

"Apparatus for setting the direction of movement and
power of a watercraft"

The invention relates to apparatus for setting the direction of movement and the power in this direction of movement of a watercraft which comprises at least two thrust generators arranged in pairs, with at least one drive unit for the thrust generators, the apparatus comprising an input device by which a turning movement of the watercraft about a vertical axis and a non-turning movement in the horizontal plane as well as the power for movement can be set. In the context of the invention thrust generators are to be taken to mean all drive means which are suitable for driving ships mechanically, such as for example rudder propellers, jet drives, and cycloidal propellers.

Apparatus of this type is already known, such as for example a steering device with a single control lever which is mounted in two slotted guides disposed crosswise and rotatable about axes orientated at right angles, and the slotted guides actuate electrical transmitters for controlling a pair of rudder propellers. If the lever is deflected in any direction which is not in an axis of rotation of the slotted

(17)

guides, all the transmitters are actuated (US Patent 3 967 023).

Apparatus of the type described above is also known, by which a ship may be steered to perform slewing (turning) and traversing (longitudinal or transverse motion) by means of a single control lever. The control pulses are transmitted from the lever via pick-ups to the thrust generators which serve various functions. They come into effect both during traversing and during slewing of the ship (published U.K. patent application GB 2 074 115A).

If two or more functions are combined with a coordinate lever and such a control element serves several functions, it is hardly possible to produce a change in the direction of travel without the thrust force also being altered. If the helmsman wishes to perform only one single steering function, he must draw on a great deal of skill and experience in order to be able to do this accurately. In the case of the known apparatus the thrust of the rudder propellers or other thrust generators, for example during forward travel, is stronger than in the transverse direction with the same inclination of the lever. The reason is that in any direction of movement other than straight ahead the rudder propellers or the like are always orientated against one another in some way, namely at different angles.

It would be desirable to avoid these effects, i.e. an apparatus for driving and steering ships and the like should be provided, by means of which all conceivable manoeuvres and movements may be performed, such as for example travel straight ahead and astern, with any desired curves, and also in any desired directions a beam and where appropriate with superimposed slewing, even turning on the spot, so that it is always possible for the helmsman to foresee the propulsion forces without their changing unpredictably when the control lever is moved. It is also very important to prevent steering pulses being inadvertently produced which would endanger the ship.

It would also be desirable to indicate, in a clearly perceptible and visible manner on the input device, i.e. on a lever, handwheel, etc., which direction of the watercraft and what thrust force have been set. In this way a command for thrust reversal for stopping the craft by means of the input device would be made possible for the first time, or at least made easier.

In accordance with the present invention the input device comprises the following elements: (a) a first transmitter, e.g. a potentiometer, exclusively for setting the power of the non-turning movement of the watercraft, and (b) a second transmitter, e.g. a potentiometer, exclusively for setting the direction of

the non-turning movement of the watercraft, a separate independent control element being provided for each transmitter, the arrangement being such that, at a predetermined position of the control element for the first transmitter, the control element for the second transmitter is locked in a position corresponding to forwards and backwards travel.

Since the first transmitter does not affect the power for turning, it is particularly advantageous for the input device to include a third transmitter exclusively for setting the direction and power of the turning of the watercraft, a third control separate independent element being provided for the said transmitter. By virtue of the above features all the movements of the ship are clearly separated from one another at the control desk.

Preferably, the transmitters act upon servo motors for the thrust generators by way of a microcomputer. By virtue of the fact that a special transmitter which is not affected by the other transmitters is provided for each movement function, the microcomputer can control the following functions: thrust of non-turning movement, direction of non-turning movement, direction of turning, force of turning. Furthermore, additional manoeuvring aids may be incorporated, for example transverse-jet rudders. If jet drives are used, not only their rotation but also flaps or the like may be controlled. In the case of cycloidal propellers the blades may be set. In addition, the microcomputer controls the regulation of the drive motor or motors, clutches, and where appropriate the setting of the propeller blade pitch.

In accordance with the invention, at a predetermined position of the control element for the first transmitter, the control element for the second transmitter is locked in the position corresponding to forwards and backwards travel. In this way a very dangerous steering error (application of lateral thrust inadvertently during full forward travel) can be prevented.

The features of claim 5 provide a simple and central combination of the control elements to form one unit. This advantage is enhanced by the feature of claim 6. For avoiding the above-mentioned defective control, the features of claim 7 may be provided. In order that the thrust in the forward and reverse direction may be exerted with greater power than during traversing movement and in order that the helmsman may be aware of these conditions, it is preferable that the available setting range of the control element for the first transmitter is greater in the direction for forwards and reverse than in all other directions.

The invention allows the helmsman to perform all conceivable manoeuvres rapidly, without having to think of the engine speed, propeller pitch, or thrust direction. The movements of the ship may be performed with a precision which is not achieved with manual steering even by experienced operators.

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

5 Fig. 1 is a block diagram of the entire layout of one embodiment of apparatus for setting the direction of movement and power of a watercraft;

Fig. 2 is a vertical section through an input device for the embodiment according to Fig. 1, being a section on line II-II in Fig. 3;

10 Fig. 3 is a plan view and a partial section through the input device;

Fig. 4 is a section on line IV-IV in Fig. 2;

Fig. 5 is a vertical section through an alternative input device;

15 Fig. 6 is a plan view of the input device according to Fig. 5; and

20 Figs. 7 to 16 are diagrammatic examples of the movements of the watercraft and the corresponding state of the input device, namely in each case

a) the movement of the watercraft,

b) the corresponding position of the input device,

c) the corresponding force diagram thrusts, in which S_{BB} signifies port thrust, S_{StB} signifies starboard thrust, and S_{Res} signifies resulting thrust; and

5 Figure 17 is a circuit diagram of the microcomputer in Figure 1.

A general arrangement of an apparatus for driving and steering a watercraft 1, whose centre of gravity is designated 2, is illustrated in the form of a block
10 diagram in Fig. 1. Two rudder propellers 4, 5, which form a pair, are pivotable in known manner about respective vertical pivot axes 6, 7, and are driven by servo motors 8, 9 for this purpose, are provided on both sides of the longitudinal median plane 3 of the
15 watercraft. One or two motors 10, 11 are provided for driving the propellers. Clutches 25a and 25b are interposed between the motors and the propellers.

Three groups of input elements are provided for controlling this drive unit, namely

20 a first potentiometer 12 which is actuated by a lever (first control element) 15 and which changes the thrust force (by way of a microcomputer) by adjusting the pivot angle of the propellers, by changing the speed of the

motor or motors, or by changing the pitch of the propeller blades (Figs. 7 to 9);

a second potentiometer 13 which is actuated by a head (second control element) 16 and which determines the
5 non-turning movement (thrust, traversing) of the watercraft by pivoting the propellers or altering the speed or pitch of the propeller blades (Figs. 12, 13);

a third potentiometer 14 which is actuated by a hand-wheel (third control element) 17 and which determines
10 the slewing of the water craft in accordance with the direction of turning and the force of turning, i.e. specifying the radius of curving and, where appropriate, turning on the spot (Figs. 10, 14, 16).

The three potentiometers 12 to 14 act upon a micro-
15 computer 18. The outputs of the microcomputer act upon displacement-dependent remote-control devices 19 to 24. Such remote-control devices are known. In principle they are amplifiers with an electronic compensating circuit, which adapt the output signals of the microcom-
20 puter to the devices to be controlled, e.g. servo motors, throttle flaps, clutches, and so forth. The microcomputer 18 is programmed in such a way that it converts the command from the transmitters
(potentiometers) into the desired direction of movement
25 (positions of the rudder propellers) and force of

movement (motor regulation, propeller blade pitch). It calculates the necessary rotational speeds and rudder positions. It monitors the values fed in and emitted, the program, and the operating sequence by means of test calculations. It is arranged in each case in accordance with the disposition of the propellers in the watercraft, i.e. whether forward or stern drive is provided, or both. If jet drives are provided instead of rudder propellers, it handles either the angular positions or — if present — the flaps. In the case of cycloidal propellers the blade positions may be incorporated in the program. In addition, transverse-jet rudders or other manoeuvring aids may also be taken into consideration.

For steering the ship the movement of the watercraft is basically separated into two components, namely into traversing (non-turning movement in any direction) and slewing (turning). Both components may be set separately with the input device according to direction and force and are then superimposed.

A setting device 50, in which the transmitters 12, 13, and 14 and the control elements 15, 16, and 17 are combined is shown diagrammatically in Figs. 2 to 4. In a frame 26, the head 16 is mounted so as to be rotatable about a first axis 28 in a bearing 27 rigidly joined to

the frame. The lever 15, which is described in greater detail below, is provided in order to manipulate the head member 16. A gearwheel 29, which meshes with a mating gear 30 secured to the drive shaft of the second potentiometer 13, is secured to the lower end of the head 16.

The head 16 is slotted. In the slot a gearwheel 31 is mounted for rotation about a second axis 32 which is orthogonal to the first axis and intersects. The lever 15 is secured to the gearwheel 31. The gearwheel 31 meshes with an intermediate gear 33. The latter is securely connected to a coaxial intermediate gear 34, which meshes with a toothed rack 35 displaceable along the first axis 28. The toothed rack meshes with a pinion 36 mounted on the drive shaft of the first potentiometer 12.

The handwheel 17 is mounted coaxially with the first axis 28 in the frame, and is rigid with a gearwheel 37 which meshes with a mating gear 38 secured to the drive shaft of the third potentiometer 14.

The bearing 27 is provided with two opposed slots 39, 40 which are parallel to the median plane of the watercraft. The lever 15 fits into these slots in its two outermost positions. Important positions of the

control elements 15, 16, 17 may be marked with locking spheres 41, 42. The end of the bearing 27 is formed as a sliding surface 49 for the lever 15. This is interrupted by the slots 39, 40. In this way the setting angle available for the lever 15 in the direction forward-reverse is greater than in all other directions. Consequently in forward travel and reverse a greater thrust force is exerted than in all other directions and this is perceived by the helmsman. A scale 43 is arranged on the bearing 27 in order to indicate the position of the head 16. A double arrow 44 is formed on the frame in order to indicate the turning angle of $\pm 90^\circ$.

Figs. 5 and 6 show a variation of the input device according to Fig. 2, which relates to the slots for receiving the lever 15. The two input devices are otherwise identical. Whereas in the first embodiment the lever 15 engages in the slots 39, 40 (i.e. the head 16 is not rotatable) only in its outermost position, in the case of the embodiment according to Figs. 5 and 6 slots 45, 46 are extended with shoulders 47, 48 overlapping the head towards the axis 28. In this way the fixing of the head already begins at an angle β of the lever 15.

Figs. 7 to 16 show the cooperation of the input device with the thrust generators, in these examples

therefore with rudder propellers 4, 5. In the diagrams the arrows indicate the direction of the propeller thrusts, the parallel lines the water which is flowing away, and the length of the said lines the propulsion
5 force.

The neutral position is shown in Fig. 7. The lever 15 is on the axis 28, and the head 16 and the handwheel 17 are positioned for forward movement. The thrust directions of the propellers are orientated against one
10 another transversely to the median plane of the watercraft, and the ship does not travel. If the lever 15 is swung forward (Fig. 8) in the direction of the angle α (Fig. 2) in the basic position of the control elements 16 and 17 described, the propellers are swung
15 in opposite directions in such a way that a resulting thrust forward is produced. The ship gets under way. If the lever 15 has covered the entire angle α , the propellers will be parallel to the median plane (Fig. 9). The ship moves full speed ahead. In this position
20 the lever 15 is in the slot 40, and the head 16 is fixed. It is impossible for the ship to be set in a traversing movement, which would be very dangerous in this mode of travel.

If the ship is to be stopped, the lever 15 is swung
25 back. In this connexion it is possible to swing the

lever through zero in the opposite direction. In this way a reversal of thrust takes place, and the ship is immediately braked against the momentary direction of travel. This applies to any non-turning movement of the ship. Reverse travel is controlled with the opposite manipulations.

If the lever 15 is deflected (but not the head 16 turned) and the handwheel 17 actuated, turning is superimposed upon the watercraft during forward and reverse travel, the microcomputer deciding whether the superimposition should occur by a change in the thrust force or by a change in the pivot angles of the thrust generators. Where thrusts are orientated predominantly opposite one another (Fig. 8), a change in thrust force is superimposed, and where thrusts are orientated parallel (Fig. 9) a change in the angles of the thrust generators is superimposed.

If the handwheel 17 is in its neutral position but the head 16 together with the lever 15 is turned about the axis 28, the thrust generators will be steered in such a way with respect to their angle and/or thrust force that a lateral thrust will be produced, namely in the direction in which the lever 15 is pointing or which may be read off on the scale 43, and with a thrust force which depends upon the inclination of the lever 15 (Figs. 12, 13). The thrust angles and thrust forces required in such movements depend upon the arrangement

of the thrust generators with respect to the centre of gravity and upon the dynamic behaviour of the ship, and this should be taken into account in the program of the microcomputer.

5 In order that the resulting thrust should always correspond to the position of the head 16, the corresponding thrust angles and thrust forces are predetermined in the microcomputer (see the length of the lines indicating the thrusts behind the propellers
10 in Fig. 13a).

If the handwheel 17 is also actuated in addition to the control elements 15 and 16, turning of the ship is superimposed upon the traversing movement, Figs. 14 to 16.

15 If the lever 15 is at zero and if the handwheel 17 is rotated, then the ship will turn on the spot.

The entire arrangement for steering a ship may also be such that a control device — a steering wheel, throttle lever — which operates not by way of the
20 microcomputer but in the usual manner, is associated with each thrust generator, e.g. rudder propeller, as well as the above-described apparatus. Alternatively, it may be connected to the above-described apparatus if that is desired for any reason.

The analog signals of the potentiometers 12, 13, 14 are converted into digital signals in the microcomputer 18, Figs. 1, 17, on a suitable analog-digital converter card 51 available commercially. The rudder propeller angles and thrust values, such as engine speed, propeller blade pitch and the like, corresponding to these digital setting values are calculated from the setting values on a computing card, i.e. a microprocessor 52 (for example a module produced by the firm Motorola). These calculations depend upon the arrangement of the rudder propellers in the ship, in particular whether for example two rudder propellers are disposed in the forward or aft area of the ship. Other propeller arrangements may also be taken into consideration. These relationships are stored in the microprocessor 52 so-called EPROMs. (EPROMs are commercially available modules which are supplied for example by the firm Motorola).

The values obtained in this way are then converted into analog signals by means of a digital-analog converter card 53 and fed to the corresponding electronic cards in a basic unit 54 as a setting value. This basic unit 54 essentially contains for each rudder propeller an evaluation logic circuit 55, 55', a control card 56, 56' for the rotational speed setting, a switching or proportional amplifier 57, 57' for the 360° steering of the rudder propellers and/or for controllable pitch

propellers, a coupling card 58, 58' for the coupling and braking circuit and a bus plate (standardized term, meaning base card).

5 In addition, the computer may supply signals for coupling and uncoupling the rudder propellers, which are transmitted to the coupling card in the basic unit of the microcomputer by way of an optical coupling card 59. (An optical coupling card is an optical intermediary member between the computer output and the consumer and is available commercially.)

The entire arrangement may be provided with a switch 61 by which the centre of gravity corresponding to the state of the ship, i.e. whether empty, half-laden or fully laden is taken into consideration.

15 Additionally, the basic unit 54 may be provided with a warning card 60 (watch dog) which produces an acoustic or optical signal if a breakdown occurs.

20 For the arrangement according to the invention and the connexions described, sources are available to which the person skilled in the art can refer, such as the publications of the firms Motorola and Siemens .

CLAIMS

1. Apparatus for setting the direction of movement and the power in this direction of movement of a watercraft which comprises at least two thrust generators arranged in pairs, with at least one drive unit for the thrust generators, the apparatus comprising an input device by which a turning movement of the watercraft about a vertical axis and a non-turning movement in the horizontal plane as well as the power for movement can be set, the input device comprising the following elements:

- a) a first transmitter exclusively for setting the power for a non-turning movement of the watercraft;
- b) a second transmitter exclusively for setting the direction of the non-turning movement of the watercraft;

in which a separate independent control element is provided for each transmitter, and in which, at a predetermined position of the control element for the first transmitter, the control element for the second transmitter is locked in a position corresponding to forwards and backwards travel.



2. Apparatus as claimed in claim 1, in which the input device includes a third transmitter exclusively for setting the direction and power of the turning of the watercraft, a third separate independent control element
5 being provided for the said transmitter.

3. Apparatus as claimed in claim 1 or 2, in which the transmitters act upon servo motors for the thrust generators by way of a microcomputer.

4. Apparatus as claimed in claim 1 or 2, including a
10 microcomputer which controls the power of the thrust generators by changing the speed of the drive unit and/or a characteristic of the thrust generators.

5. Apparatus as claimed in claim 2, comprising

15 a) a head which is non-displaceably pivotable about a first axis and which actuates the second transmitter by way of gearwheels;

b) a lever which is mounted in the head, is pivotable about a second axis orthogonal to the first axis, and is operatively connected by way
20 of gearwheels to a toothed rack which is mounted so as to be longitudinally displaceable and which actuates the first transmitter by way of a pinion;



c) a handwheel which is mounted so as to be rotatable and which is operatively connected by way of gearwheels to the third transmitter.

6. Apparatus as claimed in claim 5, in which the axis of rotation of the handwheel coincides with the first axis.

7. Apparatus as claimed in claim 5, in which a frame member of the input device is provided with at least one slot which matches the lever or a part joined to it and which corresponds to a position of the thrust generators in which a thrust orientated parallel to the median plane of the watercraft is exerted in each case.

8. Apparatus as claimed in claim 1 or 2, in which the transmitters act by way of a micro-computer upon clutches between the drive unit and the thrust generators.

9. Apparatus as claimed in claim 1 or 2, in which the available setting range of the control element for the first transmitter is greater when the control element for the second transmitter is in its position for forwards and reverse than in all other positions.



10. Apparatus for setting the direction of movement and the power in this direction of movement of a watercraft, substantially as described with reference to, and as shown in, the accompanying drawings.
