is a side view of a propulsion machine of the above propulsion system;

FIG. 4 is a diagram illustrating an example of trim support control, heel control, hump control, and bogen control to be conducted in accordance with a boat speed in the above propulsion system;

FIG. 5 is a diagram illustrating an example of a set value of a trim support angle in the trim support control, the heel control, and the hump control to be conducted in accordance with the boat speed in above the propulsion system;

FIG. 6 is a view illustrating a state in which the trim support control is being conducted in the above propulsion system;

FIG. 7 is a view illustrating a state of conducting the heel control in a state in which the above boat is inclined to a port side;

FIG. 8 is a view illustrating a state of conducting the heel control in a state in which the above boat is inclined to a starboard side;

FIG. 9 is a view illustrating a state in which the above boat is conducting hump control;

FIG. 10 is a diagram illustrating an example of respective thresholds of a boat speed in the hump control;

FIG. 11 is a flowchart illustrating a method for conducting the hump control while conducting trim support control;

FIG. 12 is a flowchart illustrating a processing flow of hump control stop processing in the propulsion system.

FIG. 13 is a timing chart illustrating an example of the operation of the above propulsion system; and

FIG. 14 is a timing chart illustrating another example of the operation of the above propulsion system.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Hereinafter, embodiments of the present invention will be described with reference to the drawings. Note that it is assumed that front, rear, upper, lower, left, and right directions in the following description respectively coincide with the directions of a boat 1. In this case, an arrow FR in the drawing indicates a forward side of the boat 1, an arrow UP in the drawing indicates an upper side of the boat 1, and an arrow LH in the drawing indicates a leftward side of the boat 1. In addition, the center line CL extends in the front-rear direction at the center position in a left-right direction (a width direction) of the boat 1.

[0017] FIG. 1 is a plan view of the boat according to an embodiment. FIG. 2 is a functional block diagram of a propulsion system of the boat.

[0018] As illustrated in FIG. 1, the boat 1 includes: a hull 2; and a propulsion system 20, which is provided on the hull 2.

[0019] As illustrated in FIGS. 1 and 2, the propulsion system 20 includes a plurality of propulsion machines 3, an operation unit 7, a detector 6 (see FIG. 2), and a controller 8 (see FIG. 2).

(Propulsion Machine)

[0020] As illustrated in FIG. 1, the propulsion machine 3 includes: a right propulsion machine 3a, which is provided on the right of a stern 2b with respect to the center line CL; and a left propulsion machine 3b, which is provided on the left of the stern 2b, with respect to the center line CL. The two propulsion machines 3 (the right propulsion machine 3a and the left propulsion machine 3b) are provided on the stern 2b of the hull 2 respectively on both right and left sides of the stern 2b, interposing the center line CL between them. That is, the boat 1 in the present embodiment is a so-called small-sized boat in which the two propulsion machines are provided. Hereinafter, in a case where it is not necessary to distinguish between the propulsion machines 3a and 3b, they will be collectively described as the propulsion machine 3.

[0021] FIG. 3 is a side view of a propulsion machine of the propulsion system.

[0022] As illustrated in FIG. 3, the propulsion machine 3 is, for example, an outboard motor. The propulsion machine 3 includes: a casing 31; a drive source 32; a drive shaft 33; a propulsor 34; and a shift switching mechanism 35.

[0023] The casing 31 is attached to a bracket 22, which is provided on the stern 2b, via a steering shaft (a swivel shaft) 36, which extends in an up-down direction. The propulsion machine 3 is attached to the hull 2 so as to be rotatable around the steering shaft 36 in accordance with the operation of a steering actuator 41 (see FIG. 2).

[0024] The drive source 32 is, for example, an internal combustion engine such as an engine. The drive source 32 is accommodated in an upper portion of the casing 31

with a crankshaft extending in the up-down direction. Dynamic power (an engine speed) of the drive source 32 is set, based on an opening degree of a throttle valve. The throttle valve is driven by the operation of a throttle actuator 42 (see FIG. 2). Note that the drive source 32 may be an electric motor.

[0025] The drive shaft 33 transmits the dynamic power generated by the drive source 32 to the propulsor 34 via the shift switching mechanism 35. The drive shaft 33 extends in the up-down direction in the casing 31. An upper end portion of the drive shaft 33 is connected with the drive source 32.

[0026] The propulsor 34 includes a propeller shaft 341 and propellers 342.

[0027] The propeller shaft 341 is provided at a lower end portion of the casing 31 so as to be rotatable around an axis along a front-rear direction. A front end portion of the propeller shaft 341 is connected with the shift switching mechanism 35 in the casing 31.

[0028] The propellers 342 are provided projecting outside of the casing 31 at a rear end portion of the propeller shaft 341. The propellers 342 rotate integrally with the propeller shaft 341.

[0029] The shift switching mechanism 35 includes a drive gear 351, a forward gear 352, a reverse gear 353, and a clutch 354.

[0030] The drive gear 351 is provided at a lower end portion of the drive shaft 33. The drive gear 351 is rotatable integrally with the drive shaft 33.

[0031] The forward gear 352 and the reverse gear 353 are rotatably provided at positions facing each other in the front-rear direction, interposing the drive gear 351 between them on the propeller shaft 341. The forward gear 352 and the reverse gear 353 are capable of meshing with the drive gear 351. The forward gear 352 and the reverse gear 353 rotate in opposite directions to each other in accordance with the rotation of the drive gear 351.

[0032] The clutch 354 switches between a connection state and a disconnection state of the dynamic power between either the forward gear 352 or the reverse gear 353 and the propeller shaft 341. The clutch 354 is provided to be rotatable integrally with the propeller shaft 341. The clutch 354 is provided to be movable in the front-rear direction along the propeller shaft 341 in accordance with the operation of a shift actuator 43. The clutch 354 alternatively meshes with the forward gear 352 and the reverse gear 353 to switch the rotation directions of the propeller shaft 341 and the propellers 342, and is capable of switching the propulsion direction of the boat 1.

[0033] The propulsion machine 3 is supported by the bracket 22, which is attached to the stern 2b of the hull 2, so as to be rotatable around a support shaft 38, which extends in the left-right direction. This enables the propulsion machine 3 to be rotatable (swingable) around the support shaft 38 with respect to a reference plane Fv. Here, the reference plane Fv denotes a virtual plane along a vertical plane that passes through the center

axis of the support shaft 38 when the hull 2 is simply floated on the water surface.

[0034] Here, a trim angle θ_t is defined as an angle at which the direction in which the steering shaft 36 of the propulsion machine 3 extends is inclined in the front-rear direction around the support shaft 38 with respect to the reference plane Fv. In the present embodiment, with regard to the trim angle θ_t , a positive (plus) direction represents a direction in which a lower end portion of the propulsion machine 3 is apart rearward from the stern 2b, and a negative (minus) direction represents a direction in which the lower end portion of the propulsion machine 3 approaches the stern 2b. In addition, in the present embodiment, rotating the propulsion machine 3 in the positive direction will be expressed as increasing the trim angle θ_t , and rotating the propulsion machine 3 in the negative direction will be expressed as decreasing the trim angle θ_t .

[0035] The trim angle θ_t of the propulsion machine 3 is adjustable by a trim angle adjuster 45. The trim angle adjuster 45 uses an actuator, not illustrated, to rotate the propulsion machine 3 around the support shaft 38 within a preset angle range. The rotation of the propulsion machine 3 in the positive direction and the negative direction is restricted by hitting a stopper, not illustrated, or the like provided on the bracket 22. In the present embodiment, the trim angle θ_t when the propulsion machine 3 is rotated in the most negative direction is set as a trim angle lower limit value θ_{td} (in FIG. 3, for example, $\theta_t =$ about -10 degrees).

[0036] In the present embodiment, the bracket 22 is attached to an attachment surface 2f, which is formed on the stern 2b, via an intermediate member 37. The intermediate member 37 is sandwiched between the bracket 22 and the attachment surface 2f. The intermediate member 37 is formed in a wedge shape having a thickness in the front-rear direction gradually decreasing from the top to the bottom. Thus, the bracket 22 is provided to be further inclined rearward than a case of being directly attached to the attachment surface 2f without the use of the intermediate member 37. This constitution enables setting of a larger rotation angle (rotation range) of the propulsion machine 3 in the negative direction.

(Operation Unit)

[0037] As illustrated in FIGS. 1 and 2, the operation unit 7 is provided to allow a boat operator to perform an operation input in order to navigate the boat 1. In the present embodiment, the operation unit 7 includes, for example, a steering angle inputter 71, a thrust inputter 72, a trim angle operation unit 73, and an operation inputter 74.

[0038] The steering angle inputter 71 is provided in a cockpit of the hull 2. The steering angle inputter 71 is, for example, a steering wheel provided to be rotatable clockwise and counterclockwise. The steering angle inputter 71 receives an operation input by the boat operator from

the outside, in changing the course of the boat 1 (the hull 2). That is, the steering angle inputter 71 receives an operation, by the boat operator, for changing the direction (the steering angle) of the propulsion machine 3 around the steering shaft 36. The steering angle denotes an inclination angle of the propulsion machine 3 with respect to the center line CL in a plan view. In the present embodiment, the steering angle of the propulsion machine 3 when the course of the boat 1 is the straight advancing direction is set as the reference value (0 degrees). Note that as the steering angle inputter 71, in addition to the steering wheel, a joystick may be used, and the steering angle inputter 71 may be mounted as a switch or the like of the operation inputter 74.

[0039] The thrust inputter 72 is provided in the cockpit of the hull 2. The thrust inputter 72 is, for example, a throttle lever. In changing the thrust of the propulsion machine 3 or the shift position of the propulsion machine 3, the thrust inputter 72 receives an operation input from the outside by the boat operator. The thrust inputter 72 is constituted to be capable of reciprocating in accordance with rotation, sliding, or the like. The thrust inputter 72 is capable of reciprocating within an operation region in which three shift regions of the forward position F, the neutral position N, and the reverse position R are aligned. When the thrust inputter 72 is located at the forward position F, the propulsion machine 3 exerts thrust for moving the boat 1 forward. When the thrust inputter 72 is located at the reverse position R, the propulsion machine 3 exerts thrust for moving the boat 1 rearward. When the thrust inputter 72 is located at the neutral position N, the drive gear 351, which is illustrated in FIG. 3, is disconnected from the forward gear 352 and the reverse gear 353, and the propulsion machine 3 does not exert thrust for propelling the boat 1.

[0040] As illustrated in FIG. 1, a trim angle operation switch is provided as the trim angle operation unit 73 in the vicinity of the thrust inputter 72. The boat operator of the boat 1 is able to change the trim angle θ_t of the propulsion machine 3 by manually operating the trim angle operation switch (the trim angle operation unit 73).

[0041] The operation inputter 74 receives various operations on the boat 1. The operation inputter 74 is constituted to be manually operable by the boat operator, such as a multi-function display (MFD). Note that the operation inputter 74 may be an external device such as a mobile terminal connected to the boat 1 in a wired or wireless manner.

(Detector)

[0042] The detector 6 illustrated in FIG. 2 detects a state (a navigation state) of the boat 1. In the present embodiment, the detector 6 includes a position sensor 61, a boat speed sensor 62, a steering angle sensor 63, an inertial sensor 64, a trim operation sensor 65, a trim angle sensor 66, and an actual steering angle sensor 67.

[0043] The position sensor 61 detects the position of

the thrust inputter 72. The position sensor 61 detects the lever opening rate of the propulsion machine 3, based on the position of the thrust inputter 72, which is, for example, a throttle lever for instructing the lever opening rate.

The position sensor 61 outputs, to the controller 8, a detection signal based on the position of the thrust inputter 72.

[0044] As illustrated in FIG. 2, the boat speed sensor 62 detects a boat speed V of the boat 1. The boat speed sensor 62 is, for example, a global positioning system (GPS) or the like, and calculates the boat speed V, based on a positioning signal from a positioning satellite. Note that the boat speed sensor 62 may be an acoustic sensor or an electromagnetic sensor that detects the boat speed (a boat speed relative to the water) V of the boat 1. The boat speed sensor 62 may estimate the boat speed V, based on the engine speed. The boat speed sensor 62 outputs a signal indicating the detected boat speed V to the controller 8.

[0045] The steering angle sensor 63 detects an operation amount (a steering instruction angle) in accordance with the rotation operation on the steering angle inputter 71. The steering angle sensor 63 outputs, to the controller 8, a detection signal based on the steering instruction angle on the steering angle inputter 71.

[0046] The inertial sensor 64 detects the inclination in the roll direction of the hull 2, that is, a heel angle θ_h . The inertial sensor 64 detects the inclination in the pitch direction of the hull 2, that is, a pitch angle θ_p . The inertial sensor 64 outputs, to the controller 8, detection signals based on the detected inclinations in the roll direction and the pitch direction of the hull 2.

[0047] The trim operation sensor 65 detects whether an operation input has been made on the trim angle operation switch, which serves as the trim angle operation unit 73. The trim operation sensor 65 outputs, to the controller 8, a detection signal indicating the presence or absence of the detected operation input.

[0048] The trim angle sensor 66 is provided in the trim angle adjuster 45. The trim angle sensor 66 detects an actual trim angle θ_t to be adjusted by the trim angle adjuster 45. The trim angle sensor 66 outputs, to the controller 8, a detection signal indicating the detected trim angle θ_t .

[0049] The actual steering angle sensor 67 is provided on the steering actuator 41. The actual steering angle sensor 67 detects the actual steering angle of the propulsion machine 3, and outputs the actual steering angle to the controller 8.

(Controller)

[0050] The controller 8 integrally controls the operation of the boat 1 (the propulsion machine 3). The controller 8 is an integrated electronic control device or a plurality of electronic control devices included in the boat 1. The controller 8 is implemented by, for example, a hardware processor such as a central processing unit (CPU) ex-

ecuting a program (software) stored in a storage 80 such as a read only memory (ROM), a random access memory (RAM), or the like. Some or all of these constituent elements may be implemented by a hardware (a circuit unit; including circuitry) such as a large scale integration (LSI), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a graphics processing unit (GPU), or system on chip (SOC) or may be implemented by software and hardware in cooperation.

[0051] The controller 8 includes a storage 80, an acquirer 81, a determiner 82, and a drive processor 83.

[0052] The storage 80 records programs, various data, and the like necessary for navigation of the boat 1, such as the trim support control, the heel control, the hump control, and the bogen control.

[0053] The acquirer 81 acquires detection results of various sensors of the detector 6.

[0054] The determiner 82 determines the state of the boat 1, based on information obtained by the acquirer 81 and information stored in the storage 80.

[0055] The drive processor 83 controls operations of various actuators, based on a determination result by the determiner 82 and the information stored in the storage 80 or the acquirer 81. In the present embodiment, in a case where the determiner 82 determines that a predetermined condition is satisfied, the drive processor 83 controls the operations of the trim angle adjuster 45, the steering actuator 41, and the like to conduct the trim support control, the heel control, the hump control, and the bogen control. In the present embodiment, when the boat 1 is in a straight advancing state, the drive processor 83 conducts the trim support control, the heel control, the hump control, and the bogen control. In the present embodiment, the drive processor 83 does not conduct the bogen control, when the boat 1 is not in the straight advancing state.

(Trim Support Control)

[0056] FIG. 4 is a diagram illustrating an example of the trim support control, the heel control, the hump control, and the bogen control to be conducted in accordance with the boat speed in the propulsion system.

[0057] As illustrated in FIG. 4, when the boat 1 is in the straight advancing state, the drive processor 83 is capable of conducting the trim support control in the regions of the heel control, the hump control, and the bogen control in accordance with settings by the boat operator to be input from the trim angle operation unit 73 and the operation inputter 74, for example.

[0058] FIG. 5 is a diagram illustrating an example of set values of the trim support angles in the trim support control, the heel control, and the hump control to be conducted in accordance with the boat speed in the propulsion system.

[0059] As illustrated in FIG. 5, in the trim support control, the trim angle adjuster 45 is caused to adjust a trim angle θ_t to be a trim support angle θ_{sp} , which is set in

accordance with a preset boat speed V (or rotation speed of the propulsion machine). In the present embodiment, in the trim support control, the trim support angle θ_{sp} is set in accordance with the boat speed V to optimize stability, acceleration, a maximum speed, energy efficiency, and the like. The trim support angle θ_{sp} may be set in accordance with the rotation speed of the propulsion machine. Therefore, in the storage 80, the boat speed V (or the rotation speed of the propulsion machine) and the trim support angle θ_{sp} , at which the stability, the acceleration, the maximum speed, the energy efficiency, and the like are optimized, are stored beforehand in association with each other. In the example of FIG. 5, the trim support angle θ_{sp} is set in a stepwise manner with respect to the boat speed V (or the rotation speed of the propulsion machine).

[0060] The drive processor 83 acquires, from the storage 80, the trim support angle θ_{sp} , which is associated with the boat speed acquired by the acquirer 81.

[0061] The drive processor 83 controls the trim angle adjuster 45 so that the trim angle θ_t of the propulsion machine 3 approaches the acquired trim support angle θ_{sp} .

[0062] FIG. 6 is a view illustrating a state in which the trim support control is being conducted in the propulsion system.

[0063] As illustrated in FIG. 6, in conducting the trim support control, the drive processor 83 sets the trim support angles θ_{sp} of the propulsion machines 3a and 3b on both sides in the left-right direction to the same value.

(Heel Control)

[0064] As illustrated in FIG. 4, when the boat 1 is in the straight advancing state and the boat speed V is equal to or higher than the second threshold V_2 , while the trim support control is being conducted, and in a case where the determiner 82 determines that a preset condition is satisfied, the drive processor 83 conducts the heel control in addition to the trim support control. Specifically, when the boat 1 is in the straight advancing state, while the trim support control is being conducted, and when the boat speed becomes equal to or higher than the second threshold V_2 , the drive processor 83 conducts the heel control in addition to the trim support control, that is, both the trim support control and the heel control.

[0065] In this case, the drive processor 83 conducts the heel control, in a case where the heel angle θ_h , which is detected by the inertial sensor 64, and which is the inclination in the roll direction of the hull 2, is equal to or larger than a preset heel angle reference value θ_{hs} (for example, several degrees). That is, in a case where the heel angle θ_h is smaller than the heel angle reference value θ_{hs} , the drive processor 83 continuously conducts the trim support control without conducting the heel control.

[0066] In conducting the heel control, the drive proces-

sor 83 sets a heel suppression angle θ_d as a target value in accordance with the heel angle θ_h of the hull 2. Here, the heel suppression angle θ_d denotes a trim angle of the propulsion machines 3 on both sides in the left-right direction for suppressing the inclination in the roll direction of the hull 2. The drive processor 83 calculates a heel suppression angle θ_d , which is capable of effectively suppressing the inclination in the roll direction of the hull 2, in accordance with the heel angle θ_h of the hull 2 in a preset calculation formula.

[0067] The drive processor 83 sets the heel suppression angle θ_d with reference to the trim support angle θ_{sp} of the propulsion machine 3 at such a timing. With regard to the trim support angle θ_{sp} , the drive processor 83 sets the heel suppression angle θ_d of the propulsion machine 3 on one side in the left-right direction to a value larger than the trim support angle θ_{sp} , and also sets the heel suppression angle θ_d of the propulsion machine 3 on the other side in the left-right direction to a value smaller than the trim support angle θ_{sp} .

[0068] FIG. 7 is a view illustrating a state of conducting the heel control in a state in which the boat is inclined to the port side. FIG. 8 is a view illustrating a state of conducting the heel control in a state in which the boat is inclined to the starboard side.

[0069] For example, as illustrated in FIG. 7, when the hull 2 is inclined to the port side, the drive processor 83 sets a heel suppression angle θ_{d2} of the right propulsion machine 3a to a value larger than the trim support angle θ_{sp} , and sets a heel suppression angle θ_{d1} of the left propulsion machine 3b to a value smaller than the trim support angle θ_{sp} . For example, as illustrated in FIG. 8, when the hull 2 is inclined to the starboard side, the drive processor 83 sets the heel suppression angle θ_{d1} of the left propulsion machine 3b to a value larger than the trim support angle θ_{sp} , and sets the heel suppression angle θ_{d2} of the right propulsion machine 3a to a value smaller than the trim support angle θ_{sp} .

(Hump Control)

[0070] FIG. 9 is a view illustrating a state in which the boat is conducting the hump control.

[0071] In a case where the determiner 82 determines that the preset condition is satisfied, the drive processor 83 conducts the hump control. While the trim support control is being conducted, in a case where the determiner 82 determines that the preset condition is satisfied, the drive processor 83 is capable of conducting the hump control in addition to the trim support control.

[0072] As illustrated in FIG. 9, the hump control is conducted to suppress excessive lifting of a bow 2a when the bow 2a is largely lifted with respect to the stern 2b and the pitch angle θ_p is large. In conducting the hump control, the drive processor 83 sets the trim angles θ_t of the propulsion machines 3a and 3b on both sides in the left-right direction to the same value. In conducting the hump control, the drive processor 83 rotates the propulsion

machine 3 further in the negative direction than a state in which the trim angle $\theta_t = 0$ degrees. In the hump control, the drive processor 83 adjusts the trim angle θ_t of the propulsion machine 3 with the trim angle lower limit value θ_{td} as a lower limit.

[0073] FIG. 10 is a diagram illustrating an example of respective thresholds of the boat speed in the hump control.

[0074] As will be described later in detail, the drive processor 83 enables conducting the hump control in a case where the boat speed V of the hull 2 falls within a set speed region that has been set beforehand.

[0075] Specifically, as illustrated in FIG. 10, the drive processor 83 conducts the hump control, assuming that the boat speed V falls within the set speed region when the boat speed V is equal to or higher than a preset first threshold V_1 and is lower than a second threshold V_2 , while the hull 2 is accelerating. The drive processor 83 enables conducting the hump control when the boat speed V becomes equal to or higher than the preset first threshold V_1 , while the hull 2 is accelerating. While conducting the hump control and while the hull 2 is accelerating, the drive processor 83 stops conducting the hump control when the boat speed V becomes equal to or higher than a second threshold V_2 , which is larger than the first threshold V_1 .

[0076] In addition, while the hull 2 is accelerating, the drive processor 83 enables conducting the hump control when the boat speed V is lower than the first threshold V_1 and the lever opening rate of the propulsion machine 3 becomes equal to or larger than a preset reference opening rate.

[0077] Further, the drive processor 83 conducts the hump control, assuming that the boat speed V falls within the set speed region when the boat speed V is higher than a preset fourth threshold V_4 and is equal to or lower than the third threshold V_3 , while the hull 2 is decelerating. The drive processor 83 enables conducting the hump control when the boat speed V becomes equal to or lower than the third threshold V_3 , which is smaller than the second threshold V_2 , while the hull 2 is decelerating. While the hull 2 is decelerating and while conducting the hump control, the drive processor 83 stops conducting the hump control when the boat speed V becomes equal to or lower than the fourth threshold V_4 , which is smaller than the first threshold V_1 .

[0078] In addition, while the hull 2 is decelerating, the drive processor 83 enables conducting the hump control when the boat speed V becomes equal to or lower than a fifth threshold V_5 , which is smaller than the second threshold V_2 and is larger than the third threshold V_3 , and the pitch angle θ_p of the hull 2 is equal to or larger than a preset third reference pitch angle.

[0079] Further, in a case where it is determined that the boat speed V falls within the set speed region and the hull 2 is turning, the drive processor 83 may enable conducting the hump control.

[0080] In stopping the hump control from the state of

conducting the hump control, the drive processor 83 causes the trim angle adjuster 45 to adjust the trim angle θ_t of the propulsion machine 3 in accordance with the state of the hull 2.

[0081] In stopping the hump control from the state of conducting the hump control, the drive processor 83 is capable of performing an acceleration-time trim angle adjustment mode, a deceleration-time trim angle adjustment mode, and a manual operation-time trim angle adjustment mode, as will be described below. In each of the acceleration-time trim angle adjustment mode, the deceleration-time trim angle adjustment mode, and the manual operation-time trim angle adjustment mode, the trim angle adjuster 45 adjusts the trim angle θ_t of the propulsion machine 3 in accordance with the state of the hull 2.

(Acceleration-Time Trim Angle Adjustment Mode)

[0082] While the hull 2 is accelerating, in stopping conducting the hump control from the state of conducting the hump control, the drive processor 83 performs the acceleration-time trim angle adjustment mode. Specifically, while the hull 2 is accelerating, while conducting the hump control, in a case where the boat speed V becomes equal to or higher than the second threshold V2, and in stopping conducting the hump control, the drive processor 83 conducts the acceleration-time trim angle adjustment mode.

[0083] In the acceleration-time trim angle adjustment mode, in a case where the trim angle θ_t of at least one propulsion machine 3 is smaller than a preset trim angle reference value θ_{ts} at the time of stopping conducting the hump control, the trim angle adjuster 45 adjusts the trim angle θ_t of the propulsion machine 3 so that the trim angles θ_t of all the propulsion machines 3 become the trim angle reference value θ_{ts} . Here, the trim angle reference value θ_{ts} is set in a direction (a positive direction) in which the propulsion machine 3 is upright forward in the propulsion direction of the hull 2 and the trim angle θ_t is larger than the trim angle lower limit value θ_{td} . In the present embodiment, the trim angle reference value θ_{ts} is, for example, $\theta_t = \text{about } -5 \text{ degrees}$. Thus, while in acceleration, after conducting the hump control is stopped, a state in which the trim angle θ_t of the propulsion machine 3 is smaller than the trim angle reference value θ_{ts} is maintained to suppress continuation of a state of strongly suppressing the hump state.

[0084] In the acceleration-time trim angle adjustment mode, in a case of conducting the trim support control at the time of stopping the hump control, conducting the hump control is stopped from the state of conducting the trim support control and the hump control. In this case, the drive processor 83 disables the control of decreasing the trim angle θ_t of the propulsion machine 3 in subsequent trim support control. That is, after conducting the hump control is stopped, the drive processor 83, in the trim support control, is capable of controlling the trim

angle θ_t so as to maintain the trim angle θ_t of the propulsion machine 3 at the trim angle θ_t at the time of stopping conducting the hump control, or so as to make the trim angle θ_t larger in the positive direction than the trim angle θ_t at the time of stopping conducting the hump control.

(Deceleration-Time Trim Angle Adjustment Mode)

[0085] While the hull 2 is decelerating, in stopping conducting the hump control from the state of conducting the hump control, the drive processor 83 performs the deceleration-time trim angle adjustment mode. Specifically, while the hull 2 is decelerating, from the state of conducting the hump control, the boat speed V becomes equal to or lower than the fourth threshold V4, and in stopping conducting the hump control, the drive processor 83 performs the deceleration-time trim angle adjustment mode.

[0086] In the deceleration-time trim angle adjustment mode, in a case where the trim angle θ_t of at least one propulsion machine 3 is smaller than the trim angle reference value θ_{ts} at the time of stopping conducting the hump control, the trim angle adjuster 45 adjusts the trim angle θ_t of the propulsion machine 3 so that the trim angles θ_t of all the propulsion machines 3 become the trim angle reference value θ_{ts} . Thus, also while in deceleration, after conducting the hump control is stopped, a state in which the trim angle θ_t of the propulsion machine 3 is smaller than the trim angle reference value θ_{ts} is maintained to suppress the continuation of the state of strongly suppressing the hump state.

[0087] In the deceleration-time trim angle adjustment mode, in a case of conducting the trim support control at the time of stopping the hump control, conducting the hump control is stopped from the state of conducting the trim support control and the hump control. In this case, the drive processor 83 enables conducting control of decreasing the trim angle θ_t of the propulsion machine 3 in subsequent trim support control. In the hump state while in deceleration, the pitch angle θ_p is smaller than that in the hump state while in acceleration. Therefore, in the trim support control, even though the trim angle θ_t of the propulsion machine 3 is decreased, an uneasy feeling is less likely to occur. Therefore, the control of decreasing the trim angle θ_t of the propulsion machine 3 is enabled.

(Manual Operation-Time Trim Angle Adjustment Mode)

[0088] While conducting the hump control, upon receipt of an operation input from the trim angle operation unit 73, the drive processor 83 stops conducting the hump control. In this case, the drive processor 83 performs the manual operation-time trim angle adjustment mode. In the manual operation-time trim angle adjustment mode, in a case where the trim angle θ_t of at least one propulsion machine 3 is smaller than the trim angle reference value θ_{ts} at the time of stopping conducting the

hump control, the trim angle adjuster 45 adjusts the trim angle θ_t of the propulsion machine 3 so that the trim angles θ_t of all the propulsion machines 3 become the trim angle reference value θ_{ts} . Thus, also in the manual operation, after conducting the hump control is stopped, the state in which the trim angle θ_t of the propulsion machine 3 is smaller than the trim angle reference value θ_{ts} is maintained to suppress the continuation of the state of strongly suppressing the hump state.

(Bogen Control)

[0089] The drive processor 83 conducts the bogen control in a case where the boat speed V is lower than the first threshold V1. In the bogen control, the plurality of propulsion machines 3 are steered in a direction intersecting the front-rear direction of the hull 2 in a yaw direction. When the boat 1 is in the straight advancing state and the boat speed V is lower than the first threshold V1, the left and right propulsion machines 3 are rotated in directions opposite to each other around the swivel axis and at almost the same steering angle in the bogen control. It becomes possible to reduce the forward propulsion force that works on the entirety of the hull 2 and to navigate the hull 2 at a low speed or an extremely low speed in the bogen control, as compared with a case where the propulsion machines 3 are disposed in parallel with the front-rear direction of the hull 2. Note that in the present embodiment, there is no limitation to the specific content of the bogen control.

(Control Method of Propulsion System)

[0090] Next, an operation method of the propulsion system will be described. Processing to be described below is repeatedly performed, for example, at a predetermined control cycle (for example, several tens of milliseconds).

[0091] FIG. 11 is a flowchart illustrating a processing flow of a control method of the propulsion system.

[0092] The flowchart illustrated in FIG. 11 illustrates a processing flow of conducting the hump control, in the control to be conducted by the controller 8 of the propulsion system 20.

[0093] As illustrated in FIG. 11, in step S11, the controller 8 causes the acquirer 81 to acquire a detection result of the boat speed in the boat speed sensor 62. In step S11, in order to detect a change in the boat speed, the controller 8 acquires the detection result of the boat speed a plurality of times after a predetermined control cycle elapses.

[0094] In step S12, the controller 8 determines whether the boat speed V of the hull 2 falls within a preset speed region, based on the detection result of the boat speed sensor 62.

[0095] In this case, while the hull 2 is accelerating, the controller 8 determines that the boat speed V falls within a set speed region in a case where the boat speed V is

equal to or higher than the preset first threshold V1 and is lower than the second threshold V2. while the hull 2 is decelerating, in a case where the boat speed V is higher than the preset fourth threshold V4 and is equal to or lower than the third threshold V3, the controller 8 determines that the boat speed V falls within the set speed region, and conducts the hump control. Here, the fourth threshold V4 is set to be lower than the first threshold V1 by 5 km/h to 10 km/h, for example. The third threshold V3 is set to be lower than the second threshold V2 by 5 km/h to 10 km/h, for example.

[0096] In a case where the boat speed V is out of the set speed range and the determination result in step S12 is "No", the processing proceeds to step S13 to be described later.

(Case of Determining That Boat Speed Falls within Set Range)

[0097] In a case where the boat speed V falls within the set speed range and the determination result in step S12 is "Yes", the processing skips to step S15, and the controller 8 sets a standby state that enables conducting the hump control.

[0098] Subsequently, in step S16, the controller 8 determines whether the hump control conducting condition is satisfied in a case where the boat speed V falls within the set speed range.

[0099] The hump control conducting condition in the case where the boat speed V falls within the set speed range includes, for example, the following conditions a1 and a2.

[0100] Condition a1: A detection value of the pitch angle θ_p acquired by the inertial sensor 64 is larger than a preset first reference pitch angle.

[0101] Condition a2: It is determined that the hull 2 is turning, based on the actual steering angle detected by the actual steering angle sensor 67.

[0102] In a case where the boat speed V falls within the set speed range, and when at least one of the conditions a1 and a2 is satisfied in step S16, the controller 8 determines that the hump control conducting condition is satisfied.

[0103] In a case where the determination result in step S16 is "No", the processing ends. The processing from step S11 is repeated after a predetermined control cycle elapses.

[0104] In a case where the determination result in step S16 is "Yes", the processing proceeds to step S17.

(Case of Determining That Boat Speed Is Out of Set Range)

[0105] In a case where the boat speed V is out of the set speed range and the determination result in step S12 is "No", the controller 8 determines in step S13 whether an acceleration exceptional condition is satisfied.

[0106] The acceleration exceptional condition in-

cludes, for example, the following conditions b1 to b3.

[0107] Condition b1: The hull 2 is accelerating.

[0108] Condition b2: The boat speed V is lower than the first threshold V1.

[0109] Condition b3: The lever opening rate of the propulsion machine 3 acquired by the position sensor 61 is larger than a preset reference opening rate.

[0110] In a case where the boat speed V is out of the set speed range and all of the conditions b1 to b3 are satisfied, the controller 8 determines in step S13 that the acceleration exceptional condition is satisfied.

[0111] In a case where the determination result in step S13 is "Yes", the processing skips to step S15, and the controller 8 sets a standby state that enables conducting the hump control.

[0112] Subsequently, in step S16, the controller 8 determines whether the hump control conducting condition is satisfied in a case where the acceleration exceptional condition is satisfied.

[0113] The hump control conducting condition, in a case where the boat speed V is out of the set speed range and the acceleration exceptional condition is satisfied in step S13, includes the following conditions c1 to c3.

[0114] Condition c1: The lever opening rate of the propulsion machine 3 acquired by the position sensor 61 is larger than a preset first lever opening rate.

[0115] Condition c2: A detected value of the pitch angle θ_p acquired by the inertial sensor 64 is larger than a preset reference pitch angle.

[0116] Condition c3: It is determined that the hull 2 is turning, based on the actual steering angle detected by the actual steering angle sensor 67.

[0117] Here, the first lever opening rate may be the same value as the reference opening rate, or may be a value slightly larger than the reference opening rate.

[0118] In a case where the boat speed V is out of the set speed range and the acceleration exceptional condition is satisfied, and when at least one of the conditions c1 to c3 is satisfied in step S16, the controller 8 determines that the hump control conducting condition is satisfied.

[0119] In a case where the determination result in step S16 is "No", the processing ends. The processing from step S11 is repeated after a predetermined control cycle elapses.

[0120] In a case where the determination result in step S16 is "Yes", the processing proceeds to step S17.

(Case of Determining That Boat Speed Is Out of Set Range)

[0121] In a case where the boat speed V is out of the set speed range and the determination result in step S13 is "No", the controller 8 determines in step S14 whether a deceleration exceptional condition is satisfied.

[0122] The deceleration exceptional condition includes, for example, the following conditions d1 and d2.

[0123] Condition d1: The hull 2 is decelerating.

[0124] Condition d2: The boat speed V is equal to or higher than the third threshold V3 and is equal to or lower than the fifth threshold V5.

[0125] In a case where the boat speed V is out of the set speed range and all of the conditions d1 and d2 are satisfied, the controller 8 determines that the deceleration exceptional condition is satisfied.

[0126] In a case where the determination result in step S14 is "No", the processing ends. The processing from step S11 is repeated after a predetermined control cycle elapses.

[0127] In a case where the determination result in step S14 is "Yes", the processing proceeds to step S15, and the controller 8 sets a standby state that enables conducting the hump control.

[0128] Subsequently, in step S16, the controller 8 determines whether the hump control conducting condition is satisfied in a case where the deceleration exceptional condition is satisfied.

[0129] The hump control conducting condition, in a case where the boat speed V is out of the set speed range and the deceleration exceptional condition is satisfied, includes the following condition e1, for example.

[0130] Condition e1: A detection value of the pitch angle θ_p acquired by the inertial sensor 64 is larger than a preset third reference pitch angle.

[0131] Here, the third reference pitch angle may be the same value as the first reference pitch angle, or may be a value slightly larger than the first reference pitch angle.

[0132] In a case where the boat speed V is out of the set speed range and the deceleration exceptional condition is satisfied, and when the condition e1 is satisfied in step S16, the controller 8 determines that the hump control conducting condition is satisfied.

[0133] In a case where the determination result in step S16 is "No", the processing ends. The processing from step S11 is repeated after a predetermined control cycle elapses.

[0134] In a case where the determination result in step S16 is "Yes", the processing proceeds to step S17.

(Conducting Hump Control)

[0135] In step S17, the controller 8 conducts the hump control. In this case, the controller 8 decreases the trim angles θ_t of all the propulsion machines 3 to the trim angle lower limit value.

[0136] After starting conducting the hump control in step S17, while conducting the hump control, the controller 8 determines whether a predetermined stop condition for stopping the hump control is satisfied in step S18. In the present embodiment, as the predetermined stop conditions for stopping the hump control, for example, the following conditions g1 to g3 are given.

[0137] Condition g1: A case where the boat speed V becomes equal to or higher than the second threshold V2 while in acceleration,

[0138] Condition g2: A case where the boat speed V

becomes equal to or lower than the fourth threshold V_4 while in deceleration, and

[0139] Condition g3: A case of receiving an operation input by the boat operator from the trim angle operation unit 73.

[0140] In a case where at least one of the conditions g1 to g3 is satisfied, the controller 8 determines that the stop condition for stopping the hump control is satisfied.

[0141] In a case where the determination result in step S18 is "No", the processing ends. Step S11 is repeated after a predetermined control cycle elapses.

[0142] In a case where the determination result in step S18 is "Yes", the processing proceeds to step S20, and stops conducting the hump control.

[0143] FIG. 12 is a flowchart illustrating a processing flow of hump control stop processing in the propulsion system.

[0144] As illustrated in FIG. 12, in step S20, the hump control is stopped in the following processing flow.

[0145] In step S21, the controller 8 determines whether the stop condition g1 of the hump control while in acceleration is satisfied.

[0146] In a case where the determination result in step S21 is "No", the processing proceeds to step S22.

[0147] In a case where the determination result in step S21 is "Yes", the processing proceeds to step S24.

[0148] In step S24, the controller 8 stops conducting the hump control, and performs the acceleration-time trim angle adjustment mode.

[0149] In the acceleration-time trim angle adjustment mode, in a case where the trim angle θ_t of at least one propulsion machine 3 is smaller than a preset trim angle reference value θ_{ts} at the time of stopping conducting the hump control, the trim angle adjuster 45 adjusts the trim angle θ_t of the propulsion machine 3 so that the trim angles θ_t of all the propulsion machines 3 become the trim angle reference value θ_{ts} .

[0150] In the acceleration-time trim angle adjustment mode, in a case of conducting the trim support control at the time of stopping conducting the hump control, the control of decreasing the trim angle θ_t of the propulsion machine 3 is disabled in subsequent trim support control.

[0151] In step S22, the controller 8 determines whether the stop condition g2 of the hump control while in deceleration is satisfied.

[0152] In a case where the determination result in step S22 is "No", the processing proceeds to step S23.

[0153] In a case where the determination result in step S22 is "Yes", the processing proceeds to step S25.

[0154] In step S25, the controller 8 stops conducting the hump control, and performs the deceleration-time trim angle adjustment mode.

[0155] In the deceleration-time trim angle adjustment mode, in a case where the trim angle θ_t of at least one propulsion machine 3 is smaller than the trim angle reference value θ_{ts} at the time of stopping conducting the hump control, the trim angle adjuster 45 adjusts the trim angle θ_t of the propulsion machine 3 so that the trim

angles θ_t of all the propulsion machines 3 become the trim angle reference value θ_{ts} .

[0156] In the deceleration-time trim angle adjustment mode, in a case of conducting the trim support control at the time of stopping conducting the hump control, the control of decreasing the trim angle θ_t of the propulsion machine 3 is enabled in subsequent trim support control.

[0157] In step S23, the controller 8 determines whether the stop condition g3 of the hump control at the time of manual operation is satisfied.

[0158] In a case where the determination result in step S23 is "No", the processing ends. The processing from step S11 is repeated after a predetermined control cycle elapses.

[0159] In a case where the determination result in step S23 is "Yes", the processing proceeds to step S26.

[0160] In step S26, the controller 8 stops conducting the hump control, and performs the manual operation-time trim angle adjustment mode.

[0161] In the manual operation-time trim angle adjustment mode, in a case where the trim angle θ_t of at least one propulsion machine 3 is smaller than the trim angle reference value θ_{ts} at the time of stopping conducting the hump control, the trim angle adjuster 45 adjusts the trim angle θ_t of the propulsion machine 3 so that the trim angles θ_t of all the propulsion machines 3 become the trim angle reference value θ_{ts} .

[0162] FIG. 13 is a timing chart illustrating an example of the operation of the above propulsion system.

[0163] In FIG. 13, "0" indicates that the determination result in the controller 8 is "No", and "1" indicates that the determination result in the controller 8 is "Yes" in each a "boat speed determination flag", a "hump state determination flag", and a "trim operation determination flag",

[0164] As illustrated in FIG. 13, for example, the boat operator operates the thrust inputter 72, then the lever opening rate is increased, and the boat speed V is increased. As the boat speed V increases, when the pitch angle θ_p exceeds a first reference pitch angle (time t_1), the hump state determination flag changes from "0" to "1", and the hump control starts. At this timing, the controller 8 sets the trim operation determination flag from "0" to "1", and performs the trim operation.

[0165] Then, by conducting the hump control, the increase in the pitch angle θ_p ends, the pitch angle θ_p decreases, and when the pitch angle θ_p becomes equal to or smaller than the second reference pitch angle, which is smaller than the first reference pitch angle (time t_2), the hump determination flag changes from "1" to "0". Then, the controller 8 sets the trim operation determination flag from "1" to "0", and stops conducting the hump control.

[0166] FIG. 14 is a timing chart illustrating another example of the operation of the propulsion system.

[0167] As illustrated in FIG. 14, for example, when the lever opening rate rapidly increases in accordance with the operation by the boat operator on the thrust inputter 72, the above conditions b1 to b3 are satisfied (time t_{11}), and the hump control starts. Thus, the hump state de-

termination flag changes from "0" to "1", and the trim operation determination flag changes from "0" to "1".

[0168] Then, by conducting the hump control, when the trim angle θ_t of the propulsion machine 3 decreases to the trim angle lower limit value (time t_{12}), it is not possible to further decrease the trim angle θ_t for the hump control. Then, the trim operation determination flag changes from "1" to "0", and the trim operation stops.

[0169] Then, by conducting the hump control, the increase in the pitch angle θ_p ends, and the pitch angle θ_p decreases.

[0170] When the boat speed V further increases and exceeds the second threshold V_2 (time t_{13}), the hump determination flag changes from "1" to "0", and the hump control ends. Then, the controller 8 sets the trim operation determination flag from "0" to "1", and the trim operation is returned to the normal control.

[0171] In this situation, the hump control is stopped while in acceleration. Therefore, the condition of step S21 is satisfied, and the controller 8 performs the acceleration-time trim angle adjustment mode, and adjusts the trim angle θ_t of the propulsion machine 3 so that the trim angles θ_t of all the propulsion machines 3 become the trim angle reference value θ_{ts} . Then, when the trim angles θ_t of all the propulsion machines 3 are the trim angle reference value θ_{ts} (time t_{14}), the controller 8 returns the trim operation determination flag from "1" to "0".

[0172] In this manner, in the propulsion system 20 according to the present embodiment, in a case of stopping conducting the hump control from the state of conducting the hump control, the trim angle adjuster 45 adjusts the trim angle θ_t of the propulsion machine 3 in accordance with the state of the hull 2. This enables smooth transition of the state, in transitioning from the state of conducting the hump control to another state.

[0173] In addition, since the propulsion system 20 according to the present embodiment includes the acceleration-time trim angle adjustment mode and the deceleration-time trim angle adjustment mode, it becomes possible to make a suitable transition for a case of stopping conducting the hump control from the state of conducting the hump control while the hull 2 is accelerating, and a case of stopping conducting the hump control from the state of conducting the hump control while the hull 2 is decelerating.

[0174] Further, in the acceleration-time trim angle adjustment mode, the propulsion system 20 according to the present embodiment adjusts the trim angle θ_t of the propulsion machine 3 so that the trim angle θ_t becomes the trim angle reference value θ_{ts} , in a case where the trim angle θ_t of the propulsion machine 3 at the time of stopping conducting the hump control is smaller than the trim angle reference value θ_{ts} . In this manner, in the case where the trim angle θ_t of the propulsion machine 3 at the time of stopping conducting the hump control is smaller than the trim angle reference value θ_{ts} , the trim angle θ_t is increased to the trim angle reference value θ_{ts} , so that the

efficiency of navigation can be improved.

[0175] In addition, in stopping conducting the hump control from the state of conducting the trim support control and the hump control while the hull 2 is accelerating, the propulsion system 20 according to the present embodiment disables the control of decreasing the trim angle θ_t of the propulsion machine 3 by the trim support control. Thus, the trim angle θ_t of the propulsion machine 3 is equal to or larger than the angle at the time of conducting the hump control. That is, it becomes possible to suppress a decrease in efficiency of navigation due to a decrease in the trim angle θ_t of the propulsion machine 3.

[0176] In addition, in the deceleration-time trim angle adjustment mode, in a case where the trim angle θ_t of the propulsion machine 3 at the time of stopping conducting the hump control is smaller than the trim angle reference value θ_{ts} , the propulsion system 20 according to the present embodiment adjusts the trim angle θ_t of the propulsion machine 3 so that the trim angle θ_t becomes the trim angle reference value θ_{ts} . In this manner, in the case where the trim angle θ_t of the propulsion machine 3 at the time of stopping conducting the hump control is smaller than the trim angle reference value θ_{ts} , the trim angle θ_t is increased to the trim angle reference value θ_{ts} , so that the efficiency of navigation can be improved.

[0177] In addition, in stopping conducting the hump control from the state of conducting the trim support control and the hump control while in deceleration, the propulsion system 20 according to the present embodiment enables conducting control of decreasing the trim angle θ_t of the propulsion machine 3 in the trim support control. While in deceleration, the trim angle θ_t is smaller than that while in acceleration. Therefore, it becomes possible to conduct the trim support control effectively while suppressing a decrease in efficiency of navigation.

[0178] In addition, while conducting the hump control, upon receipt of the operation input from the trim angle operation unit 73, the propulsion system 20 according to the present embodiment stops conducting the hump control. In the case where the trim angle θ_t of the propulsion machine 3 at the time of stopping conducting the hump control is smaller than the trim angle reference value θ_{ts} , the trim angle θ_t of the propulsion machine 3 is adjusted so that the trim angle θ_t becomes the trim angle reference value θ_{ts} . In this manner, in the case where the trim angle θ_t of the propulsion machine 3 at the time of stopping conducting the hump control is smaller than the trim angle reference value θ_{ts} , the trim angle θ_t is increased to the trim angle reference value θ_{ts} , so that the efficiency of navigation can be improved.

[0179] Note that the present invention is not limited to the above-described embodiments with reference to the drawings, and various modifications are conceivable within the technical scope.

[0180] For example, in the above embodiment, various conditions for conducting the hump control have been given as examples, but the conditions can be appropriately changed.

[0181] In addition, in the above embodiment, the trim support control, the hump control, and the like are conducted, based on the boat speed V. However, the trim support control, the hump control, and the like may be conducted, based on the rotation speed of the propulsion machine 3 instead of the boat speed V.

[0182] In addition, in the above embodiment, one propulsion machine 3 is provided on each of both left and right sides. However, a plurality of propulsion machines 3 may be provided on each of both left and right sides, or one propulsion machine 3 may be provided at the center.

[0183] In addition, the procedure and contents of the control conducted by the controller 8 can be changed as appropriate.

[0184] Then, the constitution in the above embodiment is an example of the present invention, and various changes can be made without departing from the gist of the present invention.

[0185] While preferred embodiments of the invention have been described and illustrated above, it should be understood that these are exemplary of the invention and are not to be considered as limiting. Additions, omissions, substitutions, and other modifications can be made without departing from the scope of the present invention. Accordingly, the invention is not to be considered as being limited by the foregoing description, and is only limited by the scope of the appended claims.

Reference Signs List

[0186]

1	Boat	
2	Hull	
3	Propulsion Machine	
3a	Right propulsion machine (propulsion machine)	
3b	Left propulsion machine (propulsion machine)	
8	Controller	
20	Propulsion system	
32	Drive source	
34	Propulsor	
45	Trim angle adjuster	
73	Trim angle operation unit	
V	Boat speed	
θ_{sp}	Trim support angle	
θ_t	Trim angle	
θ_{td}	Trim angle lower limit value	
θ_{ts}	Trim angle reference value	

Claims

1. A propulsion system of a boat, the propulsion system comprising:

a propulsion machine including a drive source, and a propulsor configured to generate thrust with power transmitted from the drive source, the propulsion machine being provided on a hull;

a trim angle adjuster configured to adjust a trim angle of the propulsion machine with respect to the hull; and

a controller configured to control the trim angle adjuster, wherein

the controller is capable of conducting hump control of causing the trim angle adjuster to adjust the trim angle of the propulsion machine with a preset trim angle lower limit value as a lower limit to suppress an inclination in a pitch direction of the hull, and

in stopping conducting the hump control from a state of conducting the hump control, the controller causes the trim angle adjuster to adjust the trim angle of the propulsion machine in accordance with a state of the hull.

2. The propulsion system of the boat according to claim 1, wherein the controller includes:

an acceleration-time trim angle adjustment mode of adjusting the trim angle in stopping conducting the hump control from the state of conducting the hump control while the hull is accelerating; and

a deceleration-time trim angle adjustment mode of adjusting the trim angle in stopping conducting the hump control from the state of conducting the hump control while the hull is decelerating.

3. The propulsion system of the boat according to claim 2, wherein

in the acceleration-time trim angle adjustment mode, in a case where the trim angle of the propulsion machine at a time of stopping conducting the hump control is smaller than a trim angle reference value set to be larger than the trim angle lower limit value in a direction in which the propulsion machine is upright forward in a propulsion direction of the hull, the controller causes the trim angle of the propulsion machine to be adjusted to the trim angle reference value.

4. The propulsion system of the boat according to claim 3, wherein

the controller is capable of conducting trim support control of causing the trim angle adjuster to adjust the trim angle to a trim support angle set in accordance with either a preset boat speed or a rotation speed of the propulsion machine, and in stopping conducting the hump control from a state of conducting the trim support control and the hump control while the hull is accelerating, the controller disables conducting control of decreasing the trim angle of the propulsion machine by the trim support control, in the accel-

eration-time trim angle adjustment mode.

5. The propulsion system of the boat according to any one of claims 2 to 4, wherein
 in the deceleration-time trim angle adjustment mode, 5
 in a case where the trim angle of the propulsion machine at a time of stopping conducting the hump control is smaller than a trim angle reference value set to be larger than the trim angle lower limit value in a direction in which the propulsion machine is upright forward in a propulsion direction of the hull, the controller causes the trim angle of the propulsion machine to be adjusted to the trim angle reference value. 10

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6. The propulsion system of the boat according to claim 5, wherein

the controller is capable of conducting trim support control of causing the trim angle adjuster to adjust the trim angle to a trim support angle set in accordance with either a preset boat speed or a rotation speed of the propulsion machine, and in stopping conducting the hump control from a state of conducting the trim support control and the hump control while the hull is decelerating, the controller enables conducting control of decreasing the trim angle of the propulsion machine by the trim support control, in the deceleration-time trim angle adjustment mode. 20 25 30

7. The propulsion system of the boat according to any one of claims 1 to 6, further comprising a trim angle operation unit configured to operate the trim angle adjuster in accordance with an external input, wherein 35

the controller includes a manual operation-time trim angle adjustment mode to be conducted in stopping conducting the hump control upon receipt of an operation input from the trim angle operation unit, while conducting the hump control, and 40
 in the manual operation-time trim angle adjustment mode, in a case where the trim angle of the propulsion machine at a time of stopping conducting the hump control is smaller than a trim angle reference value set to be larger than the trim angle lower limit value in a direction in which the propulsion machine is upright forward in a propulsion direction of the hull, the controller causes the trim angle of the propulsion machine to be adjusted to the trim angle reference value. 45 50

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FIG. 1

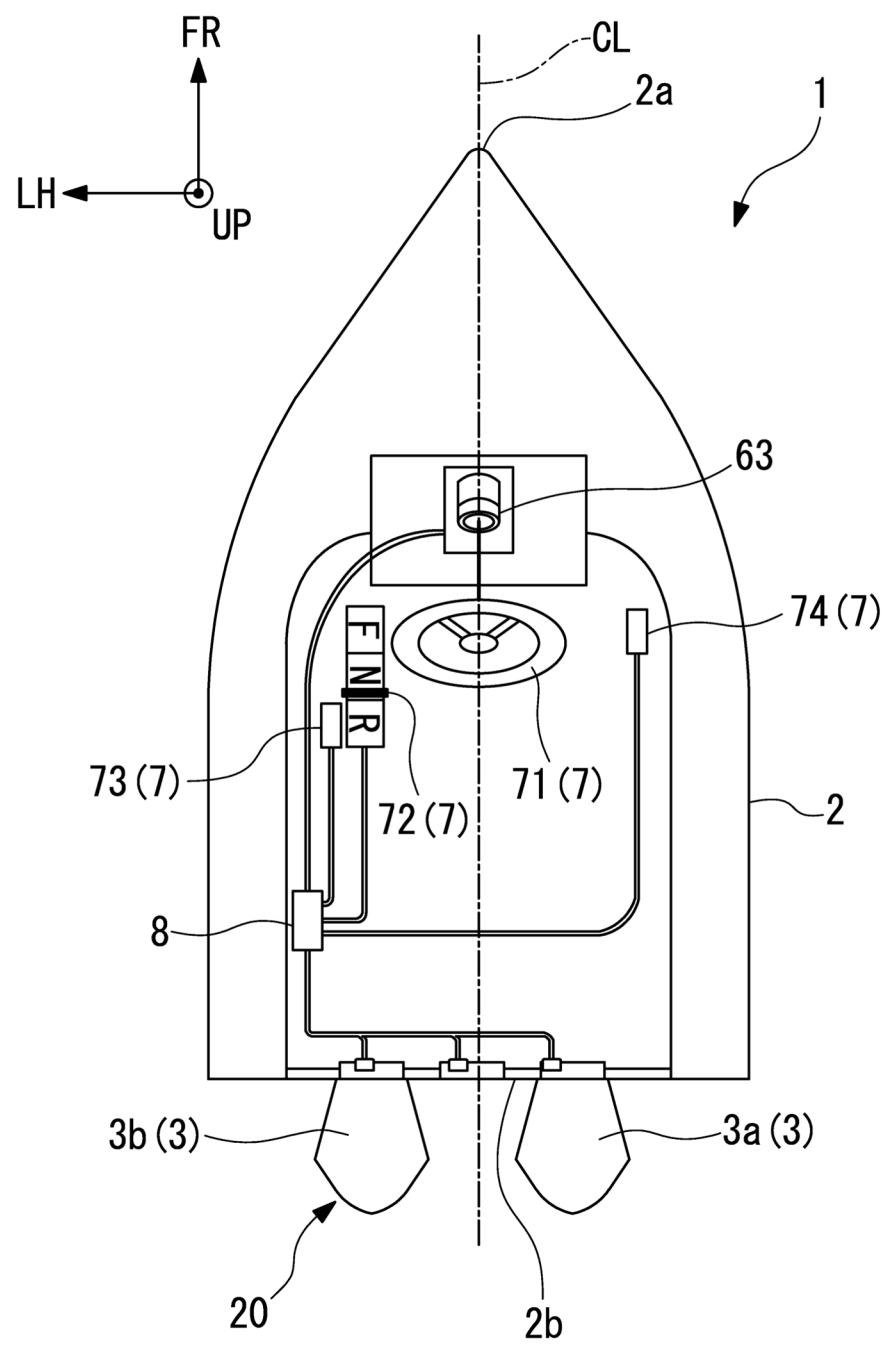


FIG. 2

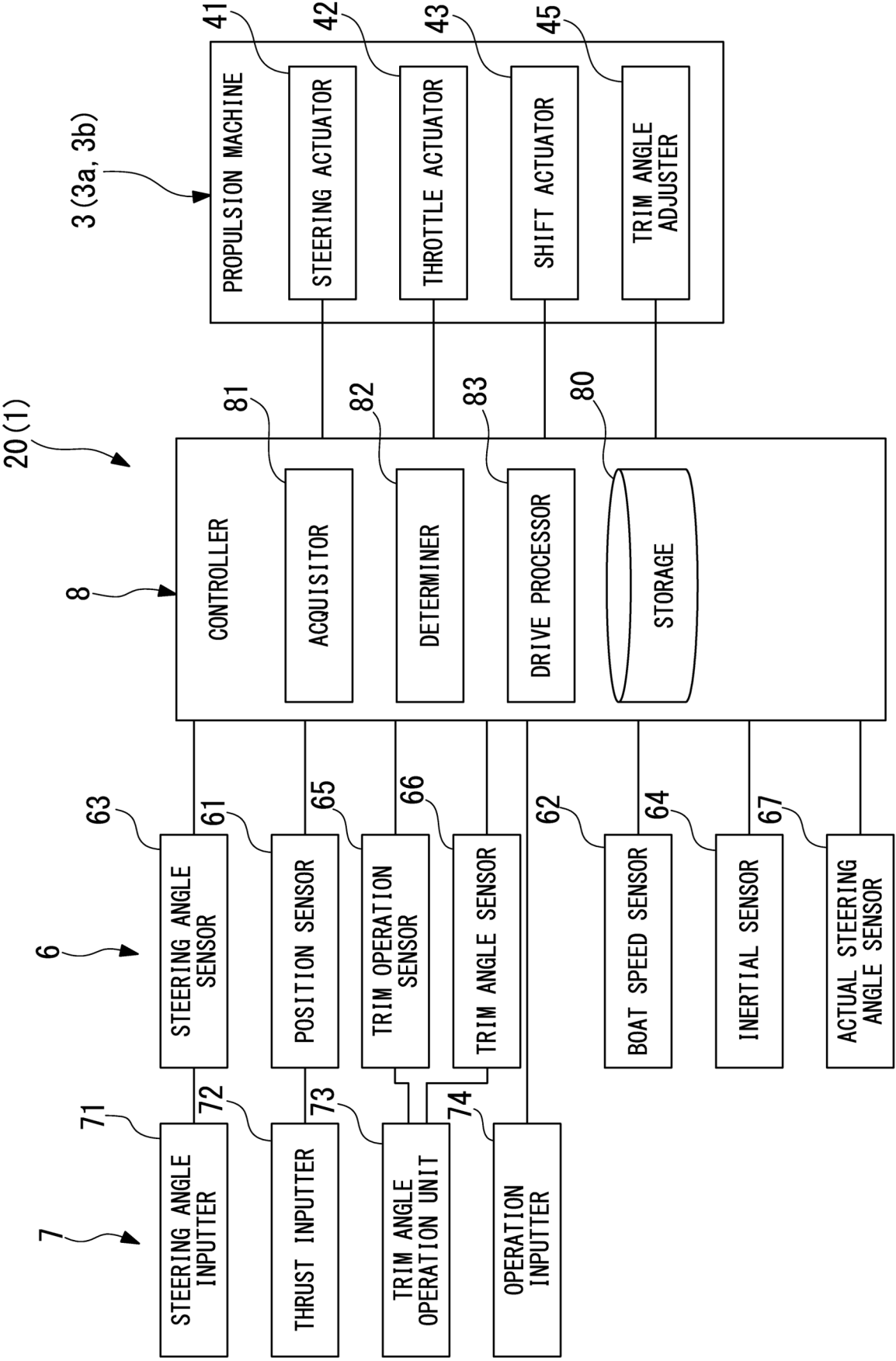


FIG. 3

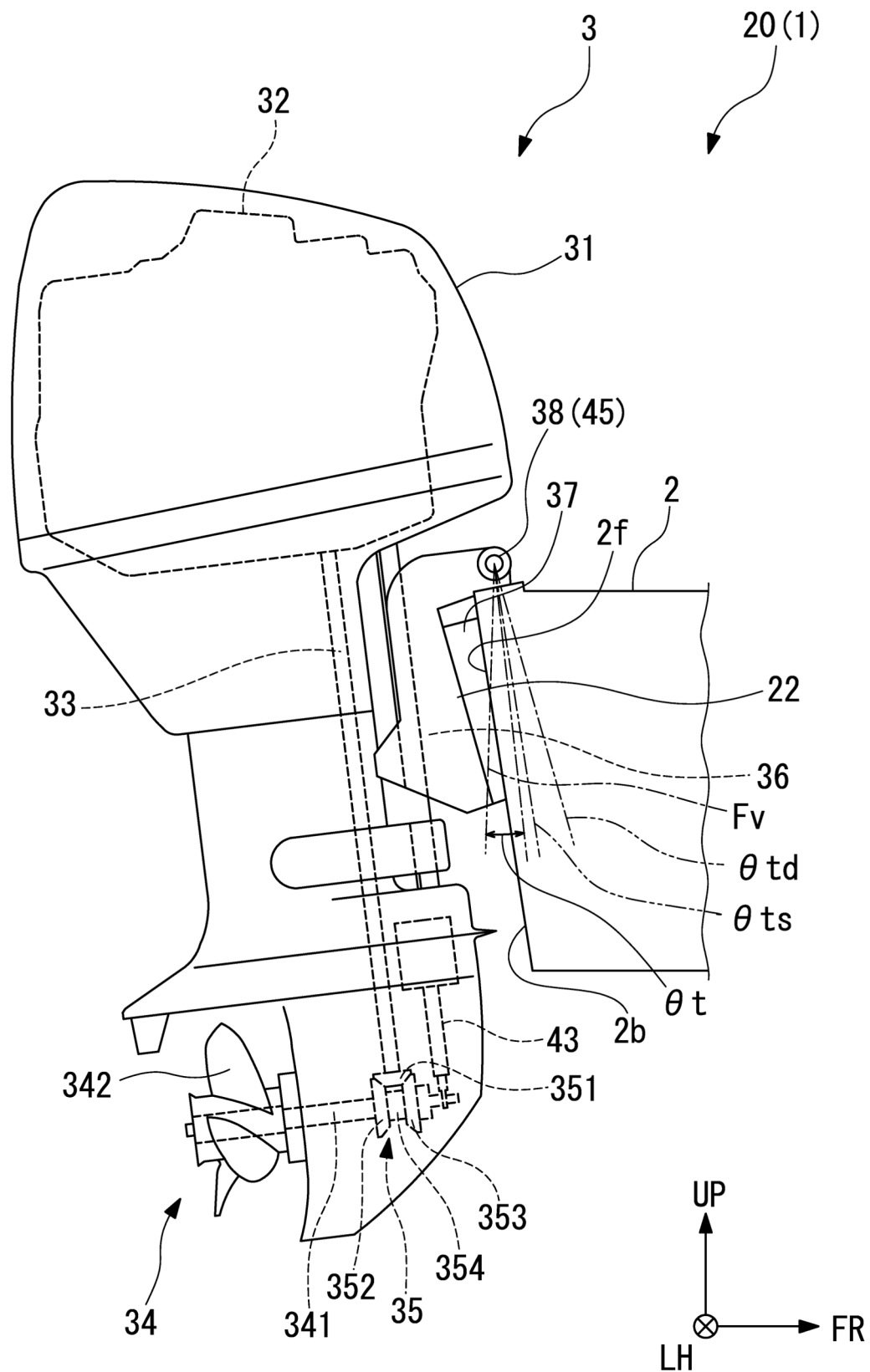


FIG. 4

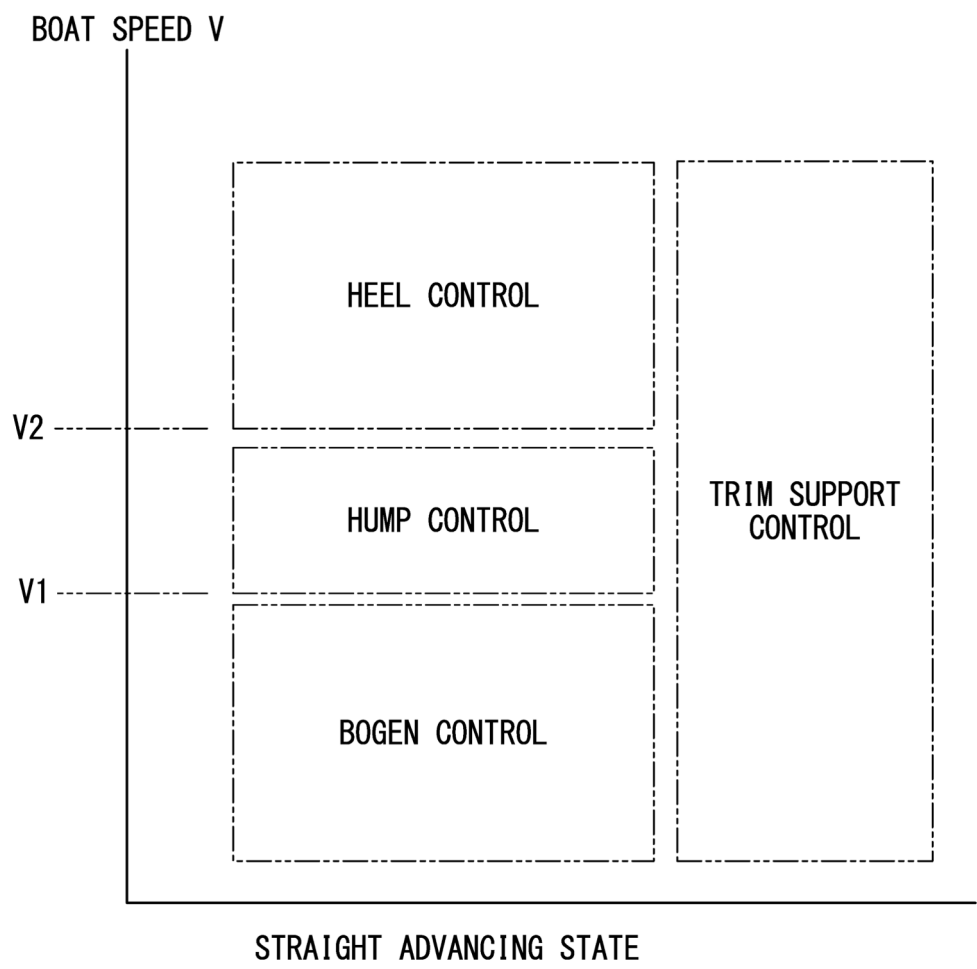


FIG. 5

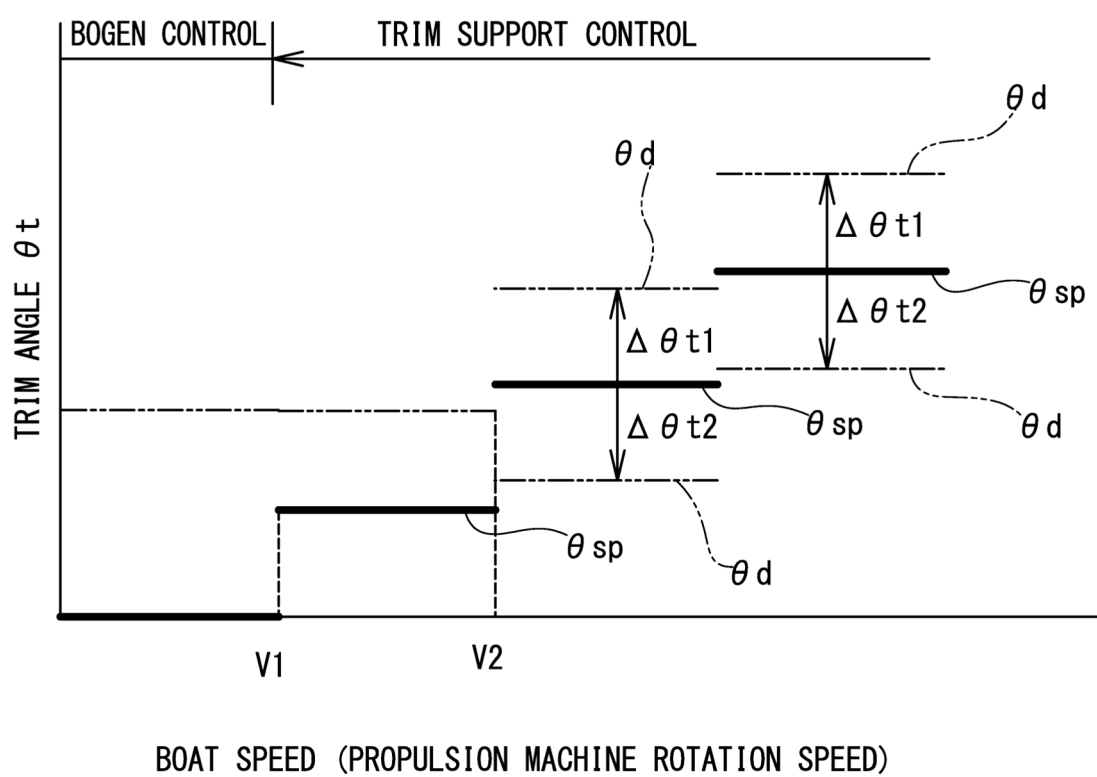


FIG. 6

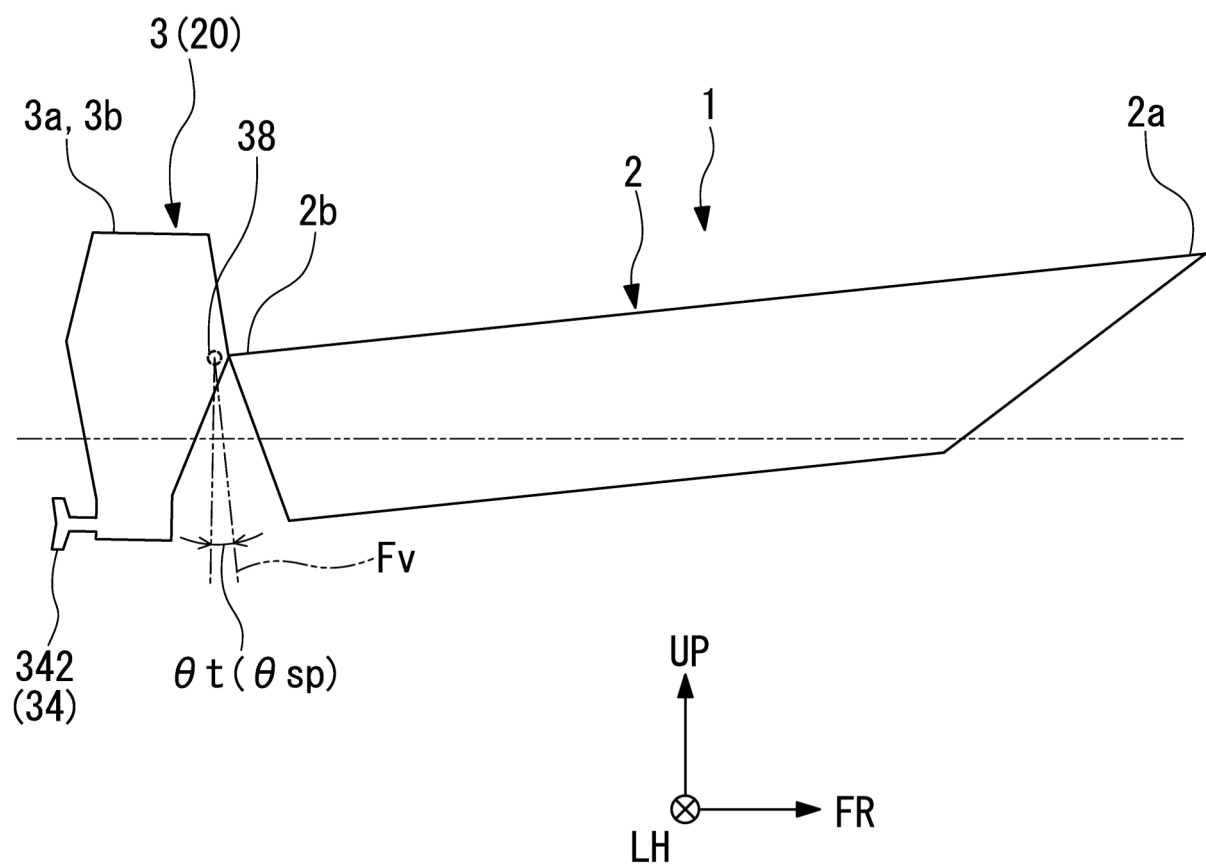


FIG. 7

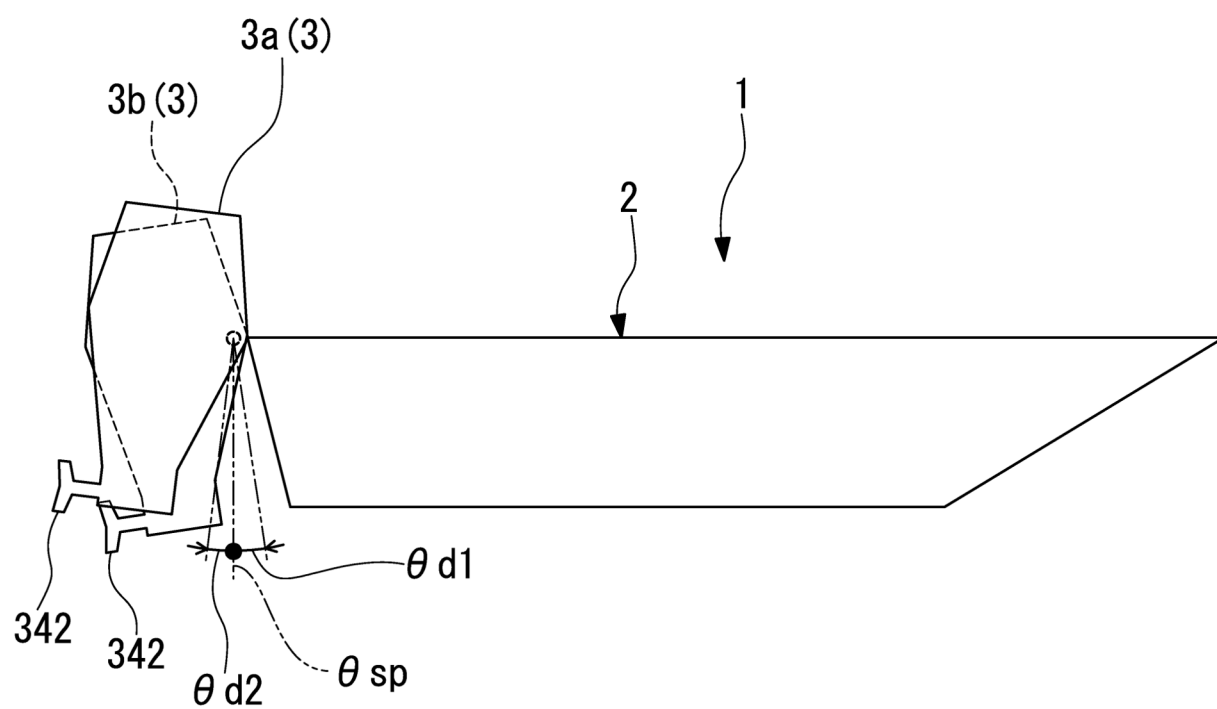


FIG. 8

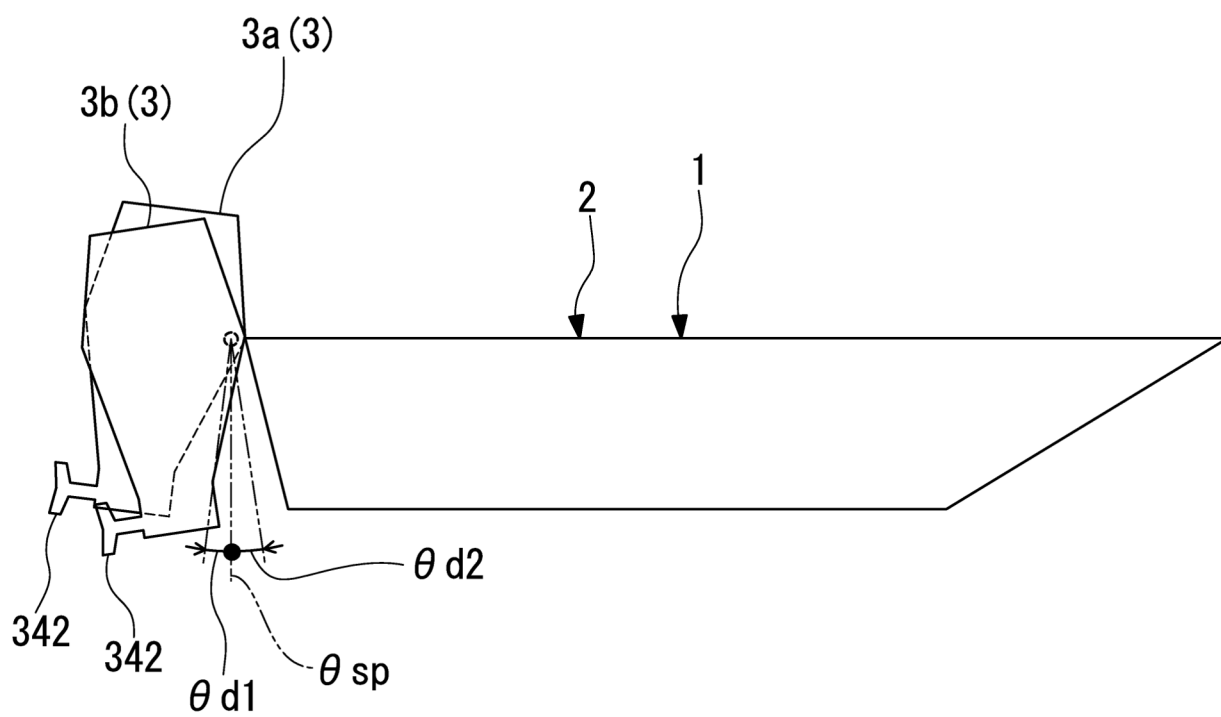


FIG. 9

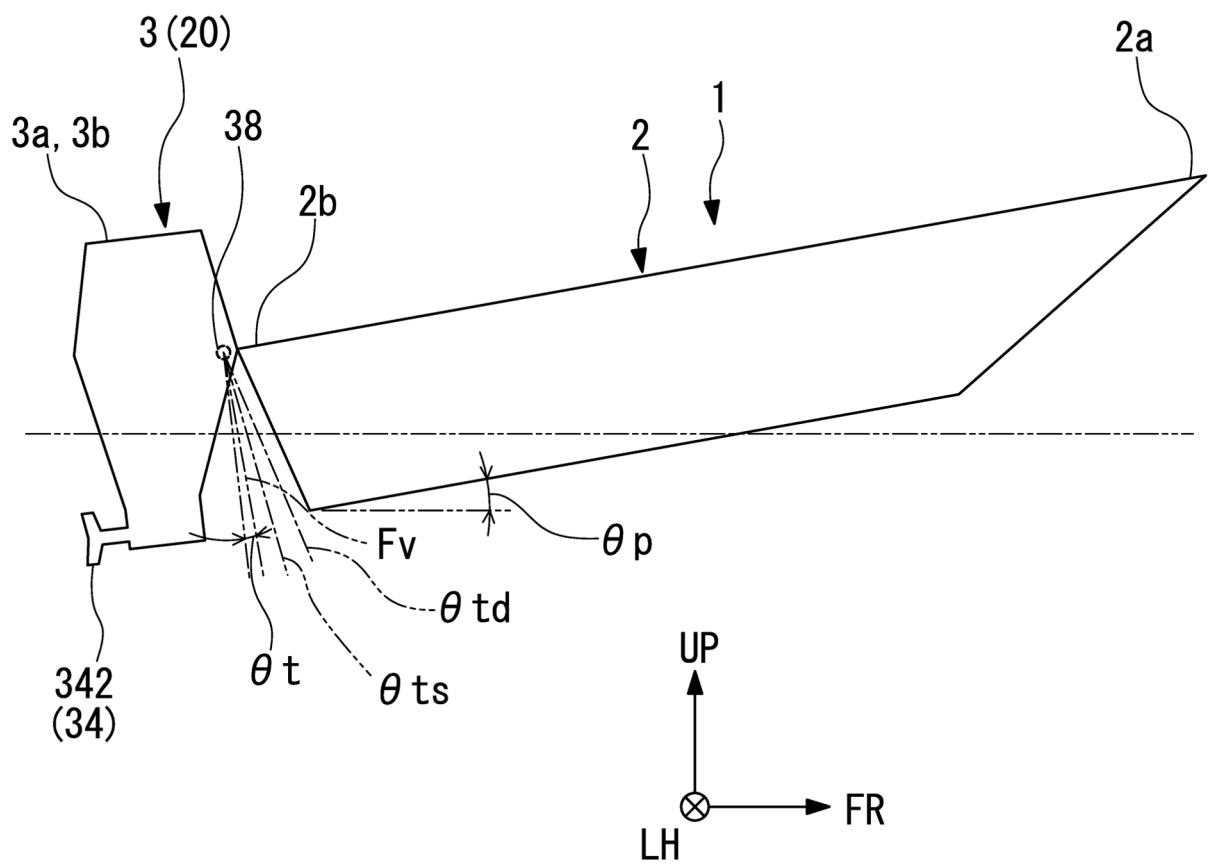


FIG. 10

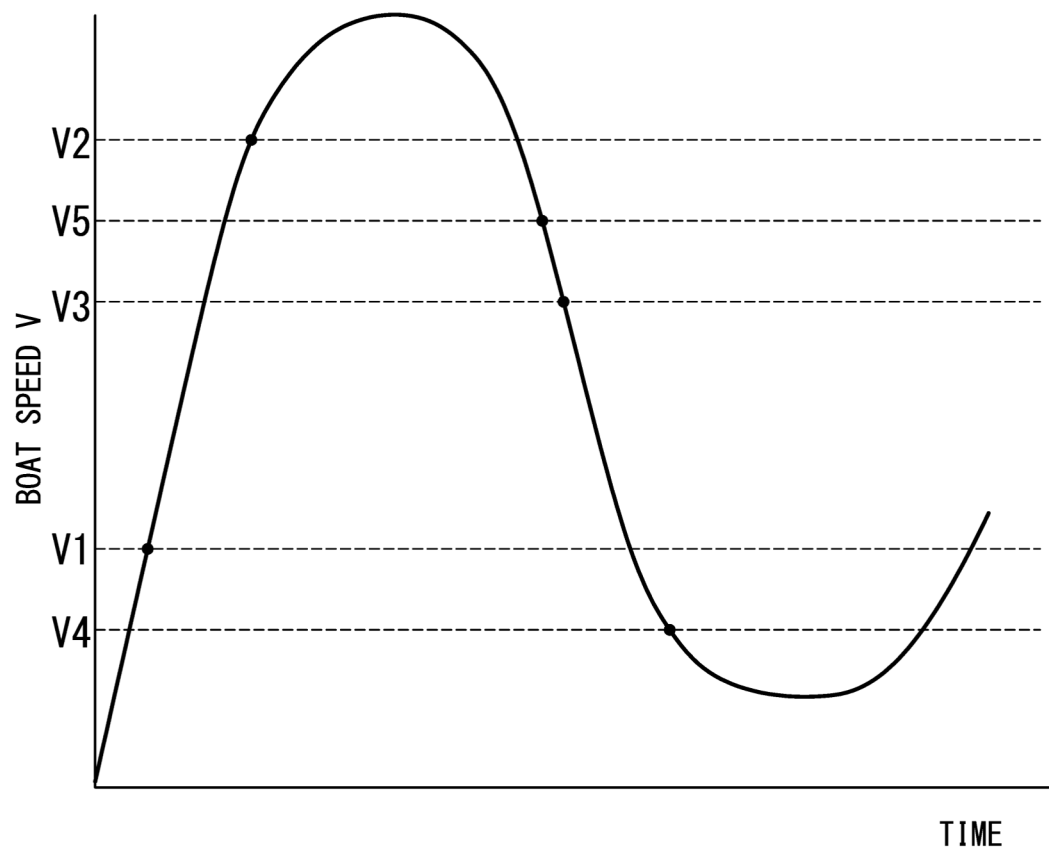


FIG. 11

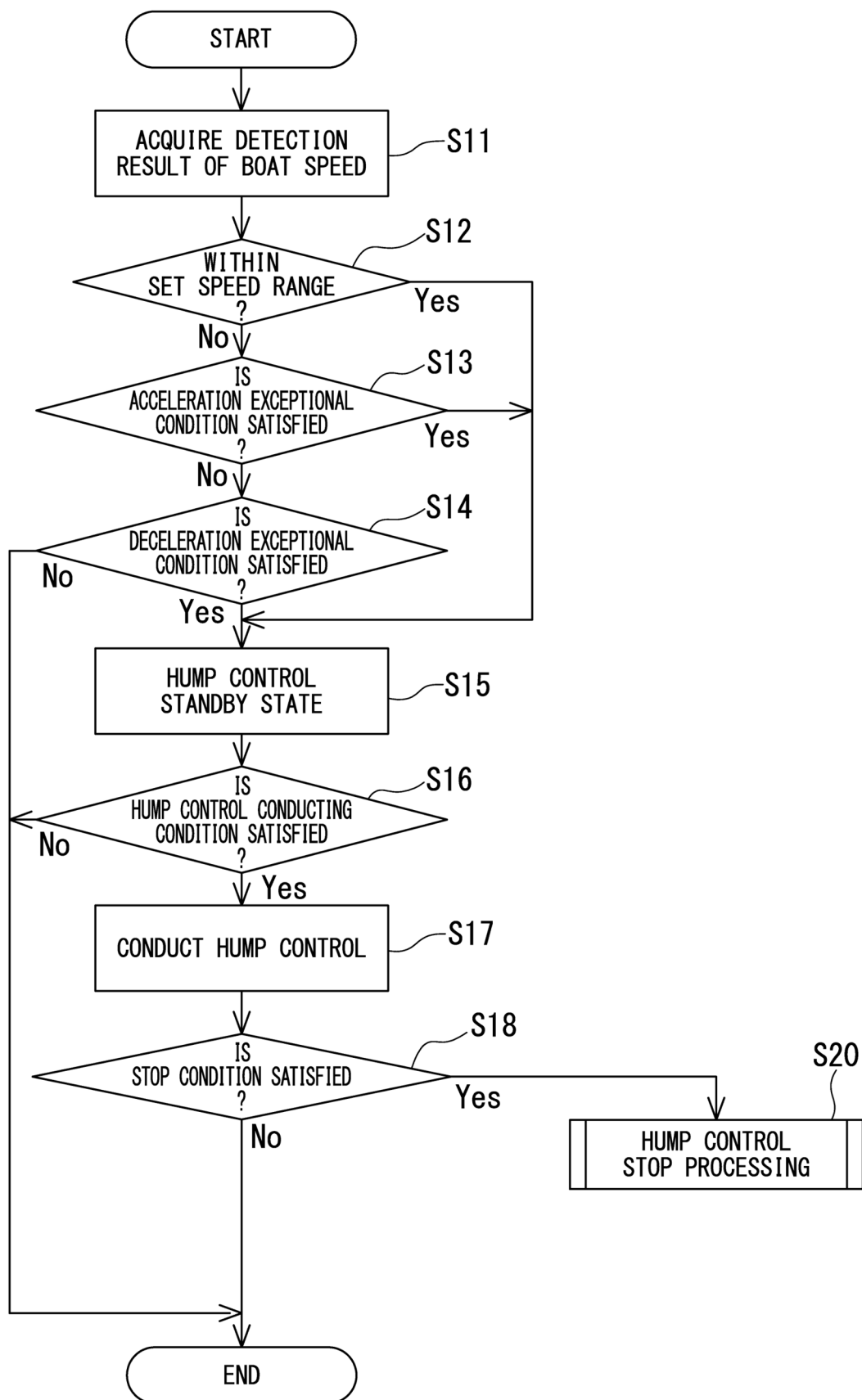


FIG. 12

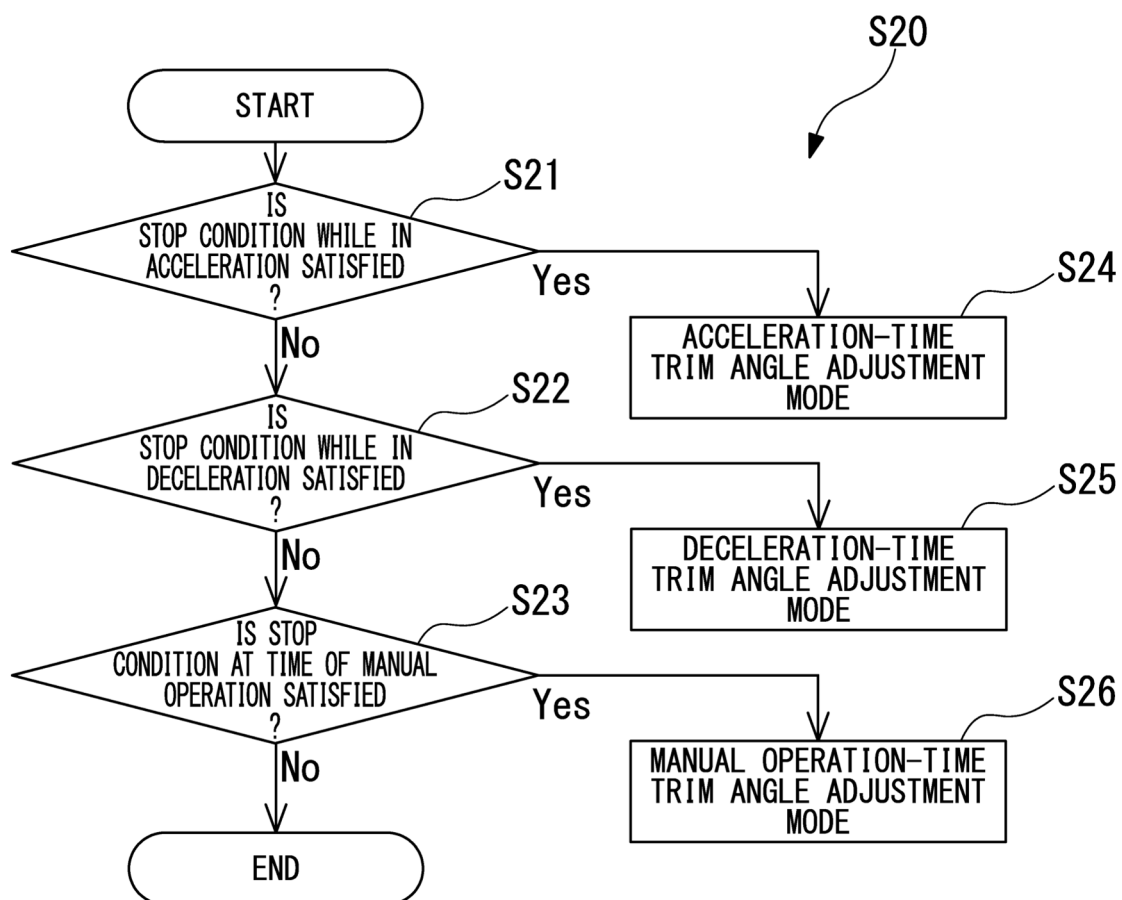


FIG. 13

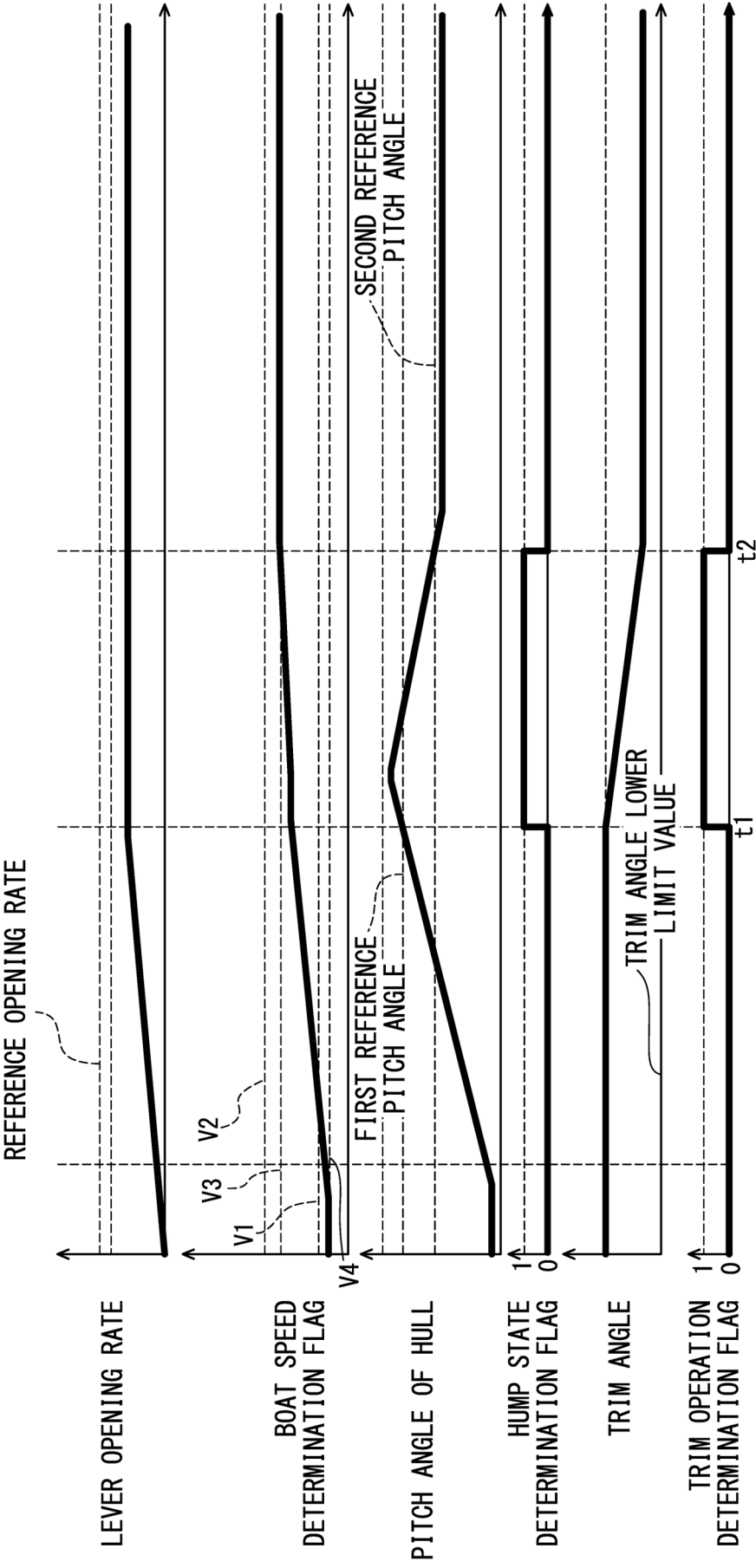
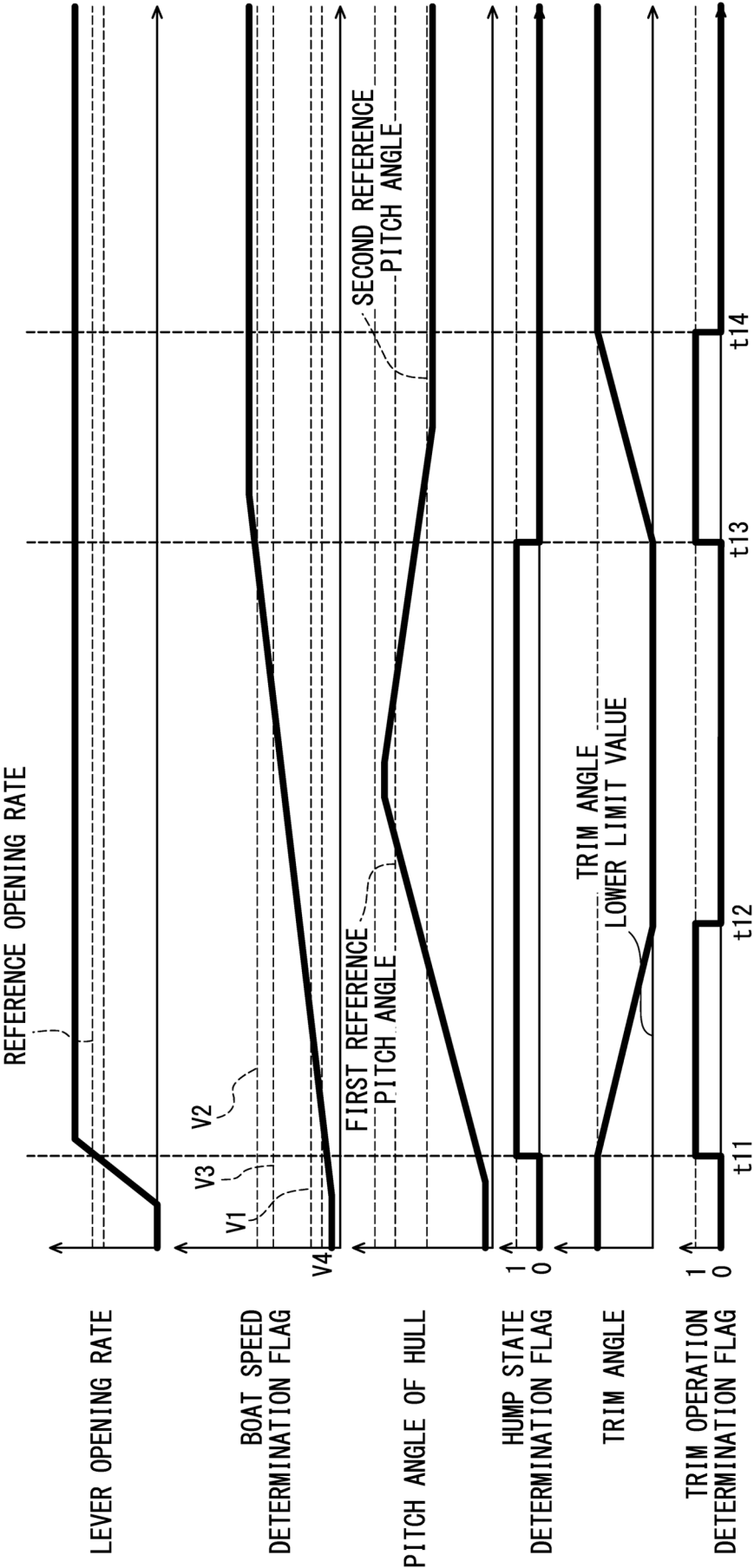


FIG. 14





EUROPEAN SEARCH REPORT

Application Number

EP 26 15 8917

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A	* paragraph [0009] - paragraph [0110]; figures 1-10 *	2-6	
X	CA 2 921 006 A1 (HONDA MOTOR CO LTD [JP]) 27 August 2016 (2016-08-27)	1-6	
A	* page 4, line 21 - page 34, line 29; figures 1-23 *	7	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63H B63B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		17 August 2026	Martínez, Felipe
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17-08-2026

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