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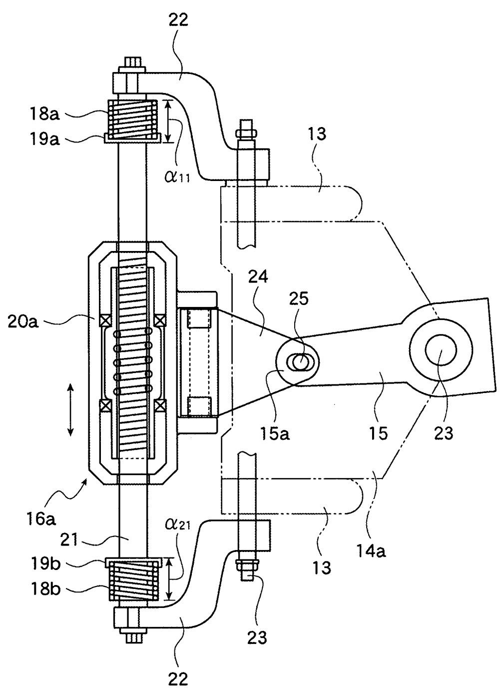
(54) Steering system for a watercraft

(57) The present invention relates to a steering system for a watercraft having a steering actuator (20a,20b, 20c) configured to pivot a watercraft propulsion unit such as an outboard motor (12) relative to a watercraft hull (10) to steer the watercraft propulsion unit (12) from a neutral position to a right/left direction by driving force of the steering actuator (20a,20b,20c), and comprising steering assist means such as cylinders (42a,42b), pistons (43a,43b), supporting member (51) or springs (18a, 18b,62,74,84), for generating predetermined urging force in a direction toward the neutral position when the watercraft propulsion unit (12) is steered in at least one of the right direction and the left direction relative to the neutral position.

[FIG. 2]



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Description

[0001] This invention relates to a steering system for a watercraft and to a watercraft with such a steering system, both electrically connecting a steering means and an outboard motor to each other.

[0002] Conventionally, in this kind of watercraft steering systems, there is one described in Patent Document 1. That is, in the Patent Document 1, an outboard motor functioning as a watercraft propulsion unit having an internal combustion engine, a propeller (screw) for advancing, a rudder, etc. is disposed outside of a watercraft hull, a steering motor functioning as a steering actuator for steering the outboard motor in a right/left direction is provided in a coupling portion between the watercraft hull and the outboard motor, and the steering motor and a steering wheel (steering means) disposed at a cockpit are connected to each other via a signal cable through which signals can be transmitted and received. The steering wheel has a rotational angle sensor. The steering motor rotates based upon a rotational direction and a rotational angle of the steering wheel detected by the rotational angle sensor to steer the outboard motor.

[0003] FIG. 10 is a schematic illustration showing relationships between steered angles of a conventional outboard motor and torque necessary for steering operations. FIG. 10, as is explained in "the way for understanding the figure," the horizontal axis indicates steering angles ("0" represents a steering angle 0°, and the right side range relative to the position of "0" represents right directional steering angles, while the left side range relative to the position of "0" represents left directional steering angles), and the vertical axis represents magnitudes of the torque necessary for the steering operations (it is depicted that the higher the location is in FIG. 10 the larger the torque is when the outboard motor is steered rightward, and it is depicted that the lower the location is in FIG. 10 the larger the torque is when the outboard motor is steered leftward). Also, regarding the torque necessary to steer, it is depicted that the higher the location (the first quadrant) is in FIG. 10 the larger the torque is when steered rightward (the right side range relative to the vertical axis), and it is also depicted that the lower the location (the third quadrant) is in FIG. 10 the larger the torque is when steered leftward (the left side range relative to the vertical axis). On the other hand, regarding the torque necessary to steer back, it is depicted that the lower the location (the fourth quadrant) is in FIG. 10 the larger the torque is when steered back from the right direction (the right side range relative to the vertical axis), and it is also depicted that the higher the location (the second quadrant) is in FIG. 10 the larger the torque is when steered back from the left direction (the left side range relative to the vertical axis).

[0004] As shown in FIG. 10, when the outboard motor is steered rightward from the steered angle 0° (in the situation indicated by the arrow (1) of FIG. 10) and also when the outboard motor is steered leftward from the steered angle 0° (in the situation indicated by the arrow (3) of FIG. 10), the necessary torque is the maximum at the steered angle 0°, and the larger the steered angle the smaller the necessary torque. On the other hand, when the outboard motor is steered back in the direction toward the steered angle 0° under a condition that the outboard motor has been rightward steered (in the situation indicated by the arrow (2) of FIG. 10) and also when the outboard motor is steered back in the direction toward the steered angle 0° under a condition that the outboard motor has been leftward steered (in the situation indicated by the arrow (4) of FIG. 10), the larger the steered angle the larger the necessary torque, and the smaller the steered angle the smaller the necessary torque.

[0005] Patent Document 1: JP-B-2959044

[0006] In this connection, if the watercraft turns when the watercraft is running, the water pressure is added to the outboard motor in a direction in which the outboard motor is steered. Therefore, as shown in the schematic illustration of FIG. 10, larger steering torque is necessary when the outboard motor that has been once steered rightward or leftward is steered to a neutral position (the position of the steered angle 0 degree at which a fore to aft direction of the outboard motor extends along a fore to aft direction of the watercraft). This is described as "steered back" through this specification. Compared thereto, when the outboard motor is steered in a direction in which the steered angle becomes larger either in the right direction or the left direction, this is described as "steered" through this specification.

[0007] However, because no mechanism coping with such an imbalance of the steering torque is applied in the steering system described in the cited Document 1, there is a problem that the steering torque required when the outboard motor is steered back is larger than the steering torque required when the outboard motor is steered. Also, the steering torque necessary to steer the outboard motor varies in accordance with a magnitude, a direction, etc. of a propeller rotation reaction force generated by rotation of a propeller (screw) applied to the outboard motor (for example, as shown in the schematic illustration of FIG. 10, the maximum steering torque A for being steered in one direction is larger than the maximum steering torque B for being steered in the other direction). Thus, there is another problem, in the steering system described in the cited Document 1, that the operational feeling caused when the outboard motor is steered back from the particular direction is not good due to the various conditions.

[0008] The present invention is made in view of the problems described above, and it is an objective thereof to provide a steering system for a watercraft that can make a steering operation with good feeling when a watercraft propulsion unit that has been steered in a right/left direction is steered back to a neutral position, and also to provide a watercraft in which the watercraft steering system is incorporated.

[0009] This objective is solved in an inventive manner by a steering system for a watercraft having a steering actuator configured to pivot a watercraft propulsion unit relative to a watercraft hull to steer the watercraft propulsion unit from a neutral position to a right/left direction by driving force of the steering actuator, and comprising steering assist means for generating predetermined urging force in a direction toward the neutral position when the watercraft propulsion unit is steered in at least one of the right direction and the left direction relative to the neutral position.

[0010] Preferably, the steering assist means is configured to apply the urging force to the steering actuator when a steered angle of the watercraft propulsion unit is in a predetermined angle range including the maximum steered angle.

[0011] Further, preferably the steering assist means is configured to apply the urging force in an opposite direction relative to a direction in which propeller rotation reaction force, generated when the watercraft propulsion unit is driven, acts.

[0012] According to a preferred embodiment, the steering system further comprises a shaft whose axial direction is arranged along the right/left direction of the watercraft hull, wherein the steering actuator is disposed movably along the axial direction of the shaft.

[0013] According to another preferred embodiment, the steering system further comprises a joint bracket attached to the steering actuator, and a swivel shaft whose axis is a pivot center for the joint bracket and for the watercraft propulsion unit.

[0014] Preferably, the steering assist means are urging means disposed at end portions of the shaft and for pressing the steering actuator in the direction toward the neutral position.

[0015] Further, preferably the steering assist means are urging means for moving the steering actuator parallel in a forward direction of the watercraft hull.

[0016] Still further, preferably the steering assist means are urging means disposed in a steered direction of the watercraft propulsion unit and for pressing a portion of the watercraft propulsion unit when the watercraft steering unit is steered.

[0017] Therein, it is beneficial if the urging means are formed with at least one of a cylinder and piston combination, a spring and a torsion spring.

[0018] It is further beneficial if the steering actuator is an electrically operable actuator.

[0019] There is further provided a watercraft having a watercraft propulsion unit and a steering system according to one of the above embodiments mounted to the watercraft.

[0020] In the following, the present invention is explained in greater detail with respect to several embodiments thereof in conjunction with the accompanying drawings, wherein:

FIG. 1 is a top plan view of a watercraft according to a first embodiment,

FIG. 2 is an enlarged top plan view of a steering device for the watercraft according to the embodiment, showing a portion thereof as a cross sectional view,

FIG. 3 is a functional block diagram of a control system for the watercraft according to the embodiment,

FIG. 4 is a schematic illustration showing relationships between steered angles of an outboard motor according to the embodiment and torque necessary for steering operations thereof,

FIG. 5 is an enlarged top plan view of a steering device for a watercraft according to a second embodiment, showing a portion thereof as a cross sectional view,

FIG. 6 is a partial, enlarged side elevational view of a steering device for a watercraft according to a third embodiment,

FIG. 7 is a partial, enlarged top plan view of a steering device for a watercraft according to a fourth embodiment,

FIG. 8 is a partial, enlarged top plan view of a steering device for a watercraft according to a fifth embodiment,

FIG. 9 is a partial, enlarged top plan view of a steering device for a watercraft according to a sixth embodiment, and

FIG. 10 is a schematic illustration showing relationships between steered angles of a conventional outboard motor and torque necessary for steering operations thereof.

Description of Reference Numerals and Symbols:

[0021]

10: watercraft hull
12: outboard motor (watercraft propulsion unit)
14: swivel shaft
15, 61: steering bracket
18a, 18b: spring (steering assist means, urging means)
20a, 20b, 20c: electric motor (steering actuator, electrically operable actuator)
21: screw bar (shaft)
22, 53: joint bracket
42a, 42b: cylinder (steering assist means, urging means)
43a, 43b: piston (steering assist means, urging

means)

51: supporting member (steering assist means, urging means)

62, 74, 84: spring (steering assist means, urging means)

[0022] Hereunder, embodiments will be described.

Embodiment 1

[0023] FIGs. 1 through 3 depict a first embodiment.

[0024] First, describing the structure, as shown in FIG. 1, a watercraft of this first embodiment has an outboard motor 12 functioning as a "watercraft propulsion unit," mounted to a transom 11 of a watercraft hull 10 via a clamping bracket 13. The outboard motor 12 is pivotable about an axis of a swivel shaft (steering pivot shaft) 14 extending vertically.

[0025] A steering bracket 15 is fixed to a top end of the swivel shaft 14. A steering device 16a is coupled with a front end 15a of the steering bracket 15. The steering device 16a is operated by a steering wheel 17 disposed at a cockpit and is driven.

[0026] As shown in FIG. 2, the steering device 16a has, for example, a DD (direct drive) type electric motor 20a functioning as a "steering actuator" and an "electrically operable actuator." The electric motor 20a is mounted to a screw bar 21 functioning as a "shaft" extending in a right/left direction and is structured to move in the right/left direction along the screw bar 21.

[0027] The screw bar 21 is supported at both ends thereof by supporting members 22 each of which is one of a right and left pair. The supporting members 22 are supported by a tilt shaft 23.

[0028] A joint bracket 24 is projected rearward from the electric motor 20a. The joint bracket 24 and the steering bracket 15 are coupled with each other through a coupling pin 25.

[0029] Thereby, it is constructed so that, when the electric motor 20a operates and moves in the right/left direction relative to the screw bar 21, the outboard motor 12 pivots about the axis of the swivel shaft 14 through the joint bracket 24 and the steering bracket 15.

[0030] Springs 18a, 18b functioning respectively as "steering assist means" and "urging means" are placed at the respective ends of the screw bar 21. Each spring 18a, 18b is a coil spring whose inner diameter is slightly larger than the screw bar 21, and is interposed between an end of the respective supporting member 22 and a circular stopper 19a, 19b placed adjacent to the respective end of the screw bar 21. Because the "steering assist means" and the "urging means" are formed with the mechanical structures such as the springs 18a, 18b, the assist force can be surely applied to the electric motor 20a with the simple construction.

[0031] The resilient force of the springs 18a, 18b are decided in such a manner that one of them placed on a side where the propeller rotation reaction force generated when the outboard motor 12 is steered back is large is greater than the other placed on another side where the propeller rotation reaction force is small.

[0032] A magnitude of the resilient force of each spring 18a, 18b is decided based upon a steering torque amount required by the electric motor 20a. Specifically, the resilient force of the spring (herein, the spring 18a) placed on the side where the propeller rotation reaction force generated when the outboard motor is steered back is large is greater than the spring (herein, the spring 18b)placed on the other side where the propeller rotation reaction force generated when the outboard motor is steered back is small by an amount which is resulted when the maximum steering torque of one side is subtracted from the maximum steering torque of the other side (for example, in FIG. 4, by an amount which is resulted when the maximum steering torque of one side B is subtracted from the maximum steering torque of the other side A). As thus set, the imbalance of the steering torque of the electric motor 20a is corrected.

[0033] Further, the resilient force of each spring 18a, 18b is also decided based upon physical amounts such as, weights of the outboard motor 12 and the watercraft hull 10, affecting the steering torque of the electric motor 20a when the outboard motor 12 is steered. Specifically, the larger the weights of the outboard motor 12 and the watercraft hull 10 are, the larger the resilient force of the springs 18a, 18b is set.

[0034] Additionally, although the following has no direct relationship with this embodiment, if the present teaching is applied to a watercraft having a plurality of outboard motors 12 mounted on the watercraft hull 10, set positions of the respective outboard motors relative to the watercraft hull are used as one of the physical amounts that are bases for the resilient setting of the springs 18a, 18b. Specifically, if the respective outboard motors are placed near the center of the transom 11, the resilient force of each spring 18a, 18b is set to be small. To the contrary, if the respective outboard motors are placed near the outer ends of the transom 11, the resilient force of each spring 18a, 18b is set to be large.

[0035] On the other hand, as shown in FIG. 1, the steering wheel 17 is fixed to a steering shaft 26. A steering wheel control section 27 is disposed at a bottom end of the steering shaft 26. The steering wheel control section 27 has a steering wheel operation angle sensor 28 which detects an operation angle of the steering wheel 17 and a reaction motor 29 which applies desired reaction force to the steering wheel 17 when the steering wheel 17 is operated.

[0036] A system is constructed in such a manner that the steering wheel section 27 is connected to a control unit (ECU: engine control unit) 31 through a signal cable 30, the control unit 31 is connected to the electric motor 20a of the steering device 16a, a signal from the steering wheel operation angle sensor 28 is inputted to the control unit 31, and the control unit 31 controls and drives the electric motor 20a and also controls the reaction motor

29.

[0037] Detection signals indicative of a steering condition of the steering wheel 17, a steered condition of the outboard motor 12, a running condition of the watercraft hull 10, etc. are supplied to the control unit 31 from various detecting means 32 provided to portions of the watercraft hull 10 and the outboard motor 12. The various detecting means 32 include, for example, a torque sensor detecting steering torque necessary for steering the outboard motor in accordance with an operation of the steering wheel, an outboard motor steered angle sensor detecting present steered angle, steered speed, steered direction of the outboard motor 12, deviation detecting means for detecting steered angle deviation in accordance with the operation of the steering wheel, weight detecting means for detecting the waterline and weight of the watercraft, a trim angle sensor detecting a trim angle of the watercraft, a speed sensor detecting speed, acceleration, thrust of the watercraft, an output of the outboard motor, and so forth.

[0038] Further, steering storing means 34 for storing information about the number of outboard motors 12, mount positions of the outboard motors 12 relative to the watercraft and rotational directions of the propeller 33 provided to each outboard motor 12 (see FIG. 3), and for outputting the information based upon requests of the control unit 31 are connected to the control unit 31. Of course, the steering storing means 34 can be built in the control unit 31.

[0039] Next, actions of this embodiment will be described.

[0040] First, when the steering wheel 17 is pivoted by a preset amount by a watercraft operator, detection signals of the steering wheel operation angle sensor 28 and the various detecting means 32 are transmitted to the control unit 31. Further, detection signals and various signals are transmitted to the control unit 31 from the various detecting means 32. The control unit 31 calculates steering torque necessary for steering the outboard motor 12 and a steering angle, steering speed, steering direction, etc. of the steering in accordance with the steering wheel operation based upon those detection signals and various pieces of information and also various pieces of information stored in the steering storing means 34. The control unit 31 rotates the electric motor 20a based upon those signals and the calculation results. When the electric motor 20a rotates, the motor 20a moves in the right/left direction along the screw bar 21, and the outboard motor 12 pivots about the axis of the swivel shaft 14 to change its direction.

[0041] For example, a situation in which the outboard motor 12 is fully steered leftward (lower side of FIG. 2) will be considered. When the steering wheel 17 is operated counterclockwise, the electric motor 20a pivots in one direction and moves rightward on the screw bar 21 (upper side of FIG. 2) to the vicinity of the right end of the screw bar 21. On this occasion, an end portion of the electric motor 20a presses the spring 18a in a contacting zone $\alpha 11$ where the electric motor 20a and the stopper 19a contact with each other. When, under this condition, the steering wheel 17 is operated clockwise to steer back the outboard motor, the electric motor 20a pivots in the other direction. On this occasion, the resilient force of the spring 18a is added to the electric motor 20a in the contacting zone $\alpha 11$. The electric motor 20a thus moves toward the center on the screw bar 21 by the resilient force of the spring 18a in addition to the rotational force of its own. On the other hand, when the outboard motor 12 is steered back after being fully steered rightward, the electric motor 20a moves on the screw bar 21 in the contacting zone $\alpha 21$ toward the center by the resilient force of the spring 18b in addition to the rotational force of its own.

[0042] As discussed above, in this embodiment, the springs 18a, 18b pressing the electric motor 20a in the axial direction of the screw bar 21 are provided at the ends of the screw bar 21; thereby, the electric motor 20a is moved in the right/left direction along the screw bar 21 to steer the outboard motor 12. In this construction, the assist force can be surely applied to the electric motor 20a with the simple structure.

[0043] Also, in this embodiment, when the electric motor 20a is in the contacting zone $\alpha 11$, i.e., when the steered angle of the outboard motor 12 is in a predetermined angular range including the maximum steered angle, the springs 18a, 18b can assist the steering torque of the electric motor 20a by applying the assist force to the electric motor 20a at a time that the steering torque amount necessary for steering back the outboard motor 12 is the maximum or almost the maximum.

[0044] Also, in this embodiment, either one of the springs 18a, 18b applies the assist force on the side where the propeller rotation reaction force generated when the outboard motor 12 is steered back is large; thereby, the spring 18a, 18b can assist the steering torque of the electric motor 20a in the steering direction in which the steering torque necessary for steering back the outboard motor 12 is the maximum.

[0045] Also, in this embodiment, the assist force of the springs 18a, 18b are decided based upon the steering torque applied when the outboard motor 12 is steered back, and the respective weights of the watercraft hull 10 and the outboard motor 12 provided as the physical amounts affecting the steering torque. Therefore, the resilient force of the springs 18a, 18b is decided in a manner such that proper assist force is applied to the electric motor 20a.

[0046] FIG. 4 is a schematic illustration showing relationships between steered angles of the outboard motor 12 and torque necessary for steering operations in this embodiment. This figure is the illustration showing the relationships between steered angles of the outboard motor 12 and the torque necessary for the steering operations, similarly to the schematic illustration of FIG. 10 described above.

[0047] As shown in the schematic illustration of this FIG. 4, in the situation that the outboard motor 12 that has been steered in the right/left direction is steered back, the imbalance appearing between the steering torque applied when the outboard motor is steered back from one side and the steering torque applied when the outboard motor is steered back from the other side can be corrected.

[0048] In this embodiment, the load added to the electric motor 20a when the outboard motor 12 is steered back can be decreased. Specifically, as shown in the schematic illustration of FIG. 4, the assist force of the respective springs 18a, 18b is added to the electric motor 20a at an angle of $\alpha 1$ in the contacting zone $\alpha 11$ (see FIG. 2) and at an angle of $\alpha 2$ in the contacting zone $\alpha 21$ (see FIG. 2). As a result, a torque value T1 applied when the outboard motor is steered back decreases more than a torque value T2 applied when the outboard motor is steered back without the assist force. Thereby, the steering operation can be made with good feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

[0049] Additionally, in this embodiment, the structure in which the springs 18a, 18b are provided at both of the ends of the screw bar 21 is employed. Alternatively, another structure in which a spring is provided only at one of the ends on the side where the propeller rotation reaction force generated when the outboard motor 12 is steered back is large can be employed.

Embodiment 2

[0050] FIG. 5 shows a second embodiment.

[0051] In this embodiment, a steering device 16b shown in FIG. 5 replaces the steering device 16a disposed in the watercraft of the embodiment 1. As shown in FIG. 5, the electric motor 20b of the steering device 16b has pressing projections 41a, 41b at both ends.

[0052] Each pressing projection 41a, 41b generally has a cylindrical shape whose inner diameter is slightly larger than an outer diameter of the screw bar 21 and is disposed over the screw bar 21.

[0053] Also, in this embodiment, an end of each supporting member 22 has a cylinder 42a, 42b. A piston 43a, 43b is disposed in each cylinder 42a, 42b. The cylinder 42a, 42b and the piston 43a, 43b together form the "urging member." Each cylinder 42a, 42b generally has a cylindrical shape whose inner diameter is larger than the outer diameter of the screw bar 21, and extends inward in a configuration such that an axial direction thereof extends along the axial direction of the screw bar 21. Each piston 43a, 43b is formed circularly in such a manner that an inner diameter thereof is generally equal to the outer diameter of the screw bar 21 and an outer diameter thereof is generally equal to the inner diameter of the cylinder 42a, 42b. Each piston 43a, 43b is slidable inside of the associated cylinder 42a, 42b in the axial direction of the cylinder 42a, 42b and the screw bar 21. Because the "urging means" are formed with the mechanical structures such as the cylinders 42a, 42b and the pistons 43a, 43b, the assist force can be surely applied to the electric motor 20b with the simple construction.

[0054] The inside of each cylinder 42a, 42b is formed as an air space 44a, 44b. Each air space 44a, 44b encloses gas whose pressure is higher than the atmospheric pressure, such as compressed air.

[0055] A pressure of the air enclosed in the air space 44a, 44b is decided based upon the steering torque amount required by the electric motor 20b, similarly to the resilient force of each spring 18a, 18b in the embodiment 1. Specifically, the air pressure of the air space (herein, the air space 44a) in the cylinder (herein, the cylinder 42a) placed on the side where the propeller rotation reaction force generated when the outboard motor is steered back is large is greater than the air space (herein, the air space 44b) in the cylinder (herein, the cylinder 42b) placed on the other side where the propeller rotation reaction force generated when the outboard motor is steered back is small by an amount which is resulted when the maximum steering torque of one side is subtracted from the maximum steering torque of the other side (for example, by an amount which is resulted when the maximum steering torque of one side B is subtracted from the maximum steering torque of the other side A, shown in FIG. 4). As thus set, the imbalance of the steering torque of the electric motor 20a is corrected.

[0056] Further, the air pressure of each air space is decided based upon physical amounts affecting the steering torque of the electric motor 20b when the outboard motor 12 is steered, such as the weights of the outboard motor 12 and the watercraft hull 10.

[0057] The other construction is the same as the teaching in connection with the embodiment 1.

[0058] Next, actions of this embodiment will be described.

[0059] When the steering wheel 17 is rotated and the electric motor 20b rotates under control of the control unit 31 to move in the right/left direction along the screw bar 21, the outboard motor 12 pivots about the axis of the swivel shaft 14 to change its direction.

[0060] Similarly to the embodiment 1, for example, a situation in which the outboard motor 12 is fully steered leftward (lower side of FIG. 5) will be considered. When the steering wheel 17 is operated counterclockwise and the electric motor 20a moves rightward on the screw bar 21 to the vicinity of the right end of the screw bar 21, the pressing projection 41 a is inserted into the cylinder 42a, and the pressing projection 41a contacts with the cylinder 42a and presses the cylinder 42a toward the end of the screw bar 21. When, under this condition, the steering wheel 12 is operated clockwise, the electric motor 20b starts to move toward the center. On this occasion, in the contacting zone $\alpha 12$ in which the pressing projection 41a and the cylinder 42a contact with each other, the resilient force based upon the air pressure in the air space 44a is added to the electric motor 20b through the piston 43a. Then, when the electric motor 20b placed in the vicinity of the end of the screw bar 21 is returned to the center (i.e., when the outboard motor 12 is returned to the neutral position, starting from the condition under which the outboard motor has been steered to the maximum steered angle), the electric motor 20b moves in the contacting zone α12 toward the center on the screw bar 21 by the resilient force of the piston 43a in addition to the rotational force of its own. Similarly, in the contacting zone α12 on the other side of the screw bar 21, the electric motor 20b moves on the screw bar 21 toward the center by the resilient force of the piston 43b in addition to the rotational force of its own.

[0061] This embodiment also provides the same actions as those of the embodiment 1 and decreases the load of the electric motor 20b generated when the outboard motor 12 is steered back, and the steering operation can be made with good feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

Embodiment 3

[0062] FIG. 6 shows an embodiment.

[0063] In this embodiment, a steering device 16c replaces the steering device 16a of the embodiment 1. In the steering device 16c, an electric motor 20c replaces the electric motor 20a and a pair of supporting members 51 functioning as the "urging means" replaces the pair of supporting members 22 supporting the screw bar 21. Each supporting member 51 includes a coupling body 52a, a generally cylindrically shaped post 52b and a spring 52c positioned around the post 52b. The post 52b is retractably formed because of being inserted into and drawn out from the interior of the coupling body 52a in the fore to aft direction (right/left direction in FIG. 6). One end of the coupling bracket 53 is coupled with a top portion of the electric motor 20c, while the other end of the coupling bracket 53 is coupled with the steering bracket 15 through a connecting pin 54.

[0064] The other construction is the same as the embodiment 1.

[0065] Next, actions of this embodiment will be described.

[0066] When the steering wheel 17 is rotated and the electric motor 20c rotates under control of the control unit 31 to move in the right/left direction along the screw bar 21, the outboard motor 12 pivots about the axis of the swivel shaft 14 to change its direction.

[0067] On this occasion, the screw bar 21 and the clamping bracket 13 are pressed by the urging force of the spring 52c in a direction in which the screw bar 21 and the clamping bracket 13 are separated from each other. Therefore, the closer the electric motor 20c approaches the end of the screw bar 21, the longer the posts 52b of the respective supporting members 51 extend in the fore to aft direction. As a result, a distance from the electric motor 20c to the axis of the swivel bracket 14 (not shown in FIG. 6) that is the pivot center when the outboard motor is steered becomes farther. Accordingly, the larger the steered angle of the outboard motor 12 is, the farther the distance from the pivot center is at which the electric motor 20c applies the pivot force to the steering bracket 15. In other words, the larger the steered angle of the outboard motor 12 is, the lower the load that is instantly added to the electric motor reduces. The steering torque of the electric motor 20c required when the outboard motor is steered back decreases (that is necessary per unit time).

Embodiment 4

[0068] FIG. 7 shows an embodiment.

[0069] In this embodiment, a steering device 16d replaces the steering device 16a of the embodiment 1. In the steering device 16d, a steering bracket 61 replaces the steering bracket 15. The steering bracket 61 has a spring 62 functioning as the "urging means" positioned at one side thereof that is the side where the propeller rotation reaction force generated when the outboard motor 12 is steered back is larger than that on the other side. The spring 62 is a coil spring, and one end thereof is fastened to the steering bracket 61. Also, the swivel bracket 14a disposed below the steering bracket 61 has a stopper 63 projecting at a position where the spring 62 touches the stopper 63 when the steering bracket 61 fully pivots.

[0070] The resilient force of the spring 62 is decided based upon the steering torque amount required to the electric motor 20a (not shown in FIG. 7). Specifically, the resilient force of the spring 62 is set to be a magnitude which is resulted when the maximum steering torque of one side is subtracted from the maximum steering torque of the other side (for example, in FIG. 4, a magnitude which is resulted when the maximum steering torque of one side B is subtracted from the maximum steering torque of the other side A).

[0071] The other construction is the same as the embodiment 1.

[0072] Next, actions of this embodiment will be described.

[0073] Assuming that the outboard motor 12 is fully steered to the other side (right side in FIG. 7), when the steering wheel 17 is rotated in the other direction, the electric motor 20a rotates in one direction (left side in FIG. 7) and moves leftward on the screw bar 21 to reach the vicinity of the left end of the screw bar 21. On this occasion, the stopper 63 touches the spring 62 and the resilient force of the spring 62 is added to the stopper 63 in a contacting zone α13 where the stopper 63 and the spring 62 contact with each other. Then, when the electric motor 20a placed in the vicinity of the left end of the screw bar 21 is returned to the center (i.e., when the outboard motor 12 is returned to the center, starting from the condition under which the outboard motor has been steered to the maximum steered angle), the electric motor 20a moves in the contacting zone α13 toward the center on the screw bar 21 by the resilient force of the spring 62 in addition to the rotational force of its own.

[0074] As discussed above, in this embodiment, the load to the electric motor 20a added when the outboard motor 12 is steered back can decrease without a special structure for directly pressing the electric motor 20a being provided, and the steering operation can be made with good feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

[0075] Additionally, in the embodiment 4 described above, the spring 62 and the stopper 63 are placed on the one side where the steering torque for steering the outboard motor becomes large. However, the spring and the stopper can be placed on the other side to reduce the load added to the electric motor 20a when the steering torque of both of the sides becomes the maximum.

Embodiment 5

[0076] FIG. 8 shows a fifth embodiment.

[0077] In this embodiment, a steering bracket 71 replaces the steering bracket 15 in the embodiment 1. The steering bracket 71 has a structure in which one end of a first member 72 provided on the swivel shaft side and one end of a second member 73 provided on the joint bracket 24 side are coupled with each other by a spring 74 functioning as the "urging means." The spring 74 is a coil spring, and provides high resilient force and also provides high urging force in its returning direction against pulling force pulling the first member 72 and the second member 73 in a direction in which those members are separated from each other. Additionally, if having the same functions, springs other than the coil spring or resilient members other than those springs can be employed for forming the "urging means."

[0078] The other construction is the same as the embodiment 1.

[0079] Next, actions of this embodiment will be described.

[0080] When the steering wheel 17 is rotated and the electric motor 20a (not shown in FIG. 8) rotates under control of the control unit 31 to move in the right/left direction along the screw bar 21 (not shown in FIG. 8), the outboard motor 12 pivots about the axis of the swivel shaft 14 to change its direction. On this occasion, the pulling force pulling the first member 72 and the second member 73 in a direction in which those members are separated from each other is added to the steering bracket 71 existing between the electric motor 20a and the swivel shaft 14. The spring 74 is extended by the pulling force. Thereby, the spring 74 generates the urging force. By the urging force, force F1 affects the second member 73 in the same direction as the pulling force (obliquely left and upper direction in FIG. 8). The force F1 acts as a component of force F2 heading to the center of the screw bar 21 with regard to the electric motor 20a mounted to the screw bar 21. Accordingly, if the outboard motor is steered back after being steered, the electric motor 20a is moved on the screw bar 21 toward the center by the component of force F2 in addition to the rotational force of its own.

[0081] As discussed above, in this embodiment, the coil spring 74 extending and contracting the steering bracket 71 in the axial direction thereof is provided; thereby, in the structure that the electric motor 20a is moved in the right/left direction along the screw bar 21 to steer the outboard motor 12, the assist force can be surely applied to the electric motor 20a with the simple construction.

Embodiment 6

[0082] FIG. 9 shows a sixth embodiment.

[0083] In this embodiment, a joint bracket 81 replaces the joint bracket 24 in the watercraft of the embodiment 1. The joint bracket 81 has a structure in which one end of a first member 82 provided on the steering bracket 15 side and one end of a second member 83 provided on the electric motor 20a (not shown in FIG. 9) side are coupled with each other by a spring 84 functioning as the "urging means." The spring 84 is a coil spring, and provides high resilient force and also provides high urging force in its returning direction against pulling force pulling the first member 82 and the second member 83 in a direction in which those members are separated from each other. Additionally, if having the same functions, springs other than the coil spring or resilient members other than those springs can be employed for forming the "urging means."

[0084] The other construction is the same as the embodiment 1.

[0085] Next, actions of this embodiment will be described.

[0086] When the steering wheel 17 is rotated and the electric motor 20a rotates under control of the control unit 31 to move in the right/left direction along the screw bar 21 (not shown in FIG. 9), the outboard motor 12 pivots about the axis of the swivel shaft 14 to change its direction. On this occasion, the pulling force pulling the first member 82 and the second member 83 in a direction such that those members are separated from each other is added to the joint bracket 81 existing between the electric motor 20a and the swivel shaft 14. The spring 84 is extended by the pulling force. Thereby, the spring 84 generates the urging force. By the urging force, force F11 affects the first member 82 in the opposite direction against the pulling force (lower direction in FIG. 9). The force F11 acts as a moment M which pivots about the axis of the swivel shaft 14 in a direction in which the outboard motor is steered back (lower direction in FIG. 9) in the steering bracket 15. The moment acts as a component of force F12 heading to the center of the screw bar with regard to the electric motor 20a. Accordingly, if the outboard motor is steered back after being steered, the electric motor 20a is moved on the screw bar 21 toward the center by the component of force F12 in addition to the rotational force of its own.

[0087] As discussed above, in this embodiment, the coil spring 84 extending and contracting the joint bracket 81 in the axial direction thereof is provided; thereby, in the structure that the electric motor 20a is moved in the right/left direction along the screw bar 21 to steer the outboard motor 12, the assist force can be surely applied to the electric motor 20a with the simple construction.

[0088] Although the urging means are formed with the cylinders and the pistons, or the springs in the embodiments 1, 2 and 4 discussed above, torsion springs can be employed for forming the urging means.

[0089] In the respective embodiments discussed above, the structures reducing the load added to the steering motor 20a, 20b, 20c are provided each by each. However, combinations of two or more structures provided in the respective embodiments are also applicable to further reduce the load added to the electric motor 20a, 20b, 20c.

[0090] In the respective embodiments discussed above, the "steering actuator" is formed with the electric motor 20a, 20b, 20c functioning as the "electrically operable actuator". However, the "steering actuator" is not limited to the electric motor and can be formed with an actuator driven by power other than the electric power.

[0091] In the respective embodiments discussed above, the "shaft" on which the electric motor 20a, 20b, 20c is provided is formed with the screw bar 21. However, a "shaft" other than the screw bar 21 can be used for providing the "steering actuator."

[0092] Although the outboard motor 12 is applied as the "watercraft propulsion device" in the respective embodiments discussed above, the "watercraft propulsion device" is not limited to the outboard motor and an inboard and outboard unit is of course applicable.

[0093] The respective embodiments discussed above are exemplarily provided, and it goes without saying that it does not mean that the present teaching is limited to the respective embodiments.

[0094] The description above discloses (amongst others), in order to achieve the objective, according to a preferred first aspect, a steering system for a watercraft which pivots a watercraft propulsion unit in a horizontal direction relative to a watercraft hull to steer the watercraft propulsion unit from a neutral position to a right/left direction by driving force of a steering actuator, and having steering assist means for generating predetermined urging force in a direction toward the neutral position when the watercraft propulsion unit is steered at least one of the right direction and the left direction relative to the neutral position.

[0095] According to a preferred second aspect, in addition to the construction recited in the preferred first aspect, the steering assist means apply the urging force to the steering actuator when a steered angle of the watercraft propulsion unit is in a predetermined angle range including the maximum steered angle.

[0096] According to a preferred third aspect, in addition to the construction recited in the preferred first or second aspect, the steering assist means apply the urging force in an opposite direction relative to a direction in which propeller rotation reaction force generated when the watercraft propulsion unit is driven acts.

[0097] According to a preferred fourth aspect, in addition to the construction recited in any one of the first to third aspects, the watercraft steering system has a shaft whose axial direction arranged along the right/left direction of the watercraft hull, the steering actuator is disposed movably along the axial direction of the shaft, and the steering assist means are urging means disposed at end portions of the shaft and for pressing the steering actuator in the direction toward the neutral position.

[0098] According to a preferred fifth aspect, in addition to the construction recited in any one of the first to fourth aspects, the watercraft steering system has the steering actuator disposed on the shaft, a joint bracket attached to the steering actuator, and a swivel shaft whose axis that is a pivot center for the joint bracket and for the watercraft propulsion unit, and the steering assist means are urging means for moving the steering actuator parallel in a forward direction of the watercraft hull.

[0099] According to a preferred sixth aspect, in addition to the construction recited in any one of the first to fifth aspects, the steering assist means are urging means disposed in a steered direction of the watercraft propulsion unit and for pressing a portion of the watercraft propulsion unit when the watercraft steering unit is steered.

[0100] According to a preferred seventh aspect, in addition to the construction recited in any one of the fourth to sixth aspects, the urging means are formed with at least one of a cylinder and piston combination, a spring and a torsion spring.

[0101] According to a preferred eighth aspect, in addition to the construction recited in any one of the first to seventh aspects, the steering actuator is an electrically operable actuator.

[0102] The description above further discloses a watercraft in which the watercraft propulsion unit according to any one of the first to eighth aspects is mounted to the watercraft.

[0103] According to the teaching of the first aspect, because, in the watercraft steering system, the steering assist means is provided for generating the predetermined urging force in the direction toward the neutral position when the watercraft propulsion unit is steered at least one of the right direction and the left direction relative to the neutral position, the steering assist means generate the urging force in the same direction as the steering actuator when the watercraft propulsion unit is steered back in the direction toward the neutral position after the propulsion unit was steered to decrease loads to the steering actuator. Thereby, a steering operation can be made with good feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

[0104] According to the teaching of the second aspect, because the urging force is applied to the steering actuator when the steered angle of the watercraft propulsion unit is in the predetermined angle range including the maximum steered angle, the steering torque of the steering actuator is assisted at a moment that the steering torque amount necessary for steering the watercraft propulsion unit is the maximum or almost the maximum and thus the steering torque of the steering actuator can be decreased. Thereby, the steering operation can be made with better feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

[0105] According to the teaching of the third aspect, because the steering assist means apply the urging force in the opposite direction relative to the direction in which the propeller rotation reaction force generated when the watercraft propulsion unit is driven acts, the steering assist means assist the steering torque of the steering actuator in the steering direction in which the steering torque amount necessary for steering the watercraft propulsion unit is the maximum and thus the steering torque of the steering actuator can be decreased. Thereby, the steering operation can be made with better feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

[0106] According to the teaching of the fourth aspect, the watercraft steering system has the shaft whose axial direction arranged along the right/left direction of the watercraft hull, the steering actuator is disposed movably along the axial direction of the shaft, and the steering assist means are urging means disposed at end portions of the shaft and for pressing the steering actuator in the direction toward the neutral position. Therefore, in the watercraft steering system that steers the watercraft propulsion unit by moving the steering actuator in the right/left direction along the shaft, the assist force can be surely applied to the steering actuator with the simple construction, and the steering torque of the steering actuator can be decreased. Thereby, the steering operation can be made with better feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

[0107] According to the teaching of the fifth aspect, the watercraft steering system has the steering actuator disposed on the shaft, the joint bracket attached to the steering actuator, and the swivel shaft whose axis is the pivot center for the joint bracket and for the watercraft propulsion unit, and the steering assist means are urging means for moving the steering actuator parallel in a forward direction of the watercraft hull. Therefore, the closer the steering actuator approaches the end portion of the shaft, the more forward the steering actuator moves relative to the watercraft hull by the urging force of the urging means. The larger the steering torque, the farther the distance between the steering actuator and the swivel axis. The steering torque of the steering actuator required when the propulsion unit is steered back can be decreased. Thereby, the steering operation can be made with better feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

[0108] According to the teaching of the sixth aspect, because the steering assist means are the urging means disposed in the steered direction of the watercraft propulsion unit and for pressing the portion of the watercraft propulsion unit when the watercraft steering unit is steered, the assist force can be applied to the steering actuator without a special structure being added for directly pressing the steering actuator and thus with a simple construction. Thereby, the steering operation can be made with better feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

[0109] According to the teaching of the seventh aspect, because the urging means are formed with at least one of a cylinder and piston combination, a spring and a torsion spring, an urging member can be formed with a mechanical structure. Thereby, the assist force can be surely applied to the steering actuator with the simple construction.

[0110] According to the teaching of the eighth aspect, because the steering actuator is the electrically operable actuator, in the actuator driven by the electric power, the steering operation can be made with good feeling when the watercraft propulsion unit that has been steered in the right/left direction is steered back to the neutral position.

[0111] According to the teaching of the ninth aspect, the watercraft in which the watercraft steering system having the above effects is incorporated can be provided.

[0112] Thus, according to a preferred first aspect, the description discloses a steering system for a watercraft which pivots a watercraft propulsion unit in a horizontal direction relative to a watercraft hull to steer the watercraft propulsion unit from a neutral position to a right/left direction by driving force of a steering actuator, wherein the steering system comprises steering assist means for generating predetermined urging force in a direction toward the neutral position when the watercraft propulsion unit is steered at least one of the right direction and the left direction relative to the neutral position.

[0113] Further, according to a preferred second aspect, the steering assist means apply the urging force to the steering actuator when a steered angle of the watercraft propulsion unit is in a predetermined angle range including the maximum steered angle.

[0114] Further, according to a preferred third aspect, the steering assist means apply the urging force in an opposite direction relative to a direction in which propeller rotation reaction force generated when the watercraft propulsion unit is driven acts.

[0115] Further, according to a preferred fourth aspect, the watercraft steering system has a shaft whose axial direction arranged along the right/left direction of the watercraft hull, the steering actuator is disposed movably along the axial direction of the shaft, and the steering assist means are urging means disposed at end portions of the shaft and for pressing the steering actuator in the direction toward the neutral position.

[0116] Further, according to a preferred fifth aspect, the watercraft steering system has the steering actuator disposed on the shaft, a joint bracket attached to the steering actuator, and a swivel shaft whose axis that is a pivot center for the joint bracket and for the watercraft propulsion unit, and the steering assist means are urging means for moving the steering actuator parallel in a forward direction of the watercraft hull.

[0117] Further, according to a preferred sixth aspect, the steering assist means are urging means disposed in a steered direction of the watercraft propulsion unit and for pressing a portion of the watercraft propulsion unit when the watercraft steering unit is steered.

[0118] Further, according to a preferred seventh aspect, the urging means are formed with at least one of a cylinder and piston combination, a spring and a torsion spring.

[0119] Further, according to a preferred eighth aspect, there is provided a watercraft steering system wherein the steering actuator is an electrically operable actuator.

[0120] Further, according to a preferred ninth aspect, there is provided a watercraft wherein the watercraft propulsion unit is mounted to the watercraft.

[0121] Further, according to a preferred embodiment, in order to provide a watercraft steering system and a watercraft both of which can make a steering operation with good feeling when a watercraft propulsion unit that has been steered in a right/left direction is steered back to a neutral position, in a watercraft having an electric motor 20a mounted on a screw bar 21 extending in a right/left direction, the electric motor 20a moving along the screw bar 21 in the right/left direction to steer an outboard motor 12, springs 18a, 18b are provided at both ends of the screw bar 21. When the outboard motor 12 whose steered angle exists in a predetermined angle range including the maximum steered angle is steered back to a neutral position, either one of the springs 18a, 18b presses the electric motor 20a toward the center of the screw bar 21 to assist the steering torque of the electric motor 20a.

Claims

1. Steering system for a watercraft having a steering actuator configured to pivot a watercraft propulsion unit relative to a watercraft hull to steer the watercraft propulsion unit from a neutral position to a right/left direction by driving force of the steering actuator, and comprising steering assist means for generating predetermined urging force in a direction toward the neutral position when the watercraft propulsion unit is steered in at least one of the right direction and the left direction relative to the neutral position.

2. Steering system according to claim 1, wherein the steering assist means is configured to apply the urging force to the steering actuator when a steered angle of the watercraft propulsion unit is in a predetermined angle range including the maximum steered angle.

3. Steering system according to claim 1 or 2, wherein the steering assist means is configured to apply the urging force in an opposite direction relative to a direction in which propeller rotation reaction force, generated when the watercraft propulsion unit is driven, acts.

4. Steering system according to one of the claims 1 to 3, further comprising a shaft whose axial direction is arranged along the right/left direction of the watercraft hull, wherein the steering actuator is disposed movably along the axial direction of the shaft.

5. Steering system according to one of the claims 1 to 4, further comprising a joint bracket attached to the steering actuator, and a swivel shaft whose axis is a pivot center for the joint bracket and for the watercraft propulsion unit.

6. Steering system according to claim 4 or 5, wherein the steering assist means are urging means disposed at end portions of the shaft and for pressing the steering actuator in the direction toward the neutral position.

7. Steering system according to one of the claims 1 to 6, wherein the steering assist means are urging means for moving the steering actuator parallel in a forward direction of the watercraft hull.

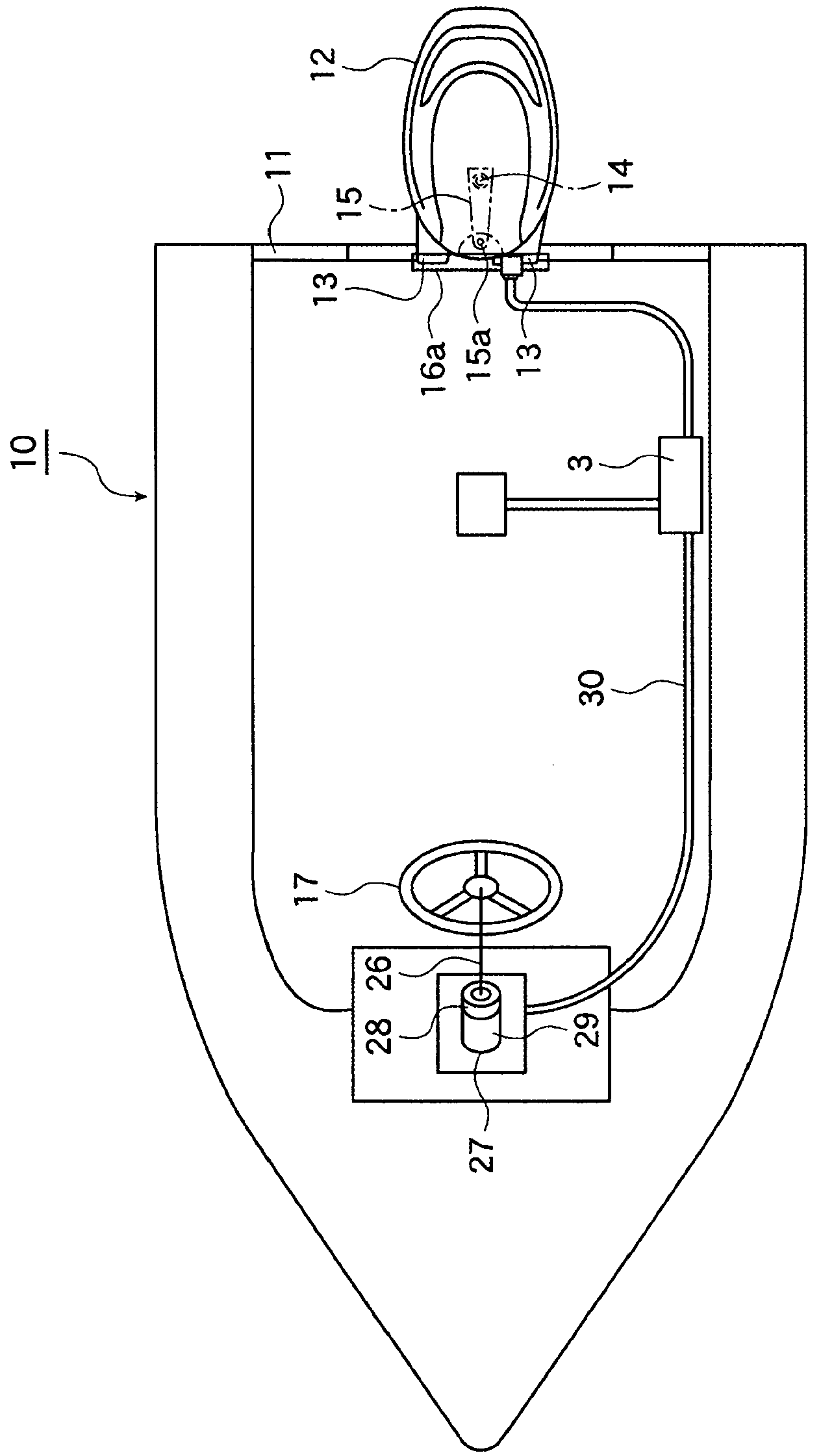
8. Steering system according to one of the claims 1 to 7, wherein the steering assist means are urging means disposed in a steered direction of the watercraft propulsion unit and for pressing a portion of the watercraft propulsion unit when the watercraft steering unit is steered.

9. Steering system according to one of the claims 4 to 8, wherein the urging means are formed with at least one of a cylinder and piston combination, a spring and a torsion spring.

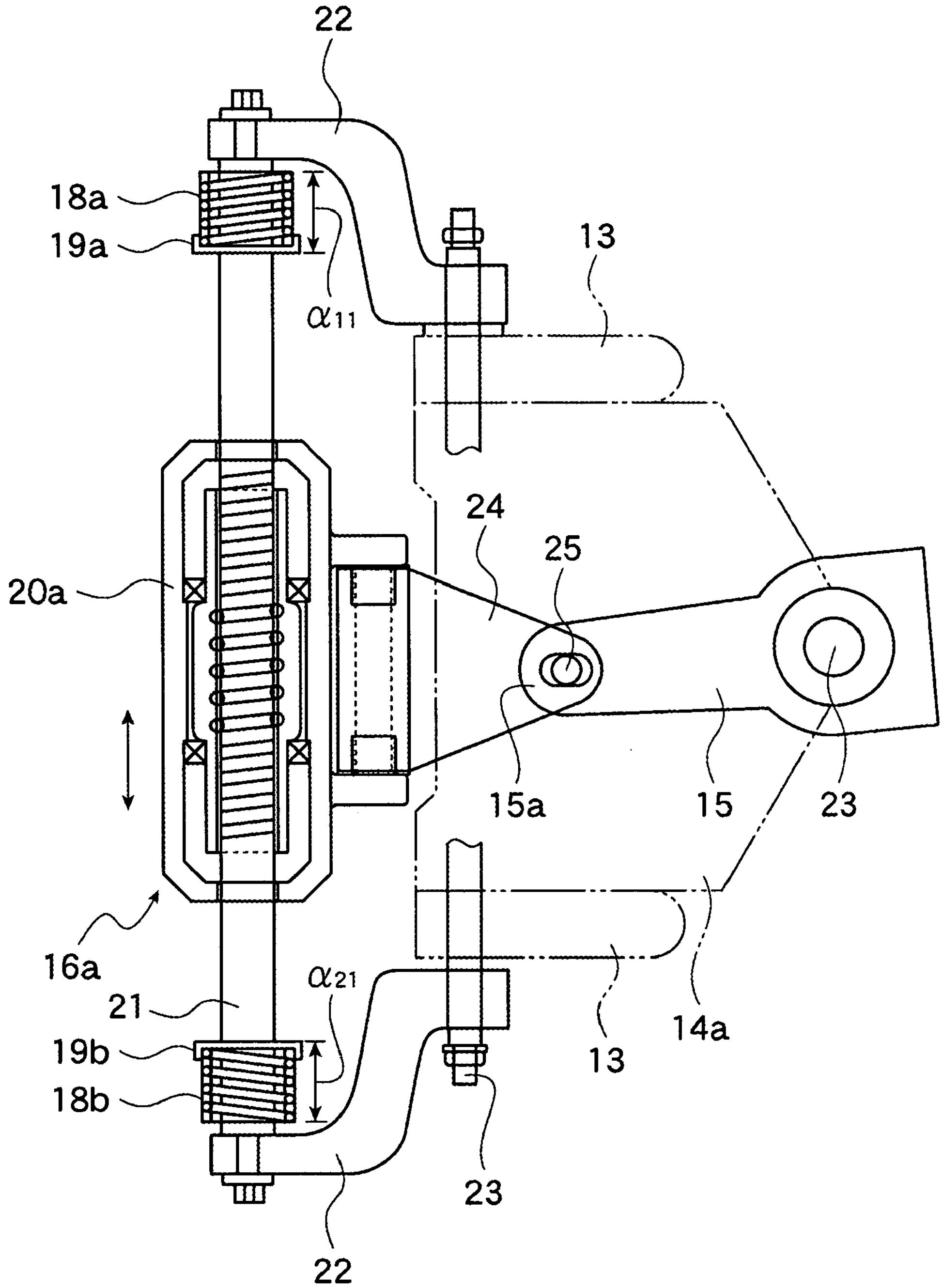
10. Steering system according to one of the claims 1 to 9, wherein the steering actuator is an electrically operable actuator.

11. Watercraft having a watercraft propulsion unit and a steering system according to one of the claims 1 to 10 mounted to the watercraft.

[FIG. 1]



[FIG. 2]


22
18a
19a
α_{11}
13
24
25
20a
15a
15
23
16a
21
α_{21}
19b
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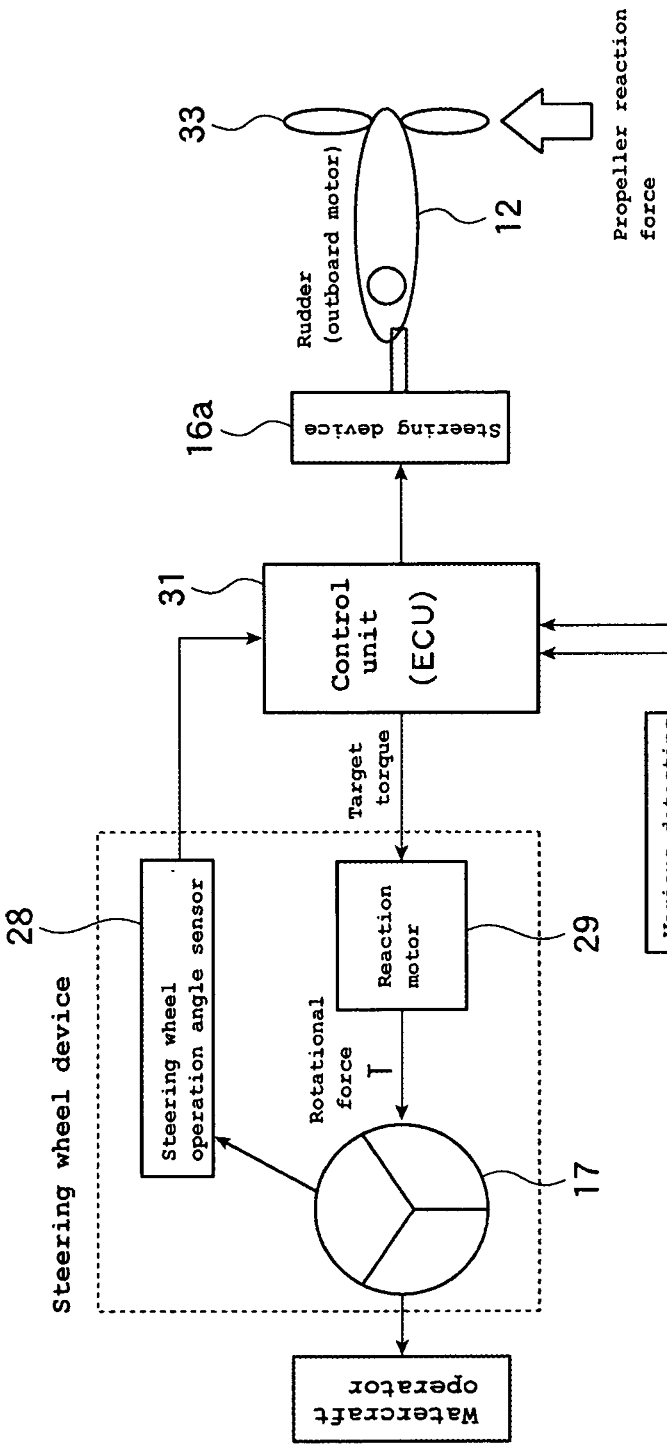
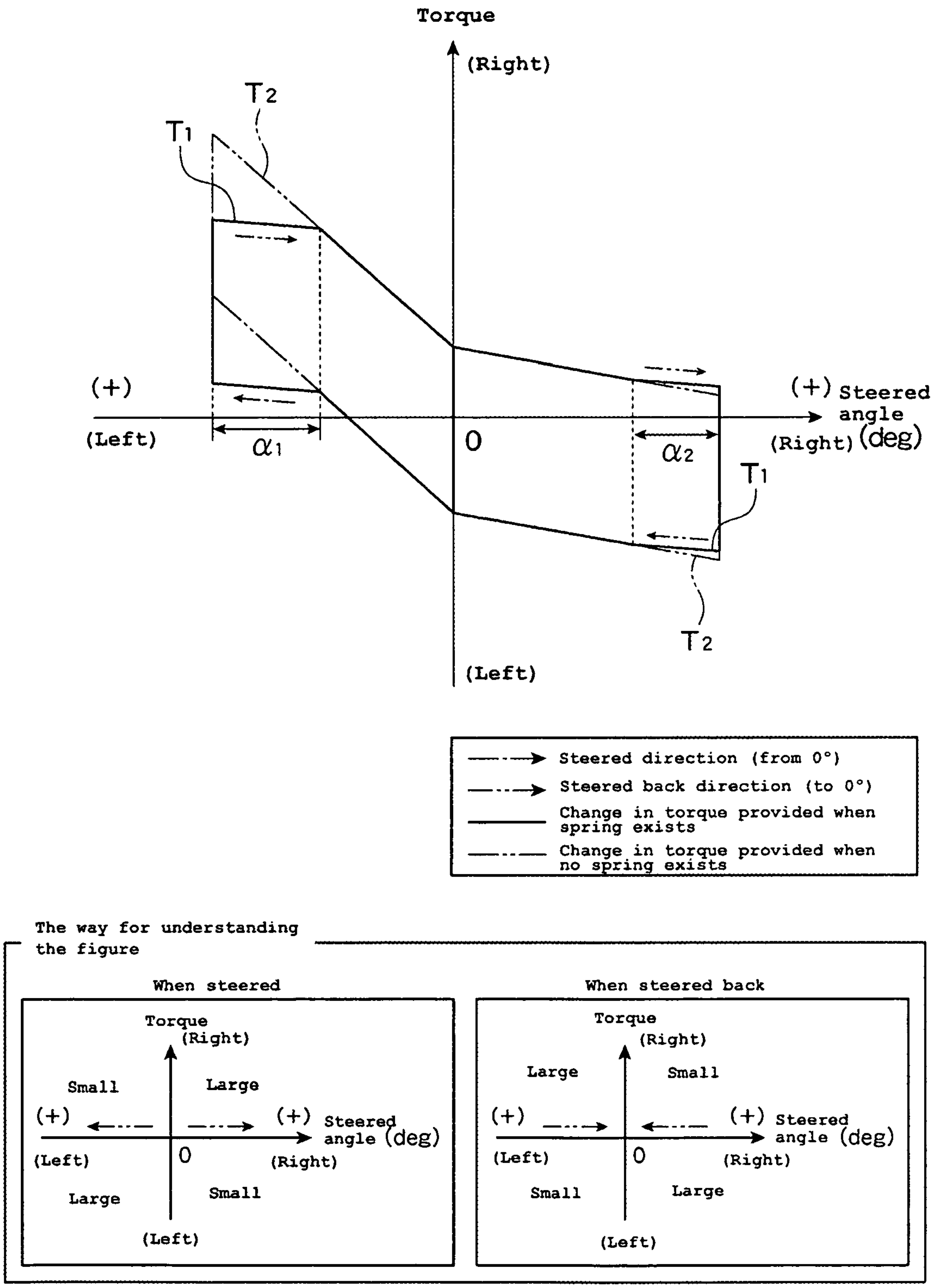
14a
13
23
22

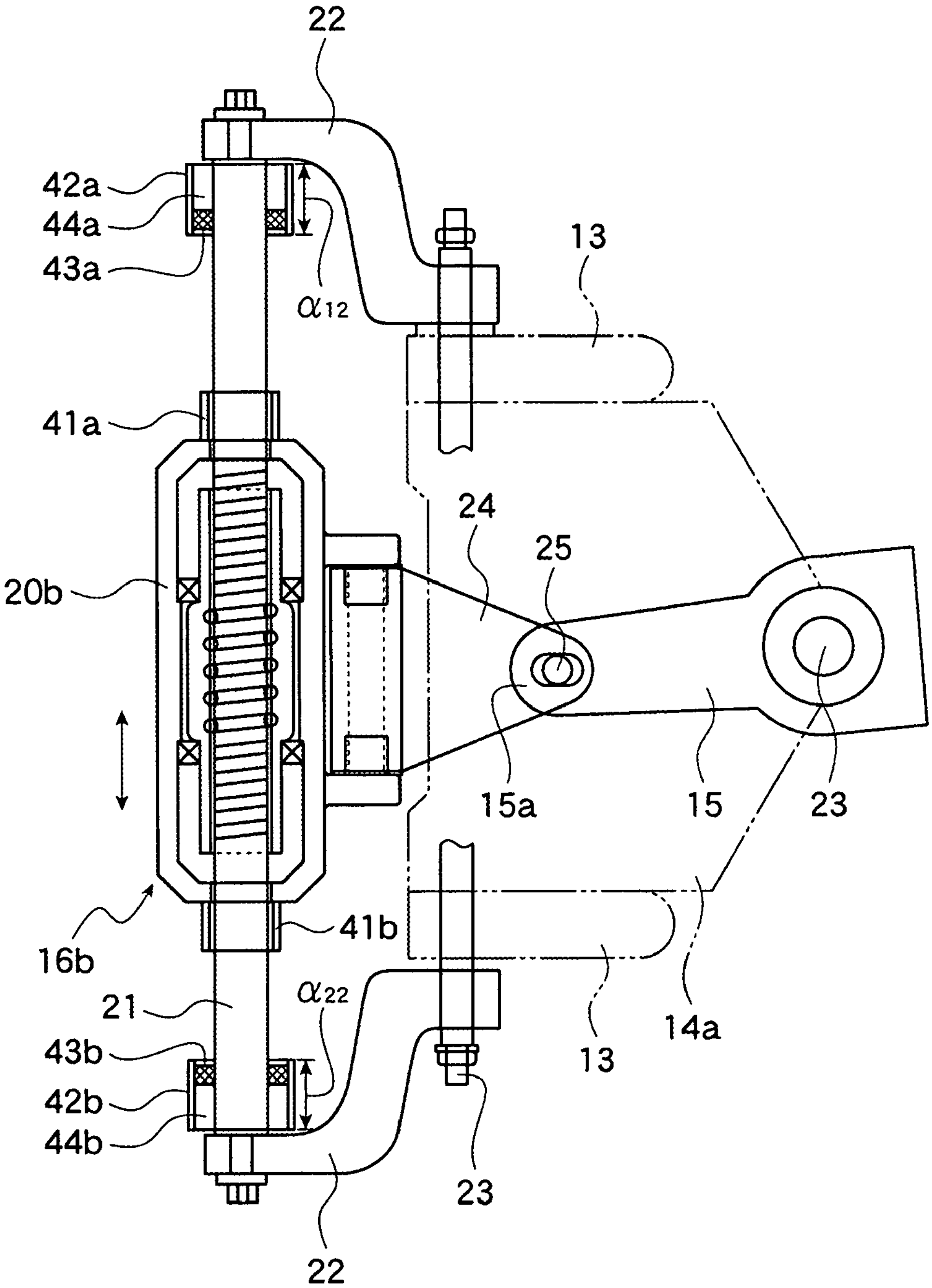
[FIG. 3]


Propeller reaction force
33
12
Rudder (outboard motor)
16a
Steering device
31
Control unit (ECU)
Target torque
Various detecting means
32
Steering storing means
34
Steering wheel device
28
Steering wheel operation angle sensor
Reaction motor
29
Rotational force T
17
Watercraft operator

[FIG. 4]


Torque
(Right)
T2
T1
(+)
(Left)
α1
0
α2
(+) Steered angle
(Right) (deg)
T1
T2
(Left)
Steered direction (from 0°)
Steered back direction (to 0°)
Change in torque provided when spring exists
Change in torque provided when no spring exists
The way for understanding the figure
When steered
Torque
(Right)
Small
Large
(+)
(+) Steered angle (deg)
(Left)
0
(Right)
Large
Small
(Left)
When steered back
Torque
(Right)
Large
Small
(+)
(+) Steered angle (deg)
(Left)
0
(Right)
Small
Large
(Left)

[FIG. 5]


22
42a
44a
43a
α12
13
41a
24
25
20b
15a
15
23
16b
41b
21
α22
14a
43b
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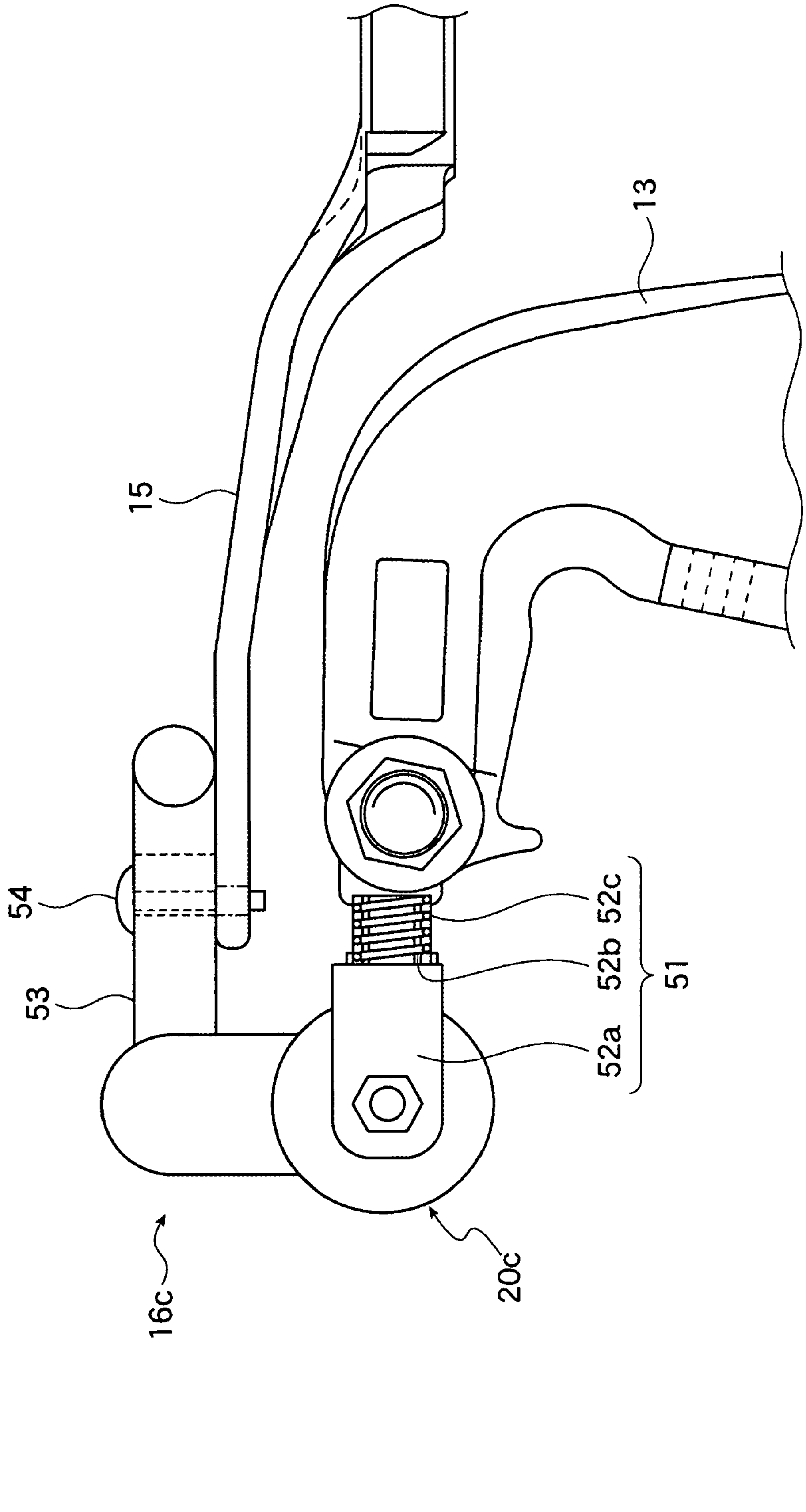
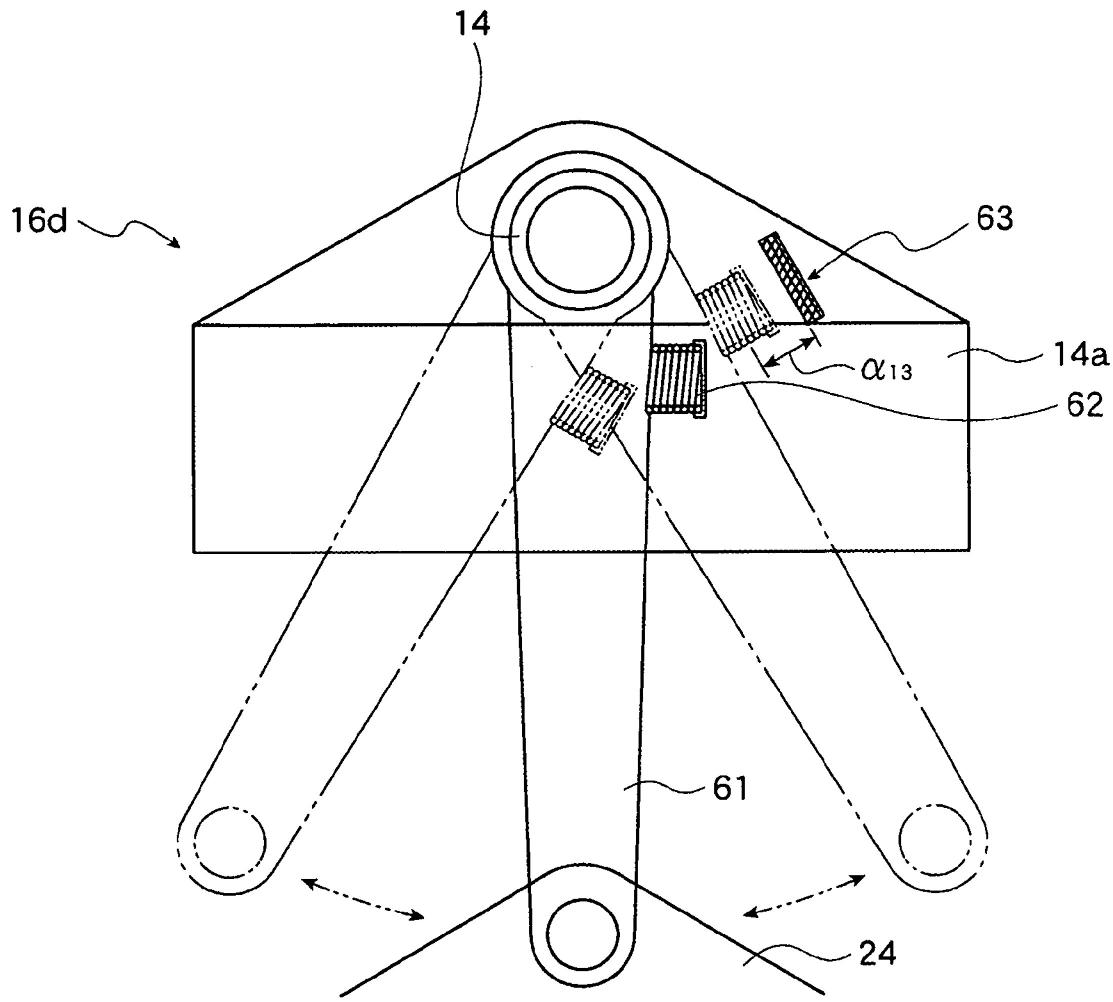
44b
13
23
22

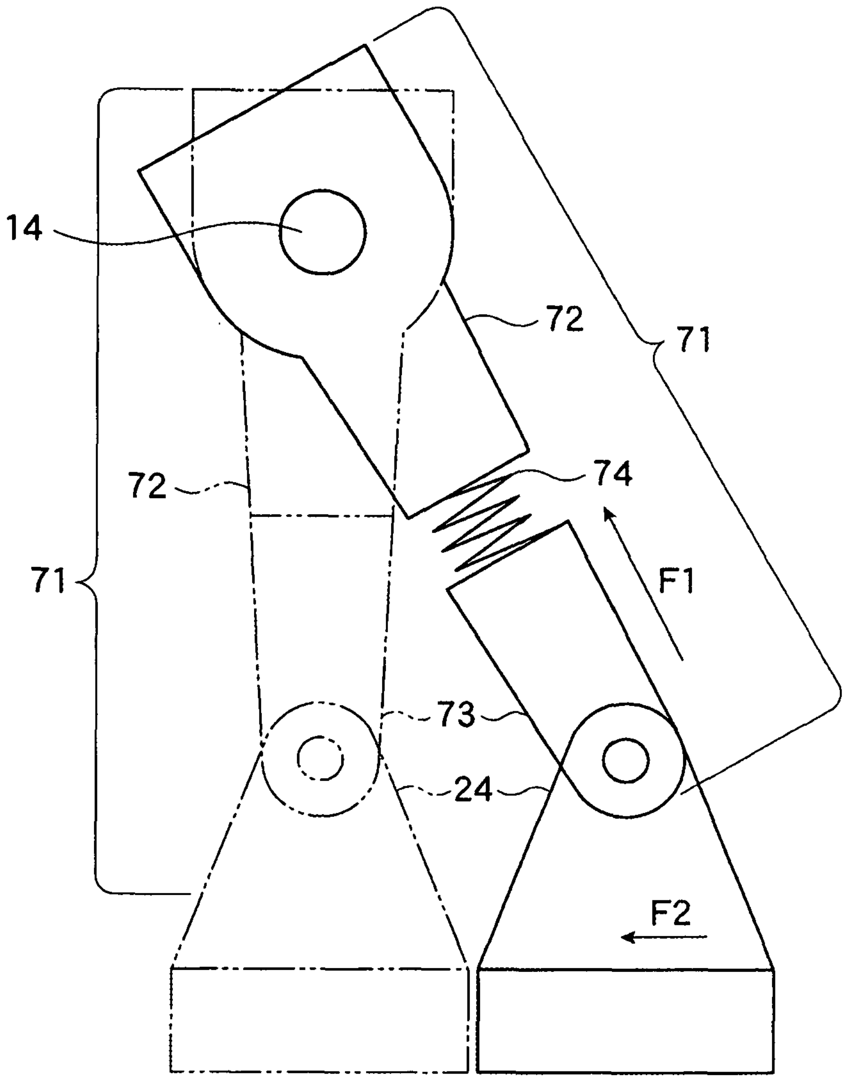
[FIG. 6]



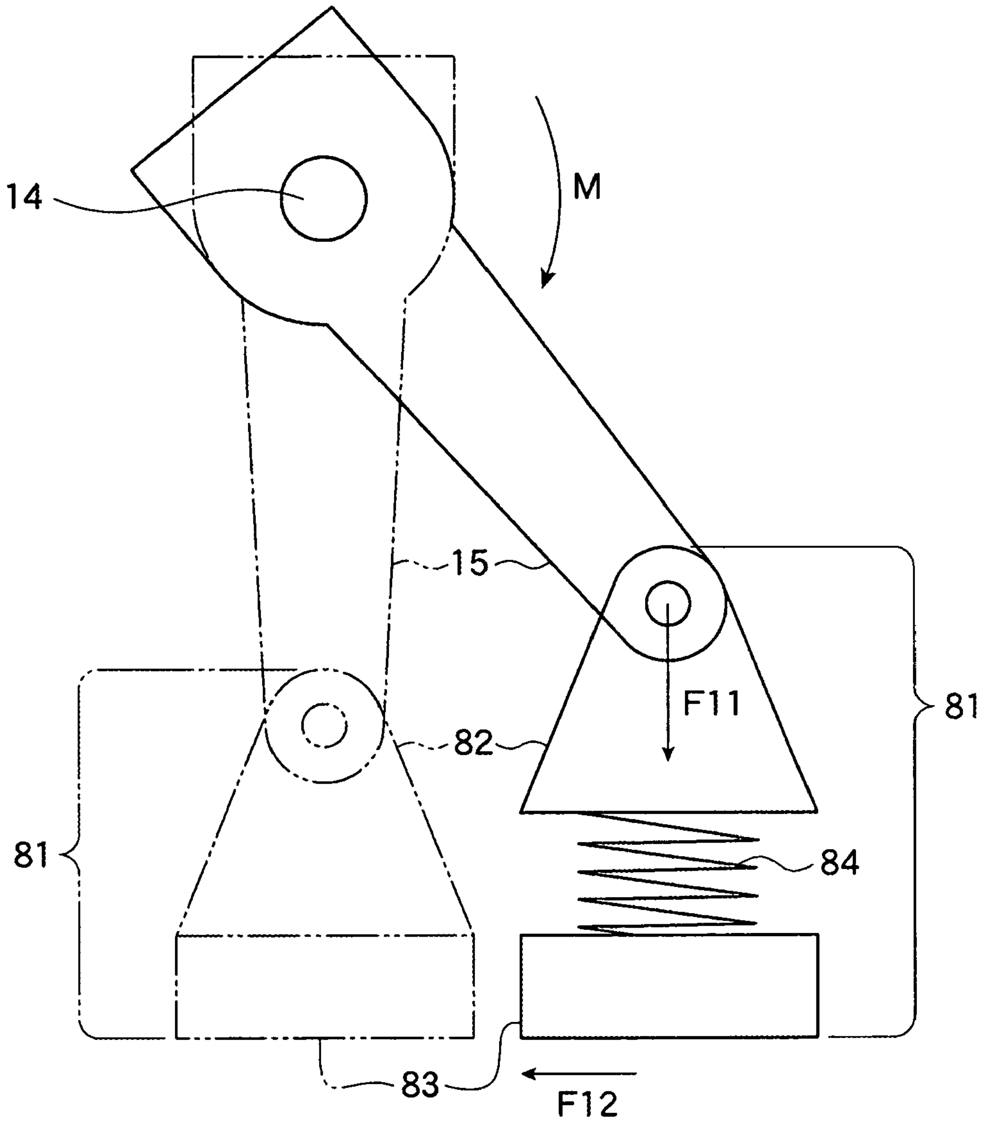
[FIG. 7]



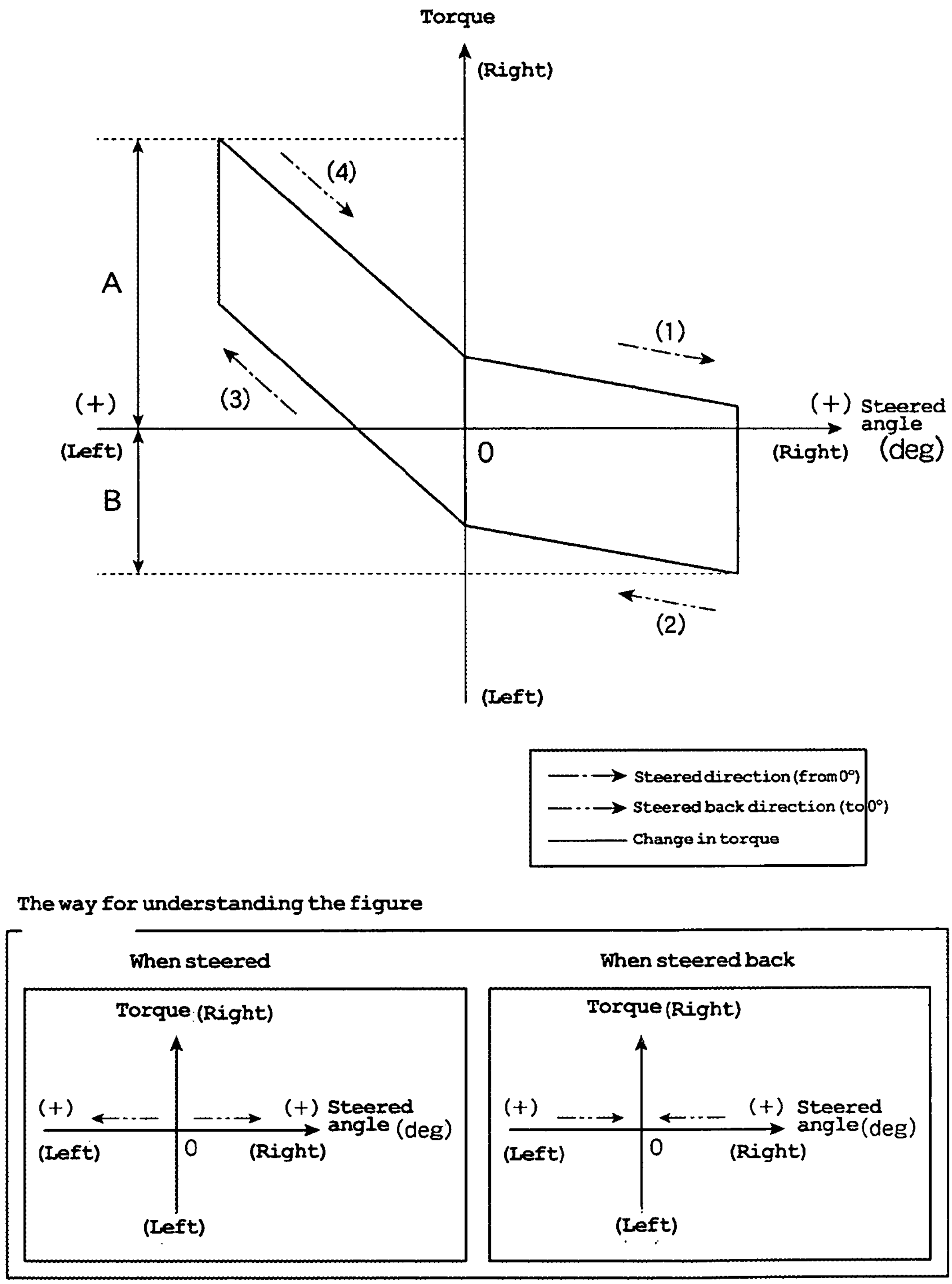
[FIG. 8]



[FIG. 9]



[FIG. 10]


Torque
(Right)
(4)
A
(1)
(+)
(3)
(+) Steered angle (deg)
(Left)
0
(Right)
B
(2)
(Left)
Steered direction (from 0°)
Steered back direction (to 0°)
Change in torque
The way for understanding the figure
When steered
Torque (Right)
(+)
(+) Steered angle (deg)
(Left)
0
(Right)
(Left)
When steered back
Torque (Right)
(+)
(+) Steered angle (deg)
(Left)
0
(Right)
(Left)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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