



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
11.01.2023 Bulletin 2023/02

(51) International Patent Classification (IPC):
B63H 25/38 (2006.01)

(21) Application number: **21765320.3**

(52) Cooperative Patent Classification (CPC):
B63H 25/38

(22) Date of filing: **01.03.2021**

(86) International application number:
PCT/JP2021/007639

(87) International publication number:
WO 2021/177213 (10.09.2021 Gazette 2021/36)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(30) Priority: **02.03.2020 JP 2020034917**

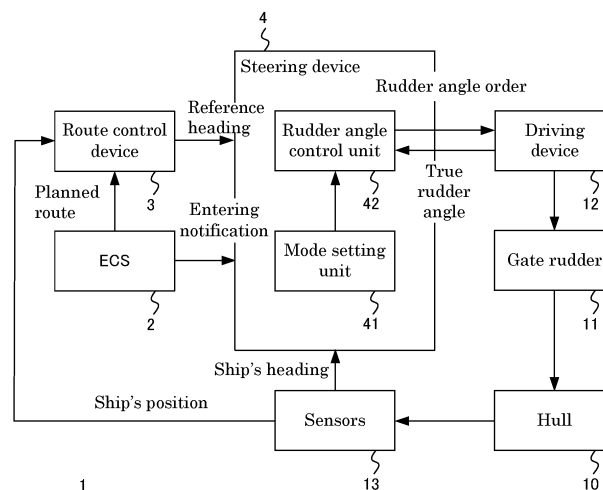
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(54) **STEERING DEVICE**

(57) A steering device 4 for steering a gate rudder 11 comprising two rudder plates disposed so as to flank a propulsion device from lateral directions, includes a mode setting unit 41 that sets a steering mode to either a first steering mode in which the gate rudder 11 is steered with the two rudder plates kept substantially parallel to each other, or a second steering mode in which

the gate rudder 11 is steered with rear edges of the two rudder plates kept closer to each other than when in the first steering mode, and a rudder angle control unit 42 that controls rudder angles of the two rudder plates according to the steering mode set by the mode setting unit 41.

FIG.1



Description**Technical field**

[0001] This invention relates to a technique for steering a ship equipped with a rudder having two rudder plates.

Background Art

[0002] In recent years, a rudder system for ships, e.g., Gate Rudder™, is known, in which two rudder plates are arranged to flank a propeller from both sides perpendicular to the direction of propulsion. Since the gate rudder does not obstruct the propulsive flow behind the propeller, it substantially improves the propulsive capability of the propeller and thus the fuel efficiency of the ship, compared to conventional rudders located behind the propeller.

[0003] As a technique related to the gate rudder, a steering device is known, which comprises a driving mechanism for rotating steering shafts, and a power mechanism for driving the steering shafts, in which two steering shafts are rotatably arranged with vertical rotation axes located on both sides of the propeller shaft, an upper portion of each of the rudder plates is connected to and suspended from each steering shaft, and rotation of the two steering shafts can turn the two rudder plates from the position aside the propeller to the down stream side of the propeller where the propeller aft flow is mostly blocked directly behind the propeller (e.g., Patent Document 1).

Citation List**Patent Document**

[0004] Patent document 1: JP 5833278

Disclosure of the Invention**Problems to be solved by the invention**

[0005] The problem to be solved by the present invention is to provide a steering device that can switch steering modes.

Means for Solving the Problems

[0006] In an embodiment, a steering device for steering a rudder comprising two rudder plates disposed so as to flank a propulsion device from lateral directions, includes a mode setting unit that sets a steering mode to either a first steering mode in which the rudder is steered with the two rudder plates kept substantially parallel to each other, or a second steering mode in which the rudder is steered with rear edges of the two rudder plates being positioned closer to each other than when in the first steering mode, and a rudder angle control unit that con-

trols rudder angles of the two rudder plates according to the steering mode set by the mode setting unit.

Advantageous Effects of the Invention

[0007] An aspect of the present invention provides a steering device that can switch between steering modes.

Brief Description of the Drawings**[0008]**

Fig. 1 is a block diagram of the steering system in the first embodiment.

Fig. 2 is a schematic plan view of the gate rudder.

Fig. 3 is a schematic rear view of the gate rudder.

Fig. 4 is a flowchart showing the operation of the steering mode setting process for the first embodiment.

Fig. 5 is a schematic plan view of the gate rudder when the ship is steered in the starboard direction in the first steering mode.

Fig. 6 is a schematic plan view of the gate rudder when the ship is steered in the port direction in the first steering mode.

Fig. 7 is a schematic plan view of the gate rudder when the ship is steered in the straight-ahead direction in the second steering mode.

Fig. 8 is a schematic plan view of the gate rudder when the ship is steered in the starboard direction in the second steering mode.

Fig. 9 is a schematic plan view of the gate rudder when the ship is steered in the port direction in the second steering mode.

Fig. 10 is a flowchart showing the operation of the steering mode setting process for the second embodiment.

Best Mode for Carrying Out the Invention

[0009] A steering device according to embodiments of the present invention will now be described with reference to the drawings.

<First embodiment>

(Steering system)

[0010] The configuration of a steering system according to the first embodiment is described below. Fig. 1 is a block diagram showing the configuration of the steering system.

[0011] As shown in Fig. 1, the steering system 1 is equipped with an ECS (Electronic Chart System) 2, a route control unit 3, a steering device 4, a ship's hull 10, a gate rudder 11 that changes the direction of travel of the hull 10, a driving device 12 that drives the gate rudder 11, and sensors 13 that detect the state of the hull 10.

The sensors 13 include at least a gyrocompass to detect the heading of the hull 10, a GNSS sensor that detects the ship's position by a satellite positioning system (GNSS). The ECS 2 may be an ECDIS (Electronic Chart Display and Information System).

[0012] The ECS 2 displays own ship and other ships on the electronic chart, as well as various information and user interface for the ship's navigator to set the ship's planned route. The ECS 2 also issues an entering notification to the steering device 4 indicating that the ship has entered a predetermined area. The route control device 3 performs navigation control to control the ship's position to follow the planned route set in the ECS 2, and heading control to control the ship's heading to follow the reference heading, and outputs the reference heading to the steering device.

[0013] The steering device 4 includes a mode setting unit 41 whose steering mode is set to either a first or second steering mode by the mode setting process described below, and a rudder angle control unit 42 that controls the driving device 12, that drives the gate rudder 11, so that the ship's heading follows the reference heading in the steering mode set by the mode setting unit 41.

(Gate Rudder)

[0014] The configuration of the gate rudder is described below. Figs. 2 and 3 show a schematic plan view and a schematic rear view, respectively, of the gate rudder configuration.

[0015] As shown in Figs. 2 and 3, the gate rudder 11 has two rudder plates 110a and 110b arranged to flank the propeller 14 from the lateral directions, i.e., perpendicular to the direction of the ship's propulsion and vertical direction, and two rudder shafts 111a and 111b provided corresponding to each of the rudder plates 110a and 110b. In the following description, when the two rudder plates 110a, 110b are not specifically distinguished, they are simply referred to as a rudder plate 110. The two rudder shafts 111a and 111b are also referred to simply as a rudder shaft 111 when they are not specifically distinguished.

[0016] In this embodiment, the rudder plates 110 are substantially plate-shaped members installed substantially vertically. The rudder shafts 111 are installed at positions relatively offset inwardly in the lateral direction from the positions of the corresponding rudder plates 110, with the shaft's axes oriented substantially vertical, and the orientation of the rudder plates 110 are adjusted by the rotation of the corresponding rudder shafts driven by the driving device 12.

(Mode setting process)

[0017] The mode setting process is described below. Fig. 4 is a flowchart showing the operation of the steering mode setting process. Figs. 5 and 6 are schematic plan views showing the gate rudder when steered, respec-

tively, into starboard and port directions in the first steering mode. Figs. 7, 8 and 9 are schematic plan views showing the gate rudder when steered, respectively, in the straight ahead, starboard, and port directions in the second steering mode.

[0018] As shown in Fig. 4, first, the mode setting unit 41 of the steering device 4 calculates the rate of turn (S101) based on the headings of the ship detected by the sensors 13 during a duration of time immediately after the true rudder angle has matched the rudder angle order by the rudder angle control unit 42, and determines whether the calculated rate of turn is less than a preset threshold value (S102).

[0019] If the rate of turn is not less than the threshold value (S102, NO), the mode setting unit 41 determines whether or not an entering notification has been issued by the ECS 2 (S103). The entering notification is issued when the ship is located within a predetermined area on the electronic chart displayed by the ECS 2, for example, areas within a certain distance from a wharf, mooring buoy, planned offshore anchorage point, offshore structure, etc.

[0020] If no entering notifications are issued (S103, NO), the mode setting unit 41 sets the steering mode of the rudder angle control unit 42 to the first steering mode (S104). When set to the first steering mode, the rudder angle control unit 42 controls the rudder angle of the gate rudder 11 in such a way that the two rudder plates 110 are kept parallel to each other, as shown in Figs. 2, 5, and 6. The rudder angle control unit 42 may also control the rudder angles of the gate rudder 11 to keep the rear sides of the two rudder plates 110 inclined outward in the lateral direction.

[0021] On the other hand, if an entering notification is issued (S103, YES), the mode setting unit 41 sets the steering mode of the rudder angle control unit 42 to the second steering mode (S105). The rudder angle control unit 42 set to the second steering mode controls the rudder angle of the gate rudder 11 to keep the rear sides of the two rudder plates 110 inclined inward in the lateral direction, as shown in Figs. 7, 8 and 9.

[0022] If the rate of turn is less than the threshold value in step S102 (S102, YES), the mode setting unit 41 sets the steering mode of the rudder angle control unit 42 to the second steering mode (S105).

[0023] Thus, by switching between the first steering mode, which prioritizes fuel efficiency, and the second steering mode, which prioritizes rudder effectiveness compared to the first steering mode, the gate rudder 11 can be steered appropriately for the navigational situation. While, in the description above, the first steering mode is a steering mode in which the rudder is steered with the rudder plates held parallel or inclined outward, and the second steering mode is a steering mode in which the rudder is steered with the rudder plates held inclined inward, the second steering mode may be a steering mode in which the rudder is steered with rear edges of the two rudder plates 110 kept closer to each other than

in the first steering mode. While the present embodiment is described for a ship equipped with a propeller 14, the ship may alternatively be a one equipped with other propulsion devices, for example, a water jet propulsion system, etc.

[0024] <Second embodiment>

[0025] In the first embodiment, the steering mode is switched based on the rate of turn; however, in this embodiment, the steering system differs from that of the first embodiment in that the steering mode is switched based on the speed-through-water instead of the rate of turn. Fig. 10 is a flowchart showing the operation of the steering mode setting process for this embodiment.

[0026] The steering system 1 of this embodiment differs from that of the first embodiment in that the sensors 13 include a speed log that detects a speed-through-water of the hull 10, and the steering device 4 receives the speed-through-water detected by the sensors 13.

[0027] First, as shown in Fig. 10, the mode setting unit 41 of the steering device 4 determines whether or not the speed-through-water detected by the sensors 13 is less than or equal to a predetermined threshold value (S201). The threshold value is set based on the pre-confirmed rudder effectiveness against speed-through-water. The correlation between the speed-through-water and rudder effectiveness is established based on, for example, simulations using ship motion models, measurements from water tank experiments, and measurements from test sailing of real ships.

[0028] If the speed-through-water is not less than the threshold value (S201, NO), the mode setting unit 41 sets the steering mode of the rudder angle control unit 42 to the first steering mode (S202).

[0029] On the other hand, if the speed-through-water is less than or equal to the threshold value (S201, YES), the mode setting unit 41 sets the steering mode of the rudder angle control unit 42 to the second steering mode (S203).

[0030] Thus, the calculation of the rate of turn may be spared and the amount of calculation involved in setting the steering mode may be reduced by setting the steering mode based on the evaluation of speed-through-water against a threshold value, wherein the threshold value is set based on the rudder effectiveness or, in other words, the correlation between the rate of turn and the speed-through-water. In addition, the use of the speed-through-water allows a switching of the steering mode that takes account of the effects on the hull 10 from wind directions, wind speeds, and direction and speed of currents.

[0031] The embodiment of the present invention has been presented by way of example only, and is not intended to limit the scope of the invention. The novel embodiment described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes may be made without departing from the spirit of the invention. The embodiment and modifications are included in the scope or spirit of the present invention and in the appended claims and their equivalents.

lents.

Reference Signs List

5 **[0032]**

- 4 Steering device
- 11 Gate rudder
- 41 Mode setting unit
- 10 42 Rudder angle control unit

Claims

- 15 **1.** A steering device for controlling a rudder comprising two rudder plates disposed so as to flank a propulsion device from lateral directions, comprising:

a mode setting unit that sets a steering mode to either

a first steering mode wherein the rudder is steered with the two rudder plates kept substantially parallel to each other, or

a second steering mode wherein the rudder is steered with rear edges of the two rudder plates kept closer to each other than in the first steering mode; and

a rudder angle control unit that controls angles of the two rudder plates according to the steering mode set by the mode setting unit.

- 35 **2.** The steering device according to claim 1, wherein the mode setting unit sets the steering mode to the second steering mode when a rate of turn of a ship on which the rudder is disposed is below a predetermined threshold value.

- 40 **3.** The steering device according to claim 1, wherein the mode setting unit sets the steering mode to the second steering mode when a speed-through-water of a ship on which the rudder is disposed is below a predetermined threshold value.

- 45 **4.** The steering device according to either one of claims 1 - 3, wherein the mode setting unit sets the steering mode to the second steering mode when a position of a ship on which the rudder is disposed is within a predetermined area set on an electronic chart.

FIG.1

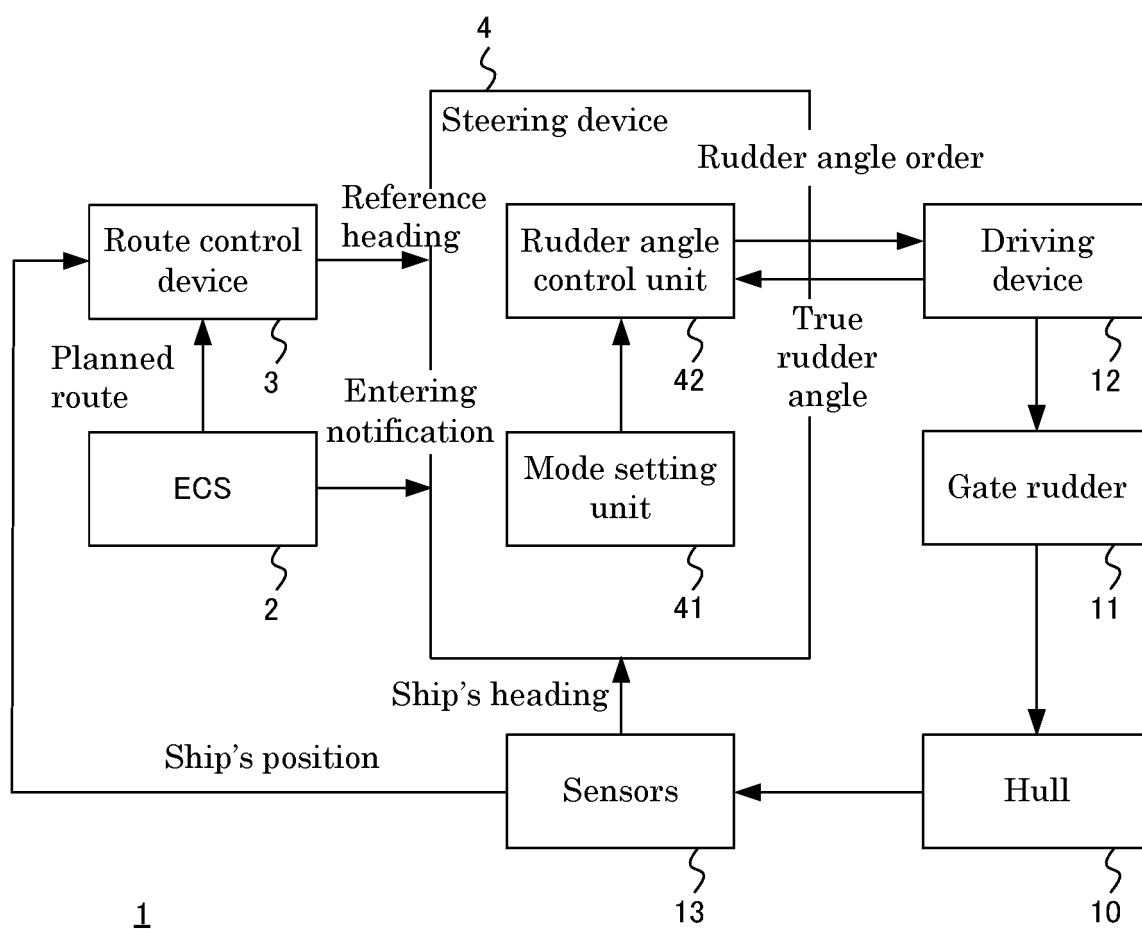


FIG.2

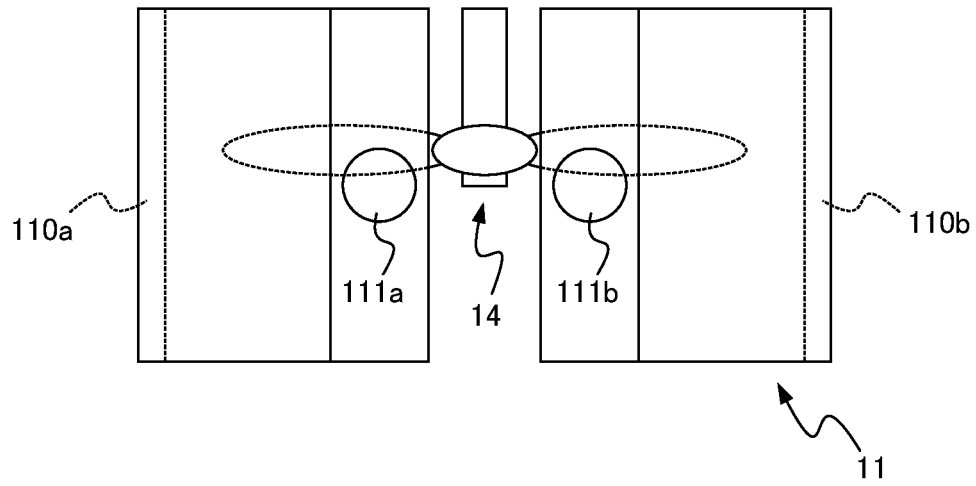


FIG.3

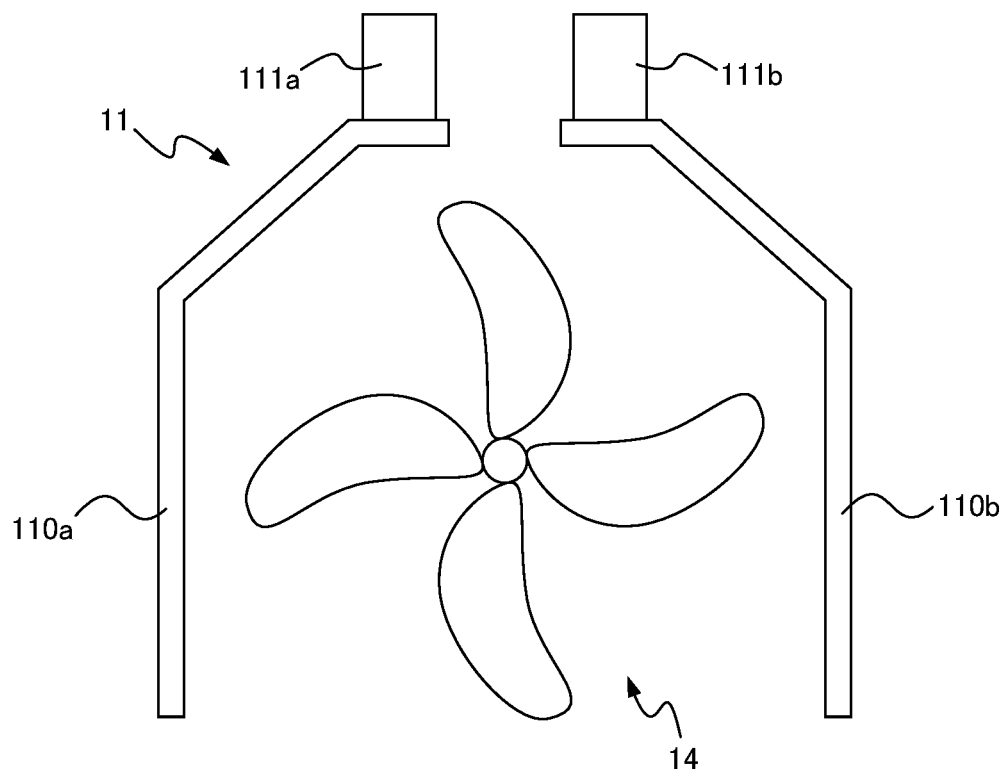


FIG.4

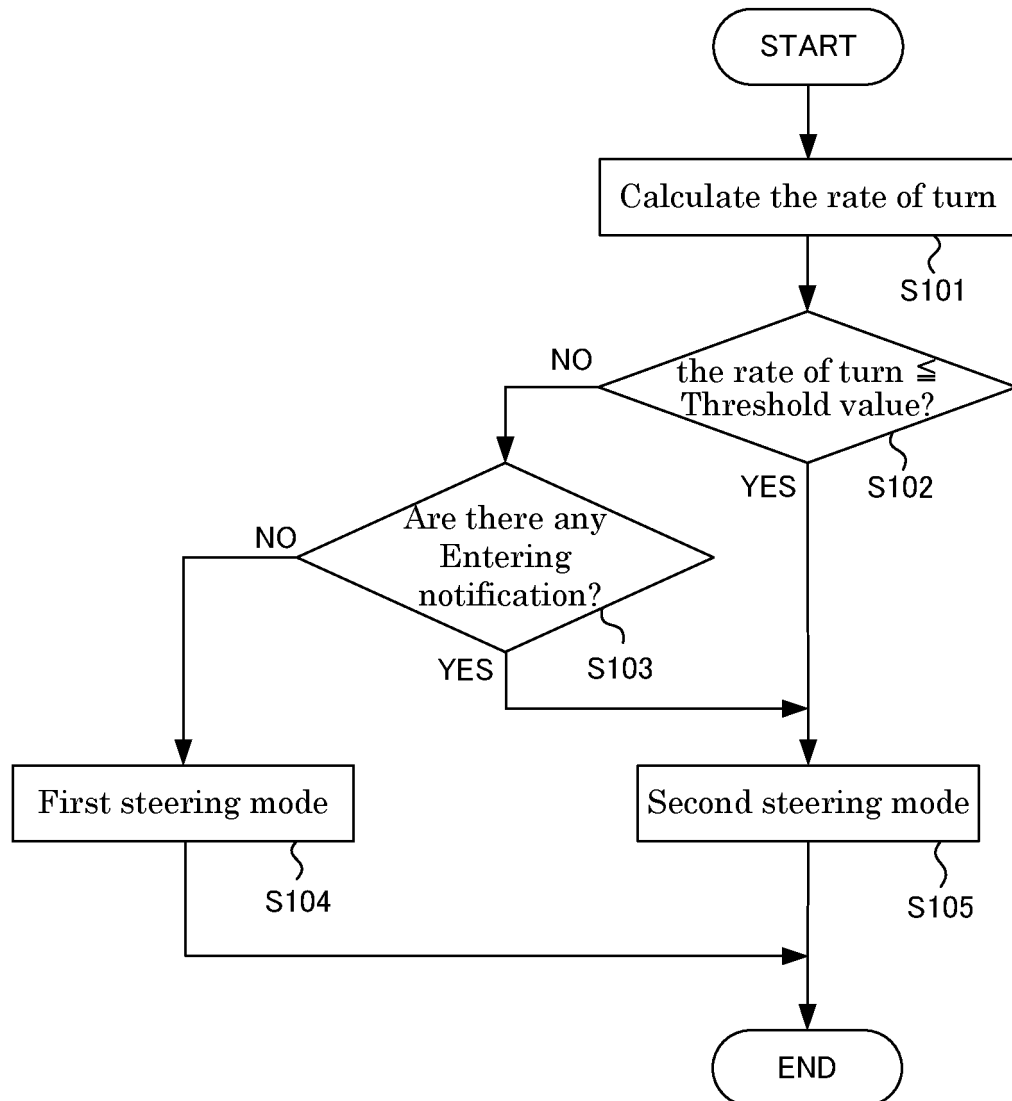


FIG.5

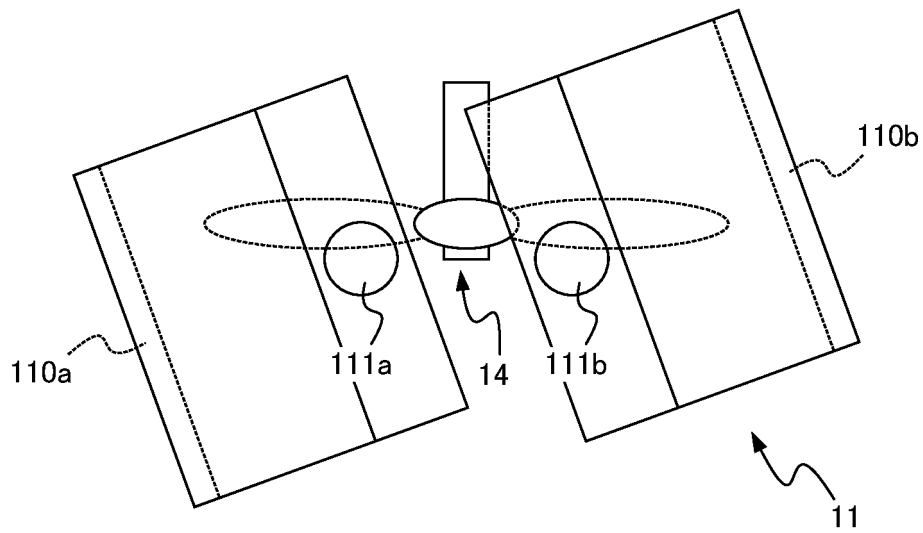


FIG.6

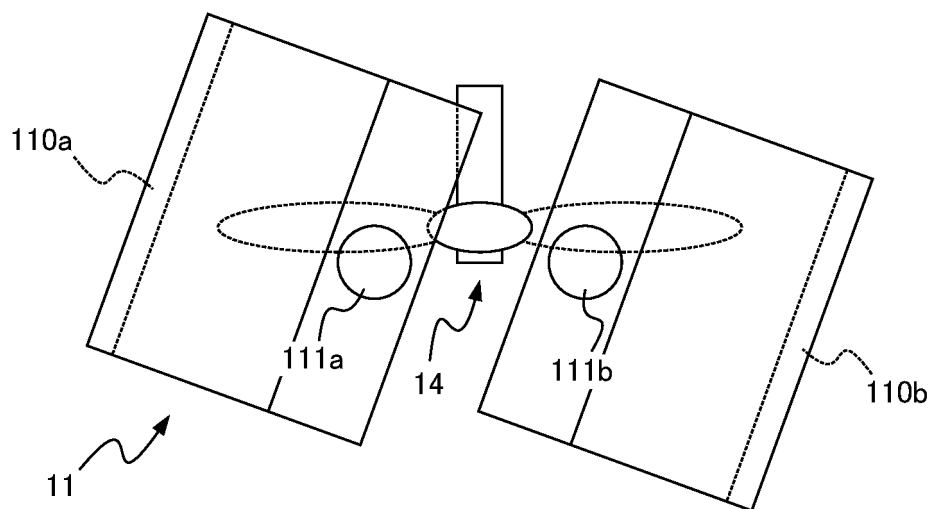


FIG.7

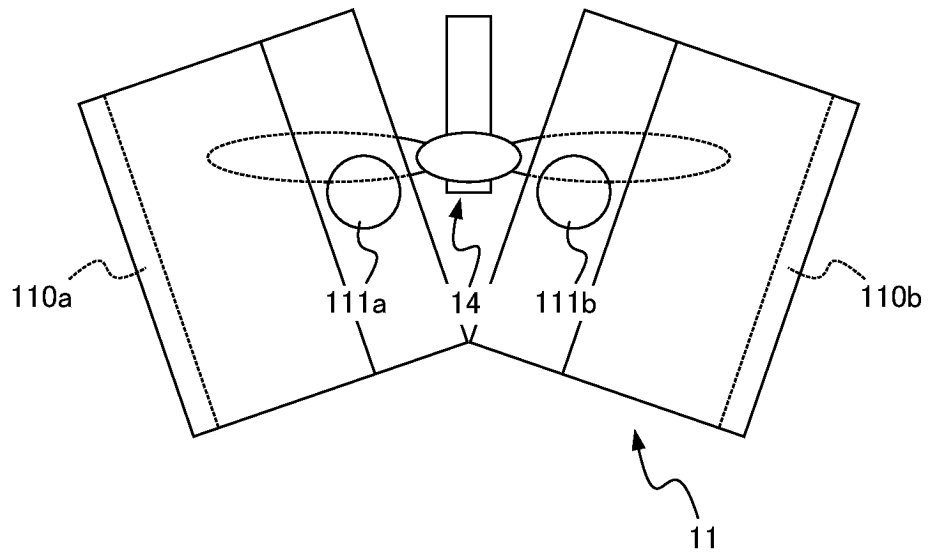


FIG.8

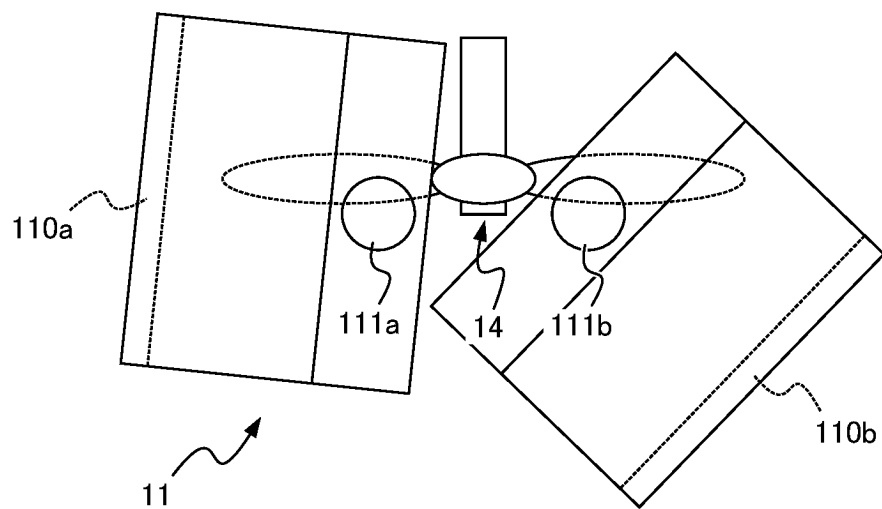


FIG.9

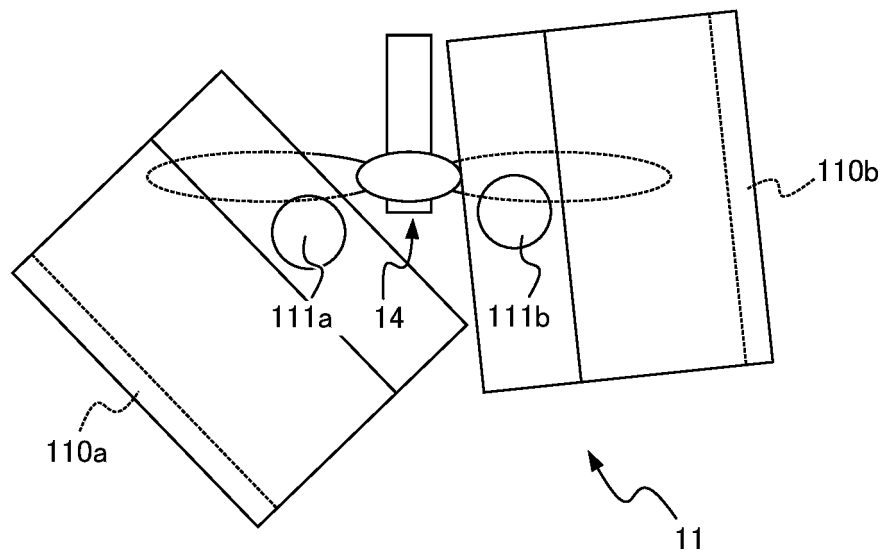
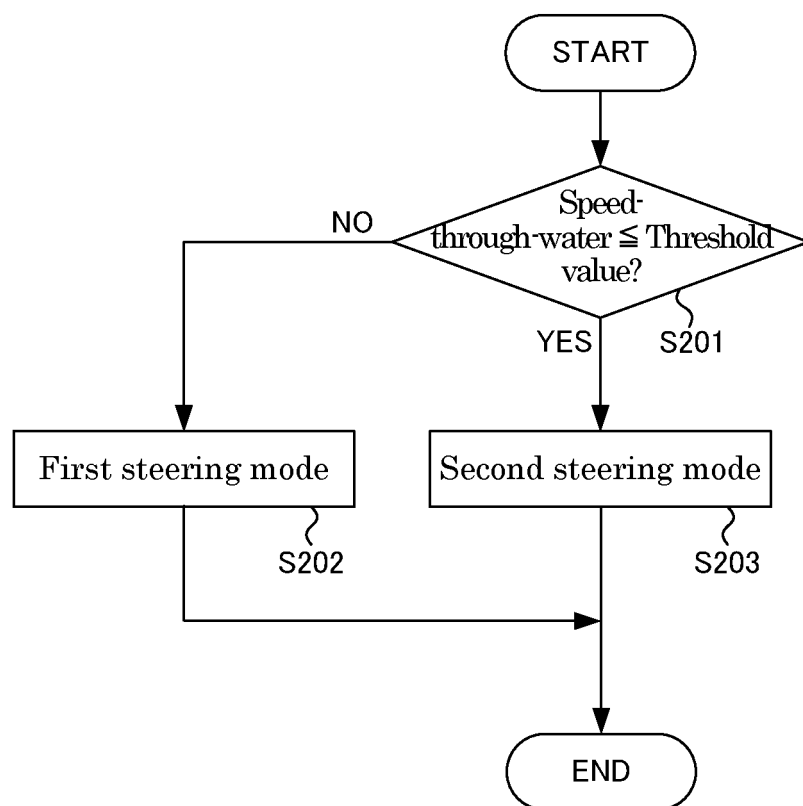


FIG.10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/007639

A. CLASSIFICATION OF SUBJECT MATTER

B63H 25/38 (2006.01) i

FI: B63H25/38 B

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B63H25/38

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2021

Registered utility model specifications of Japan 1996-2021

Published registered utility model applications of Japan 1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	平成 30 年度 (2018 年度) ゲートラダーを使用した省エネ推進システムの技術開発 成果報告書, 一般社団法人日本船用工業会, March 2019, pp. 1-99, pp. 8-61, non-official translation (The 30th Heisei period (Fiscal 2018), "Research report of the technology development of energy-saving promotion system using Gate Rudder", Japan Ship Machinery and Equipment Association)	1-4
X	JP 1-501384 A. (MARIKO A/S) 18 May 1989 (1989-05-18) page 2, upper right column, line 24 to page 3, lower left column, line 14, fig. 1-8	1-4

<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.	<input checked="" type="checkbox"/> See patent family annex.
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family

Date of the actual completion of the international search 28 April 2021 (28.04.2021)	Date of mailing of the international search report 18 May 2021 (18.05.2021)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/007639

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	土井征一郎, SES の未来に向けて スーパーエコシップ研究会 第 9 回「ゲートラダーを用いた省エネ推進システム」新製品開発の概要, 月刊共有船, 20 January 2019, new year issue, pp. 59-65, entire text, all drawings, non-official translation (DOI, Seiichiro, "For the future of SES: Summary of new product development of the 9th 'Energy-saving promotion system using Gate Rudder' of the super eco-ship study group", Monthly Kyoyusen)	1-4
A	JP 2014-73815 A (INDEPENDENT ADMINISTRATIVE INSTITUTION, NATIONAL MARITIME RESEARCH INSTITUTE) 24 April 2014 (2014-04-24) entire text, all drawings	1-4
A	栗林定友ら, ダクト効果を有する非対称断面ツイン舵船型の開発 (第 3 報 操縦性能), 日本船舶海洋工学会講演会論文集, 26 May 2016, no. 22, pp. 305-308, DOI:10.14856/conf.22.0_305, entire text, all drawings, (KURIBAYASHI, Sadatomo et al., "The New Hull Form with Twin Rudders Utilizing Duct Effects (3rd Report)", Conference Proceedings of the Japan Society of Naval Architects and Ocean Engineers)	1-4
A	JP 2008-230379 A (UNIVERSAL SHIPBUILDING CORP.) 02 October 2008 (2008-10-02) entire text, all drawings	1-4
A	<シリーズ>新技術開発ものがたり 舵とプロペラを一体の推進器に かもめプロペラ、新型舵開発に挑戦, 海事プレス, 海事プレス社, 04 February 2020, pp. 10-11, entire text, all photos, non-official translation ("<Series > Story of new technology development, Rudder and propeller are integrated into a thruster, Kamome propeller challenges new rudder development", Kaiji Press, KAIJI PRESS CO., LTD.)	1-4
A	JP 6515171 B1 (KAYSEVEN CO., LTD.) 15 May 2019 (2019-05-15) entire text, all drawings	1-4
E, A	JP 6860642 B1 (KAYSEVEN CO., LTD.) 21 April 2021 (2021-04-21) entire text, all drawings	1-4

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2021/007639

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JP 1-501384 A	18 May 1989	US 4895093 A column 1, line 57 to column 3, line 36, fig. 1-8 WO 1988/003891 A1 EP 290507 A1 NO 160840 B AT 55583 T KR 10-1989-0700097 A NO 864628 L	
JP 2014-73815 A	24 Apr. 2014	(Family: none)	
JP 2008-230379 A	02 Oct. 2008	(Family: none)	
JP 6515171 B1	15 May 2019	(Family: none)	
JP 6860642 B1	21 Apr. 2021	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 5833278 B [0004]