

SPECIFICATION

Propulsion and control system for a watercraft

The invention relates to a watercraft having a propulsion and control system comprising at least one pair of thrust-generating rudders, e.g. rudder propellers, disposed one on each side of the longitudinal axis of the craft.

The prior art discloses a system in which use is made of a lever which is pivotable about two axes and which produces pivoting of the rudders by means of a transmitter, a phase discriminator, and a servo motor (US Patent 3 976 023). The known system is complicated, and traversing without slewing is not possible in all desired directions.

The present invention provides a water-craft having at least one pair of rudder propellers and the rudder propellers of each pair are disposed substantially symmetrically on both sides of the centre line of the watercraft, which said centre line extends through the lateral centre of gravity, with a steering element which can perform steering motions in two degrees of freedom and each steering motion acts on each of two transmitters for remote control of the rudder propellers, in which the movement of the steering element in one degree of freedom is a rotation about an axis by means of which synchronous pivoting of the rudder propellers of each pair is controlled via the transmitters, for example electric rotary transmitters, while the motion of the control element in the second degree of freedom causes displacement of a rock element by means of which pivoting of the rudder propellers relative to each other in opposite senses is controlled via the same transmitters.

The transmitters may operate electrically and/or hydraulically and/or pneumatically.

In one embodiment, with transmitters each substantially comprising two elements which are movable relative to each other, for example (in the case of an electrical rotary transmitter) a coil or the like and a sliding brush or the like for tapping the coil, the steering element acts on a first element of each transmitter via gearwheels when the steering element is rotated, and the steering element acts on the second element of each transmitter via the rack element when the steering element is slidably displaced.

Alternatively, the steering element may act on the same element of each transmitter in both degrees of freedom.

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

Figure 1 shows in diagrammatic form a propulsion and control system of a watercraft;

Figure 2 shows in diagrammatic form a steering element, transmitters, and a gear train in one embodiment of the system;

Figure 3 shows a diagram of examples indicating the position of the steering element with the associated thrust directions of the propellers;

Figure 4 shows in diagrammatic form another embodiment of the system;

Figure 5 shows in diagrammatic form yet another embodiment.

The motion of a watercraft can be divided into two components, viz. traversing (longitudinal or transverse motion without turning) and slewing (turning). Both motions can be superimposed on each other. The pivoting point of the watercraft is the centre of gravity. Under acceleration, the centre of mass also plays a part but this will always be disposed near the lateral centre of gravity so that the centre of gravity can be regarded with sufficient accuracy at the pivoting point. If a craft is to traverse without slewing, the thrust forces, with reference to the centre of gravity, must act without producing a moment, i.e. the moments of the forces must cancel each other.

Given a symmetrical arrangement of the rudder propellers on both sides of the central plane of the watercraft, upstream or downstream of the centre of gravity, and given a parallel alignment with respect to the middle plane, ahead or astern travel will be achieved without slewing (assuming the rudders generate equal thrusts). Corresponding pivoting angles of the rudder propellers must be found for all transverse motions.

With the invention it is possible to produce moment-free forces at any desired direction by a single departure from the parallel alignment of the rudder propellers.

Traversing in any desired direction alone is not sufficient for all manoeuvres. External forces, such as wind, currents, and drag forces which do not act exactly at the centre of gravity, or any shift of the centre of gravity due to differences in loading or trim can result in turning of the watercraft, which must be compensated. It must therefore also be possible to superimpose slewing on traversing.

A turning moment superimposed on the traversing force can be generated by turning the rudders in opposite directions (detuning). This results in a change of the available traversing power. Right-hand traversing plus right-hand inward turning of the rudders results in increased traversing plus right-hand slewing of the vessel. Right-hand traversing plus left-hand inward turning results in reduced traversing plus left-hand slewing. Traversing can be reduced to such an extent as to result in slewing in one place. This is the only possibility for pure slewing in one place.

The following functions can be performed by means of the invention:

1) Infinite synchronous steering of parallel aligned rudder propellers through 360°.

2) Setting to an initial traversing position from the parallel alignment of the rudder propellers.

3) Infinite synchronous steering of the rudder propellers from the initial traversing position through 360°, for traversing in a desired direction.

4) Superimposition of slewing motion on a traversing motion by turning the rudder propellers in opposite senses (rudder detuning).

The watercraft 10 shown in Figure 1 has a pair of rudder propellers 11, 12 disposed symmetrically with respect to the middle plane 13 of the watercraft, which plane extends through the centre of gravity 14. The rudder propellers are disposed beneath the hull upstream of the centre of gravity, but they could instead be disposed downstream. The propellers 11, 12 are driven by respective motors 61, 62 (or by common motor). The propellers are each pivotable about a vertical axis, by means of servo motors, for instance, such an arrangement being already known, so that it is sufficient to indicate the rudder propellers schematically, as has been done in Figure 1.

Pivoting of the rudder propellers, for manoeuvring the watercraft is performed by means of a remote control system. Two transmitters are provided for the remote control system and in the present example they are electrical rotary transmitters 15, 16. The transmitters act, via a conductor system 17, 18, on known servo motors (not shown). The electrical rotary transmitters can be variable resistors or potentiometers or they can be of the inductive or capacitive kind. Remote control can also be hydraulic or pneumatic. The elements for all these control systems are well known.

Figure 2 shows a control element 19 which acts on the transmitters, in this case the electrical rotary transmitters 15, 16. A lever 22 is mounted in a frame 21 so as to be rotatable but not longitudinally slidable. A pinion 24 is coaxially associated with the lever 22 meshes with a cylindrical rack 25 formed at the top of a rod 26 which extends coaxially through the shaft 20 and can be rotated and longitudinally slid relative thereto. The lever 22 can assume two limiting positions 1, 4 and two ratchet positions 2, 3 between them; the ratchets are not shown.

A gearwheel 27 on the bottom end of the shaft 20 engages with an intermediate gear 28 which meshes with two gearwheels 29, 30. A first element 31 of each of the rotary transmitters 15, 16 is coaxially and non-rotationally coupled to a respective one of the gearwheels 29, 30. The second element 32, cooperating with the first element 31, is supported so as to be rotatable but not axially slidable. The first element can be a sliding brush and the second element can be a coil of an electrical resistor or a potentiometer.

The bottom end of the rod 26 engages by means of a cross pin 33 with a slot 34 in one end of a two-armed lever 35. A slot 36 in the other end is engaged by a pin 37 disposed at one end of an actuating rod 38 which is longitudinally slidable but not rotatable. A two-sided rack 39 is provided at the other end of the actuating rod 38. First teeth 40 on one side of the rack 39 mesh with a gear wheel 41 connected to the second element 32 of the rotary transmitter 15. Second teeth 42 on the other side mesh with a gearwheel 43 connected to the second element of the rotary transmitter 16.

If the shaft 20 is rotated by means of the lever 22 the first elements of the rotary transmitters will

be rotated in synchronism in the same direction via the gearwheel 27, the intermediate gear 28, and the gearwheels 29, 30. If the lever 22 is pivoted about the horizontal axis 23, the second elements of the rotary transmitters will be rotated in opposite directions via the elements 26, 35, 38, 39, 40, 41, 42, 43.

Figure 3 shows in diagrammatic form some steering functions which can be performed with the above described control system. Column 100 indicates the numbered lines in which the steering functions are described. Column 101 indicates the angular position of the lever 22 on being rotated about the shaft 20; column 102 indicates the numbered positions of the lever 22 on being pivoted about the horizontal axis 23. Column 103 symbolizes the position of the lever 22. Columns 104 and 105 indicate the direction of the thrusts obtained with the appropriate positions of the rudder propellers.

Line 111: If the lever 22 has not been rotated (i.e. is set to 0°) and is in the limiting position 1, the rudder propellers will be orientated parallel straight ahead.

Line 112: If the lever 22 is pivoted about the vertical axis 20' (Figure 2) the rudder propellers will be pivoted in synchronism in the same direction and the vessel will be manoeuvred in the conventional manner.

Line 113: If the lever 22 is set at 0° and in the ratchet position 2, the rudder propellers will be in an initial position for traversing (in this case ahead traversing).

Line 114: Rotation of the lever in this ratchet position in conjunction with the rack causes traversing in a desired direction, for example traversing 45° to the right ahead.

Line 115: Traversing 90° to the right.

Line 116: Pivoting of the lever away from the ratchet position 2 results in neutral "detuning" of the rotary transmitters by means of the gear rack and causes slewing to be superimposed on the traversing, for example traversing 45° to the right ahead and slewing to the left.

Line 117: Traversing 90° to the right and slewing to the left.

Line 118: In position 3 of the lever, both propellers are positioned opposite each other; no motion of the craft takes place.

Line 119: Slow astern.

Line 120: If the lever is pivoted about the horizontal axis into position 4, the rudder propellers will move in opposite senses into the astern parallel position for full astern. (The same would also be achieved by turning the lever about the vertical axis, but pivoting of the rudder propellers in the same sense would then result in side thrust which could be detrimental.)

Figure 4 shows an embodiment in which a gearwheel 51, disposed on the vertical shaft, meshes with gear wheels 52, 53 which drive the respective first element 31 of the rotary transmitters 15, 16. The bottom end of the rod 54, supported coaxially with the vertical shaft, is provided with a second cylindrical rack 55 which

meshes with a pinion 56 of involute shape. (The pinion can have any other suitable shape.) On the same shaft as the pinion 56 and non-rotationally coupled thereto, there are two bevel gears 57, 58, adapted to mesh with respective bevel gears 59, 60 which are connected to the respective second element 32 of the rotary transmitters. The function of this control system is the same as that described above with reference to Figure 2.

Another embodiment is shown in diagrammatic form in Figure 5. A lever 70 (corresponding to the lever 22 of the above-described embodiments) is mounted at one end of a shaft 71 which is supported by bearings (not shown) so as to be rotatable and longitudinally slidable. Two helical gears 72, 73 are mounted on the shaft 71 and their teeth have helices orientated in opposite directions; the tooth helices are indicated by the dash-dot lines 74, 75. The helical gears 72, 73 mesh with respective mating gears 76, 77 which are coupled to respective first elements of the rotary transmitters 15, 16, for example via shafts 78, 79. The second elements of the rotary transmitters are fixed. If the lever 70 is turned about the axis 70' of the shaft 71, together with the shaft the rotary transmitters 15, 16 will be synchronously rotated in the same direction. The rudder propellers 11, 12 will thus be pivoted in parallel and in the same sense. If the lever 70 is moved from position 1 to position 2, 3, or 4, the mating gears 76, 77 will be rotated in opposite senses via the toothed helices 74, 75, and the rotary transmitters will therefore be "detuned" as indicated by lines 113 to 119 in Figure 3.

CLAIMS

1. A watercraft having a propulsion and control system comprising a pair of thrust-generating rudders disposed one on each side of the longitudinal axis of the craft, two transmitters for remotely controlling pivoting of the respective rudders, and a steering element mounted for movement according to two degrees of freedom, movement according to one of the degrees of freedom being rotation about an axis, the steering element being kinematically connected to the transmitters so that movement according to said one degree of freedom causes synchronous pivoting of the rudders in the same sense as each

other, movement of the steering element according to the other degree of freedom causing longitudinal displacement of a rack kinematically connected to the transmitters so that the said displacement causes pivoting of the rudders in the opposite sense relative to each other.

2. A watercraft as claimed in claim 1, in which each transmitter comprises first and second elements whose relative position controls the position of the corresponding rudder, movement of the steering element according to the said one degree of freedom causing movement of the first element of each transmitter, and movement of the steering element according to the second degree of freedom causing movement of the second element of each transmitter.

3. A watercraft as claimed in claim 1, in which each transmitter comprises two elements whose relative position of the corresponding rudder, and movement of the steering element according to both of the degrees of freedom causes movement of the same element of each transmitter.

4. A watercraft as claimed in any of claims 1 to 3, in which the steering element is kinematically connected to the transmitters by a gear member so that movement of the steering element according to the said one degree of freedom causes synchronous pivoting of the rudders in the same sense as each other, the gear member having helical teeth and being so arranged that movement of the steering element according to the said other degree of freedom causes axial displacement of the gear member resulting in pivoting of the rudders in the opposite sense relative to each other.

5. A watercraft as claimed in claim 4, in which the gear member comprises two helical gears having helices orientated in opposite directions.

6. A watercraft as claimed in any of claims 1 to 5, in which the movement of the steering element according to the said other degree of freedom occurs between two limiting positions, the steering element being capable of being retained at two predetermined positions between the limiting positions.

7. A watercraft having a propulsion and control system substantially as described with reference to, and as shown in, Figures 1 and 2, Figures 1 and 4, or Figures 1 and 5.



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Another embodiment is shown in diagrammatic form in Figure 5. A lever 70 (corresponding to the lever 22 of the above-described embodiments) is mounted at one end of a shaft 71 which is supported by bearings (not shown) so as to be rotatable and longitudinally slidable. Two helical gears 72, 73 are mounted on the shaft 71 and their teeth have helices orientated in opposite directions; the tooth helices are indicated by the dash-dot lines 74, 75. The helical gears 72, 73 mesh with respective mating gears 76, 77 which are coupled to respective first elements of the rotary transmitters 15, 16, for example via shafts 78, 79. The second elements of the rotary transmitters are fixed. If the lever 70 is turned about the axis 70' of the shaft 71, together with the shaft the rotary transmitters 15, 16 will be synchronously rotated in the same direction. The rudder propellers 11, 12 will thus be pivoted in parallel and in the same sense. If the lever 70 is moved from position 1 to position 2, 3, or 4, the mating gears 76, 77 will be rotated in opposite senses via the toothed helices 74, 75, and the rotary transmitters will therefore be "detuned" as indicated by lines 113 to 119 in Figure 3.

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other, movement of the steering element according to the other degree of freedom causing longitudinal displacement of a rack kinematically connected to the transmitters so that the said displacement causes pivoting of the rudders in the opposite sense relative to each other.

2. A watercraft as claimed in claim 1, in which each transmitter comprises first and second elements whose relative position controls the position of the corresponding rudder, movement of the steering element according to the said one degree of freedom causing movement of the first element of each transmitter, and movement of the steering element according to the second degree of freedom causing movement of the second element of each transmitter.

3. A watercraft as claimed in claim 1, in which each transmitter comprises two elements whose relative position of the corresponding rudder, and movement of the steering element according to both of the degrees of freedom causes movement of the same element of each transmitter.

4. A watercraft as claimed in any of claims 1 to 3, in which the steering element is kinematically connected to the transmitters by a gear member so that movement of the steering element according to the said one degree of freedom causes synchronous pivoting of the rudders in the same sense as each other, the gear member having helical teeth and being so arranged that movement of the steering element according to the said other degree of freedom causes axial displacement of the gear member resulting in pivoting of the rudders in the opposite sense relative to each other.

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6. A watercraft as claimed in any of claims 1 to 5, in which the movement of the steering element according to the said other degree of freedom occurs between two limiting positions, the steering element being capable of being retained at two predetermined positions between the limiting positions.

7. A watercraft having a propulsion and control system substantially as described with reference to, and as shown in, Figures 1 and 2, Figures 1 and 4, or Figures 1 and 5.