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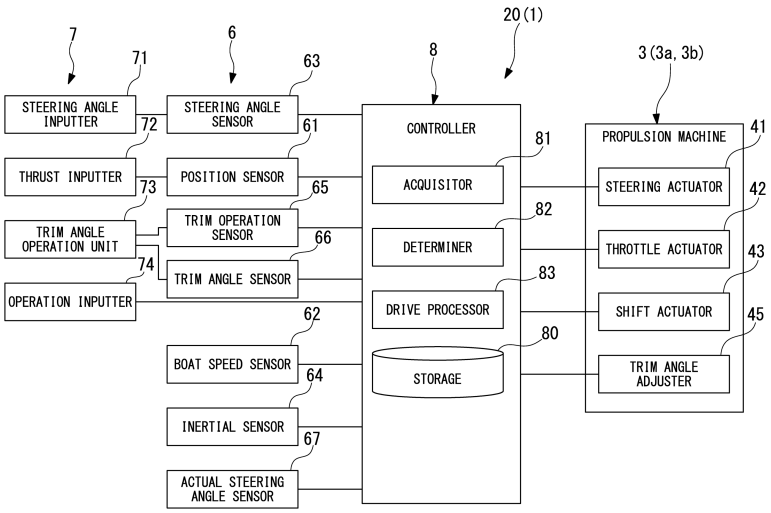
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(54) OUTBOARD PROPULSION SYSTEM OF BOAT

(57) A propulsion system of a boat includes: a propulsion machine including a drive source, and a propulsor configured to generate thrust with dynamic 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 each of propulsion machines on both sides in a left-right direction with respect to the hull; 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 of the propulsion machine to be adjusted with a preset trim angle lower limit value as a lower limit, and while conducting the hump control, in a case where a preset condition is satisfied, the controller causes the trim angle of the propulsion machine to be adjusted to a trim angle reference value set to be larger than the trim angle lower limit value.

FIG. 2



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Description

BACKGROUND OF THE INVENTION

[0001] Priority is claimed on Japanese Patent Application No. 2025-057505, 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 order to more effectively suppress the hump state of the hull, by the way, in a case where the trim angle of the propulsion machine is largely decreased, the stability or the like of the boat may be impaired because of a change in navigation state of the boat, or the boat operator may have an uneasy feeling or the like.

[0006] 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 suppressing impairment of the stability of the boat in a case where a change or the like occurs in a navigation state of the boat while conducting hump control.

(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 dynamic 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, 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

while conducting the hump control, in a case where a preset condition is satisfied, the controller causes the trim angle adjuster to adjust the trim angle of the propulsion machine so that the trim angle of the propulsion machine is a trim angle reference value set to be larger than the trim angle lower limit value in a direction that the propulsion machine is upright forward in a propulsion direction of the hull.

(2) In the propulsion system of the boat according to the above aspect (1), while conducting the hump control, in a case where it is determined that the hull is turning, the controller may cause the trim angle adjuster to adjust the trim angle of the propulsion machine so that the trim angle of the propulsion machine is the trim angle reference value.

(3) In the boat propulsion system according to the aspect (2),while conducting the hump control, in a case where the trim angle of the propulsion machine is present between the trim angle reference value and the trim angle lower limit value at a timing when it is determined that the hull is turning, the controller may maintain the trim angle of the propulsion machine of the timing.

(4) In the propulsion system of the boat according to one of the above aspects (1) to (3), while conducting the hump control, in a case where the trim angle of the propulsion machine reaches the trim angle lower limit value, the controller may stop conducting the hump control, and may set a standby state that enables conducting the hump control.

(5) The propulsion system of the boat according to one of the above aspects (1) to (4) may further include a trim angle operation unit configured to operate the trim angle adjuster in accordance with an external input, in which while conducting the hump control, in a case where the trim angle of the propulsion machine is present between the trim angle reference value and the trim angle lower limit value at a timing of receiving an operation input from the trim angle operation unit, the controller may make the trim angle of the propulsion machine in accordance with the operation input from the trim angle operation unit adjustable with the trim angle reference value as a lower limit.

[0007] According to the aspect (1), while conducting the hump control, in a case where the preset condition is satisfied, the trim angle of the propulsion machine is

adjusted so that the trim angle of the propulsion machine becomes the trim angle reference value set to be larger than the trim angle lower limit value. Accordingly, in a case where the set condition is satisfied, the effect of suppressing the hump state by the hump control is decreased. Therefore, while conducting the hump control, in a case where a change or the like occurs in the navigation state of the boat, it becomes possible to suppress impairment of the stability of the boat.

[0008] According to the aspect (2), in a case where it is determined that the hull is turning, the trim angle of the propulsion machine is set to the trim angle reference value. This suppresses the effect of the hump control while the hull is turning, so that the behavior (e.g., attitude) of the hull can be made stable while turning.

[0009] According to the aspect (3), in a case where the trim angle of the propulsion machine is present between the trim angle reference value and the trim angle lower limit value at a timing when it is determined that the hull is turning, the trim angle of the propulsion machine at such a timing is maintained. Thus, while conducting the hump control with the trim angle of the propulsion machine set to be equal to or smaller than the trim angle reference value, when the hull transitions to the turning state, it becomes possible to transition the hull to the turning state stably while maintaining the suppression effect of the hump state by the hump control.

[0010] According to the aspect (4), while conducting the hump control, in a case where the trim angle of the propulsion machine reaches the trim angle lower limit value, conducting the hump control is stopped and a standby state that enables conducting the hump control is set. Thus, in a state in which the trim angle of the propulsion machine reaches the trim angle lower limit value and the suppression effect of the hump state by the hump control is exerted at maximum, it becomes possible to suppress frequent fluctuations of the trim angle of the propulsion machine by continuously conducting the hump control, and to stably continue the state of exerting the suppression effect of the hump state.

[0011] According to the aspect (5), while conducting the hump control, in a case where the trim angle of the propulsion machine is present between the trim angle reference value and the trim angle lower limit value at the timing of receiving the operation input from the trim angle operation unit, the trim angle reference value is set as a lower limit, in adjusting the trim angle of the propulsion machine in accordance with the operation input from the trim angle operation unit. Thus, in a case where the boat operator manually operates, it becomes possible to suppress the trim angle of the propulsion machine becoming equal to or smaller than the trim angle reference value in accordance with the manual operation. Thus, it becomes possible to suppress a strong feeling of the suppression effect of the hump state by the hump control at the time of manual operation, so that an uneasy feeling of the boat operator can be suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

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 a control method of the propulsion system, subsequently to FIG. 11;
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

[0013] 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.

[0014] 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.

[0015] As illustrated in FIG. 1, the boat 1 includes: a hull 2; and a propulsion system 20, which is provided on the hull 2.

[0016] 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)

[0017] 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.

[0018] FIG. 3 is a side view of a propulsion machine of the propulsion system.

[0019] 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.

[0020] 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).

[0021] 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.

[0022] 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.

[0023] The propulsor 34 includes a propeller shaft 341 and propellers 342.

[0024] 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.

[0025] 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.

[0026] The shift switching mechanism 35 includes a drive gear 351, a forward gear 352, a reverse gear 353, and a clutch 354.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] Here, a trim angle θt 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 θt, 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 θt, and rotating the propulsion machine 3 in the negative direction will be expressed as decreasing the trim angle θt.

[0032] The trim angle θt 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 θt when the propulsion machine 3 is rotated in the most negative direction is set as a trim angle lower limit value.

[0033] 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)

[0034] 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.

[0035] 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.

[0036] 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.

[0037] 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 θt of the propulsion machine 3 by manually operating the trim angle operation switch (the trim angle operation unit 73).

[0038] 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)

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] The inertial sensor 64 detects the inclination in the roll direction of the hull 2, that is, a heel angle θh. The inertial sensor 64 detects the inclination in the pitch direction of the hull 2, that is, a pitch angle θp. 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.

[0044] 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.

[0045] The trim angle sensor 66 is provided in the trim angle adjuster 45. The trim angle sensor 66 detects an actual trim angle θt 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 θt.

[0046] 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)

[0047] 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) executing 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.

[0048] The controller 8 includes a storage 80, an acquisitor 81, a determiner 82, and a drive processor 83.

[0049] 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.

[0050] The acquisitor 81 acquires detection results of various sensors of the detector 6.

[0051] The determiner 82 determines the state of the boat 1, based on information obtained by the acquisitor 81 and information stored in the storage 80.

[0052] 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 acquisitor 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)

[0053] 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.

[0054] As illustrated in FIG. 4, when the boat 1 is in the straight advancing state, the drive processor 83 conducts 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.

[0055] 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.

[0056] As illustrated in FIG. 5, in the trim support control, the trim angle adjuster 45 is caused to adjust a trim angle θt to be a trim support angle θsp, 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 θsp 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 θsp 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 θsp, 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 θsp is set in a stepwise manner with respect to the boat speed V (or

the rotation speed of the propulsion machine).

[0057] The drive processor 83 acquires, from the storage 80, the trim support angle θsp, which is associated with the boat speed acquired by the acquisitor 81.

[0058] The drive processor 83 controls the trim angle adjuster 45 so that the trim angle θt of the propulsion machine 3 approaches the acquired trim support angle θsp.

[0059] FIG. 6 is a view illustrating a state in which the trim support control is being conducted in the propulsion system.

[0060] As illustrated in FIG. 6, in conducting the trim support control, the drive processor 83 sets the trim support angles θsp of the propulsion machines 3a and 3b on both sides in the left-right direction to the same value.

(Heel Control)

[0061] 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 V2, 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 V2, 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.

[0062] In this case, the drive processor 83 conducts the heel control, in a case where the heel angle θh, 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 θhs (for example, several degrees). That is, in a case where the heel angle θh is smaller than the heel angle reference value θhs, the drive processor 83 continuously conducts the trim support control without conducting the heel control.

[0063] In conducting the heel control, the drive processor 83 sets a heel suppression angle θd as a target value in accordance with the heel angle θh of the hull 2. Here, the heel suppression angle θd 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 θd, which is capable of effectively suppressing the inclination in the roll direction of the hull 2, in accordance with the heel angle θh of the hull 2 in a preset calculation formula.

[0064] The drive processor 83 sets the heel suppression angle θd with reference to the trim support angle θsp of the propulsion machine 3 at such a timing. With regard to the trim support angle θsp, the drive processor 83 sets the heel suppression angle θd of the propulsion machine 3 on one side in the left-right direction to a value larger than the trim support angle θsp, and also sets the heel suppression angle θd of the propulsion machine 3 on the other side in the left-right direction to a value smaller than the trim support angle θsp.

[0065] 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.

[0066] 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 θd2 of the right propulsion machine 3a to a value larger than the trim support angle θsp, and sets a heel suppression angle θd1 of the left propulsion machine 3b to a value smaller than the trim support angle θsp. 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 θd1 of the left propulsion machine 3b to a value larger than the trim support angle θsp, and sets the heel suppression angle θd2 of the right propulsion machine 3a to a value smaller than the trim support angle θsp.

(Hump Control)

[0067] FIG. 9 is a view illustrating a state in which the boat is conducting the hump control.

[0068] 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.

[0069] 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 θp is large. In conducting the hump control, the drive processor 83 sets the trim angles θt 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 θt = 0 degrees. In the hump control, the drive processor 83 adjusts the trim angle θt of the propulsion machine 3 with the trim angle lower limit value θtd as a lower limit.

[0070] FIG. 10 is a diagram illustrating an example of respective thresholds of the boat speed in the hump control.

[0071] 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.

[0072] 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 V1 and is lower than a second threshold V2, 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 V1, 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 V2, which is larger than the first threshold V1.

[0073] 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 V1 and the lever opening rate of the propulsion machine 3 becomes equal to or larger than a preset reference opening rate.

[0074] 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 V4 and is equal to or lower than the third threshold V3, 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 V3, which is smaller than the second threshold V2, 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 V4, which is smaller than the first threshold V1.

[0075] 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 V5, which is smaller than the second threshold V2 and is larger than the third threshold V3, and the pitch angle θp of the hull 2 is equal to or larger than a preset third reference pitch angle.

[0076] While conducting the hump control, in a case where a preset condition is satisfied, the drive processor 83 causes the trim angle adjuster 45 to adjust the trim angle θt of the propulsion machine 3 so that the trim angle θt of the propulsion machine becomes the trim angle reference value θts.

[0077] For example, while conducting the hump control, in a case where it is determined that the hull 2 is turning, the drive processor 83 causes the trim angle adjuster 45 to adjust the trim angle θt of the propulsion machine 3 so that the trim angle θt of the propulsion machine 3 is the trim angle reference value θts.

[0078] Here, the determination of whether the hull 2 is turning is made by the determiner 82, for example. The determiner 82 determines whether the steering instruction angle of the steering angle inputter 71 detected by the steering angle sensor 63 exceeds a preset steering angle threshold. For example, the determiner 82 may determine whether the hull 2 is turning, based on whether the actual steering angle detected by the actual steering angle sensor 67 exceeds the steering angle threshold.

[0079] In this manner, while the hull 2 is turning, the drive processor 83 sets the trim angle θt of the propulsion machine 3 to the trim angle reference value θts. Thus, while turning, the suppression effect of the hump state by the hump control is exerted, and in addition, a large inclination in the negative direction of the propulsion machine 3 due to the trim angle θt smaller than the trim angle reference value θts is suppressed.

[0080] However, while conducting the hump control, in a case where the trim angle θt of the propulsion machine 3 is present between the trim angle reference value θts and the trim angle lower limit value θtd at a timing when it is determined that the hull 2 is turning, the drive processor 83 maintains the trim angle θt of the propulsion machine 3 at such a timing. That is, while conducting the hump control, in a case where the hull 2 transitions to the turning state, and in a case where the trim angle θt of the propulsion machine 3 is further inclined in the negative direction than the trim angle reference value θts at such a timing, the trim angle θt is not returned to the trim angle reference value θts, and the trim angle θt at such a timing is maintained. Thus, the state is transitioned to the turning state while the suppression effect of the hump state by the hump control is sufficiently exerted.

[0081] While conducting the hump control, in a case where the trim angle θt of the propulsion machine 3 reaches the trim angle lower limit value, the drive processor 83 stops conducting the hump control, and then sets a standby state that enables conducting the hump control. In this case, also after conducting the hump control is stopped, the drive processor 83 maintains the trim angle θt of the propulsion machine 3 at the trim angle lower limit value θtd.

[0082] In addition, 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. Thus, it becomes possible to suppress the trim angle of the propulsion machine becoming equal to or smaller than the trim angle reference value in accordance with the manual operation, so that an uneasy feeling of the boat operator can be suppressed.

[0083] While conducting the hump control, in a case where the trim angle θt of the propulsion machine 3 is present between the trim angle reference value θts and the trim angle lower limit value θtd at the timing of receiving the operation input from the trim angle operation unit 73, the drive processor 83 is capable of adjusting the trim angle θt of the propulsion machine 3 in accordance with the operation input from the trim angle operation unit 73 with the trim angle reference value θts as a lower limit. That is, in a case where the boat operator performs the operation input from the trim angle operation unit 73 to stop conducting the hump control, and in a case where conducting the hump control is stopped and then the boat operator adjusts the trim angle θt of the propulsion machine 3 in accordance with the operation input from the trim angle operation unit 73, the lower limit of the adjust-

ment range of the trim angle θt is the trim angle reference value θts. Accordingly, in a case where the trim angle θt of the propulsion machine 3 is manually adjusted in accordance with the operation input from the trim angle operation unit 73 from the state of conducting the hump control, the trim angle θt cannot be made lower in the negative direction than the trim angle reference value θts.

(Bogen Control)

[0084] 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)

[0085] 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).

[0086] FIG. 11 is a flowchart illustrating a processing flow of a control method of the propulsion system. FIG. 12 is a flowchart illustrating the processing flow of the control method of the propulsion system subsequent to FIG. 11.

[0087] The flowcharts illustrated in FIGS. 11 and 12 illustrate the processing flows in conducting the hump control, in the control to be conducted by the controller 8 of the propulsion system 20.

[0088] As illustrated in FIG. 11, in step S11, the controller 8 causes the acquisitor 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.

[0089] 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.

[0090] 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 5km/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.

[0091] **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)

[0092] **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.

[0093] 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.

[0094] 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.

[0095] Condition a1: A detection value of the pitch angle θp acquired by the inertial sensor 64 is larger than a preset first reference pitch angle.

[0096] Condition a2: It is determined that the hull 2 is turning, based on the steering instruction angle of the steering angle inputter 71 detected by the steering angle sensor 63 or the actual steering angle detected by the actual steering angle sensor 67.

[0097] 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.

[0098] 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.

[0099] 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)

[0100] 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.

[0101] The acceleration exceptional condition includes, for example, the following conditions b1 to b3.

[0102] Condition b1: The hull 2 is accelerating.

[0103] Condition b2: The boat speed V is lower than the first threshold V1.

[0104] 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.

[0105] 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.

[0106] 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.

[0107] 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.

[0108] 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.

[0109] 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.

[0110] Condition c2: A detected value of the pitch angle θp acquired by the inertial sensor 64 is larger than a preset reference pitch angle.

[0111] Condition c3: It is determined that the hull 2 is turning, based on the steering instruction angle of the steering angle inputter 71 detected by the steering angle sensor 63 or the actual steering angle detected by the actual steering angle sensor 67.

[0112] 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.

[0113] 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.

[0114] 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.

[0115] 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)

[0116] 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.

[0117] The deceleration exceptional condition includes, for example, the following conditions d1 and d2.

[0118] Condition d1: The hull 2 is decelerating.

[0119] 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.

[0120] 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.

[0121] 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.

[0122] 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.

[0123] 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.

[0124] 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.

[0125] Condition e1: A detection value of the pitch angle θp acquired by the inertial sensor 64 is larger than a preset third reference pitch angle.

[0126] 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.

[0127] 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.

[0128] 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.

[0129] In a case where the determination result in step S16 is "Yes", the processing proceeds to step S17.

(Conducting Hump Control)

[0130] In step S17, the controller 8 conducts the hump control. In this case, the controller 8 decreases the trim angles θt of all the propulsion machines 3 to the trim angle lower limit value.

(Transition to Another State While Conducting Hump Control)

[0131] After starting conducting the hump control in step S17, the controller 8 transitions to another state in a case where a preset condition is satisfied while conduct-

ing the hump control.

[0132] As illustrated in FIG. 12, subsequently to step S17, in step S18, while conducting the hump control, the controller 8 determines whether the trim angle θt of the propulsion machine 3 detected by the trim angle sensor 66 is larger in the positive direction than a preset trim angle lower limit value θtd.

[0133] In a case where the determination result in step S18 is "Yes", the processing proceeds to step S19.

[0134] In a case where the determination result in step S18 is "No", that is, in a case where the trim angle θt of the propulsion machine 3 reaches the trim angle lower limit value θtd, the processing proceeds to step S21.

[0135] In step S21, the controller 8 stops conducting the hump control. After conducting the hump control is stopped, the processing returns to step S15 in FIG. 11, and sets the standby state that enables conducting the hump control. In this case, in step S21, the controller 8 maintains the trim angle θt of the propulsion machine 3 at the trim angle lower limit value θtd, also after conducting the hump control is stopped (in the hump control standby state in step S15). Thus, it becomes possible to wait for conducting the hump control while maintaining the state of exerting the suppression effect of the hump state by the hump control at maximum.

[0136] In step S19, the controller 8 determines whether the hull 2 is in the turning state. In this determination, for example, the controller 8 determines whether the steering instruction angle of the steering angle inputter 71 detected by the steering angle sensor 63 exceeds a preset steering angle threshold.

[0137] In a case where the determination result in step S19 is "No", the processing proceeds to step S20.

[0138] In a case where the determination result in step S19 is "Yes", that is, in a case where the hull 2 is turning, the processing proceeds to step S22.

[0139] In step S22, the controller 8 determines whether the trim angle θt of the propulsion machine 3 is equal to or smaller than the trim angle reference value θts.

[0140] In a case where the determination result in step S22 is "Yes", that is, in a case where the trim angle θt of the propulsion machine 3 is equal to or smaller than the trim angle reference value θts and is present between the trim angle reference value θts and the trim angle lower limit value θtd, the controller 8 maintains the trim angle θt of the propulsion machine 3 at such a timing in step S23. Thus, the state is transitioned to the turning state while the suppression effect of the hump state by the hump control is sufficiently exerted.

[0141] In a case where the determination result in step S22 is "No", that is, in a case where the trim angle θt of the propulsion machine 3 is larger than the trim angle reference value θts in the positive direction, the controller 8 sets (returns) the trim angle θt of the propulsion machine 3 to the trim angle reference value θts in step S24. Thus, while the suppression effect of the hump state by the hump control is exerted, a large inclination in the negative direction of the propulsion machine 3 due to the trim angle θt, which is smaller than the trim angle reference value θts, is suppressed.

[0142] In step S20, the controller 8 determines whether an operation input by the boat operator has been received from the trim angle operation unit 73.

[0143] In a case where the determination result in step S20 is "No", the processing ends. Step S11 is repeated after a predetermined control cycle elapses.

[0144] In a case where the determination result in step S20 is "Yes", that is, in a case where it is determined that the manual operation by the boat operator has been performed, the processing proceeds to step S25, and conducting the hump control is stopped.

[0145] Subsequently, in step S26, the controller 8 determines whether the trim angle θt of the propulsion machine 3 is equal to or smaller than the trim angle reference value θts.

[0146] In a case where the determination result in step S26 is "No", that is, in a case where the trim angle θt of the propulsion machine 3 is larger than the trim angle reference value θts in the positive direction, the processing proceeds to step S27.

[0147] In a case where the determination result in step S26 is "Yes", that is, in a case where the trim angle θt of the propulsion machine 3 is equal to or smaller than the trim angle reference value θts, the controller 8 returns the trim angle θt of the propulsion machine 3 to the trim angle reference value θts in step S28, and then the processing proceeds to step S27.

[0148] In step S27, the controller 8 enables manual operation of the trim angle θt of the propulsion machine 3 in accordance with the operation input by the boat operator from the trim angle operation unit 73. In this situation, the controller 8 sets the lower limit of the adjustment range of the trim angle θt to the trim angle reference value θts.

[0149] FIG. 13 is a timing chart illustrating an example of the operation of the above propulsion system.

[0150] 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 "hump state determination flag" and a "trim operation determination flag".

[0151] As illustrated in FIG. 13, for example, as the lever opening rate is increased in accordance with the operation by the boat operator on the thrust inputter 72, the boat speed V increases. Then, when the boat speed V exceeds the first threshold V1, a standby state of the hump control is set.

[0152] When the boat operator operates the steering angle inputter 71, and starts steering, for example, in the left direction, the steering instruction angle (the steering angle) detected by the steering angle sensor 63 increases in the left direction (time t1). In a state in which the pitch angle θp of the hull 2 that increases along with the increase in the boat speed V does not exceed the first reference pitch angle, when the steering angle exceeds the steering angle threshold (time t2), the hump state

determination flag changes from "0" to "1" in step S16, and the hump control starts. At this timing, the controller 8 changes the trim operation determination flag from "0" to "1", and changes the trim angles θt of all the propulsion machines 3 toward the trim angle reference value θts in step 24.

[0153] When the trim angles θt of all the propulsion machines become the trim angle reference value θts (time t3), the trim operation determination flag changes from "1" to "0" in step S18, and the controller 8 maintains the trim angle θt of the propulsion machine 3 at the trim angle reference value θts.

[0154] Then, the boat operator operates the steering angle inputter 71 to start returning the steering, for example, in the left direction to the original position, and when the steering instruction angle (the steering angle) detected by the steering angle sensor 63 becomes smaller than the steering threshold at the time of return (time t4), the controller 8 returns the hump state determination flag from "1" to "0".

[0155] FIG. 14 is a timing chart illustrating another example of the operation of the propulsion system.

[0156] As illustrated in FIG. 14, when the lever opening rate is increased in accordance with the operation by the boat operator on the thrust inputter 72, the boat speed V increases. Then, when the boat speed V exceeds the first threshold V1 (time t11), the standby state of the hump control is set.

[0157] As the boat speed V increases, when the pitch angle θp of the hull 2 exceeds the first reference pitch angle (time t12), the hump state determination flag changes from "0" to "1" in step S16, and the hump control starts. At this timing, the controller 8 changes the trim operation determination flag from "0" to "1", and changes the trim angles θt of all the propulsion machines 3 toward the trim angle lower limit value θtd in accordance with the hump control. Thus, the pitch angle θp of the hull 2 starts to decrease with a time difference.

[0158] Then, when the trim angles θt of all the propulsion machines reach the trim angle lower limit value θtd (time t13), the trim operation determination flag changes from "1" to "0" in step S18, and the controller 8 stops conducting the hump control in step S21.

[0159] When the boat operator operates the steering angle inputter 71, and starts steering, for example, in the left direction, the steering instruction angle (the steering angle) detected by the steering angle sensor 63 increases in the left direction. When the steering angle exceeds the steering angle threshold (time t14), the controller 8 determines that the hull 2 is in the turning state. At this timing, the trim angles θt of all the propulsion machines 3 are the trim angle lower limit value θtd at time t13 and later, and thus the controller 8 causes the trim angles θt of all the propulsion machines 3 to be maintained at the trim angle lower limit value θtd.

[0160] In this manner, while conducting the hump control, in a case where the preset condition is satisfied, the propulsion system 20 according to the present embodiment adjusts the trim angle θt of the propulsion machine 3 so that the trim angle θt of the propulsion machine 3 becomes the trim angle reference value θts set to be larger than the trim angle lower limit value θtd. Accordingly, in a case where the set condition is satisfied, the effect of suppressing the hump state by the hump control is decreased. Therefore, while conducting the hump control, in a case where a change or the like occurs in the navigation state of the boat 1, it becomes possible to suppress impairment of the stability of the boat 1.

[0161] In addition, in a case where it is determined that the hull 2 is turning, the propulsion system 20 according to the present embodiment sets the trim angle θt of the propulsion machine 3 to the trim angle reference value θts. This suppresses the effect of the hump control while the hull 2 is turning, so that the behavior (e.g., attitude) of the hull 2 can be made stable while turning.

[0162] Further, in a case where the trim angle θt of the propulsion machine 3 is present between the trim angle reference value θts and the trim angle lower limit value θtd at a timing when it is determined that the hull 2 is turning, the propulsion system 20 according to the present embodiment maintains the trim angle θt of the propulsion machine 3 at such a timing. Thus, while conducting the hump control with the trim angle θt of the propulsion machine 3 set to be equal to or smaller than the trim angle reference value, when the hull 2 transitions to the turning state, it becomes possible to transition the hull 2 to the turning state stably while maintaining the suppression effect of the hump state by the hump control.

[0163] In addition, while conducting the hump control, in a case where the trim angle θt of the propulsion machine 3 reaches the trim angle lower limit value, the propulsion system 20 according to the present embodiment stops conducting the hump control, and sets the standby state that enables conducting the hump control. Thus, in a state in which the trim angle θt of the propulsion machine 3 reaches the trim angle lower limit value and the suppression effect of the hump state by the hump control is exerted at maximum, it becomes possible to suppress frequent fluctuations of the trim angle θt of the propulsion machine 3 by continuously conducting the hump control, and to stably continue the state of exerting the suppression effect of the hump state.

[0164] In addition, while conducting the hump control, in a case where the trim angle θt of the propulsion machine 3 is present between the trim angle reference value θts and the trim angle lower limit value θtd at the timing of receiving the operation input from the trim angle operation unit 73, the propulsion system 20 according to the present embodiment sets the trim angle reference value θts as a lower limit, in adjusting the trim angle θt of the propulsion machine 3 in accordance with the operation input from the trim angle operation unit 73. Thus, in a case where the boat operator manually operates, it becomes possible to suppress the trim angle θt of the propulsion machine 3 becoming equal to or smaller than the trim angle reference value in accordance with the

manual operation. Thus, it becomes possible to suppress a strong feeling of the suppression effect of the hump state by the hump control at the time of manual operation, so that an uneasy feeling of the boat operator can be suppressed.

[0165] 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.

[0166] 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.

[0167] 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.

[0168] In addition, the procedure and contents of the control conducted by the controller 8 can be changed as appropriate.

[0169] 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.

[0170] 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

[0171]

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
θt	Trim angle
θtd	Trim angle lower limit value
θts	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 dynamic 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

while conducting the hump control, in a case where a preset condition is satisfied, the controller causes the trim angle adjuster to adjust the trim angle of the propulsion machine so that the trim angle of the propulsion machine is a trim angle reference value set to be larger than the trim angle lower limit value in a direction that the propulsion machine is upright forward in a propulsion direction of the hull.

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

while conducting the hump control, in a case where it is determined that the hull is turning, the controller causes the trim angle adjuster to adjust the trim angle of the propulsion machine so that the trim angle of the propulsion machine is the trim angle reference value.

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

while conducting the hump control, in a case where the trim angle of the propulsion machine is present between the trim angle reference value and the trim angle lower limit value at a timing when it is determined that the hull is turning, the controller maintains the trim angle of the propulsion machine of the timing.

4. The propulsion system of the boat according to any one of claims 1 to 3, wherein

while conducting the hump control, in a case where the trim angle of the propulsion machine reaches the trim angle lower limit value, the controller stops conducting the hump control, and sets a standby state that enables conducting the hump control.

5. The propulsion system of the boat according to any one of claims 1 to 4, further comprising a trim angle operation unit configured to operate the trim angle adjuster in accordance with an external input, wherein

while conducting the hump control, in a case where

the trim angle of the propulsion machine is present between the trim angle reference value and the trim angle lower limit value at a timing of receiving an operation input from the trim angle operation unit, the controller makes the trim angle of the propulsion machine in accordance with the operation input from the trim angle operation unit adjustable with the trim angle reference value as a lower limit.

FIG. 1

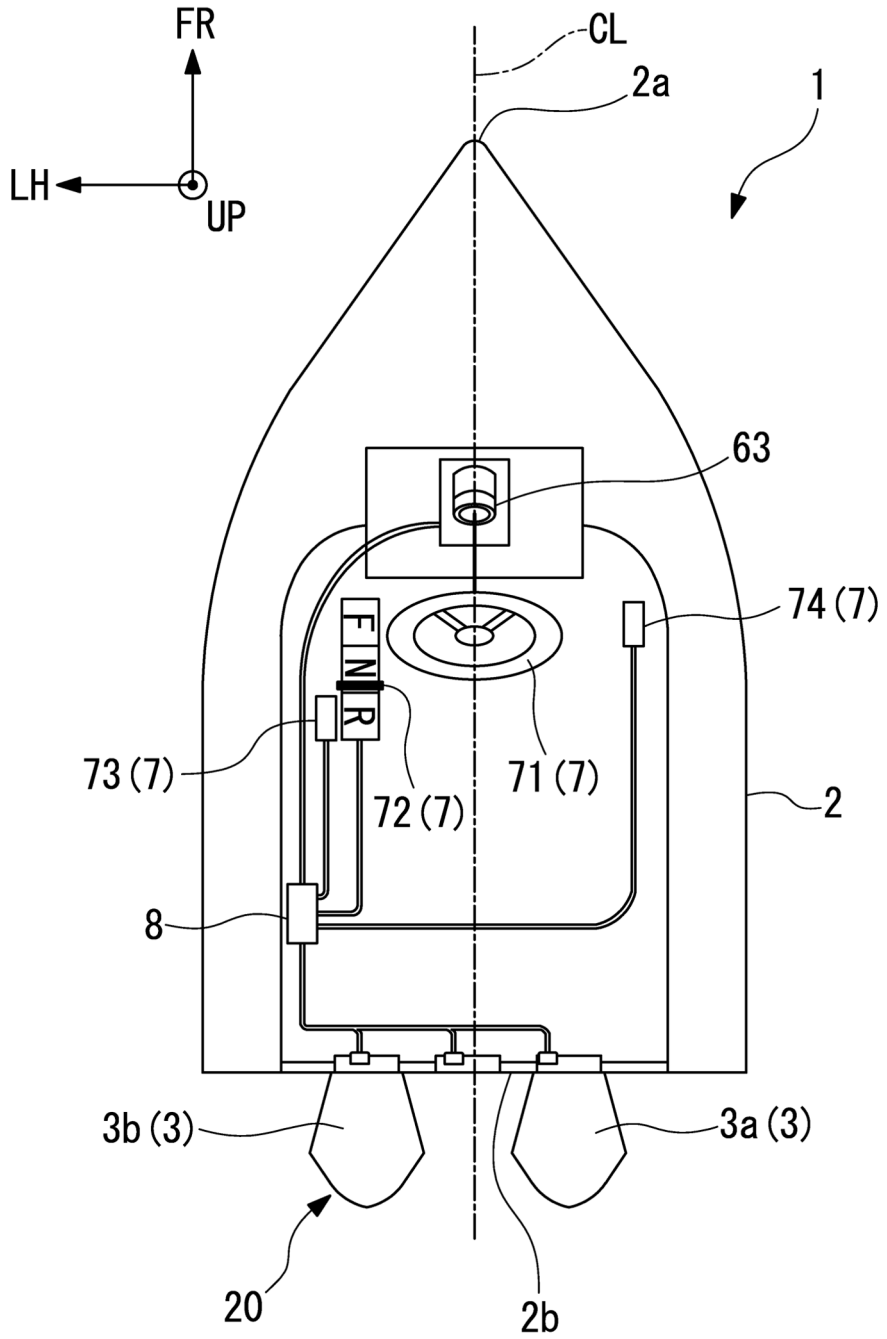


FIG. 2

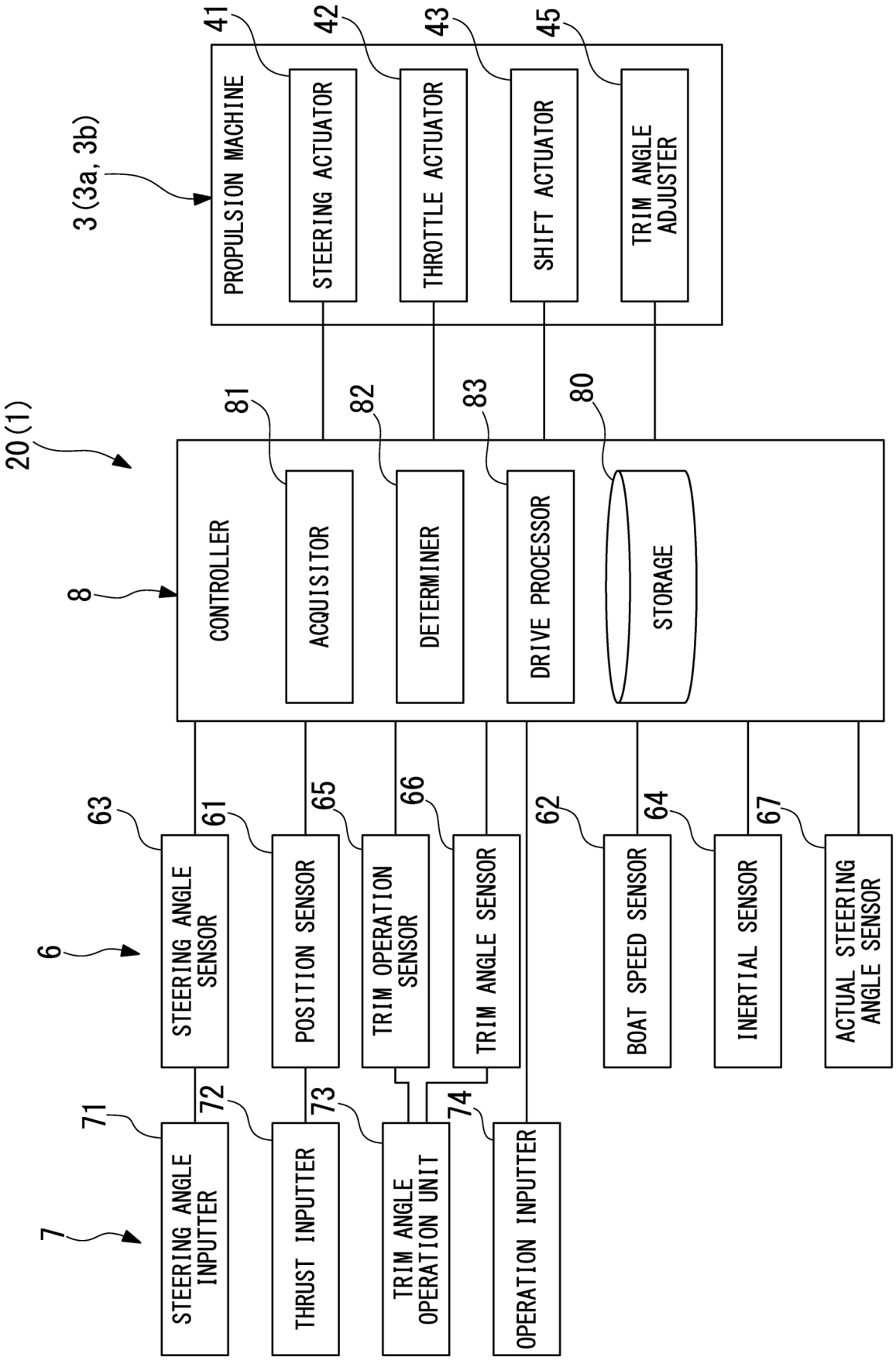

3 (3a, 3b)
PROPULSION MACHINE
41
STEERING ACTUATOR
42
THROTTLE ACTUATOR
43
SHIFT ACTUATOR
45
TRIM ANGLE ADJUSTER
20 (1)
8
CONTROLLER
81
ACQUISITOR
82
DETERMINER
83
DRIVE PROCESSOR
80
STORAGE
6
63
STEERING ANGLE SENSOR
61
POSITION SENSOR
65
TRIM OPERATION SENSOR
66
TRIM ANGLE SENSOR
62
BOAT SPEED SENSOR
64
INERTIAL SENSOR
67
ACTUAL STEERING ANGLE SENSOR
7
71
STEERING ANGLE INPUTTER
72
THRUST INPUTTER
73
TRIM ANGLE OPERATION UNIT
74
OPERATION INPUTTER

FIG. 3

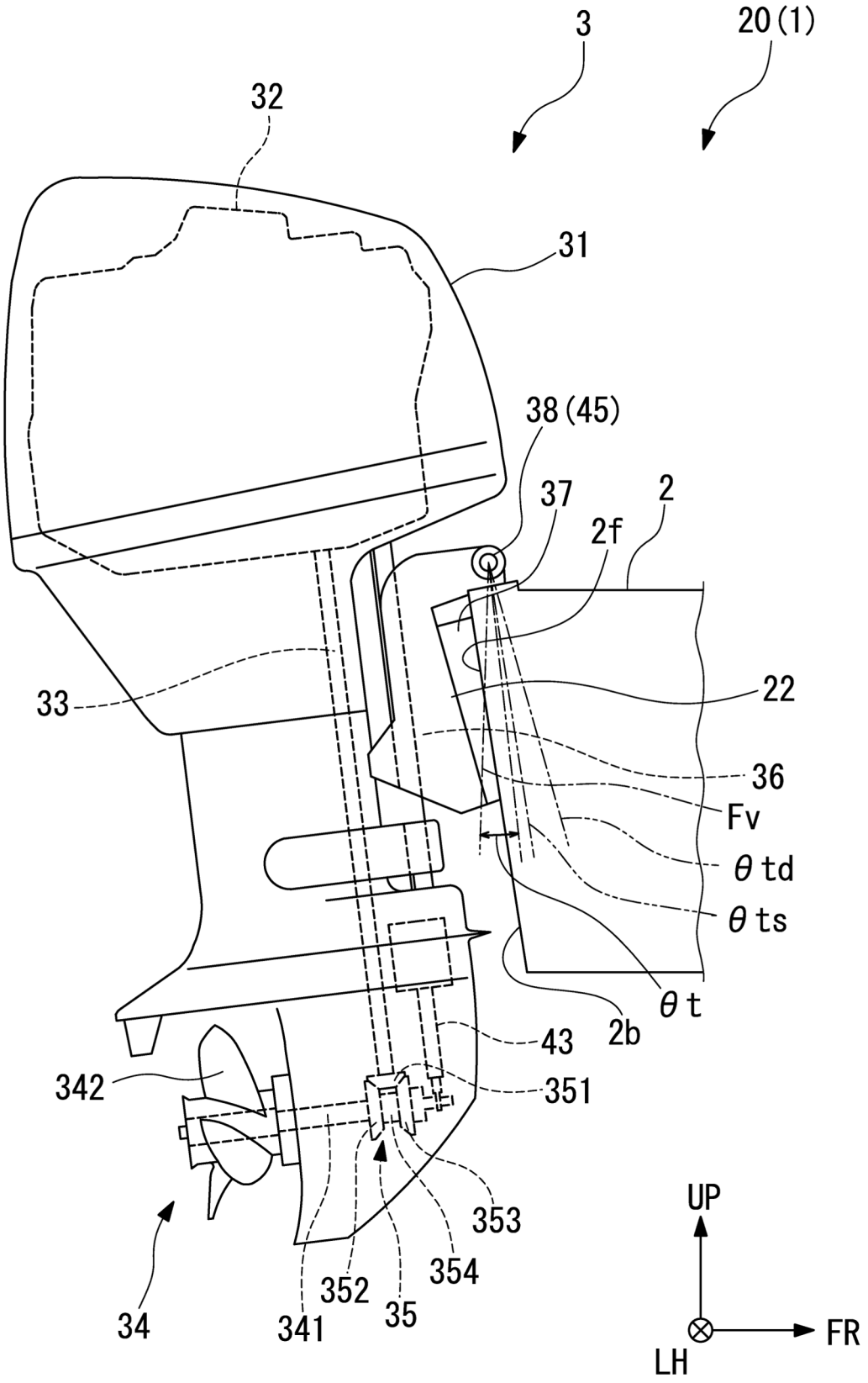

3
20(1)
32
31
38(45)
37
2
2f
33
22
36
Fv
θtd
θts
θt
2b
43
342
351
353
354
352
35
341
34
UP
FR
LH

FIG. 4

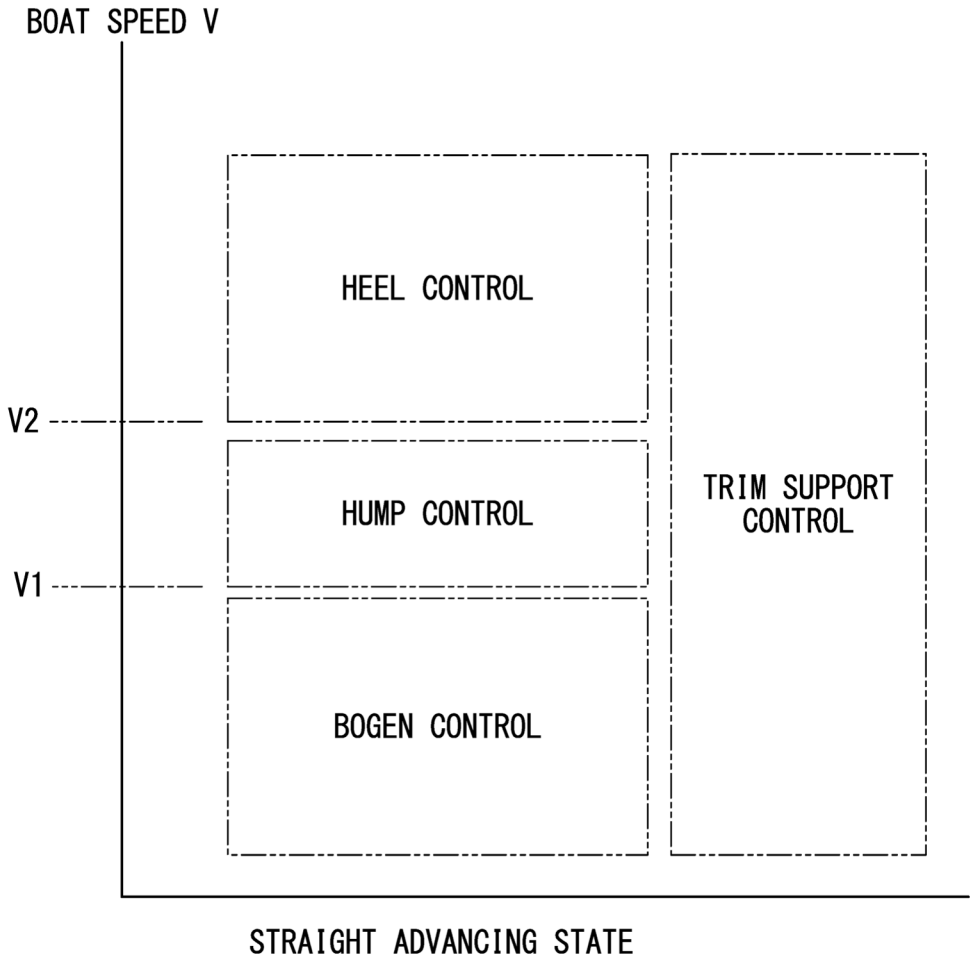

BOAT SPEED V
HEEL CONTROL
V2
HUMP CONTROL
TRIM SUPPORT CONTROL
V1
BOGEN CONTROL
STRAIGHT ADVANCING STATE

FIG. 5

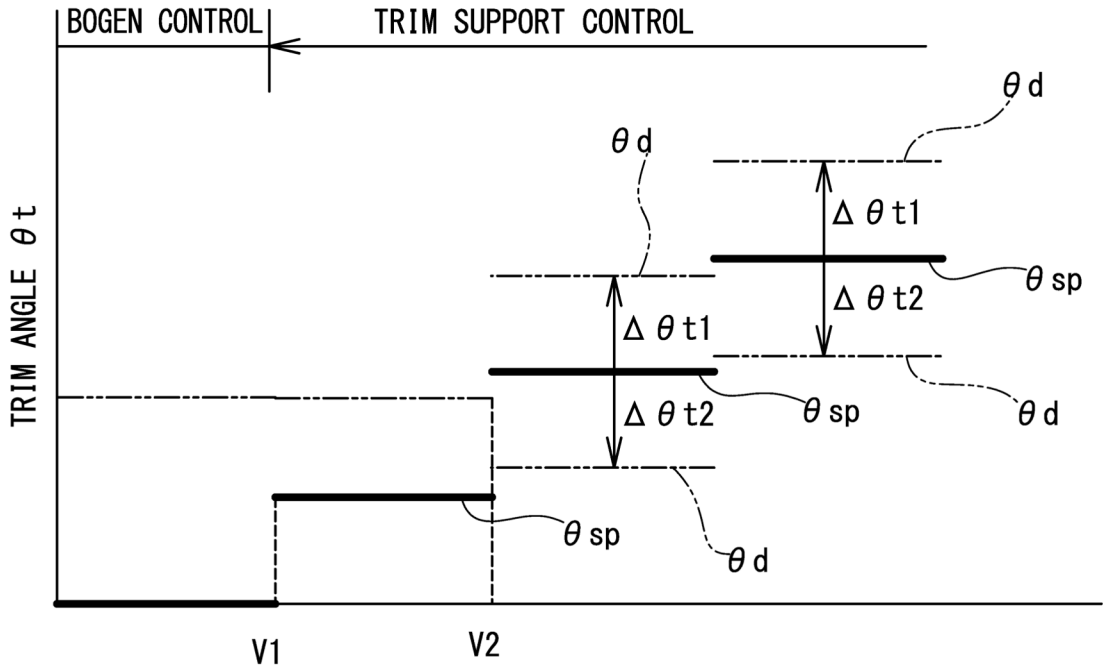

BOGEN CONTROL
TRIM SUPPORT CONTROL
TRIM ANGLE θt
θd
θd
Δθt1
θsp
Δθt2
Δθt1
θsp
Δθt2
θd
θd
θsp
θd
V1
V2
BOAT SPEED (PROPULSION MACHINE ROTATION SPEED)

FIG. 6

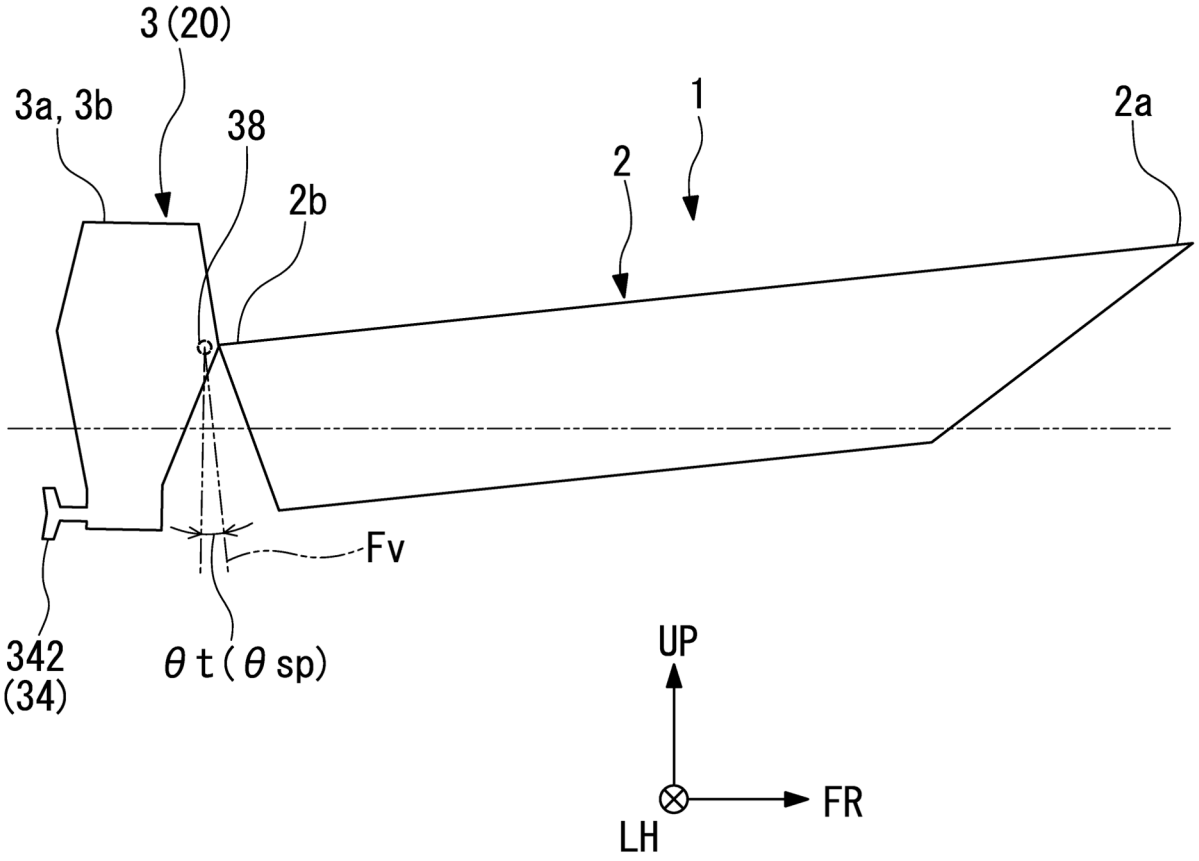


FIG. 7

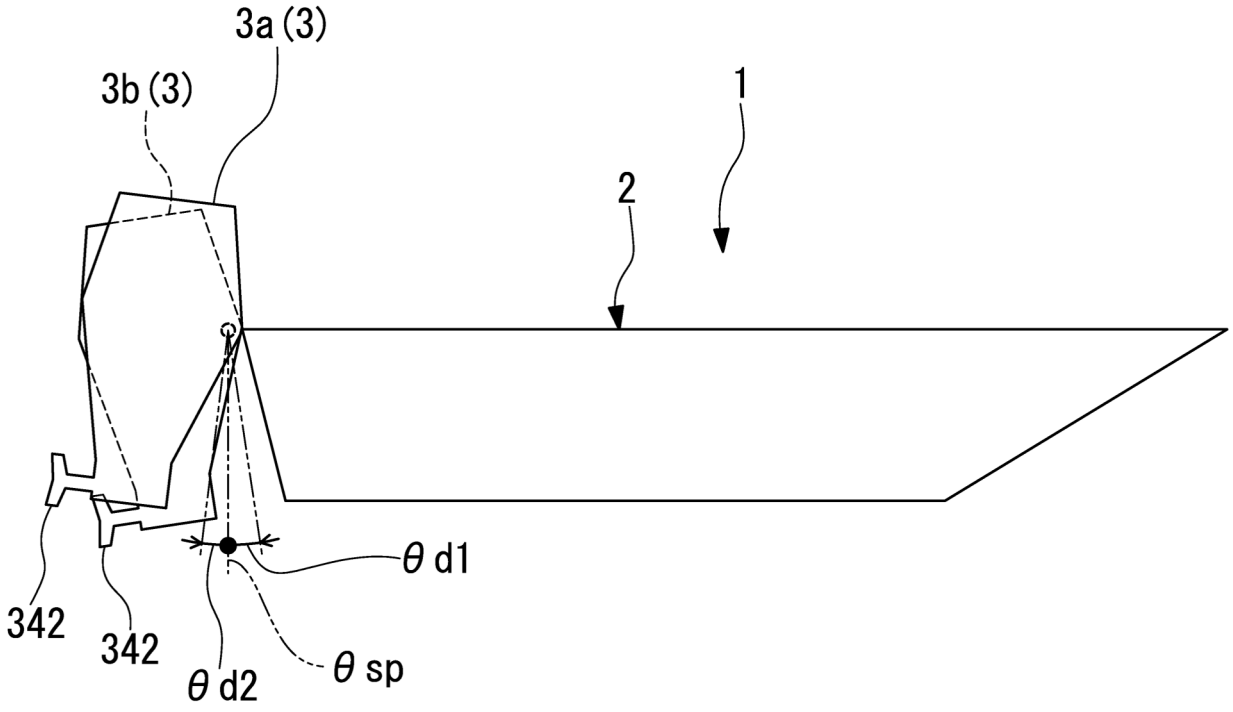


FIG. 8

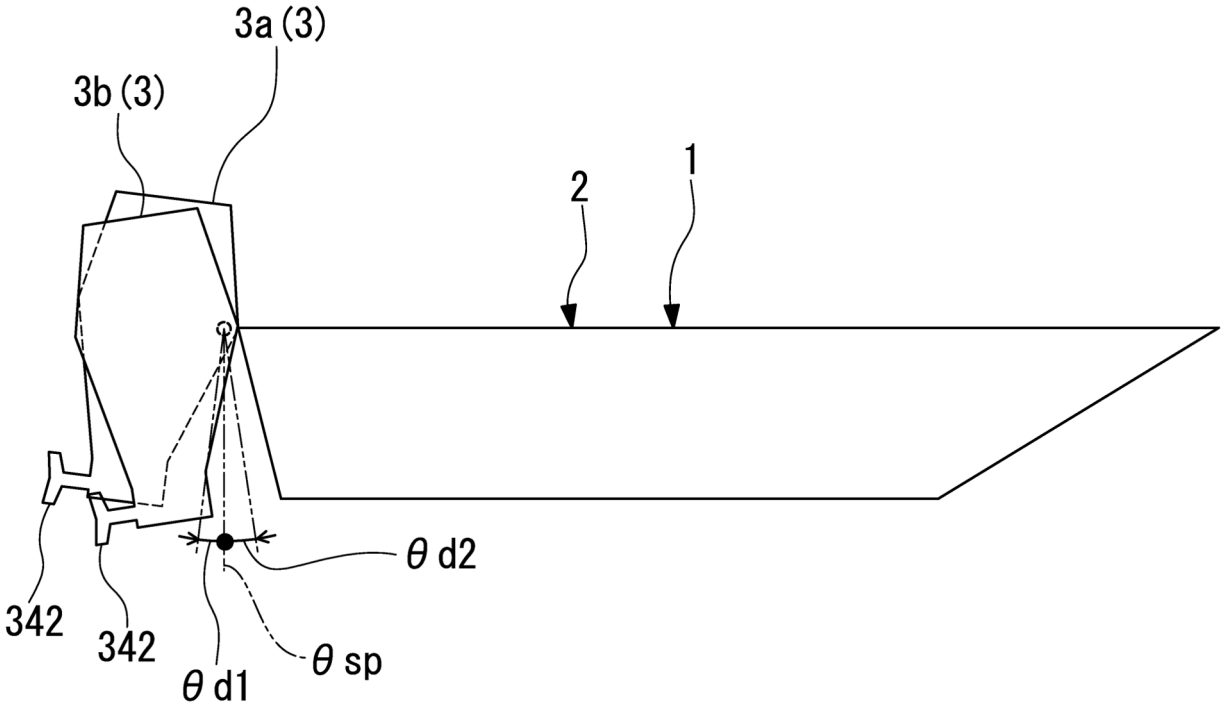


FIG. 9

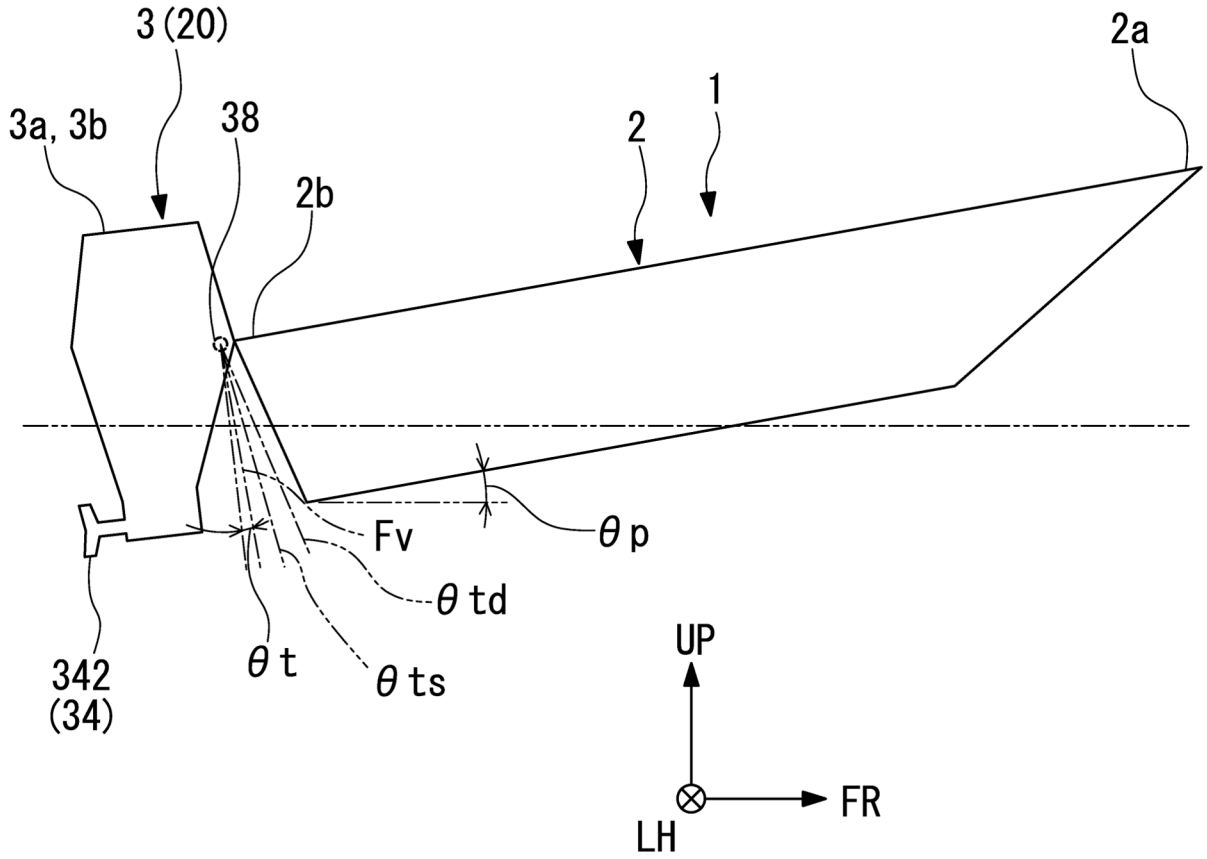


FIG. 10

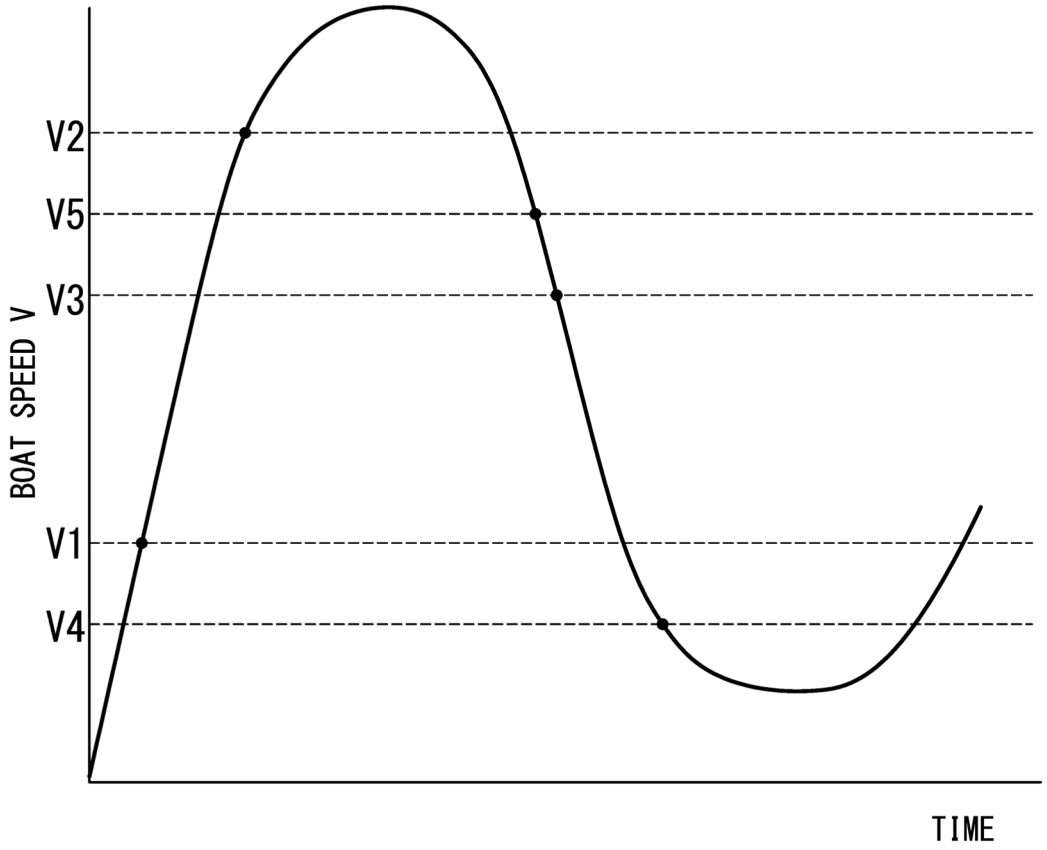


FIG. 11

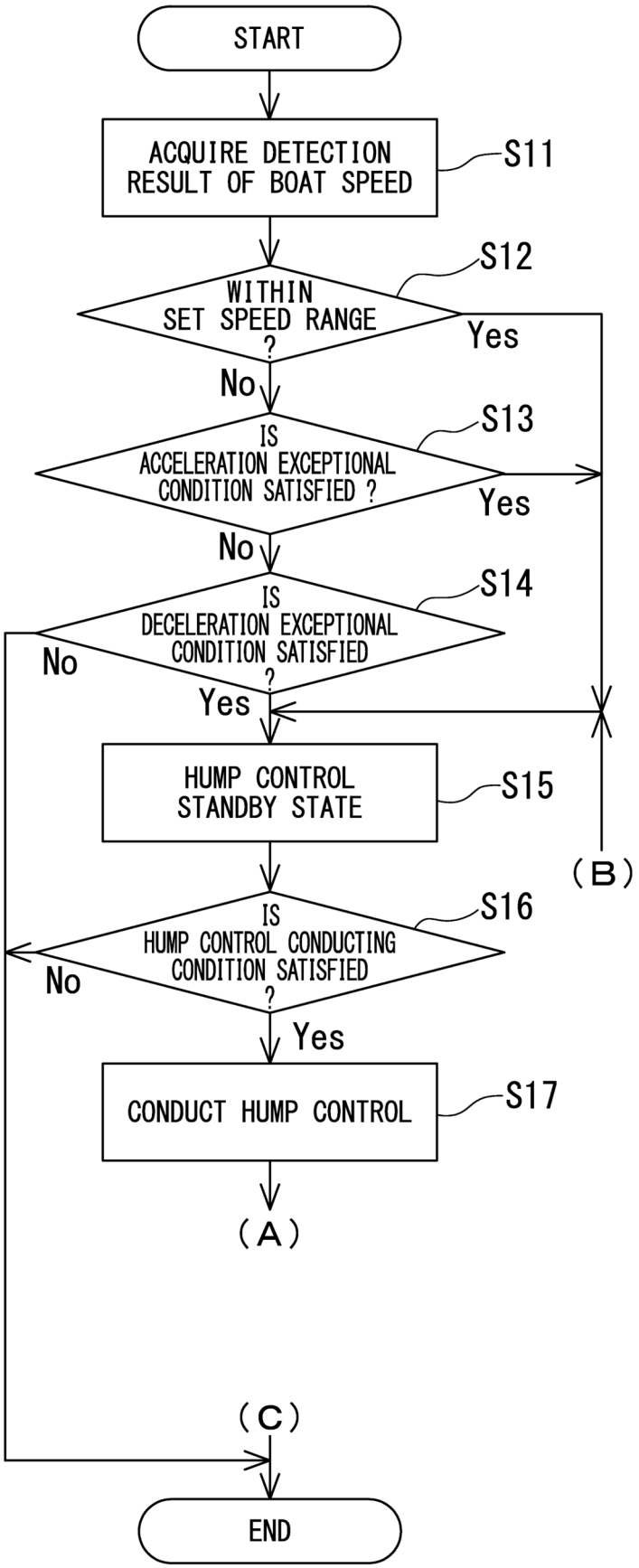

START
ACQUIRE DETECTION RESULT OF BOAT SPEED
S11
WITHIN SET SPEED RANGE ?
S12
Yes
No
IS ACCELERATION EXCEPTIONAL CONDITION SATISFIED ?
S13
Yes
No
IS DECELERATION EXCEPTIONAL CONDITION SATISFIED ?
S14
No
Yes
HUMP CONTROL STANDBY STATE
S15
(B)
IS HUMP CONTROL CONDUCTING CONDITION SATISFIED ?
S16
No
Yes
CONDUCT HUMP CONTROL
S17
(A)
(C)
END

FIG. 12

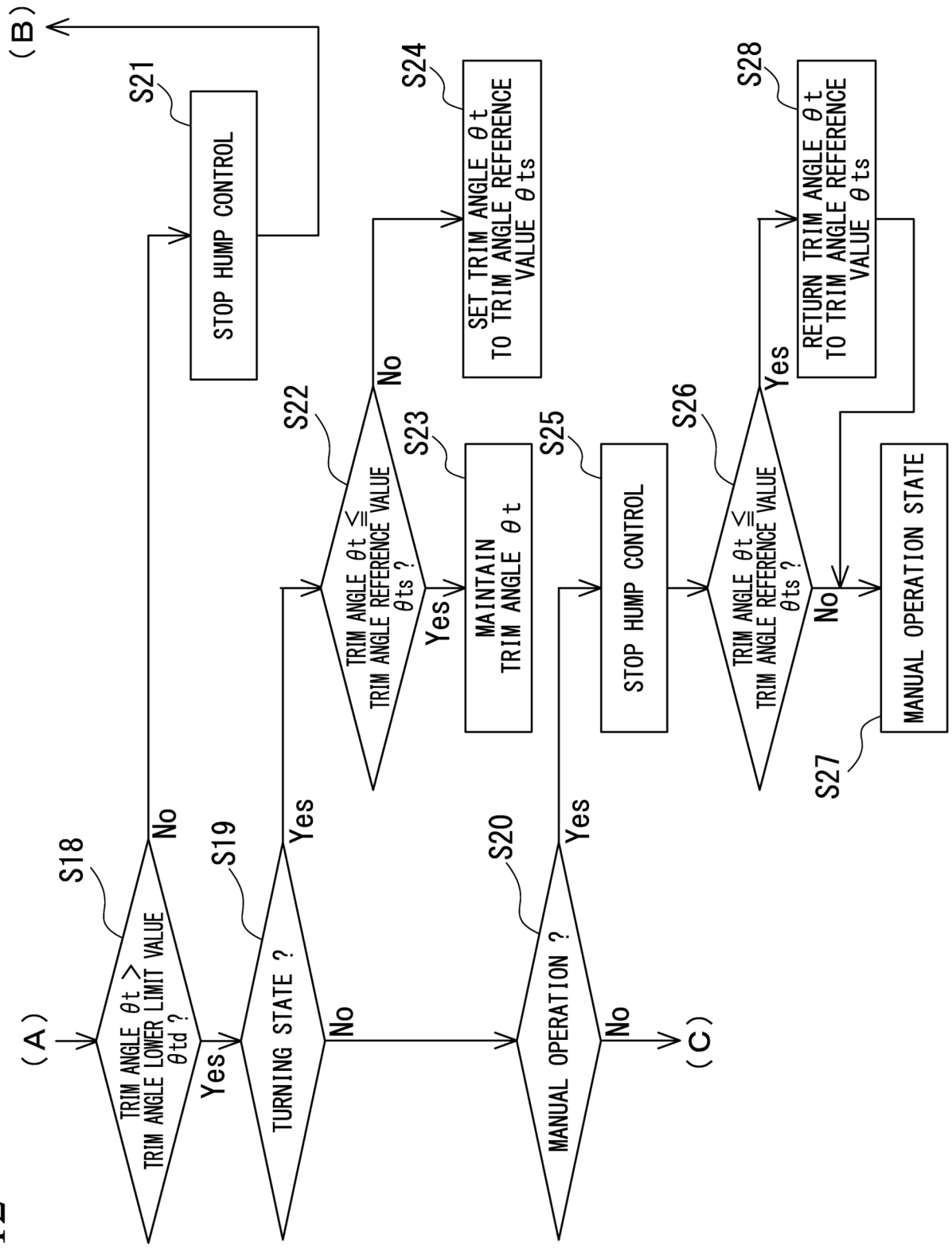

(A)
(B)
(C)
S18
TRIM ANGLE θt > TRIM ANGLE LOWER LIMIT VALUE θtd ?
No
Yes
S19
TURNING STATE ?
Yes
No
S20
MANUAL OPERATION ?
Yes
No
S21
STOP HUMP CONTROL
S22
TRIM ANGLE θt ≦ TRIM ANGLE REFERENCE VALUE θts ?
No
Yes
S23
MAINTAIN TRIM ANGLE θt
S24
SET TRIM ANGLE θt TO TRIM ANGLE REFERENCE VALUE θts
S25
STOP HUMP CONTROL
S26
TRIM ANGLE θt ≦ TRIM ANGLE REFERENCE VALUE θts ?
Yes
No
S27
MANUAL OPERATION STATE
S28
RETURN TRIM ANGLE θt TO TRIM ANGLE REFERENCE VALUE θts

FIG. 13

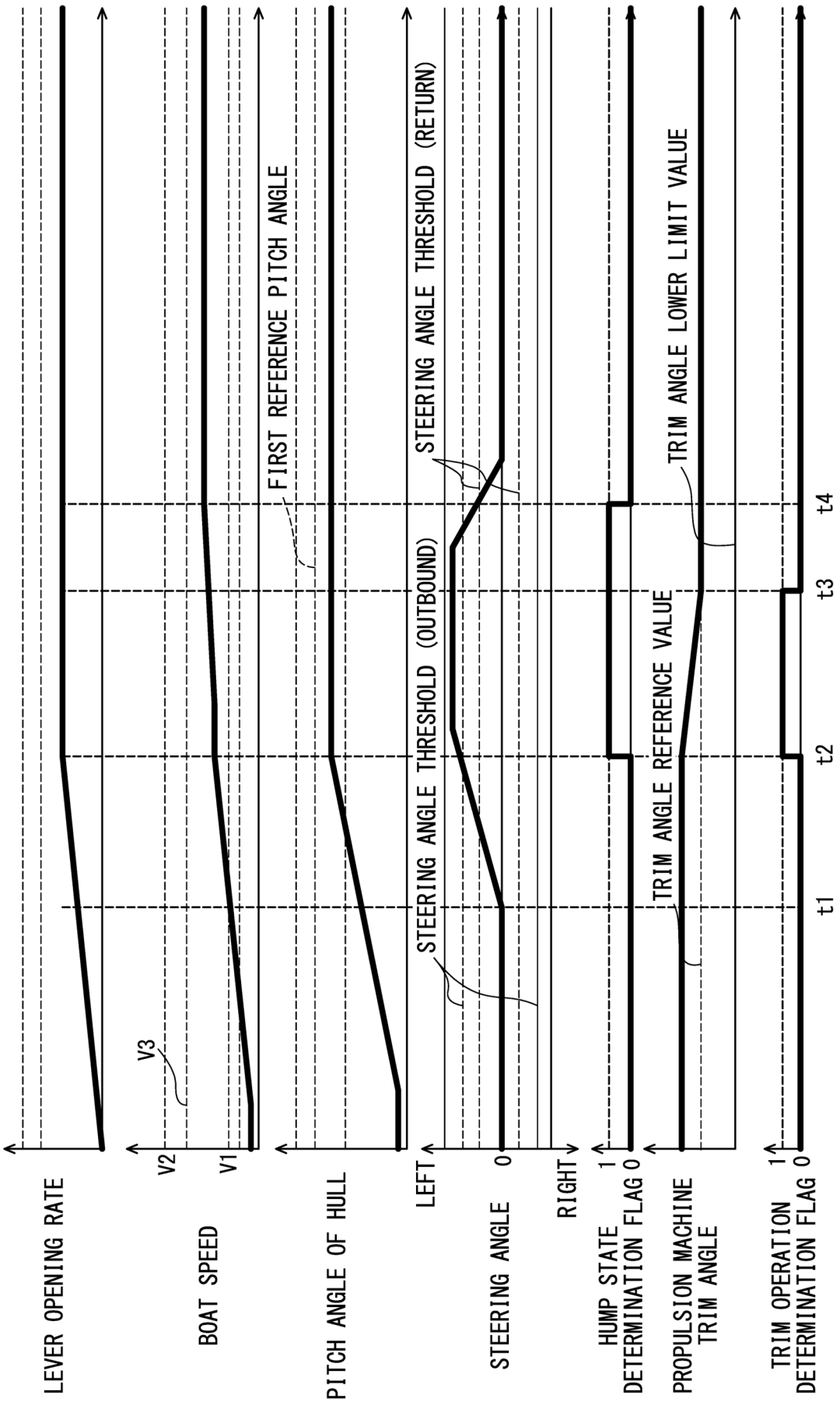
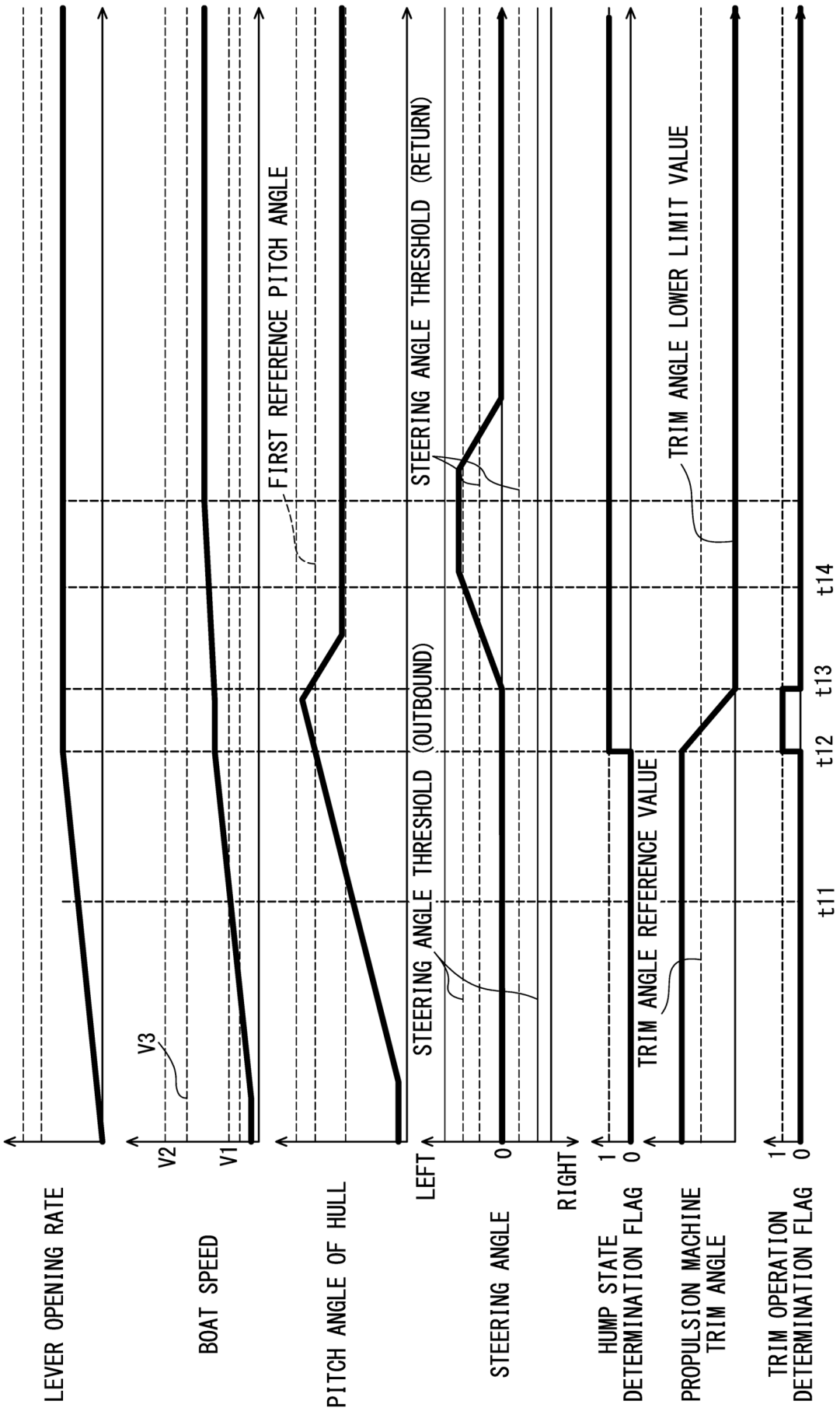

LEVER OPENING RATE
BOAT SPEED
V3
V2
V1
PITCH ANGLE OF HULL
FIRST REFERENCE PITCH ANGLE
STEERING ANGLE
LEFT
0
RIGHT
STEERING ANGLE THRESHOLD (OUTBOUND)
STEERING ANGLE THRESHOLD (RETURN)
HUMP STATE DETERMINATION FLAG
1
0
PROPULSION MACHINE TRIM ANGLE
TRIM ANGLE REFERENCE VALUE
TRIM ANGLE LOWER LIMIT VALUE
TRIM OPERATION DETERMINATION FLAG
1
0
t1
t2
t3
t4

FIG. 14


LEVER OPENING RATE
BOAT SPEED
V3
V2
V1
PITCH ANGLE OF HULL
FIRST REFERENCE PITCH ANGLE
STEERING ANGLE
LEFT
0
RIGHT
STEERING ANGLE THRESHOLD (OUTBOUND)
STEERING ANGLE THRESHOLD (RETURN)
HUMP STATE DETERMINATION FLAG
1
0
TRIM ANGLE REFERENCE VALUE
PROPULSION MACHINE TRIM ANGLE
TRIM ANGLE LOWER LIMIT VALUE
TRIM OPERATION DETERMINATION FLAG
1
0
t11
t12
t13
t14

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EUROPEAN SEARCH REPORT

Application Number
EP 26 16 0539

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2008 254641 A (KOKUSAN DENKI CO) 23 October 2008 (2008-10-23) * paragraph [0033] - paragraph [0034] * * paragraph [0039] * * paragraph [0049] * * paragraph [0058] * * claims; figures *	1-5	INV. B63H20/10 B63H20/12
X	US 5 169 348 A (OGIWARA KAZUYUKI [JP] ET AL) 8 December 1992 (1992-12-08) * column 10, line 55 - line 62; figure 7 *	1-5	
A	JP S63 301196 A (SANSHIN KOGYO KK) 8 December 1988 (1988-12-08) * claims; figures *	1-5	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	4 August 2026	Schmitter, Thierry

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04-08-2026

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- JP 2025057505 A **[0001]**
- JP H02237893 A **[0004]**