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(54) Azimuth propeller apparatus and ship equipped with the apparatus

(57) A vertical shaft (13) is connected at its upper end to the stern of a ship. A rudder plate (23) is secured to the shaft (13), for controlling the course of the ship. A pod (15) is mounted on the intermediate pate of the shaft (13). The pod (15) contains a drive device, which drives a propeller shaft. The propeller (21) connected to the propeller shaft is thereby rotated, generating a force propelling the ship. To alter the course of the ship, the shaft (13) is rotated, thereby rotating the pod (15) and the rudder plate (23). As the rudder plate (23) is thus rotated, a lift is obtained at the plate (23). The lift and the lateral component of the propelling force are combined, applying a lateral force to the hull.

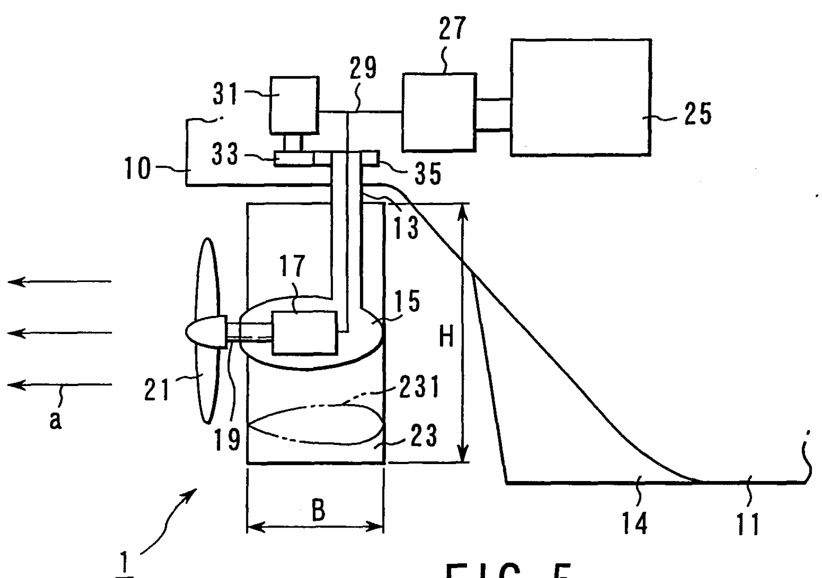


FIG. 5

EP 1 013 544 A2

Description

[0001] The present invention relates to an azimuth propeller apparatus and a ship equipped with the azimuth propeller apparatus.

[0002] Generally, ships are equipped with a propeller. The propeller is turned, propelling the ship in a direction that is controlled by a rudder.

[0003] FIG. 1 shows a typical conventional ship 80. FIG. 2 is a magnified view of a stern of the ship 80, illustrating a rudder 82 of the ship 80.

[0004] As shown in FIGS. 1 and 2, a propeller 81 is provided at the stern, along with the rudder 82. The propeller 81 is driven by the main engine 84 installed in a hull of the ship 80 at the same level. The main engine 84 is has its shaft axially aligned with the propeller 81. The rudder 82 is attached to the stern by a rudder horn 83.

[0005] As the main engine 84 drives the propeller 81, the ship 80 is propelled. The direction in which the ship 80 is propelled is controlled by turning the rudder 82 on the rudder horn 83.

[0006] In recent years, ships have been proposed, each having an azimuth propeller at the stern. The azimuth propeller can be rotated around a vertical axis. The azimuth propeller propels the ship as it is driven around the horizontal, and steers the ship as it rotates around the vertical axis.

[0007] FIG. 3 depicts a ship 90 with a conventional azimuth propeller apparatus 91. FIG. 4 is a magnified view of the stern of the ship 90, showing the conventional azimuth propeller apparatus 91.

[0008] As shown in FIGS. 3 and 4, the azimuth propeller apparatus 91 comprises a strut 92, a pod 93 and a propeller 94. The strut 92 is connected to the stern of the ship 90 and can rotate around a vertical axis. The pod 93 is secured to the strut 92. The propeller 94 is attached to the pod 93.

[0009] In the stern there is provided a generator/engine (G/E), which is located above the strut 92. The generator/engine drives a generator (not shown), which generates electric power. The electric power is supplied to the motor provided in the pod 93. Driven with the electric power, the motor drives the propeller 94.

[0010] FIG. 7 is a graph representing the various relations between the rudder angle and the lateral force, which are observed with various ships. In FIG. 7, curve D indicates the angle-force relation observed when the propeller 81 and the rudder 82 (both shown in FIG. 2) are used, propelling and steering the ship 80 shown in FIG. 1 at low speed of 18 knots. Curve E shows the angle-force relation observed when the azimuth propeller apparatus 91 (shown in FIG. 4) is used, propelling and steering the ship 90 shown in FIG. 3 at low speed of 18 knots. Curve C indicates the angle-force relation observed when the ship 80 is propelled and steered at high speed of 25 knots.

[0011] As can be understood from curve C, the ship 80 can receive a sufficient lateral force while being propelled at a relatively high speed, as in off-shore navigation. The ship 80 can therefore be well steered in off-shore navigation. However, when the ship 80 is propelled at low speed as it is navigated in the harbor, as it is moored at the pier, or as it leaves the pier, its steerability greatly decreases as curve D reveals in FIG. 7.

[0012] As described above, the ship 90 shown in FIG. 3 has the azimuth propeller apparatus 91 shown in FIG. 4. As the strut 92 of the apparatus 91 is rotated, a lateral force is applied to the ship 90. The lateral force is smaller than the lateral force applied to the ship 80 (FIG. 1) as the rudder 82 is rotated. Therefore, the greater part of the lateral force, which is applied to the ship 90 when the ship 90 is propelled at low speed, is a lateral component of the propelling force that the propeller 94 applies to the ship 90.

[0013] The lateral component of the propelling force applied to the ship 90 at low speed of 18 knots is small as is indicated by curve E in FIG. 7. In other words, the steerability of the ship 90 equipped with the azimuth propeller apparatus 91 also become insufficient during the low-speed navigation.

[0014] To impart sufficient steerability to the ship 91, a sufficiently large lateral force must be applied to the ship 91, not only when the ship 91 is propelled at low speed, but also when the wind is strong or waves are high.

[0015] If tax is levied on carbon emission in order to prevent the global warming, ships will need to be navigated at low speed to save energy. When ships are navigated at low speed, however, the rudder force decreases. Hence, the steerability of a low-speed ship is particularly lowered.

[0016] It is therefore demanded not only that a ship with an azimuth propeller apparatus maintains sufficient steerability even while navigated at low speed, but also that the propelling efficiency of azimuth propeller apparatuses be enhanced.

[0017] The present invention has been made to solve the problems described above. An object of the invention is to provide an azimuth propeller apparatus which can increase the steerability of ships during low-speed navigation and which can propel ships with high efficiency. Another object of the invention is to provide a ship which is equipped with this azimuth propeller apparatus.

[0018] According to the first aspect of the invention, there is provided an azimuth propeller apparatus which comprises: a rotatable shaft to be connected to a stern of a ship; a rudder plate secured to the shaft, for controlling the course of the ship; a pod mounted on an intermediate part of the rudder plate; a propeller having a propeller shaft connected to one end of the pod; and drive means provided in the pod, for driving the propeller shaft.

[0019] According to the second aspect of this invention, there is provided an azimuth propeller apparatus which comprises: a rotatable shaft to be connected to a stern of a ship; a pod mounted on the shaft; an upper rudder plate secured to that part of the shaft which is located above the pod, for controlling a course of the ship; a lower rudder plate secured to that part of the shaft which is located below the pod, for controlling the course of the ship; a propeller having a propeller shaft connected to one end of the pod; and drive means provided in the pod, for driving the propeller shaft.

[0020] According to the third aspect of the present invention, there is provided a ship which comprises an azimuth propeller apparatus. The azimuth propeller apparatus includes: a rotatable shaft to be connected to a stern of a ship; a rudder plate secured to the shaft, for controlling the course of the ship; a pod mounted on an intermediate part of the rudder plate; a propeller having a propeller shaft connected to one end of the pod; and drive means provided in the pod, for driving the propeller shaft.

[0021] According to the forth aspect of the present invention, there is provided a ship which comprises a azimuth propeller apparatus. The azimuth propeller apparatus includes: a rotatable shaft to be connected to a stern of a ship; a pod mounted on the shaft; an upper rudder plate secured to that part of the shaft which is located above the pod, for controlling a course of the ship; a lower rudder plate secured to that part of the shaft which is located below the pod, for controlling the course of the ship; a propeller having a propeller shaft connected to one end of the pod; and drive means provided in the pod, for driving the propeller shaft.

[0022] According to the fifth aspect of the invention, there is provided a ship according to the third or the forth aspect, which further comprises: a skeg protruding from the stern of the ship toward the rudder plate, located in front of the azimuth propeller apparatus and opposing the azimuth propeller apparatus.

[0023] According to the sixth aspect of this invention, there is provided a ship according to the fifth aspect, in which the skeg has support means supporting the shaft.

[0024] According to the seventh aspect of the present invention, there is provided a ship according to the fifth aspect, in which the skeg has a notch in an intermediate edge part, for allowing passage of the propeller being rotated around the shaft.

[0025] According to the eighth aspect of the invention, there is provided an azimuth propeller apparatus which comprises: a rotatable shaft to be connected to a stern of a ship; a pod mounted on the shaft; a propeller having a propeller shaft connected to one end of the pod; drive means provided in the pod, for driving the propeller shaft; and a reaction fin connected to the pod and located at fore-flow of the propeller, for swirling water in a direction opposite to a rotational direction of the propeller.

[0026] According to the ninth aspect of this invention, there is provided an azimuth propeller apparatus according to the eighth aspect, which further comprises a rudder plate secured to the shaft, for controlling the course of the ship.

[0027] According to the tenth aspect of the present invention, there is provided a ship which comprises an azimuth propeller apparatus. The azimuth propeller apparatus includes: a rotatable shaft to be connected to a stern of a ship; a pod mounted on the shaft; a propeller having a propeller shaft connected to one end of the pod; drive means provided in the pod, for driving the propeller shaft; and a reaction fin connected to the pod and located at fore-flow of the propeller, for swirling water in a direction opposite to a rotational direction of the propeller.

[0028] According to the eleventh aspect of the present invention, there is provided a ship according to the tenth aspect, in which the azimuth propeller apparatus further comprises a rudder plate secured to the shaft, for controlling the course of the ship.

[0029] According to the twelfth aspect of the invention, there is provided a ship according to the tenth or the eleventh aspect, which further comprises a skeg protruding from the stern toward the rudder plate, located in front of the azimuth propeller apparatus and opposing the azimuth propeller apparatus.

[0030] According to the thirteenth aspect of the present invention, there is provided a ship according to the tenth or the twelfth aspect, in which the skeg has support means supporting the shaft.

[0031] According to the fourteenth aspect of the invention, there is provided an azimuth propeller apparatus according to the twelfth aspect, in which the skeg has a notch in an edge part, for allowing passage of the propeller being rotated around the shaft.

[0032] According to the fifteenth aspect of the invention, there is provided an azimuth propeller apparatus which comprises: a rotatable shaft to be connected to a stern of a ship; a pod mounted on the shaft; a propeller having a propeller shaft connected to one end of the pod; drive means provided in the pod, for driving the propeller shaft; and a stator fin connected to the pod and located at aft-flow of the propeller, for swirling water in a direction opposite to a rotational direction of the propeller.

[0033] According to the sixteenth aspect of this invention, there is provided an azimuth propeller according to the fifteenth aspect, which further comprises a rudder plate secured to the shaft, for controlling the course of the ship.

[0034] According to the seventeenth aspect of the present invention, there is provided a ship which comprises an azimuth propeller apparatus. The azimuth propeller apparatus includes: a rotatable shaft to be connected to a stern of a ship; a pod mounted on the shaft; a propeller having a propeller shaft connected to one end of the pod; drive means provided in the pod, for driving the propeller shaft; and a stator fin connected to the pod and located at aft-flow of the propeller, for swirling water in a direction opposite to a rotational direction of the propeller.

[0035] According to the eighteenth aspect of this invention, there is provided a ship according to the seventeenth aspect, in which the azimuth propeller apparatus further comprises a rudder plate secured to the shaft, for controlling the course of the ship.

[0036] According to the nineteenth aspect of this invention, there is provided a ship according to the seventeenth or the eighteenth aspect, which further comprises a skeg protruding from the stern toward the rudder plate, located in front of the azimuth propeller apparatus and opposing the azimuth propeller apparatus.

[0037] According to the twentieth aspect of this invention, there is provided a ship according to the nineteenth aspect, in which the skeg extends to a point near the rudder plate, and the skeg has a notch in an edge part, for allowing passage of the propeller being rotated around the shaft.

[0038] This summary of the invention does not necessarily describe all necessary features so that the invention may also be a sub-combination of these described features.

[0039] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a side view showing a ship having a conventional propeller and a conventional rudder;
FIG. 2 is a magnified view of the stern of the ship shown in FIG. 1;
FIG. 3 is a side view of a ship equipped with a conventional azimuth propeller apparatus;
FIG. 4 is a magnified view of the stern of the ship shown in FIG. 3;
FIG. 5 is a side view of the stern of a ship according to the first embodiment of the invention, which is equipped with an azimuth propeller;
FIG. 6 is a side view showing a modification of the first embodiment;
FIG. 7 is a graph representing the various relations between the rudder angle and the lateral force, which are observed with various ships;
FIG. 8 is a graph illustrating the relation which the gap between the hull and rudder of a ship and the lateral force applied to the rudder have when the rudder angle is 35°;
FIG. 9 is a side view of the stern of a ship according to the second embodiment of the invention, which is equipped with an azimuth propeller apparatus of another type;
FIG. 10 is a view taken along line V-V in FIG. 9;
FIG. 11 is a side view of the stern of a ship according to the third embodiment of the invention, which is equipped with an azimuth propeller apparatus;
FIG. 12 is a side view of another ship equipped with a modification of the azimuth propeller apparatus shown in FIG. 11;
FIG. 13 is a view taken along line V-V in FIGS. 11 and 12;
FIG. 14 is a side view of the stern of a ship according to the fourth embodiment of the invention, which is equipped with an azimuth propeller apparatus of a different type;
FIG. 15 is a side view for explaining the operation of the fourth embodiment;
FIG. 16A is a side view of the stern of a ship according to the fifth embodiment of the invention, which is equipped with an azimuth propeller apparatus of a different type;
FIG. 16B is a view taken along line G-G in FIG. 16A;
FIG. 17A a side view for explaining the operation of the fifth embodiment;
FIG. 17B is a view taken along line G-G in FIG. 17A;
FIG. 18A is a side view of the stern of a ship equipped with a modification of the azimuth propeller apparatus according to first embodiment, which has a reaction fin at the fore-stream of the propeller;
FIG. 18B is a view taken along line G-G in FIG. 18A;
FIG. 19A is a side view, showing the azimuth propeller apparatus of FIG. 18A which has been rotated by 180° from the position shown in FIG. 18A;
FIG. 19B is a view taken along line G-G in FIG. 19A;
FIG. 20 is a side view of the stern of a ship equipped with a modification of the azimuth propeller apparatus according to second embodiment, which has a reaction fin at the fore-stream of the propeller;
FIG. 21 is a side view of the stern of a ship equipped with a modification of the azimuth propeller apparatus according to third embodiment, which has a reaction fin at the fore-stream of the propeller;
FIG. 22 is a side view of the stern of a ship equipped with a modification of the third embodiment, which has a reaction fin at the fore-stream of the propeller;
FIG. 23 is a side view of the stern of a ship equipped with a modification of the azimuth propeller apparatus according to fourth embodiment, which has a reaction fin at the fore-stream of the propeller;
FIG. 24A is a side view of an azimuth propeller apparatus according to the sixth embodiment of the present invention;
FIG. 24B is a view taken along line G-G in FIG. 24A;
FIG. 25A is a side view, showing the azimuth propeller apparatus of FIG. 24A which has been rotated by 180° from the position shown in FIG. 24A;
FIG. 25B is a view taken along line G-G in FIG. 25A;
FIG. 26A is a side view of the stern of a ship equipped with the azimuth propeller apparatus according to the first embodiment, which has a reaction fin at the aft-stream of the propeller;
FIG. 26B is a view taken along line G-G in FIG. 26A;
FIG. 27A is a side view, showing the azimuth propeller apparatus of FIG. 26A which has been rotated by 180° from the position shown in FIG. 26A; and
FIG. 27B is a view taken along line G-G in FIG. 27A.

[0040] The first to sixth embodiments of the invention will be described, with reference to the accompanying drawings.

First Embodiment

[0041] FIG. 5 is a side view of the stern of a ship according to the first embodiment, which is equipped with an azimuth propeller apparatus 1 according to the first embodiment.

[0042] As shown in FIG. 5, the azimuth propeller apparatus 1 comprises a shaft 13, a pod 15, a motor 17, a propeller shaft 19, a propeller 21, and a rubber plate 23. The structure of the apparatus 1 will be described below in greater detail.

[0043] The shaft 13 vertically extends, with its upper part provided in the stern 10 of the ship. The shaft 13 can rotate through 360° around its axis. The pod 15 is connected to the lower end of the shaft 13. The pod 15 incorporates the motor 17. The propeller shaft 19 is connected at one end to the motor 17. The propeller 21 is connected to the other end of the propeller shaft 19.

[0044] The rudder plate 23 is mounted on the shaft 13. Like ordinary rudders, the rudder plate 23 has a blade cross section, size and aspect ratio, all similar to the ordinary rudders in size and aspect ratio. (The aspect ratio is the ratio of the height H to the breadth B, ranging from 1.5 to 3. If the plate 23 has different breadths at the upper end and lower end, the aspect ratio will be is H/Bave., where Bave. is the average of the different breadths.) The rudder plate 23 is rotated when the shaft 13 rotates around its axis. When rotated, the rudder plate 23 controls the direction in which the ship is propelled. The plate 23 has the cross section indicated by the two-dot, dashed lines.

[0045] The ship has a drive means for driving the azimuth propeller apparatus 1. The drive means will be described below.

[0046] The drive means comprises a diesel engine 25, a generator 27, a motor 31, a gear 33, and a gear 35, all provided in the stern 10. The gear 33 is mounted on the shaft of the motor 31, and the gear 35 is mounted on the shaft 13. The gears 33 and 35 are in mesh with each other. The diesel engine 25 drives the generator 27, which generates electric power. The electric power is supplied to the motor 31 which derives the rotation of the shaft 13. The gears 33 and 35 transmit the rotation of the motor shaft to the shaft 13. The shaft 13 is therefore rotated, whereby the azimuth propeller apparatus 1 is rotated. Meanwhile, the electric power is supplied from the generator 27 to the motor 17 provided in the pod 15, through an electric cable 29 that extends through the shaft 13. Driven by the electric power, the motor 17 rotates the propeller 21.

[0047] A skeg 14 protrudes from the stern toward the rudder plate 23, to help the ship to keep its course.

[0048] It will be explained how the azimuth propeller apparatus 1 operates to propel the ship forward and backward and steer the ship.

[0049] To propel the ship forward, the diesel engine 25 provided in the stern drives the generator 27 provided in the stern, too. The electric power output from the generator 27 drives the motor 17 contained in the pod 15. The motor 17 rotates the propeller shaft 19, which rotates the propeller 21. The propeller 21, which is rotating, pushes water backward, in the direction of arrows a in FIG. 5. As a result, the ship is propelled forward.

[0050] The ship can be propelled backward, merely by rotating the propeller 21 in the reverse direction, making the propeller 21 push water forward.

[0051] To alter the ship's course to portside or starboard, the motor 31 rotates the gears 33 and 35, thereby rotating the shaft 13 and, hence, the azimuth propeller apparatus 1 turning. As a result, the direction changes in which the propeller 21 applies a propelling force to the hull, and a lift is generated at the rudder plate 23. Due to the propelling force and the lift, a lateral force is applied to the hull, altering the course of the ship. As indicated above, the rudder plate 23 has a blade cross section, size and aspect ratio, all similar to those of the ordinary rudders. The azimuth propeller apparatus 1 can therefore control the course of the ship more reliably than the conventional azimuth propeller apparatus shown in FIG. 3.

[0052] FIG. 7 is a graph representing the various relations between the rudder angle and the lateral force, which are observed with various ships. Curve D indicates the angle-force relation observed when the propeller 81 and the rudder 82 (both shown in FIG. 2) are used, propelling and steering the ship 80 shown in FIG. 1 at low speed of 18 knots. Curve E shows the angle-force relation observed when the azimuth propeller apparatus 91 (shown in FIG. 4) is used, propelling and steering the ship 90 shown in FIG. 3 at low speed of 18 knots. Curve A indicates the angle-force relation observed when the azimuth propeller apparatus 1 (shown in FIG. 4) is used, propelling and steering a ship at low speed of 18 knots.

[0053] As seen from curve A, the lateral force is almost equal to the sum of the lateral force applied to the hull when the propeller 81 and the rudder 82 (FIG. 2) are used and the lateral force applied to the hull when the azimuth propeller apparatus 91 (FIG. 4) is used. Obviously, the ship with the azimuth propeller apparatus 1 can acquire a larger lateral force than the ship 80 with the propeller 81 and rudder 82 and the ship 90 with the conventional azimuth propeller apparatus 91.

[0054] The azimuth propeller apparatus 1 having the structure described above can have a lift similar to the lift the ordinary rudder plate acquires and can provide a lateral component of propelling force by virtue of the propeller 21. The lift and the lateral component of force result in a lateral force. This lateral force is larger than the lateral force applied to the ship 90 with the conventional azimuth propeller apparatus 91. The azimuth propeller apparatus 1 can therefore control the course of a ship. In other words, it can enhance the steerability of the ship well during the low-speed navigation.

[0055] As shown in FIG. 5, the propeller 21 is located at the rear of the pod 15 while the azimuth propeller apparatus 1 is positioned to propel the ship forward. Instead, the propeller 21 may be located in front of the pod 15 as in a modification of the apparatus 1, which is illustrated in FIG. 6. In this modified azimuth propeller apparatus attains the same advantages as the azimuth propeller apparatus 1 shown in FIG. 5.

[0056] Moreover, the rudder plate 23 may be separated into two rudder plates, the one of which is an upper rudder plate which is located above the pod 15 and the other is a lower rudder plate which is located below the pod 15.

Second Embodiment

[0057] FIG. 8 is a graph illustrating the relation which the gap between the hull and rudder of a ship and the lateral force applied to the rudder have when the rudder angle is 35°. From FIG. 8 it can be understood that the lateral force increases as the gap between the hull and the rudder decreases. Since the lateral force applied to the rudder changes the course of the ship as already mentioned, the steerability of the ship depends on the lateral force. In view of this it may be proposed that the gap between the hull and the rudder be decreased to enhance the steerability of the ship.

[0058] Accordingly, the second embodiment of the present invention is a ship with an azimuth propeller apparatus that can steer the ship more reliably than does the azimuth propeller apparatus 1 shown in FIG. 5.

[0059] In the following description of the second to sixth embodiments of the invention, the components corresponding to those of the first embodiment are identified by the same reference numerals and will not be described in detail, and the new components will be described in detail.

[0060] FIG. 9 is a side view of the stern of a ship according to the second embodiment of this invention. As shown in FIG. 9, the ship has an azimuth propeller apparatus 2, a drive means, and a skeg 43.

[0061] The azimuth propeller apparatus 2 has bevel gears 37, a propeller shaft 39, and a shaft 41. The azimuth propeller apparatus 2 is driven by the drive means. The drive means comprises a diesel engine 25, a speed-reducing apparatus 28, a transmission shaft 30, and bevel gears 37. In the ship shown in FIG. 9, the diesel engine drives the transmission shaft 30 by way of the speed-reducing apparatus 28. The bevel gears 37 transmit the rotation of the shaft 30 to the shaft 41 of the azimuth propeller apparatus 2. Thus driven by the drive means, the azimuth propeller apparatus 2 propels the ship.

[0062] The skeg 43 protrudes from the stern toward the rudder plate 23 of the apparatus 2 for a longer distance than the skeg 14 shown in FIG. 5. Thus, the rear edge of the skeg 43 is located closer to the front edge of the rudder plate 23.

[0063] FIG. 10 is a view taken along line V-V in FIG. 9. As can be seen from FIG. 10, the gap between the rudder plate 23 and the hull is narrower than in the case of the ship shown in FIG. 5. Hence, a greater lateral force can be applied to the ship according to the second embodiment than to the ship according to the first embodiment, to change the course of the ship.

[0064] Curve B in FIG. 7 indicates the relation between the rudder angle and the lateral force, angle-force relation observed when the ship according to the second embodiment is propelled and steered at low speed of 18 knots. As can be evidenced by comparing curve B with curve A, the lateral force is larger than the lateral force applied to the ship according to the first embodiment.

[0065] Moreover, curve C in FIG. 7 indicates the angle-force relation observed when the ship 80 is propelled and steered at high speed of 25 knots. As can been seen from comparison between curve C and curve B, a lateral force, which is comparable with the lateral force applied to the ship 80 navigated at 25 knots, can be applied to the ship, according to the second embodiment, though the ship is navigated at low speed of 18 knots.

[0066] The drive means used in the second embodiment can be used to drive the azimuth propeller apparatus 1 according to the first embodiment and the azimuth propeller apparatuses according to the third to sixth embodiments, which will be described later. Moreover, the azimuth propeller apparatuses 2 according to the second embodiment can be derived by the derive means in the first embodiment. In this case, the motor 31 and the gears 33 and 35 cooperate to rotate the azimuth propeller apparatus 2.

[0067] In the second embodiment, the gap between the hull and the rudder is narrow. The lateral force applied to the ship as the azimuth propeller apparatus 2 is operated to change the course of the ship can therefore be increased. This enhances the steerability of the ship.

Third Embodiment

[0068] Generally, a rudder plate must be firmly and steadily supported because it receives a lateral force large enough to change the course of the ship. Accordingly, the third embodiment of the present invention is a ship that is improved in the support strength of the rudder plate of an azimuth propeller apparatus.

[0069] FIG. 11 is a side view of the stern of the ship. As shown in FIG. 11, the ship has an azimuth propeller apparatus 3 and a skeg 45. The apparatus 3 and the skeg 45 are so designed that the skeg 45 supports the azimuth propeller apparatus 3 firmly and steadily. The apparatus 3 and skeg 45 will be described with reference to FIG. 11.

[0070] The rudder plate 24 of the azimuth propeller apparatus 3 is secured at its front edge to a shaft 20. Secured to the shaft 20, the rudder plate 24 is rotated when the shaft 20 is rotated. The rudder plate 24 is identical to the rudder plate 23 of the azimuth propeller apparatus 1 and 2 in the shape of its cross section, as is indicated by the two-dot, dashed lines 241.

[0071] The skeg 45 has two bearing sections 451, on the upper and lower parts of its rear edge, respectively. The bearing sections 451 support the shaft 20. The rudder plate 24 is a flap-shaped component that is coupled to the rear edge of the skeg 45.

[0072] FIG. 12 is a side view of another ship equipped with a modification of the azimuth propeller apparatus 3 shown in FIG. 11.

[0073] The skeg 45 shown in FIG. 12 has two bearing sections 451, like the skeg 45 shown in FIG. 11, and has two intermediate bearing sections 453, on two intermediate parts of its rear edge. Thus, four bearing sections support a shaft 20. The bearing sections 451 and bearing sections 453 are axially aligned with the shaft 20. The rudder plate 23 secured to the shaft 20 can therefore be rotated smoothly around the shaft 20.

[0074] FIG. 13 is a view taken along line V-V in FIGS. 11 and 12;

[0075] The rudder plate 24 shown in FIG. 11 is supported at both ends of the shaft 20 by means of the upper and lower bearing sections 451, not by a single shaft (such as the shaft 13) as the rudder plate 23 shown in FIG. 9. Obviously, the rudder plate 24 is more firmly supported than the rudder plate 23 shown in FIG. 9.

[0076] The rudder plate of the azimuth propeller apparatus 3 shown in FIGS. 11 and 12 is supported at both ends of the shaft 20 and, if necessary, at two intermediate part of the shaft 20. Hence, the rudder plate is more firmly supported than the rudder plates of the second embodiments. Furthermore, the azimuth propeller apparatus 3 attains the same advantages as the azimuth propeller apparatus 2 shown in FIG. 9.

Fourth Embodiment

[0077] The fourth embodiment of this invention is a ship characterized in two respects. First, the gap between the rudder plate and the hull is narrow, increasing the steerability of the ship. Second, the azimuth propeller apparatus is rotated by 180° from the normal position to propel the ship backward.

[0078] FIG. 14 is a side view of the stern of the ship according to the fourth embodiment. With reference to FIG. 14 the azimuth propeller apparatus 4 and skeg 51 of the fourth embodiment will be described.

[0079] The azimuth propeller apparatus 4 has a rudder plate 53. The rudder plate 53 is a modification of the rudder plates 23 shown in FIGS. 5 and 9. The rudder plate 53 has a projection 531 on the front edge and can rotate through 360°. The rudder plate 53 is identical to the rudder plate 23 of the azimuth propeller apparatuses 1 and 2 in the shape of its cross section, as is indicated by the two-dot, dashed lines 531in FIG. 14.

[0080] The skeg 51 has a U-notch 511 in the rear edge. It is in the notch 511 in which the projection 531 of the rudder plate 53 is placed as long as the rudder plate 53 remains in the normal position. Thus, the gap between the plate 53 and the hull is much narrower than in the case of the conventional ships.

[0081] To propel the ship backward, it suffices to rotate the shaft 20 by 180°, thereby setting the rudder plate 53 in the position shown in FIG. 15. The propeller 21 is then located in the notch 511 of the skeg 51. As the propeller 21 is rotated in the notch 511, it applies a backward propelling force to the hull.

[0082] The forth embodiment attains the same advantages as the second embodiment.

Fifth Embodiment

[0083] The fifth embodiment of the present invention describes an azimuth propeller apparatus which can apply to the hull a propelling force greater than in the first to fourth embodiments described above and a ship equipped with the azimuth propeller apparatus.

[0084] FIG. 16A is a side view of the stern of the ship according to the fifth embodiment of the invention, which is equipped with an azimuth propeller apparatus designed to apply a greater propelling force to the hull. FIG. 16B is a view taken along line G-G in FIG. 16A.

[0085] The azimuth propeller apparatus 5 shown in FIG. 16A is characterized by a reaction fin 61 that is provided at the rear of the pod 15, namely at the fore-stream of the propeller 21. (Generally, a fin located at the fore-stream of a propeller is called "reaction fins," whereas a fin located at the aft-stream of a propeller is called "stator fins.") As shown in FIG. 16B, the reaction fin 16 comprises, for example, eight fin blades. The fin blades extend in radial directions from the rear end of the pod 15. The fin blades are positioned to swirl the water flow toward the propeller 21, in the direction opposite to the rotational direction of the propeller 21. More precisely, each fin blade is twisted in the same direction as the blades of the propeller 21 provided at the rear of the reaction fin 61.

[0086] How the azimuth propeller apparatus 5 exerts a propelling force to the hull to push the ship forward will be explained.

[0087] A diesel engine 25 and a generator 27 are provided in the hull, and a motor 17 is provided in the pod 15 of the azimuth propeller apparatus 5. The diesel engine 25 drives the generator 27, which generates electric power. The electric power is supplied to the motor 17. The propeller 21 is rotated by the motor 17 and pushes water backward. The reaction fin 16 swirls the water flow toward the propeller 21 in the direction opposite to the rotational direction of the propeller 21. The propeller 21, which is located at the rear of the reaction fin 16, further increases the velocity of the water flow by the rotating. Thus, the momentum of the water flow greatly changes. The reaction G resulting from the change in momentum (in the direction arrows a in FIG. 6) propels the ship forward.

[0088] The ship can be propelled backward by rotating the shaft 13 by 180° as is illustrated in FIG. 17A. The azimuth propeller apparatus 5 is thereby rotated by 180°, too. As a result, the propeller 21 pushes water forward, or in the direction of arrow b (FIG. 17A), applying a backward propelling force to the hull. FIG. 17B is a view taken along line G-G in FIG. 17A.

[0089] Whether the ship is propelled forward or backward, the reaction fin 16 can swirl water in the direction opposite to the rotational direction of the propeller 21. Hence, the energy of the swirling water would not be wasted at the rear of the propeller 21. This serves to increase the efficiency of propelling the ship.

[0090] As already described in conjunction with the first embodiment, the lateral force that controls the course of the ship results in part from the lateral component of the propelling force the azimuth propeller apparatus 5 exerts on the hull. Therefore, the increase in the ship-propelling efficiency can enhance the steerability of the ship.

[0091] The reaction fin 16 of the azimuth propeller apparatus 5 can be used in the azimuth propeller apparatuses according to the first to fourth embodiments described above. How the fin 16 may be used so will be briefly explained below.

(Use in the First Embodiment)

[0092] FIG. 18A shows a modification of the azimuth propeller apparatus 1 according to first embodiment, which has a reaction fin 50 at the fore-stream of the propeller 21. FIG. 18B is a view taken along line G-G in FIG. 18A. For example, as shown in FIG. 18B, the reaction fin 50 has six fin blades, three on each side of the rudder plate 23.

[0093] FIG. 19A is a side view, showing the azimuth propeller apparatus of FIG. 18A which has been rotated by 180° from the position shown in FIG. 18A to propel the ship backward. FIG. 19B is a view taken along line G-G in FIG. 19A.

(Use in the Second Embodiment)

[0094] FIG. 20 depicts a modification of the azimuth propeller apparatus 2 according to second embodiment, which has a reaction fin 50 at the fore-stream of the propeller 21.

(Use in the Third Embodiment)

[0095] FIG. 21 illustrates a modification of the azimuth propeller apparatus 3 according to third embodiment, which has a reaction fin 50 at the fore-stream of the propeller 21.

[0096] FIG. 22 shows another modification of the azimuth propeller apparatus 3, which has a reaction fin at the fore-stream of the propeller 21.

(Use in the Fourth Embodiment)

[0097] FIG. 23 shows a modification of the azimuth propeller apparatus 4 according to fourth embodiment, which has a reaction fin 50 at the fore-stream of the propeller 21.

[0098] In the first to fourth embodiments, the use of the reaction fin 50 can help to increase the ship-propelling efficiency.

Sixth Embodiment

[0099] The sixth embodiment of this invention will be described. This embodiment is a ship equipped with an azimuth propeller apparatus 6 that has a propeller 21 located in front of the pod 15, thereby to increase the ship-propelling efficiency further.

[0100] FIG. 24A is a side view of the azimuth propeller apparatus 6, and FIG. 24B is a view taken along line G-G in FIG. 24A.

[0101] The azimuth propeller apparatus 6 has a stator fin 16, not a reaction fin 16. The azimuth propeller apparatus 6 further comprises a shaft 13, a pod 15, and a propeller 21. The pod 15 of the apparatus 6 is connected to the shaft 13. The stator fin 16 is mounted on the pod 15 and located at the aft-flow of the propeller 21. The propeller 21 is located in front of the pod 15 as is illustrated in FIG. 24A.

[0102] The stator fin 16 is similar to the reaction fin 16 in terms of structure. It is designed to swirl water in the direction opposite to the rotational direction of the propeller 21. To swirl the water in this direction, the blades of the stator fin 16 are twisted in the same direction as the blades of the propeller 21 provided in front of the stator fin 16.

[0103] The stator fin 16 swirls the water that has gained momentum as the propeller 21 rotates, in the direction opposite to the rotational direction of the propeller 21. Thus, the momentum of the water flow greatly changes, propelling the ship forward.

[0104] The azimuth propeller apparatus 6 can be rotated by 180° around the axis of the shaft 13, as is illustrated in FIG. 25A. In this case, the ship is propelled backward.

[0105] In the sixth embodiment, the stator fin 16 is located at the aft-flow of the propeller 21 no matter whether the ship is propelled forward or backward. The stator fin 16 can therefore swirl water in the direction opposite to the rotational direction of the propeller 21. Hence, the stator fin 16 reduces the swirl of water caused by the rotating propeller 21 and converts the energy of the swirling water to a propelling force. The force propelling the hull can be thereby increased.

[0106] Moreover, the steerability of the ship can be enhanced by increasing the ship-propelling efficiency as in the fifth embodiment.

[0107] The stator fin 16 of the azimuth propeller apparatus 6 can be used in the azimuth propeller apparatuses according to the first to fourth embodiments described above. How the stator fin 16 may be used so will be briefly explained below.

(Use in the First Embodiment)

[0108] FIG. 26A shows a modification 7 of the azimuth propeller apparatus 1 according to first embodiment, which has a stator fin 50 at the aft-stream of the propeller 21. FIG. 26B is a view taken along line G-G in FIG. 26A. As shown in FIG. 26B, the stator fin 50 is similar in structure to the reaction fin 50 described above. For example, the stator fin 50 has six fin blades, three on each side of the rudder plate 23.

[0109] In order to propel the ship backward it suffices to rotate the azimuth propeller apparatus 7 by 180° as is illustrated in FIG. 27A. FIG. 27B is a view taken along line G-G in FIG. 27A.

[0110] The stator fin 50 can help to increase the ship-propelling efficiency in the first embodiment.

Claims

1. An azimuth propeller apparatus (1, 2, 3, 4) characterized by comprising:

a rotatable shaft (13, 20) to be connected to a stern of a ship;
a rudder plate (23, 24, 53) secured to the shaft (13), for controlling the course of the ship;
a pod (15) mounted on an intermediate part of the rudder plate (23, 24, 53);
a propeller (21) having a propeller shaft (19) connected to one end of the pod (15); and
drive means (17) provided in the pod (15), for driving the propeller shaft (19).

2. An azimuth propeller apparatus (1, 2, 3, 4) characterized by comprising:

a rotatable shaft (13, 20) to be connected to a stern of a ship;
a pod (15) mounted on the shaft (13, 20);
an upper rudder plate (23, 24, 53) secured to that part of the shaft (13, 20) which is located above the pod (15), for controlling a course of the ship;
a lower rudder plate (23, 24, 53) secured to that part of the shaft (13, 20) which is located below the pod (15), for controlling the course of the ship;
a propeller (21) having a propeller shaft (19) connected to one end of the pod (15); and
drive means (17) provided in the pod (15), for driving the propeller shaft (19).

3. A ship characterized by comprising an azimuth propeller apparatus (1, 2, 3, 4):
the azimuth propeller apparatus (1, 2, 3, 4) including:

a rotatable shaft (13, 20) to be connected to a stern of a ship;
a rudder plate (23, 24, 53) secured to the shaft (13), for controlling the course of the ship;
a pod (15) mounted on an intermediate part of the rudder plate (23, 24, 53);
a propeller (21) having a propeller shaft (19) connected to one end of the pod (15); and
drive means (17) provided in the pod (15), for driving the propeller shaft (19).

4. A ship characterized by comprising an azimuth propeller apparatus (1, 2, 3, 4):
the azimuth propeller apparatus (1, 2, 3, 4) including:

a rotatable shaft (13, 20) to be connected to a stern of a ship;
a pod (15) mounted on the shaft (13, 20);
an upper rudder plate (23, 24, 53) secured to that part of the shaft (13, 20) which is located above the pod (15), for controlling a course of the ship;
a lower rudder plate (23, 24, 53) secured to that part of the shaft (13, 20) which is located below the pod (15), for controlling the course of the ship;
a propeller (21) having a propeller shaft (19) connected to one end of the pod (15); and
drive means (17) provided in the pod (15), for driving the propeller shaft (19).

5. A ship according to claim 3 or claim 4, characterized by further comprising a skeg (14, 43, 45, 50, 51) protruding from the stern of the ship toward the rudder plate (23, 24, 53), located in front of the azimuth propeller (1, 2, 3, 4) apparatus and opposing the azimuth propeller apparatus (1, 2, 3, 4).

6. A ship according to claim 5, characterized in that the skeg (45, 50) has support means (451, 453) supporting the shaft (20).

7. A ship according to claim 5, characterized in that the skeg (51) has a notch (511) in an intermediate edge part, for allowing passage of the propeller (21) being rotated around the shaft (13).

8. An azimuth propeller apparatus (5) characterized by comprising:

a rotatable shaft (13) to be connected to a stern of a ship;
a pod (15) mounted on the shaft (13, 20);

a propeller (21) having a propeller shaft (19) connected to one end of the pod (15);
drive means (17) provided in the pod (15), for driving the propeller shaft (19); and
a reaction fin (16) connected to the pod (15) and located at fore-flow of the propeller (21), for swirling water in a direction opposite to a rotational direction of the propeller (21).

9. An azimuth propeller apparatus (5) according to claim 8, characterized by further comprising a rudder plate (23, 24, 53) secured to the shaft, for controlling the course of the ship.

10. A ship characterized by comprising an azimuth propeller apparatus (5):
the azimuth propeller apparatus (5) including:

a rotatable shaft (13) to be connected to a stern of a ship;
a pod (15) mounted on the shaft (13, 20);
a propeller (21) having a propeller shaft (19) connected to one end of the pod (15);
drive means (17) provided in the pod (15), for driving the propeller shaft (19); and
a reaction fin (16) connected to the pod (15) and located at fore-flow of the propeller (21), for swirling water in a direction opposite to a rotational direction of the propeller (21).

11. A ship according to claim 10, characterized in that the azimuth propeller apparatus (5) further comprises a rudder plate (23, 24, 53) secured to the shaft, for controlling the course of the ship.

12. A ship according to claim 10 or claim 11, characterized by further comprising a skeg (14, 43, 45, 50, 51) protruding from the stern toward the rudder plate (23, 24, 53), located in front of the azimuth propeller apparatus (5) and opposing the azimuth propeller apparatus (5).

13. A ship according to claim 12, characterized in that the skeg (45, 50) has support means (451, 453) supporting the shaft (20).

14. A ship according to claim 12, characterized in that the skeg (51) has a notch (511) in an edge part, for allowing passage of the propeller (21) being rotated around the shaft (13).

15. An azimuth propeller apparatus (6) characterized by comprising:

a rotatable shaft (13) to be connected to a stern of a ship;
a pod (15) mounted on the shaft;
a propeller (21) having a propeller shaft (19) connected to one end of the pod (15);
drive means (17) provided in the pod (15), for driving the propeller shaft (19); and
a stator fin (16) connected to the pod (15) and located at aft-flow of the propeller (21), for swirling water in a direction opposite to a rotational direction of the propeller (21).

16. An azimuth propeller apparatus (6) according to claim 15, characterized by further comprising a rudder plate (23, 53) secured to the shaft (13), for controlling the course of the ship.

17. A ship characterized by comprising an azimuth propeller apparatus (6):
the azimuth propeller apparatus (6) including:

a rotatable shaft (13) to be connected to a stern of a ship;
a pod (15) mounted on the shaft;
a propeller (21) having a propeller shaft (19) connected to one end of the pod (15);
drive means (17) provided in the pod (15), for driving the propeller shaft (19); and
a stator fin (16) connected to the pod (15) and located at aft-flow of the propeller (21), for swirling water in a direction opposite to a rotational direction of the propeller (21).

18. A ship according to claim 17, characterized in that the azimuth propeller apparatus (6) further comprises a rudder plate (23, 53) secured to the shaft (13), for controlling the course of the ship.

19. A ship according to claim 17 or claim 18, characterized by further comprising a skeg (14, 51) protruding from the stern toward the rudder plate (23, 53), located in front of the azimuth propeller apparatus (6) and opposing the azimuth propeller apparatus (6).

20. A ship according to claim 19, characterized in that the skeg (51) extends to a point near the rudder plate (53), and the skeg (51) has a notch (511) in an edge part, for allowing passage of the propeller (21) being rotated around the shaft (13).

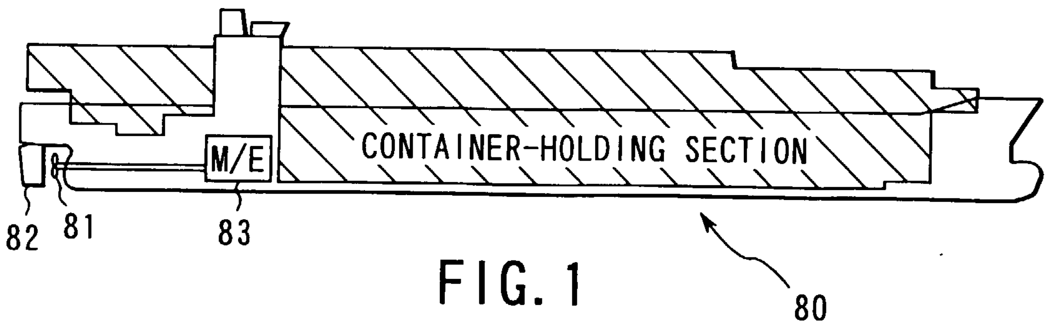


FIG. 1

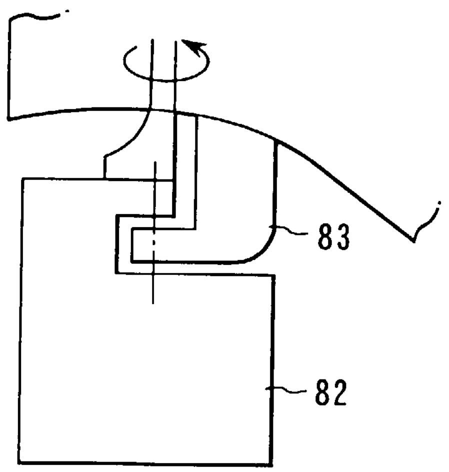


FIG. 2

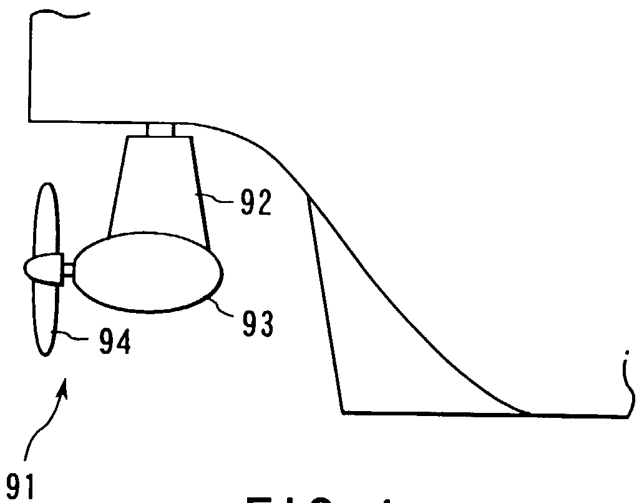


FIG. 4

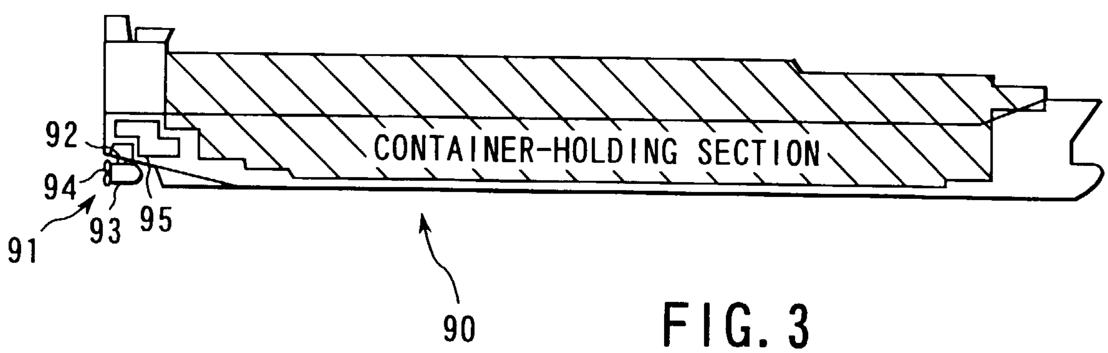


FIG. 3

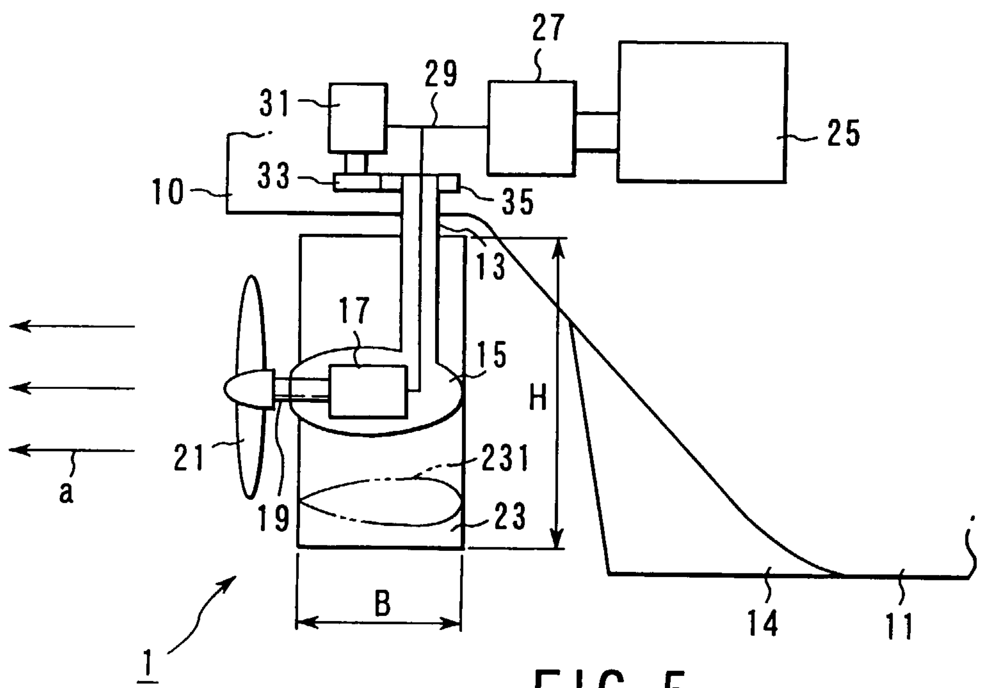

27
29
31
25
10
33
35
13
17
15
H
21
231
a
19
23
B
1
14
11

FIG. 5

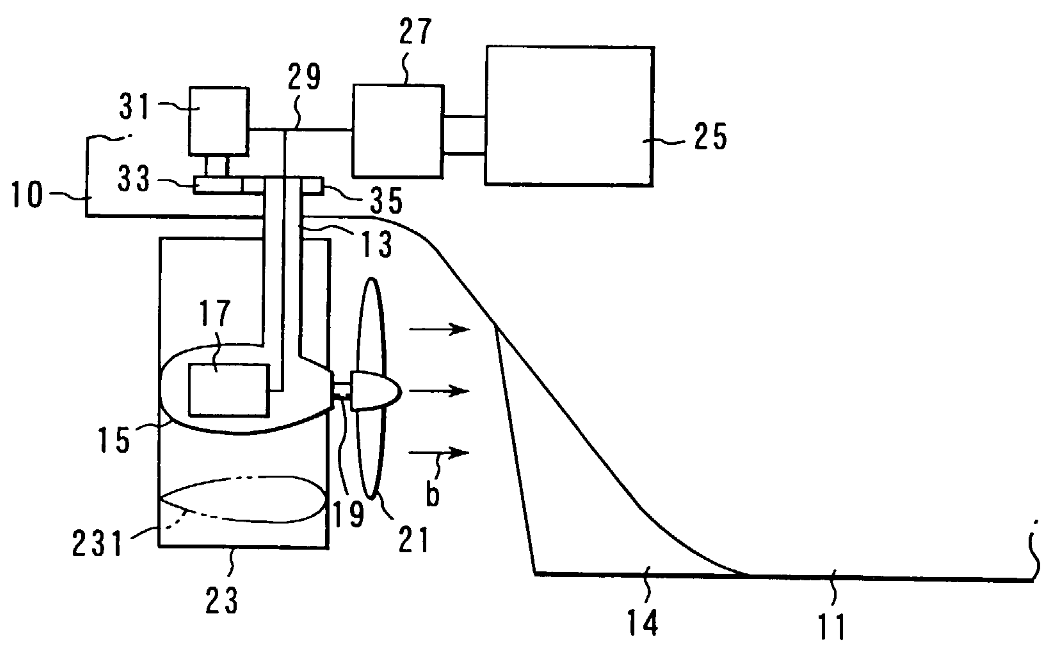
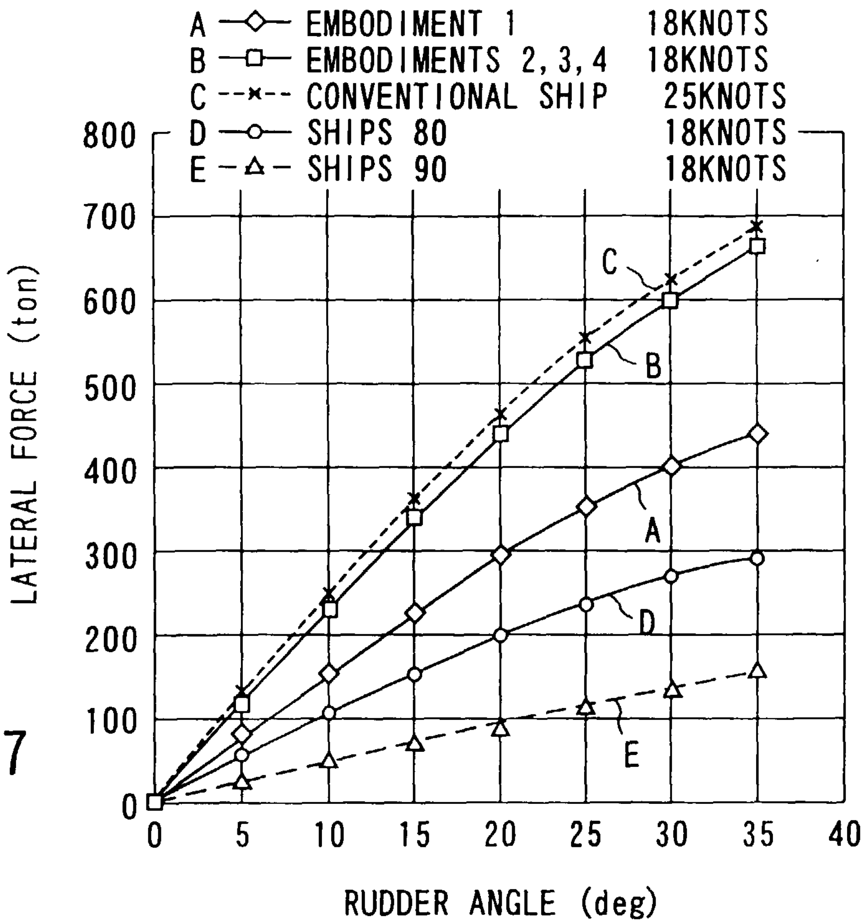
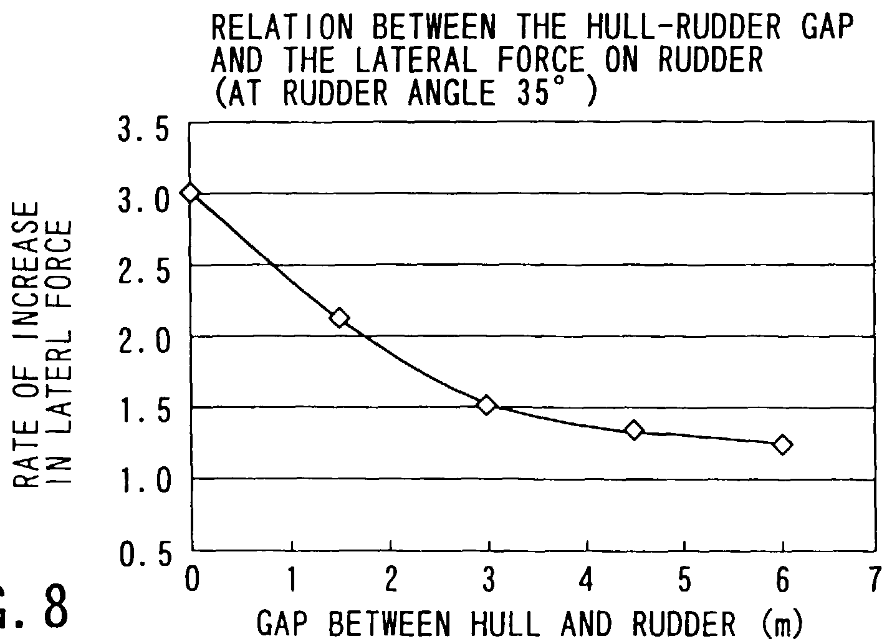

27
29
31
25
10
33
35
13
17
15
b
19
21
231
23
14
11

FIG. 6



A EMBODIMENT 1 18KNOTS
B EMBODIMENTS 2,3,4 18KNOTS
C CONVENTIONAL SHIP 25KNOTS
D SHIPS 80 18KNOTS
E SHIPS 90 18KNOTS
LATERAL FORCE (ton)
800
700
600
500
400
300
200
100
0
0 5 10 15 20 25 30 35 40
RUDDER ANGLE (deg)
A
B
C
D
E

FIG. 7



RELATION BETWEEN THE HULL-RUDDER GAP AND THE LATERAL FORCE ON RUDDER (AT RUDDER ANGLE 35°)
RATE OF INCREASE IN LATERL FORCE
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0 1 2 3 4 5 6 7
GAP BETWEEN HULL AND RUDDER (m)

FIG. 8

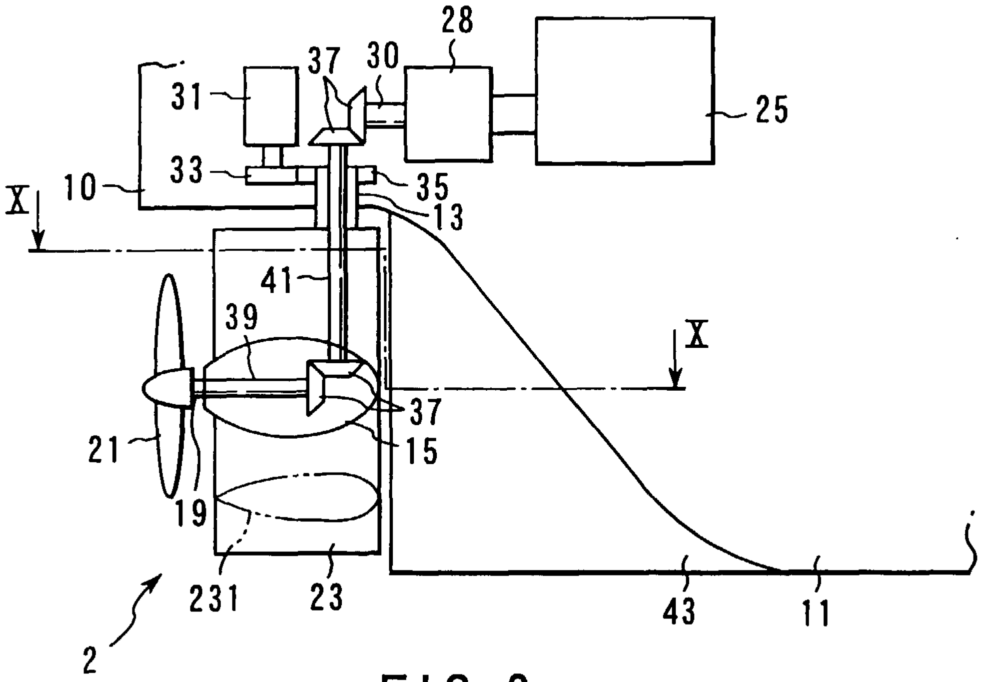

28
37
30
31
25
33
35
10
X
13
41
39
X
37
15
21
19
231
23
43
11
2

FIG. 9

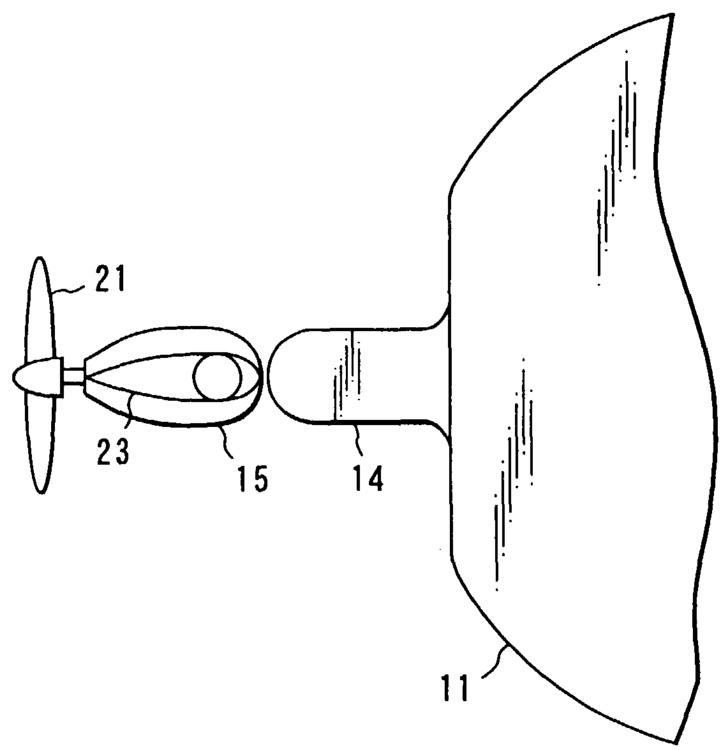

21
23
15
14
11

FIG. 10

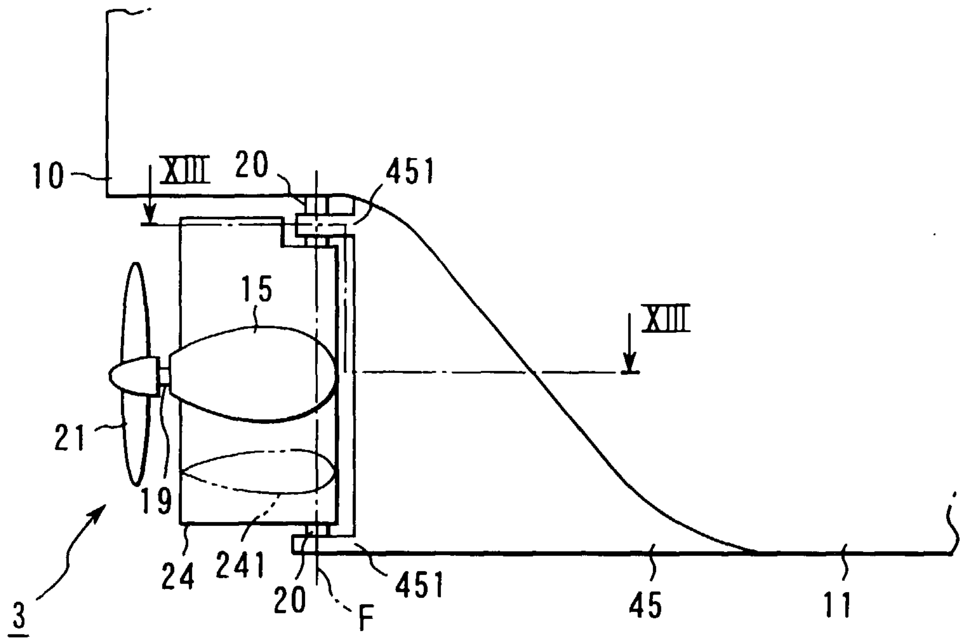

10
XIII
20
451
15
XIII
21
19
3
24
241
20
451
F
45
11

FIG. 11

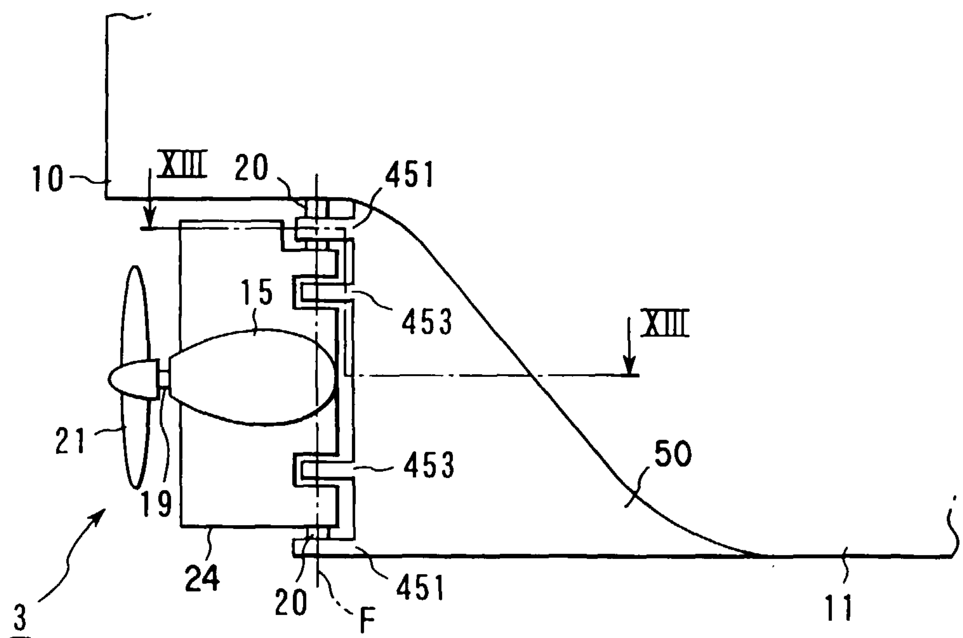

10
XIII
20
451
15
453
XIII
21
19
453
50
3
24
20
451
F
11

FIG. 12

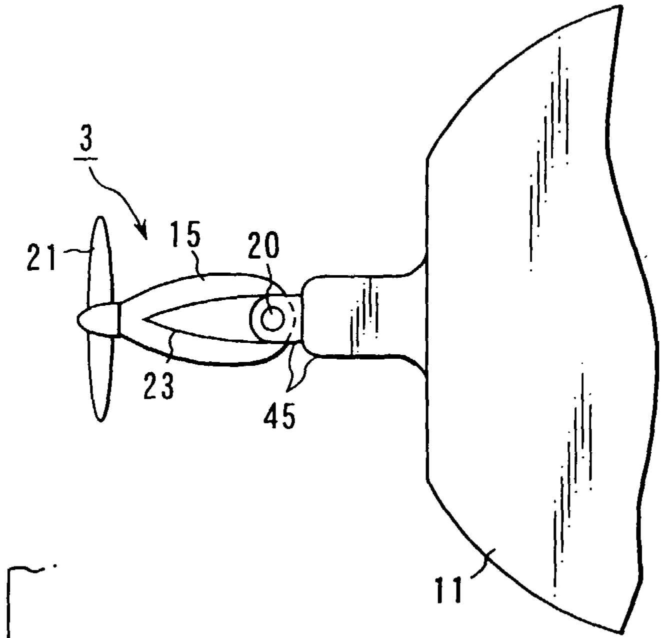


FIG. 13

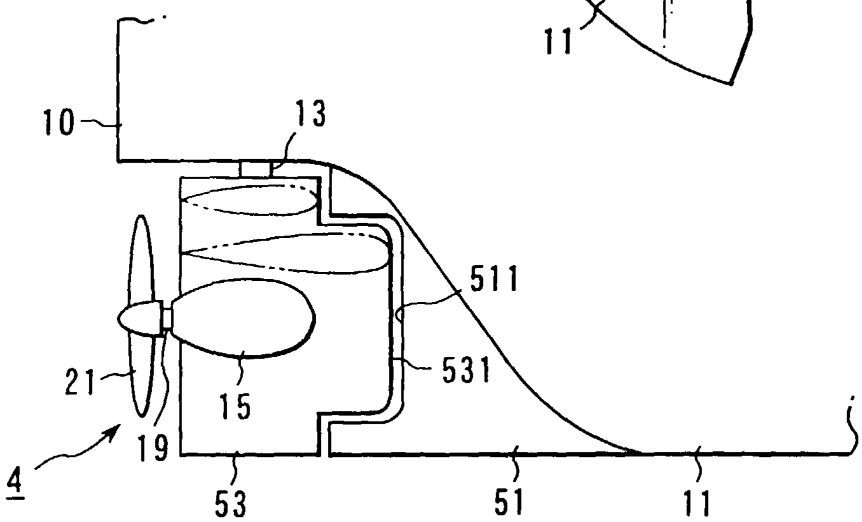


FIG. 14

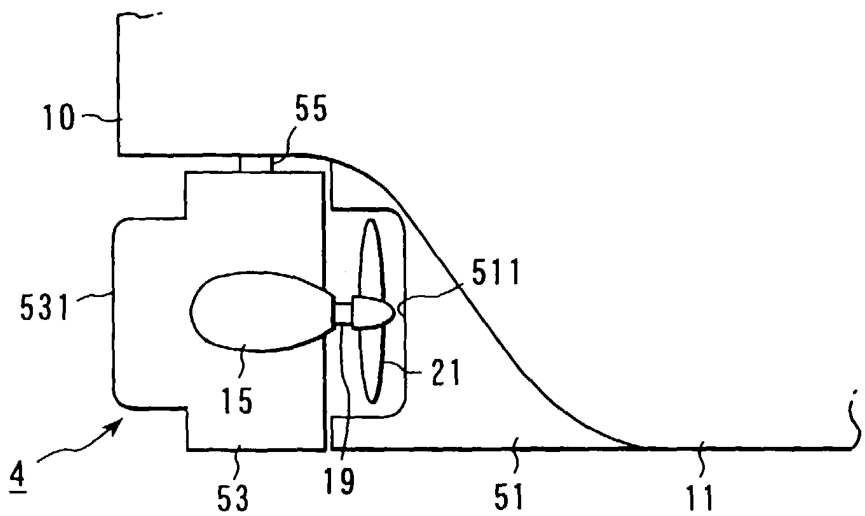


FIG. 15

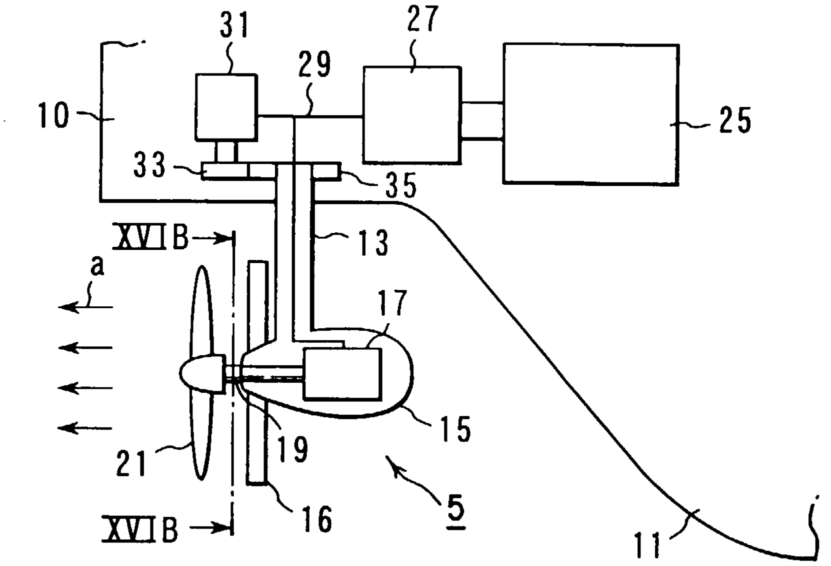


FIG. 16A

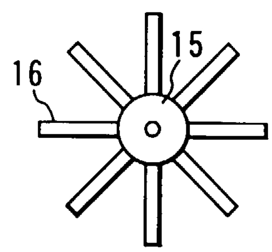


FIG. 16B

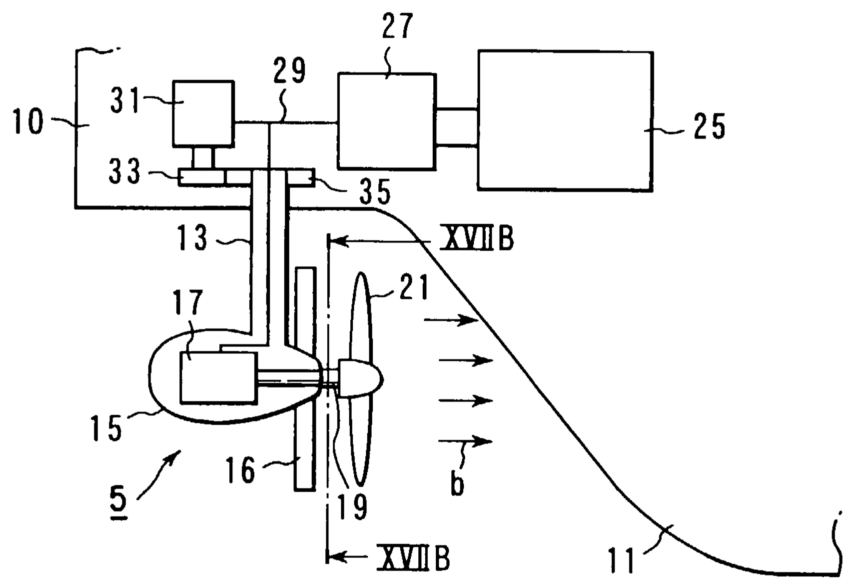


FIG. 17A

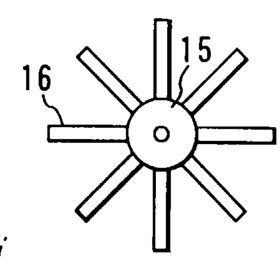


FIG. 17B

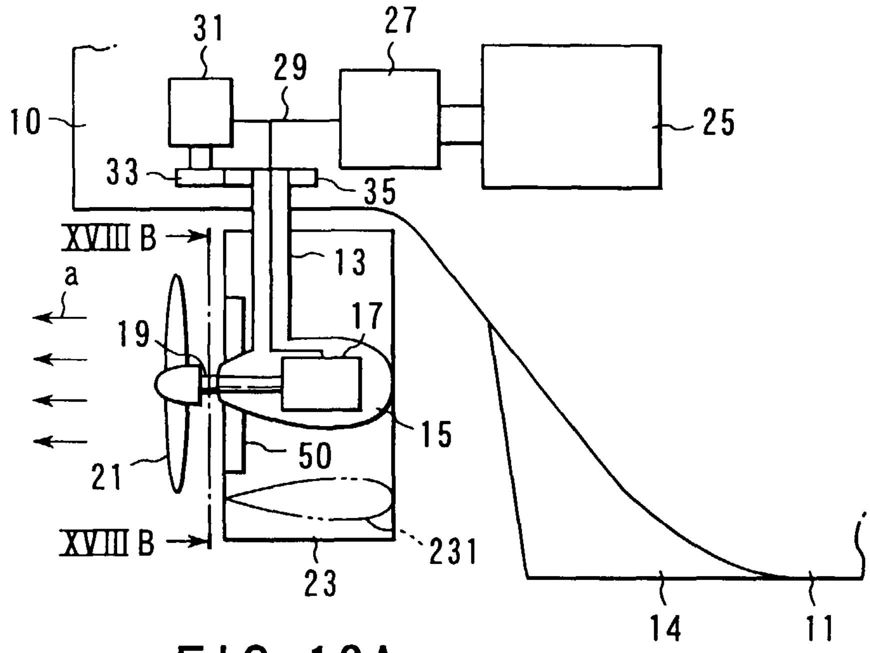


FIG. 18A

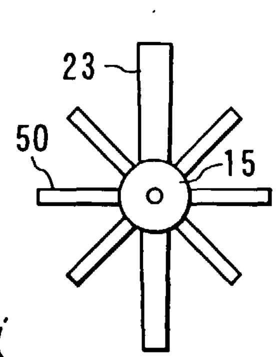


FIG. 18B

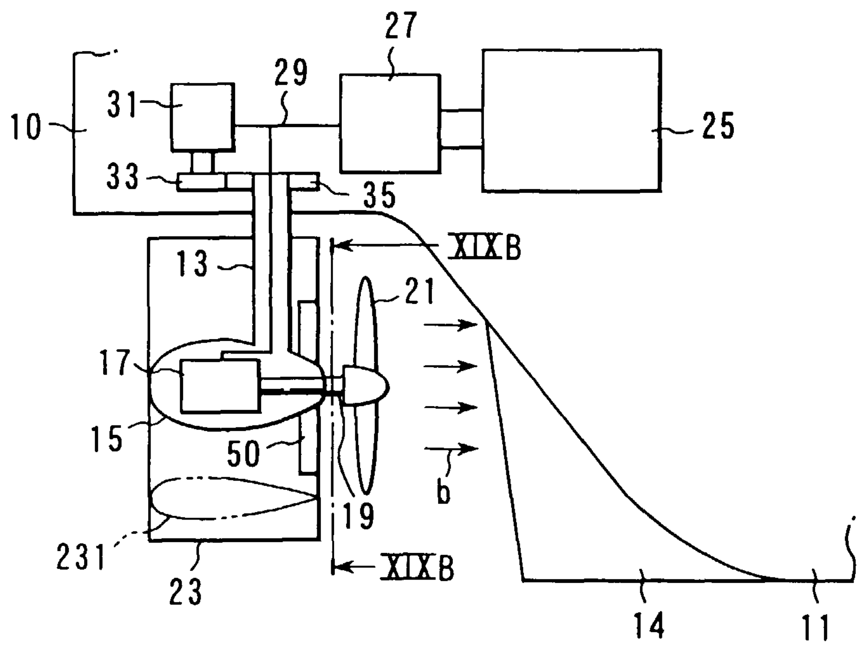


FIG. 19A

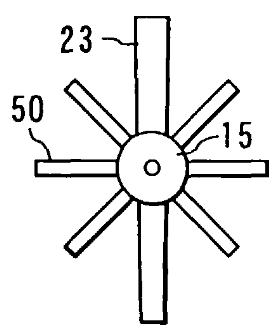


FIG. 19B

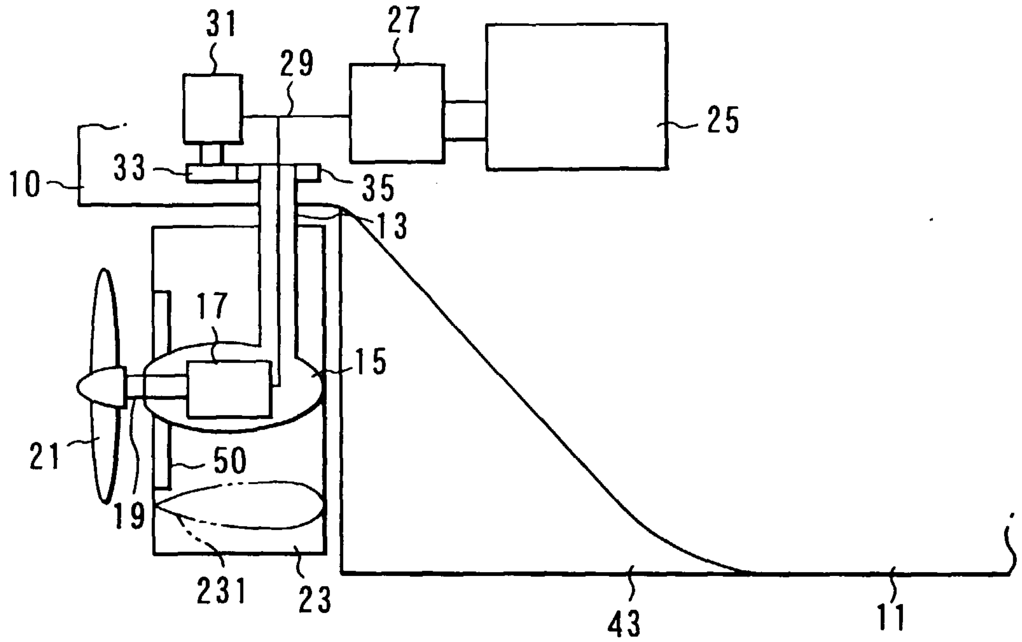

31
29
27
25
10
33
35
13
17
15
21
50
19
231
23
43
11

FIG. 20

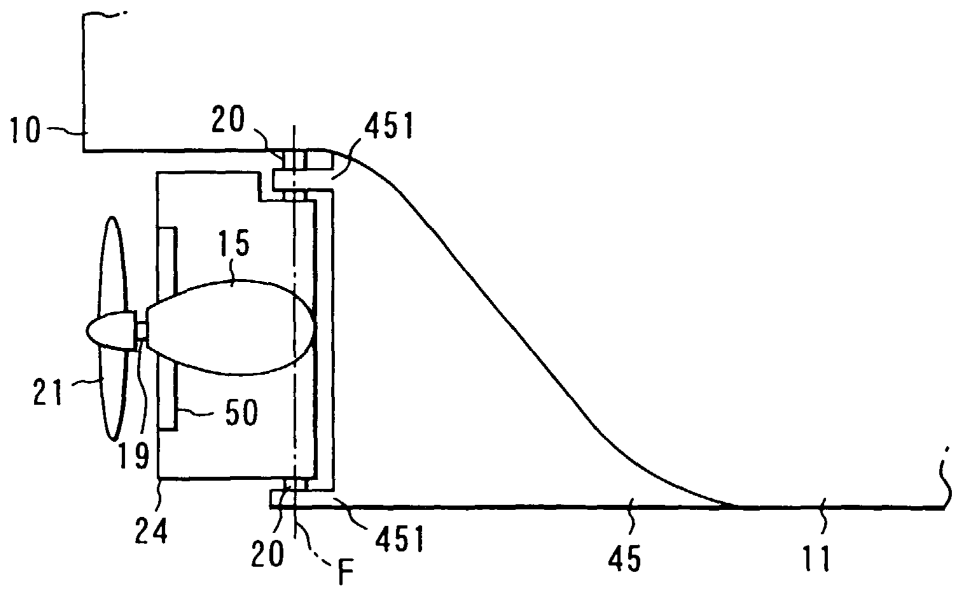

10
20
451
15
21
50
19
24
20
F
451
45
11

FIG. 21

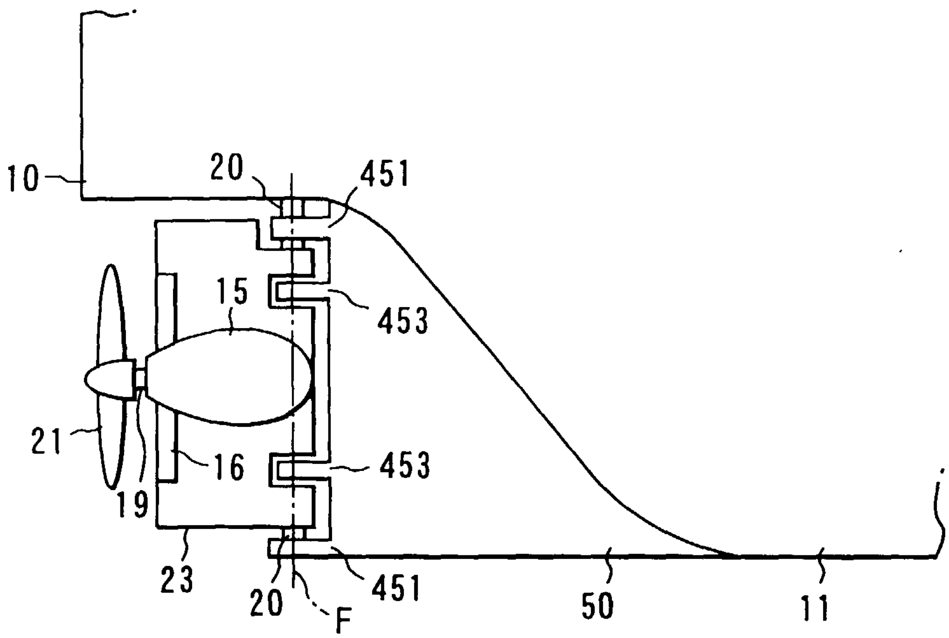

10
20
451
15
453
21
16
453
19
23
20
451
F
50
11

FIG. 22

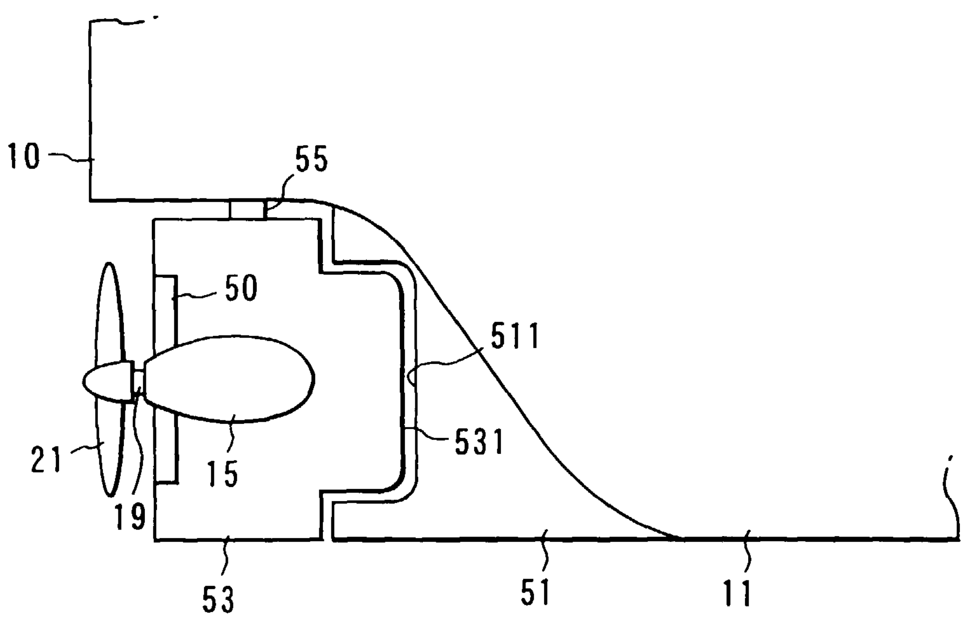

10
55
50
511
21
15
531
19
53
51
11

FIG. 23

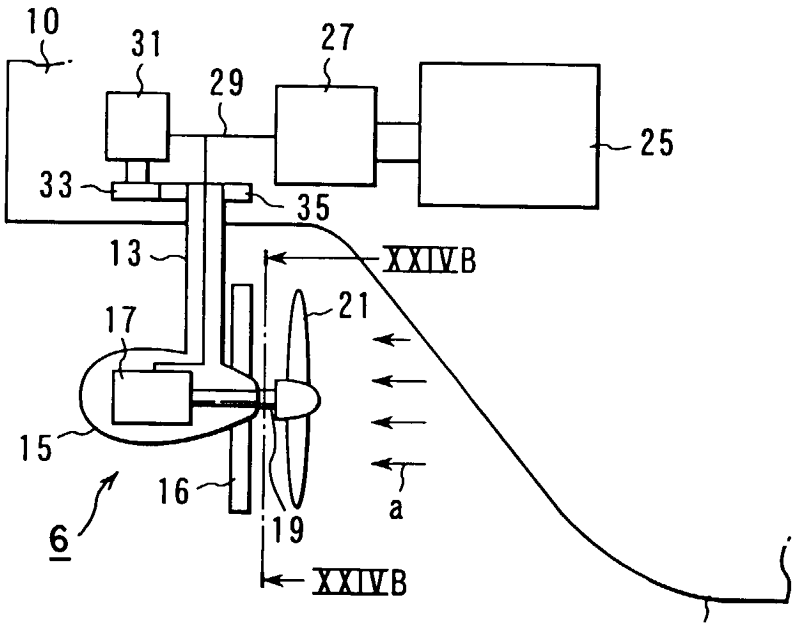


FIG. 24A

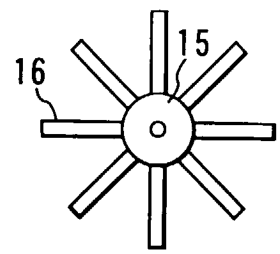


FIG. 24B

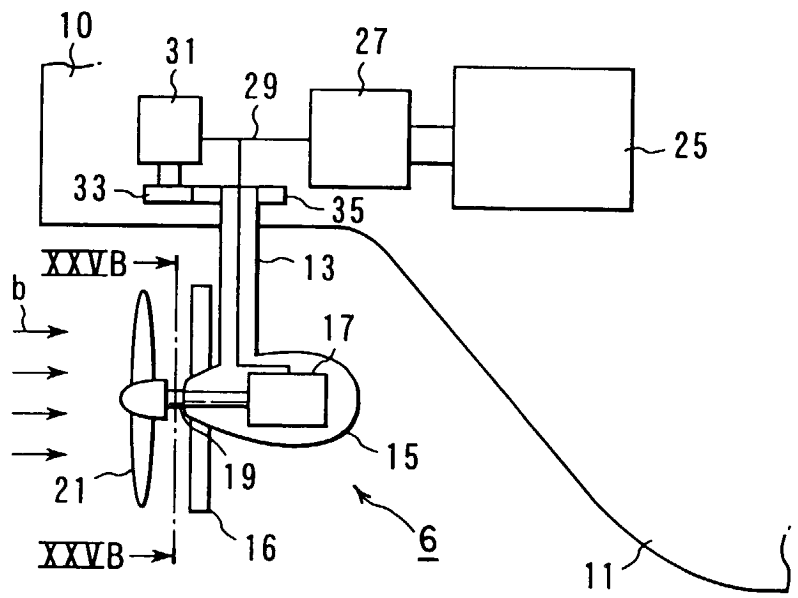


FIG. 25A

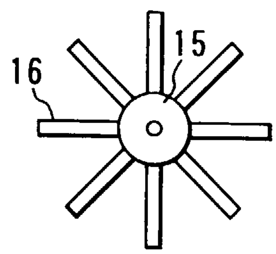


FIG. 25B

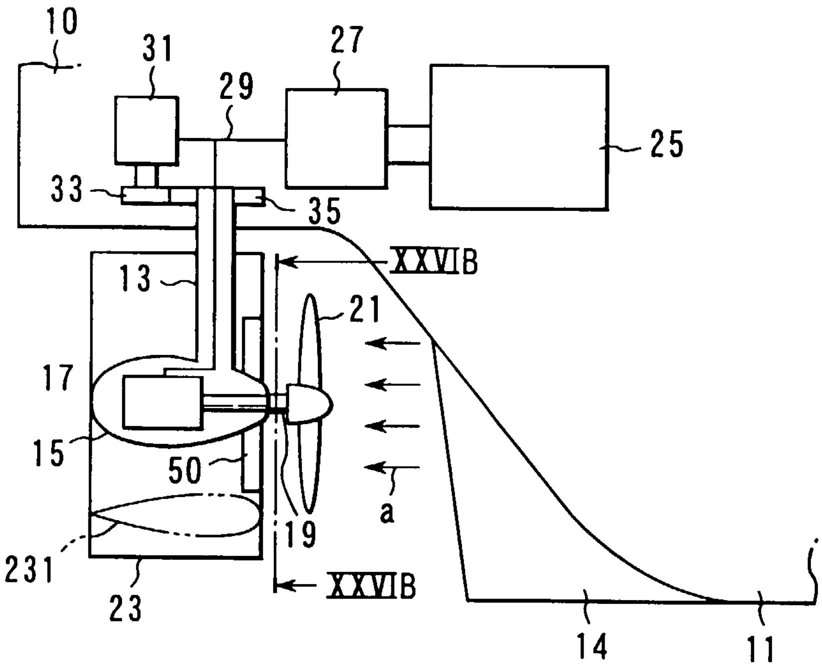


FIG. 26A

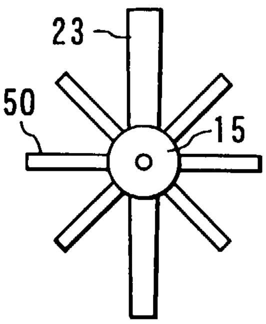


FIG. 26B

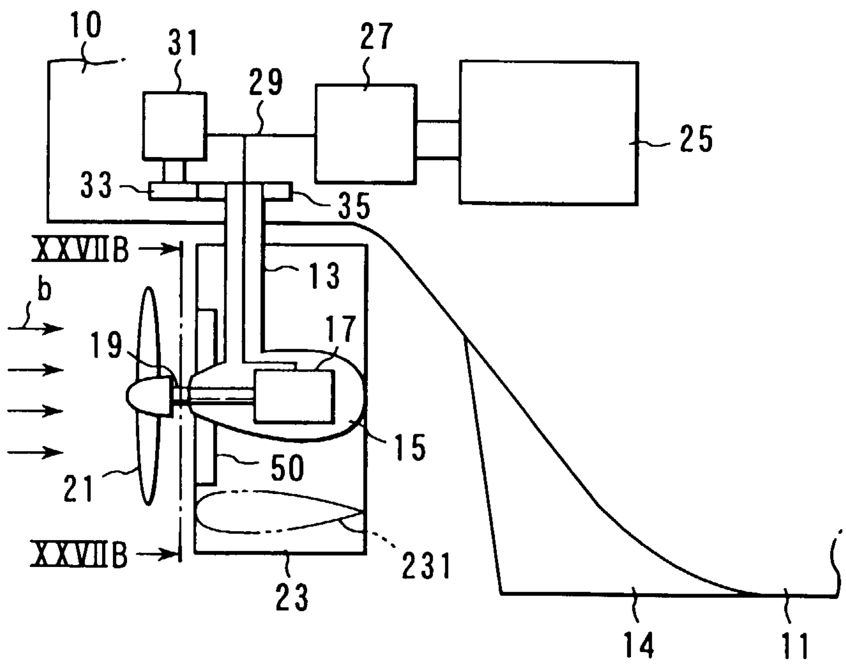


FIG. 27A

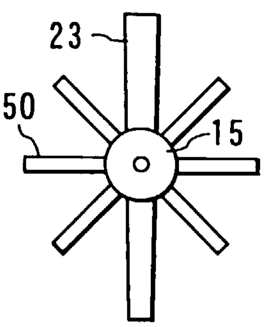


FIG. 27B