United States Patent

[11] 3,589,325

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Continuation-in-part of application Ser. No. 672,067, Oct. 2, 1967, now abandoned.

[54] METHOD AND APPARATUS FOR STEERING MARINE CRAFT

13 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** ..... **115/12 R,** 60/221
[51] **Int. Cl.** **B63h 11/00**
[50] **Field of Search** ..... 115/12; 114/163, 16, 166, 54, 66.5 H; 60/221, 222, 230

[56] **References Cited**

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ABSTRACT: A marine craft fitted with a water-jet propulsion unit having a rudder disposed adjacent the outlet of the unit so as to influence the direction taken by water discharged from the outlet. The rudder, besides being pivotable about an axis passing through the plane of its surface, is also rotatable about an axis passing through the outlet of the unit. When executing a turn the rudder is not only pivoted to execute the turn but is also rotated, in the general direction of the turn, so as to create an upward component of force on the rudder which tends to cause the craft to bank into the turn.

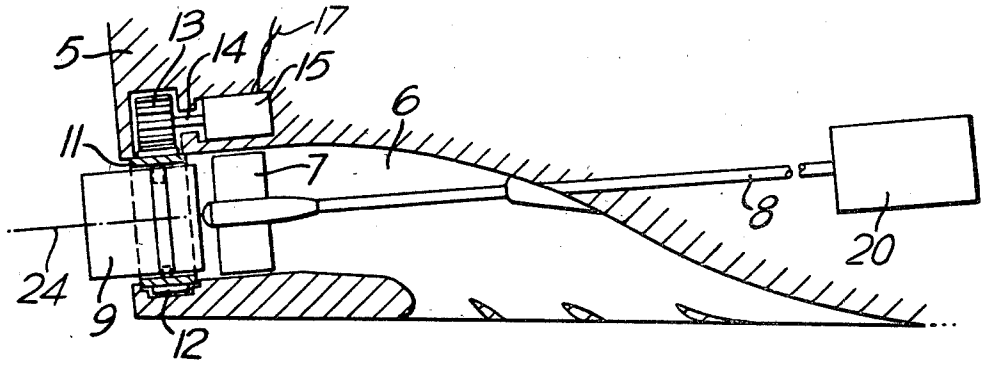


FIG. 1.

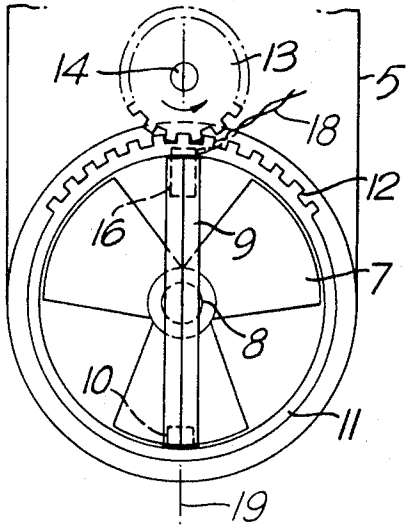
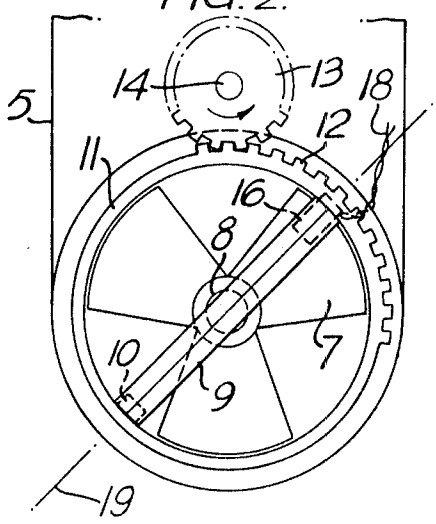


FIG. 2.



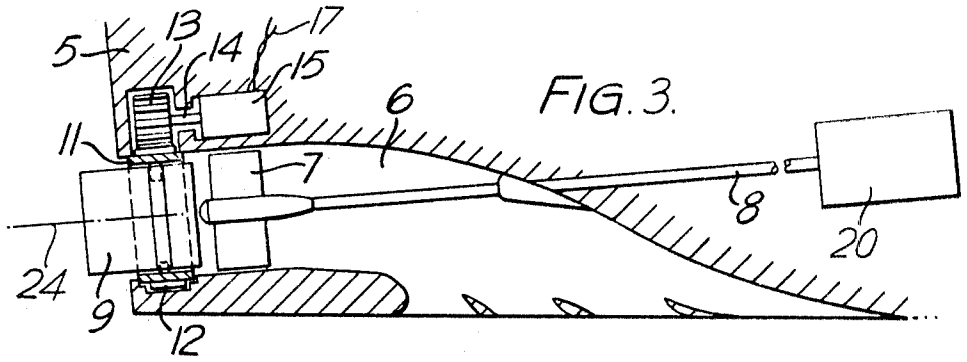


FIG. 3.

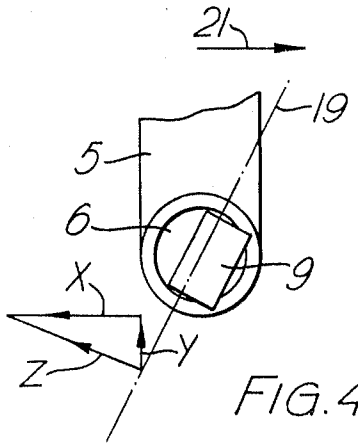


FIG. 4.

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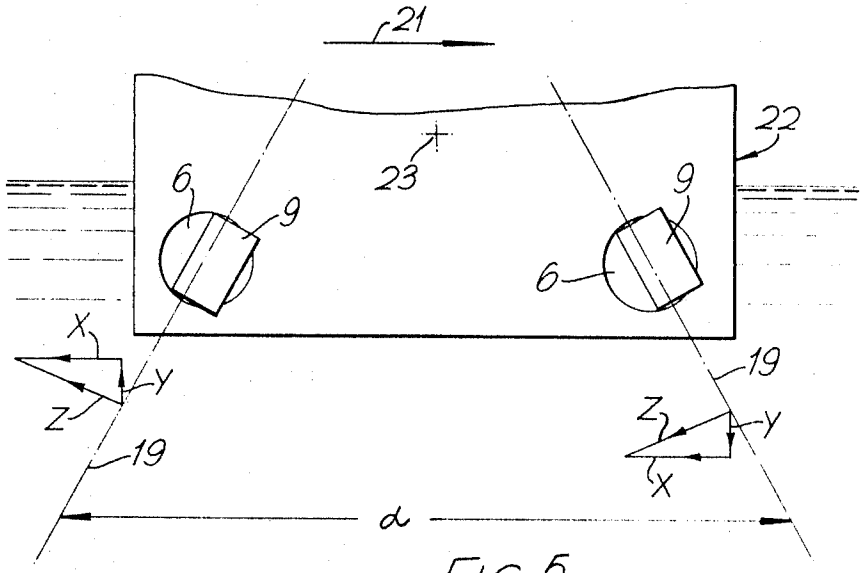


FIG. 5.

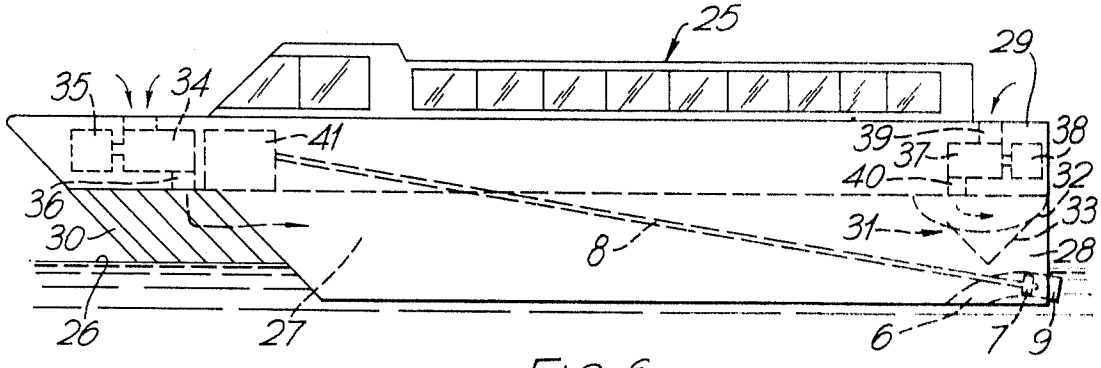


FIG. 6.

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METHOD AND APPARATUS FOR STEERING MARINE CRAFT

This is a continuation-in-part of application Ser. No. 672,067 filed Oct. 2, 1967, now abandoned.

This invention relates to methods of and apparatus for steering marine craft.

It is desirable that marine craft bank into a turn on application of rudder control surfaces. When such control surfaces are mounted in the normal, vertical position, i.e., so as to pivot on vertical shafts, and providing the control surfaces are below the center of gravity of the craft, the side forces on the control surfaces will provide a banking-in moment. This banking-in moment, however, may not be sufficient to overcome the banking-out tendency due to the couple formed by the centrifugal load acting through the center of gravity and the reaction of the hull below the water surface. In addition, since the rudder side force itself has to be reacted to prevent sideslip taking place, this adds to the reaction of the hull to the water surfaces which, if below the level of the craft's center of gravity, will aggravate its contribution to the banking-out tendency.

According to the invention, a marine craft is provided with at least two steering control members mounted for angular displacement about respective fore and aft axes which are arranged symmetrically with respect to the centerline of the craft, first means for pivoting each control member about a second axis perpendicular to the first axis and second means for effecting angular displacement of said control members about said fore and aft axes so as to enable their relative angular positions to be adjusted when steering movements are imparted to said control members by way of said first means.

Each control member may be mounted within a frame supported by the hull for angular displacement and within which the control member is pivotally mounted.

The invention will now be described by way of example with reference to the accompanying drawings in which:

FIGS. 1 and 2 are fragmentary rear or stern end elevations of a marine craft with a steering rudder in the vertical and inclined position respectively,

FIG. 3 is a sectional elevation of the same part of the craft but on a smaller scale,

FIG. 4 illustrates the forces acting on the rudder when the craft executes a turn to starboard,

FIG. 5 is a fragmentary end elevation of a marine craft employing two steering units of the form shown in FIGS. 1—3, and

FIG. 6 is a side view of an air-cushion craft propelled by two units, as shown in FIGS. 1—3.

FIGS. 1 to 3 illustrate a marine craft 5 formed at its stern with a duct or tunnel 6 extending in a substantially fore and aft direction. The fore and aft ends of the duct define a water inlet and a water outlet respectively. An impeller or propeller 7 secured to a substantially horizontal shaft 8 is fitted within the duct 6, the shaft and propeller being rotatable by a conventional source of power such as a diesel engine 20. The impeller or propeller 7 serves as a means for impelling water through the duct or tunnel 6 for discharge from the water outlet.

A steering member in the form of a rudder or control surface 9 is located in rear or outlet end of the duct 6, immediately astern of propeller 7, and is mounted for pivotal movement about a normally vertical axis 19 in bearings 10. The axis 19 is substantially perpendicular to the axis of rotation of the shaft 8. The bearings 10 are secured to the inner periphery of ringlike frame member 11 which is itself supported in the duct 6 so as to be capable of angular displacement about a substantially horizontal axis 24 which extends through the outlet end of the duct 6 so as to be coaxial with the axis of the shaft 8 and thereby substantially perpendicular to the axis 19.

The outer periphery of ring member 11 is formed with gear teeth 12 over approximately one-quarter of its periphery, this toothed portion serving as a rack and being symmetrically disposed about the topmost point of the ring member when the rudder 9 is in a vertical position.

A driving pinion 13, mounted in the craft immediately above ring member 11, is in mesh with the teeth 12 and is secured to a shaft 14 driven by an electric motor 15 which is remotely controlled, by the pilot of the craft, through electrical signal lines 17. The axis of the shaft 14 is substantially parallel to the axis of the shaft 8.

Pivotal movement of the rudder 9 is also remotely controlled by means of an electric motor 16 integral with the upper bearing 10 of the rudder. The motor 16 is controlled through electrical signal lines 18.

Alternative sources of power may be used to effect pivotal movement of the rudder 9 and/or rotational movement of the ring member 11 and actuation of these components may be direct or by remote control.

In operation, and with reference to FIG. 4, assuming it is desired to turn the craft 5 to starboard, i.e., in the direction of the arrow 21, the motor 15 of the steering mechanism is actuated to rotate the pinion 13 so that it rotates the ring member 11 to starboard. This clockwise rotation of the member 11 inclines the rudder 9 at an angle to the vertical. In the adjusted or steering position of the rudder 9 shown in FIG. 4, the rudder pivot axis 19 is inclined to and intersects a vertical plane containing the longitudinal axis 24 of the duct. The rudder 9 is then pivoted to starboard also; about its bearings 10 by means of the motor 16 so as to turn the craft to starboard. The force diagram appearing in FIG. 4 indicates the components of force in the horizontal X and vertical Y directions resulting from pivotal deflection of the rudder 9 to execute a starboard (right) turn.

It will be seen that the resultant Z of the vertical and horizontal components of force acts upwardly on the rudder 9 and in a direction normal to the surface of the rudder so as to bank the craft into the turn, which is a desirable control feature. To turn the craft to port the member 11 is rotated anticlockwise and the rudder 9 deflected to port whereby the component Z acts to bank the craft into the turn to port.

FIG. 5 illustrates a marine craft 22 provided with a pair of rudder mechanisms of the form shown in FIGS. 1 to 3, arranged symmetrically with respect to the fore and aft axis or centerline 23 of the craft. The members 11 and rudders 9 are positioned to turn the craft 22 in the direction of the arrow 21, i.e., to starboard. Both rudders 9 are therefore turned to starboard and the port or left-hand member 11 rotated in a clockwise direction whilst the starboard or right-hand member is rotated in an anticlockwise direction.

It will be seen that the vertical components of force Y act on the rudders 9 in opposite directions and thereby set up a clockwise couple of moment $Y \cdot d$ about the central longitudinal axis of the craft wherein d is the lateral distance separating the rudders. This couple acts to bank the craft into the turn to starboard and is a desirable control feature.

To turn the craft 5 to port, i.e., in a direction opposite to the arrow 21, the ring members 11 are left in their present positions but the motors 6 are rotated to pivot the rudders 9 to port. This movement of the rudders 9 results in the vertical components of force Y changing their direction of action whereby the couple $Y \cdot d$ changes in direction to become an anticlockwise couple which acts to bank the craft 5 into the turn to port.

The invention may comprise multihulled craft of conventional construction. FIG. 6 shows a "sidewall" air-cushion craft 25 travelling over water 26 and supported thereover by a cushion 27 of pressurized air. The sides of the craft-supporting air cushion 27 are contained by a pair of laterally spaced "sidewalls" 28 of rigid construction extending longitudinally in substantially parallel array along the sides of the centrally disposed craft body 29 and depending therefrom to dip into the water 26 to effect a cushion-air seal. The front end of the cushion 27 is contained by a multipart flexible skirt 30 of the form disclosed by British Pat. No. 1,043,351. The rear end of the cushion 27 is contained by a two-stage flexible skirt 31. The upper stage of the skirt 31 comprises an inflated bag 32 and the lower stage thereof a skirt 33 of the form disclosed by

British Pat. No. 1,109,562, inflated by air tapped off the bag **32**.

Air forming the cushion **27** is drawn in from the atmosphere by a compressor **34** driven by an engine **35** and discharged, by way of a duct **36**, to the space between the sidewalls **28**. The rear skirt **31** is inflated (to a pressure substantially the same as cushion pressure) by a small compressor **37** driven by an engine **38**. The compressor **37** drives in air from the atmosphere by way of an intake **39** and discharges it to the bag **32** of the skirt **31** by way of a duct **40**.

The craft **25** is steered and propelled by a pair of units, each of the form shown in FIGS. **1** to **3**. Each unit is mounted symmetrically about the fore and aft axis of the craft, and in the rear end of a sidewall **28** so that the duct **6** of the unit extends from the bottom, below waterline edge of the sidewall to the rear end thereof. The shafts **8** of each unit extend upwardly through the sidewalls **28** and are connected to a pair of engine and gear box units **41** so as to be rotated thereby. The approximate projected area of each rudder **9** is preferably one eighth that of the immersed portion of a sidewall **28**.

When the rudders **9** are arranged in pairs disposed laterally and symmetrically beneath the craft (be it the craft **5** or craft **25**) they need not be operated so as to be deflected to the same extent and in opposite directions as described above. Rotation of each ring member **11** can be effected in the same direction so as to maintain the rudders **9** in parallel inclined relationship, in which case an element of pitch control is obtained, the direction of the resultant force depending on the direction of inclination of and the direction of pivotal movement of the rudders. Each ring member **11** can also be rotated independently of the other or others.

I claim:

1. In a steerable propulsion driven marine craft, a duct extending generally fore and aft of the craft, having its foremost end open in position to provide a water inlet, and having its sternmost end open and providing a water outlet; means for impelling water through said duct for discharge from said water outlet; a rudder; means mounting said rudder at said water outlet for rotation about a first axis extending through said water outlet and for pivotal movement about a second axis substantially normal to said first axis; and means for respectively rotating and pivoting said rudder about said axes.

2. A marine craft according to claim **1** in which the rudder mounting means comprises a toothed ring mounted in said craft for rotation about said first axis; a pinion meshing with said ring; and bearing means carried by said ring and mounting said rudder for pivotal movement about said second axis.

3. In a marine craft having a steering control member defining a surface normally disposed substantially vertically and aligned generally in a fore and aft direction, the improvement comprising first means mounting the control member for angular displacement about a substantially fore and aft first axis, second means supporting the control member on said first means and permitting angular displacement of said control member about a second axis perpendicular to said first axis, first control means for effecting angular displacement of said control member about said substantially fore and aft first axis, and second control means for effecting pivotal angular displacement of said control member about said second axis.

4. The improvement according to claim **3** in which said first means mounting said control member comprises a frame surrounding said control member and being mounted in said craft for angular displacement about said first axis.

5. The improvement according to claim **4** in which said frame comprises a toothed ring and in which said first control means comprises a pinion meshing with the teeth of said ring.

6. The improvement according to claim **5** in which said second control means comprises a pair of oppositely disposed pivots carried by the inner periphery of said ring; and remotely actuated drive means in one of said pivots for effecting angular displacement of said control member about said second axis.

7. In a marine craft having a hull and being provided with at least two steering control members each formed with a surface normally disposed substantially vertically and aligned generally in a fore and aft direction, the improvement which comprises first means mounting said control members for angular displacement about respective, substantially fore and aft axes located symmetrically with respect to the centerline of the hull, second means supporting each control member on its associated said first means and permitting angular displacement of each control member about a second axis perpendicular to said first axis, and control mechanism for effecting angular displacement of said control members about said substantially fore and aft axes to enable their relative angular positions in reference to said first axis to be adjusted when steering movements are imparted to said control members by operation of said second means.

8. The method of controlling the displacement, during a turn, of a marine craft having two steering control members movable respectively about substantially vertical axes disposed symmetrically with respect to the centerline of the craft to effect steering, said method comprising, in executing a turn of said craft, imparting angular displacement to said steering control members about respective substantially fore and aft horizontal axes to vary the angular relation of their control surfaces to one another about said respective substantially fore and aft horizontal axes, whereby movement of said control members to effect steering provides components of force acting to bank the craft into a turn.

9. The method of controlling the displacement, during a turn, of a marine craft having two control surfaces disposed symmetrically laterally spaced beneath the craft waterline, said method comprising pivoting said surfaces about respective substantially vertical first axes to steer the craft, and rotating said control surfaces independently about respective substantially horizontal fore and aft second axes respectively intersecting said substantially vertical first axes, whereby pivotal movement of said control surfaces about the respective first axes and angular displacement of said control surfaces about said respective second axes provides components of steering force in the vertical as well as in the horizontal direction.

10. The improvement according to claim **3** including an open-ended duct extending in a substantially fore and aft direction with its front end disposed below the craft waterline, said control member being mounted adjacent the duct rear end; and an impeller mounted for rotation in said duct.

11. The improvement according to claim **7** including open-ended duct means extending in a substantially fore and aft direction with its front end disposed below the craft waterline, said control members being mounted adjacent the duct means rear end; and impeller means mounted for rotation in said duct means.

12. In a steerable propulsion driven marine craft, a duct extending generally fore and aft of the craft, having its foremost end open in position to provide a water inlet, and having its sternmost end open and providing a water outlet; means for impelling water through said duct for discharge from said water outlet; a rudder; means mounting said rudder at in the path of water discharged from said water outlet for pivotal movement about an axis inclined to and intersecting a vertical plane containing the longitudinal axis of the duct; and means for pivoting said rudder about said axis.

13. A marine craft according to claim **12**, comprising a pair of laterally spaced sidewall structures connected by a central body, and wherein each of said sidewall structures is provided with a duct, means for propelling water through said duct, a rudder, rudder mounting means and rudder pivoting means as specified in claim **12**, the projected area of each rudder being approximately one-eighth that of the immersed portion of each sidewall structure.