



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
14.04.2021 Bulletin 2021/15

(51) Int Cl.:
B63H 20/12 (2006.01) B63H 25/10 (2006.01)

(21) Application number: **20201067.4**

(22) Date of filing: **09.10.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **TAKEUCHI, Taiki**
Osaka-shi, Osaka 542-8502 (JP)
• **YOSHIMURA, Kyoji**
Osaka-shi, Osaka 542-8502 (JP)
• **YAMAMOTO, Yasuharu**
Osaka-shi, Osaka 542-8502 (JP)
• **YAMAMOTO, Tatsuhiro**
Osaka-shi, Osaka 542-8502 (JP)

(30) Priority: **11.10.2019 JP 2019187922**

(71) Applicant: **JTEKT CORPORATION**
Chuo-ku,
Osaka-shi,
Osaka 542-8502 (JP)

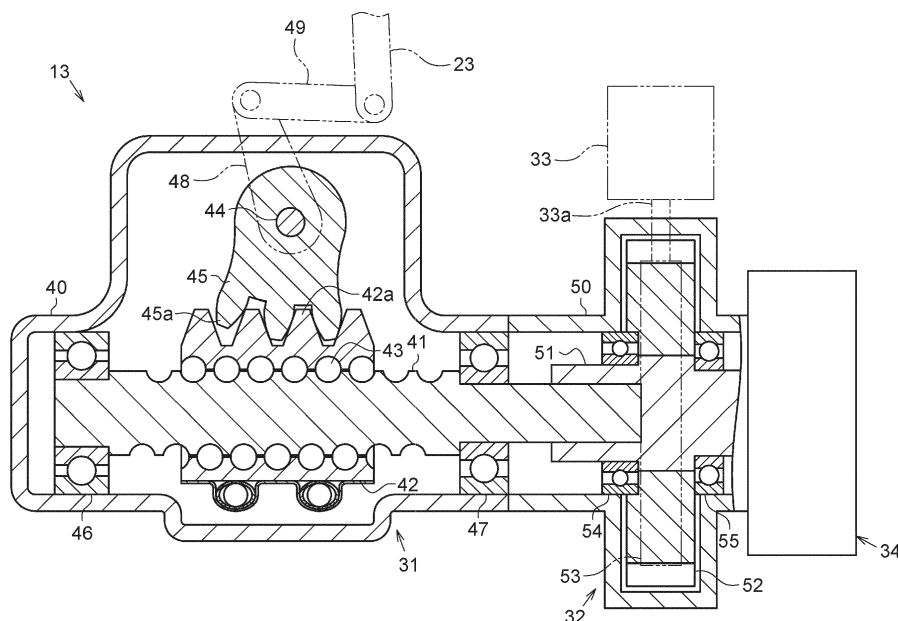
(74) Representative: **Winter, Brandl - Partnerschaft mbB**
Alois-Steinecker-Straße 22
85354 Freising (DE)

(54) **STEERING GEAR FOR BOAT**

(57) A steering gear for a boat (10) includes a steering mechanism (31, 71) that moves a rudder, and a driving source. The steering mechanism (31, 71) has: a housing (40, 80) that is fixed to a hull (10a); an output shaft (44) that is rotatably supported by the housing (40, 80); a first conversion mechanism that is provided inside the

housing (40, 80) and converts power from the driving source into rotation of the output shaft (44); and a second conversion mechanism that is provided outside the housing (40, 80) and converts rotation of the output shaft (44) into motion of the rudder.

FIG. 4



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a steering gear for a boat.

2. Description of Related Art

[0002] Examples of existing steering gears for boats include the one described in Japanese Patent Application Publication No. 2010-143413 (JP 2010-143413 A). This steering gear has a steering mechanism (turning mechanism) and a controller. The steering mechanism causes an outboard motor that is supported at the stern of a hull so as to be able to rotate around a steering shaft to swing leftward or rightward relatively to an advancing direction of the hull. The controller controls operation of the steering mechanism according to manipulation of a steering wheel provided in the cockpit of the hull.

[0003] The steering mechanism has a pair of left and right support members provided at the stern, a ball screw shaft, a ball screw nut, and a steering motor. The ball screw shaft is coupled between the two support members. The ball screw nut is screwed on the ball screw shaft. The steering motor has a housing that rotatably houses the ball screw nut, and a stator that is fixed inside the housing. As a current is applied to the stator, the ball screw nut serving as a rotor rotates.

[0004] The housing is provided with a steering arm that extends toward the outboard motor. The steering arm is rotatably coupled to a first end of a steering bracket that is coupled to the outboard motor through a coupling pin. The steering bracket is rotatably supported at a second end by the steering shaft provided at the stern.

[0005] When the ball screw nut is driven to rotate by the steering motor, the ball screw nut moves integrally with the housing leftward or rightward along the ball screw shaft. This causes the steering bracket coupled to the steering arm to swing leftward or rightward around the steering shaft. As a result, the outboard motor coupled to the steering bracket is steered leftward or rightward.

SUMMARY OF THE INVENTION

[0006] To steer the outboard motor, the steering gear of JP 2010-143413 A moves the housing along with the ball screw nut leftward or rightward along the ball screw shaft. This makes it necessary to secure in the hull a space in which the housing can move. It is also necessary to remove interfering objects from a moving path of the housing. Thus, there is room for improvement in terms of the efficiency with which the steering mechanism is mounted on a hull.

[0007] The present invention provides a steering gear for a boat of which a steering mechanism can be more

efficiently mounted on a hull.

[0008] A steering gear for a boat according to an aspect of the present invention includes a steering mechanism that moves a rudder provided at the stern of the boat, and a driving source of the steering mechanism. The steering mechanism has: a housing that is fixed to a hull; an output shaft that is rotatably supported by the housing; a first conversion mechanism that is provided inside the housing and converts power from the driving source into rotation of the output shaft; and a second conversion mechanism that is provided outside the housing and converts rotation of the output shaft into motion of the rudder.

[0009] There is an existing configuration of a steering gear for a boat in which a housing of a steering mechanism is movably provided in the hull and movement of this housing is used to move a rudder. However, employing this configuration requires securing in the hull a space in which the housing can move. In this respect, the above steering gear for a boat moves the rudder of the boat by simply rotating the output shaft of the steering mechanism, and therefore the housing of the steering mechanism is fixed to the hull. Thus, it is not necessary to secure in the hull a space in which the housing can move. As a result, the steering mechanism can be more efficiently mounted on the hull.

[0010] In the above aspect, the first conversion mechanism may have: a ball screw shaft that is rotatably supported inside the housing and rotates as the driving source operates; a ball screw nut that is screwed on the ball screw shaft through a plurality of balls and has rack teeth provided on an outer circumferential surface along an axial direction; and a sector gear that is integrally rotatably coupled to the output shaft and meshes with the rack teeth of the ball screw nut so as to swing around the output shaft as the ball screw nut moves in the axial direction.

[0011] This configuration can convert power from the driving source into rotation of the output shaft through the ball screw shaft, the ball screw nut, and the sector gear. In the above aspect, the driving source may be a motor. This configuration can meet a request for motorization of the steering mechanism.

[0012] In the above aspect, the driving source may be a motor, and the steering gear may have a speed reducer that reduces the speed of rotation of the motor and transmits the rotation at a reduced speed to the ball screw shaft. In this configuration, a torque from the motor is increased according to the reduction ratio of the speed reducer, so that a larger torque according to the reduction ratio of the speed reducer is transmitted to the ball screw shaft. Therefore, the rudder can be more reliably moved.

[0013] In the above aspect, the steering gear may further include a control valve that, on the assumption that the driving source is an electrically powered pump that discharges a hydraulic fluid, and that the ball screw nut is slidably provided in the housing, with the inside of the housing being divided by the ball screw nut into two fluid chambers, controls supply or discharge of the hydraulic

fluid to or from the two fluid chambers. The control valve may move the ball screw nut as a piston along the axial direction by selectively supplying the hydraulic fluid discharged from the electrically powered pump to one of the two fluid chambers according to manipulation of a steering wheel that is manipulated to change the direction of the hull. In this case, the control valve may move the ball screw nut as a piston along the axial direction by selectively supplying the hydraulic fluid discharged from the electrically powered pump to one of the two fluid chambers according to manipulation of a steering wheel that is manipulated to change the direction of the hull.

[0014] In this configuration, the hydraulic fluid from the electrically powered pump is selectively supplied to one of the two fluid chambers according to manipulation of the steering wheel, so that a difference in pressure occurs between the two fluid chambers. The ball screw nut functioning as a piston is pressed along the axial direction thereof according to this difference in pressure, and thus the ball screw nut is moved along the ball screw shaft. This movement of the ball screw nut is converted into rotation of the output shaft through the sector gear.

[0015] In the above aspect, the rudder may be an outboard motor that is provided as a propulsion unit of the boat on the outer side of the stern so as to be able to rotate around a pivot shaft and functions also as the rudder of the boat by rotating around the pivot shaft.

[0016] In the above aspect, the rudder may be provided separately from a propulsion unit of the boat on the outer side of the stern so as to be able to rotate around a support shaft. In the above aspect, power transmission between the rudder and a steering wheel that is manipulated to change the direction of the hull may be isolated.

[0017] In the above aspect, the rudder may be coupled to a steering wheel that is manipulated to change the direction of the hull, and the driving source may generate an assisting force that assists in moving the rudder through manipulation of the steering wheel.

[0018] These aspects allow the steering mechanism to be more efficiently mounted on a hull.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a plan view of a boat on which a first embodiment of a steering gear for a boat is mounted;
 FIG. 2 is a side view of an outboard motor in the first embodiment;
 FIG. 3 is a plan view of a steering actuator in the first embodiment;
 FIG. 4 is a sectional plan view of the steering actuator in the first embodiment;
 FIG. 5 is a plan view showing a main part of the

steering actuator in the first embodiment;

FIG. 6 is a plan view of a boat on which a second embodiment of a steering gear for a boat is mounted;
 FIG. 7 is a sectional plan view of a steering actuator in the second embodiment;

FIG. 8 is a schematic view showing the configuration of a power transmission mechanism between a steering wheel and the steering actuator in the second embodiment;

FIG. 9 is a plan view showing a main part of a steering actuator in another embodiment;

FIG. 10 is a plan view showing a main part of a steering actuator in another embodiment; and

FIG. 11 is a perspective view showing an inboard motor of a boat in another embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

First Embodiment

[0020] A first embodiment of a steering gear for a boat will be described below. As shown in FIG. 1, a boat 10 is provided with an outboard motor 12, a steering actuator 13 as a steering gear, a steering wheel 14, and a controller 15.

[0021] The outboard motor 12 is provided at the stern of a hull 10a. The outboard motor 12 is one example of a propulsion unit of the boat 10 and has an engine 12a and a propeller 12b that is driven to rotate by the engine 12a. The outboard motor 12 is capable of swinging leftward and rightward relatively to an advancing direction of the boat 10. By swinging leftward and rightward, the outboard motor 12 functions also as the rudder of the boat 10.

[0022] The steering actuator 13 causes the outboard motor 12 to swing leftward or rightward relatively to the advancing direction of the boat 10. As the outboard motor 12 swings leftward or rightward, the advancing direction of the boat 10 changes. The steering wheel 14 is provided in the cockpit of the boat 10. The steering wheel 14 is rotatably supported by the hull 10a through a steering shaft 16. The steering shaft 16 is provided with a rotation angle sensor 17. The rotation angle sensor 17 detects a rotation angle of the steering shaft 16 as a steering angle θ that is a rotation angle of the steering wheel 14.

[0023] The controller 15 controls operation of the steering actuator 13 according to the steering angle θ detected through the rotation angle sensor 17. Output of the engine 12a is controlled by another controller that is provided separately from the controller 15.

[0024] Next, a coupling structure of the hull 10a and the outboard motor 12 will be described. As shown in FIG. 2, the outboard motor 12 has a swivel bracket 21, a pivot shaft 22, and a steering bracket 23.

[0025] The swivel bracket 21 couples the outboard motor 12 to the hull 10a. The swivel bracket 21 is composed of a first coupling part 21a and a second coupling part 21b and has an L-shape as a whole. The first coupling

part 21a extends along a front-rear direction of the hull 10a (a left-right direction in FIG. 2). The second coupling part 21b extends along an up-down direction of the hull 10a. The first coupling part 21a is mounted between two clamp brackets 24 (see FIG. 1) that are provided at the stern of the hull 10a. The steering actuator 13 is installed on an upper surface of the first coupling part 21a. The second coupling part 21b is provided with a through-hole 21c that extends along the up-down direction of the hull 10a.

[0026] The pivot shaft 22 forms the center of swinging of the outboard motor 12. The pivot shaft 22 is inserted into the through-hole 21c of the second coupling part 21b of the swivel bracket 21. The pivot shaft 22 is capable of rotating relatively to the swivel bracket 21. An upper end of the pivot shaft 22 protrudes from an upper portion of the second coupling part 21b of the swivel bracket 21. The upper end of the pivot shaft 22 is coupled to the steering actuator 13 through the steering bracket 23. A part of the pivot shaft 22 that is located between the steering bracket 23 and the swivel bracket 21 is fixed to a case 12c of the outboard motor 12 through a bracket 25. A lower end of the pivot shaft 22 protrudes from a lower portion of the swivel bracket 21. The lower end of the pivot shaft 22 is fixed to the case 12c of the outboard motor 12 through a bracket 26. Each of the two brackets 25, 26 is fixed to the pivot shaft 22. Rotation of the pivot shaft 22 relative to the brackets 25, 26 is restricted, so that the outboard motor 12 can rotate around the pivot shaft 22 relatively to the swivel bracket 21.

[0027] Next, the configuration of the steering actuator 13 will be described in detail. As shown in FIG. 3, the steering actuator 13 has a steering mechanism 31, a speed reducer 32, a motor 33 as a driving source, and a rotation angle sensor 34. As the steering mechanism 31, a so-called recirculating-ball steering (RBS) gear is used. The motor 33 and the rotation angle sensor 34 are coupled to the steering mechanism 31 through the speed reducer 32.

[0028] As shown in FIG. 4, the steering mechanism 31 has a housing 40. Inside the housing 40 are provided a ball screw shaft 41, a ball screw nut 42, a plurality of balls 43, a sector shaft 44 as an output shaft, and a sector gear 45. The ball screw shaft 41 is rotatably supported by the housing 40 through two bearings 46, 47. The ball screw nut 42 is screwed on the ball screw shaft 41 through the balls 43 that are capable of circulation. The ball screw nut 42 has rack teeth 42a provided on an outer circumferential surface along an axial direction thereof. The sector shaft 44 extends along a direction orthogonal to an axis of the ball screw nut 42 (a direction orthogonal to the sheet of FIG. 4). The sector shaft 44 is rotatably supported by the housing 40 through a bearing (not shown). The sector gear 45 is integrally rotatably provided on the sector shaft 44. Teeth 45a of the sector gear 45 mesh with the rack teeth 42a of the ball screw nut 42.

[0029] As shown in FIG. 3, an upper end portion of the sector shaft 44 is exposed outside the housing 40. A lever

48 is fixed at a first end thereof to the upper end portion of the sector shaft 44. A link 49 is rotatably supported at a first end thereof by a second end of the lever 48. The steering bracket 23 provided on the outboard motor 12 is rotatably supported at an end thereof on the opposite side from the pivot shaft 22 by a second end of the link 49.

[0030] As shown in FIG. 4, the speed reducer 32 has a housing 50. The housing 50 is coupled to the housing 40 of the steering mechanism 31. The housings 40, 50 communicate with each other on an inside. The motor 33 is mounted on an outer side of the housing 50. An output shaft 33a of the motor 33 extends in a direction orthogonal to an axis of the ball screw shaft 41. The output shaft 33a of the motor 33 extends through a peripheral wall of the housing 50 and is inserted into the housing 50. The rotation angle sensor 34 is mounted at a part of the housing 50 on the opposite side from the steering mechanism 31.

[0031] Inside the housing 50 are provided a shaft 51, a worm wheel 52, and a worm 53. The shaft 51 is rotatably supported by the housing 50 through two bearings 54, 55. The shaft 51 is integrally rotatably coupled at a first end thereof (a left end in FIG. 4) to the ball screw shaft 41. The shaft 51 is rotatably supported at a second end thereof (a right end in FIG. 4) by a case that houses a detection element of the rotation angle sensor 34. The rotation angle sensor 34 detects a rotation angle of the shaft 51. The worm wheel 52 is integrally rotatably provided on the shaft 51. The worm 53 is integrally rotatably provided on the output shaft 33a of the motor 33. The worm 53 meshes with the worm wheel 52.

[0032] Next, the operation of the steering actuator 13 will be described. The controller 15 executes steering control that steers the outboard motor 12 according to an amount of manipulation of the steering wheel 14 by controlling driving of the motor 33. The controller 15 calculates a target value for an amount of steering of the outboard motor 12 based on the steering angle θ of the steering wheel 14 that is detected through the rotation angle sensor 17. Further, the controller 15 calculates an amount of steering of the outboard motor 12 based on a rotation angle of the shaft 51 that is detected through the rotation angle sensor 34. Then, the controller 15 obtains the difference between the target value for the amount of steering of the outboard motor 12 and the actual amount of steering of the outboard motor 12, and controls power supply to the motor 33 so as to eliminate this difference. Alternatively, the controller 15 may control power supply to the motor 33 based on, instead of the amount of steering of the outboard motor 12, a rotation angle of the sector shaft 44 that is one of state variables that reflect the amount of steering of the outboard motor 12.

[0033] As shown in FIG. 4, rotation of the motor 33 is transmitted to the ball screw shaft 41 through the speed reducer 32. As the ball screw shaft 41 turns, the ball screw nut 42 moves along the axial direction of the ball screw shaft 41. As the ball screw nut 42 moves, the sector gear 45 meshing with the rack teeth 42a swings leftward or

rightward around the sector shaft 44. As the sector gear 45 swings, the sector shaft 44 rotates in the same direction as the direction of swinging of the sector gear 45, according to the amount of swinging of the sector gear 45.

[0034] As shown in FIG. 5, as the sector shaft 44 rotates, the lever 48 swings leftward or rightward around the sector shaft 44. For example, when the sector shaft 44 rotates in a counterclockwise direction, the lever 48 rotates in the counterclockwise direction around the sector shaft 44. In response, the link 49 tries to rotate in a clockwise direction around a joint to the lever 48. As the link 49 rotates in the clockwise direction, the steering bracket 23 rotates in the counterclockwise direction around the pivot shaft 22. Since the pivot shaft 22 is fixed to the steering bracket 23, as the steering bracket 23 rotates in the counterclockwise direction, a torque directed in the counterclockwise direction is applied to the pivot shaft 22. Since the pivot shaft 22 is fixed to the case 12c of the outboard motor 12, as the pivot shaft 22 rotates in the counterclockwise direction, the outboard motor 12 rotates in the counterclockwise direction around the pivot shaft 22.

[0035] When the sector shaft 44 rotates in the clockwise direction, the steering bracket 23 rotates in the clockwise direction around the pivot shaft 22 through the sector gear 45, the lever 48, and the link 49 in a manner similar to that when the sector shaft 44 rotates in the counterclockwise direction, so that a torque directed in the clockwise direction is applied to the pivot shaft 22. As the pivot shaft 22 rotates in the clockwise direction, the outboard motor 12 rotates in the clockwise direction around the pivot shaft 22.

[0036] The ball screw shaft 41, the ball screw nut 42, and the balls 43 compose a ball screw mechanism. The ball screw mechanism (41 to 43) and the sector gear 45 compose a first conversion mechanism that converts power from the motor 33 that is the driving source of the steering actuator 13 into rotation of the sector shaft 44 that is the output shaft. The lever 48 and the link 49 compose a second conversion mechanism that converts rotation of the sector shaft 44 that is the output shaft into steering motion of the outboard motor 12.

Advantages of Embodiment

[0037] The embodiment can offer the following advantages: (1) The steering mechanism 31 converts rotation of the motor 33 into rotation of the sector gear 45, and transmits the rotation of the sector gear 45 as a torque for the pivot shaft 22 of the outboard motor 12. There is an existing configuration in which a housing of a steering mechanism is provided in a hull so as to be able to move along with a ball screw nut and this movement of the housing is used to steer an outboard motor. However, employing this configuration requires securing in the hull a space in which the housing can move. In this respect, the steering mechanism 31 of the embodiment steers the outboard motor 12 by simply rotating the sector shaft 44.

The housing 40 of the steering mechanism 31 need not be moved relatively to the hull 10a and is therefore fixed to the hull 10a. Thus, it is not necessary to secure in the hull 10a a space in which the housing 40 of the steering mechanism 31 can move. As a result, the steering mechanism 31 can be more efficiently mounted on the hull 10a.

[0038] (2) Rotation of the sector gear 45 is transmitted to the pivot shaft 22 that is the center of rotation of the outboard motor 12 through the sector shaft 44, the lever 48, the link 49, and the steering bracket 23. Since the outboard motor 12 rotates around the pivot shaft 22, a torque for turning the outboard motor 12 can be efficiently applied to the pivot shaft 22. While a configuration is also conceivable in which, as described above, linear motion of a housing of a steering mechanism is converted into rotary motion of an outboard motor around a pivot shaft, employing this configuration may reduce the efficiency of torque transmission to the pivot shaft 22 compared with employing the steering mechanism 31 of the embodiment.

[0039] (3) The steering actuator 13 employs the configuration in which rotation of the sector gear 45 is transmitted to the pivot shaft 22 that is the center of rotation of the outboard motor 12 through the sector shaft 44, the lever 48, the link 49, and the steering bracket 23. This configuration involves fewer wasteful actions in the steering mechanism 31 compared with the aforementioned configuration in which linear motion of a housing of a steering mechanism is converted into rotary motion of a pivot shaft. Moreover, this configuration allows the ranges of movement of the lever 48 and the link 49 that move in conjunction with the sector gear 45 to be set narrower than the range of movement of the housing of the steering mechanism in the aforementioned case where the housing is linearly moved. Since it is not necessary to move the lever 48 and the link 49 to a great extent, the installation space for the steering mechanism 31 can be set smaller.

[0040] (4) The motor 33 is used as the driving source of the steering mechanism 31. Thus, a request for motorization of the steering actuator 13 can be met. Moreover, high responsiveness and a stable steering force can be obtained regardless of the speed (low speed to high speed) of the boat 10 and the environment (waves and winds). For example, when a hydraulic pump driven by an engine is used as the driving source of the steering mechanism 31, the discharge amount of the hydraulic pump and, by extension, a steering force applied to the outboard motor 12 may vary according to the speed of the boat 10 and the environment.

[0041] (5) Since the steering actuator 13 is motorized, unlike when a hydraulic device is used as the driving source of the steering mechanism 31, it is not necessary to provide the hull 10a with hydraulic piping through which a hydraulic fluid is supplied and discharged. Thus, the configuration of the steering actuator 13 can be simplified. Moreover, eliminating the need for hydraulic piping can save the space of the hull 10a.

[0042] (6) The output shaft 33a of the motor 33 is coupled to the ball screw shaft 41 of the steering mechanism 31 through the speed reducer 32. Thus, a torque from the motor 33 is increased according to the reduction ratio of the speed reducer 32, so that a larger torque according to the reduction ratio is transmitted to the ball screw shaft 41. With the force required to steer the outboard motor 12 thus obtained, the outboard motor 12 can be more reliably steered.

Second Embodiment

[0043] Next, a second embodiment of a steering gear for a boat will be described. This embodiment is different from the first embodiment in that a hydraulic steering actuator is used instead of an electrically powered steering actuator.

[0044] As shown in FIG. 6, a boat 10 is provided with an outboard motor 12, a steering wheel 14, a controller 15, and a hydraulic steering actuator 60. The steering actuator 60 has an electrically powered pump 61 as a driving source and a reservoir tank 62. Further, the steering actuator 60 has a steering mechanism 71 and a control valve 72 that are provided on a swivel bracket 21 at the stern.

[0045] A hydraulic fluid is stored in the reservoir tank 62. The reservoir tank 62 is coupled to the electrically powered pump 61 through an intake pipe 63. The electrically powered pump 61 is coupled to a pump port of the control valve 72 through a discharge pipe 64. The tank port of the control valve 72 is connected to the reservoir tank 62 through a discharge pipe 65.

[0046] The controller 15 controls the electrically powered pump 61 based on a steering angle θ that is detected through a rotation angle sensor 17. As the electrically powered pump 61 is driven, the hydraulic fluid inside the reservoir tank 62 is supplied to the control valve 72 through the discharge pipe 64. The hydraulic fluid discharged from the control valve 72 is returned to the reservoir tank 62 through the discharge pipe 65.

[0047] Next, the configuration of the steering mechanism 71 will be described in detail. As shown in FIG. 7, the steering mechanism 71 has a housing 80. Inside the housing 80 are provided a ball screw shaft 81, a ball screw nut 82, a plurality of balls 83, a sector shaft 84, a sector gear 85, and a closing member 86 having a shape of a cylinder closed at one end.

[0048] The ball screw nut 82 is provided in the housing 80 (to be exact, a cylindrical part thereof) so as to be able to slide in a direction along an axis of the ball screw nut 82. The ball screw nut 82 has rack teeth 82a provided on an outer circumferential surface along an axial direction thereof.

[0049] The closing member 86 is tightly fitted into a first end (a left end in FIG. 7) of the ball screw nut 82. The closing member 86 moves integrally with the ball screw nut 82. The ball screw shaft 81 is screwed into the ball screw nut 82 through the balls 83 that are capable

of circulation. The first end (the left end in FIG. 7) of the ball screw shaft 81 is inserted into the closing member 86. There is a predetermined clearance left between the first end of the ball screw shaft 81 and a bottom wall of the closing member 86. The ball screw nut 82 is capable of moving relatively to the ball screw shaft 81 along the axial direction of the ball screw shaft 81, within the range of the clearance between the ball screw shaft 81 and the bottom wall of the closing member 86. A second end (a right end in FIG. 7) of the ball screw shaft 81 protrudes from a second end (a right end in FIG. 7) of the ball screw nut 82. The second end of the ball screw shaft 81 is coupled to the control valve 72.

[0050] The sector shaft 84 extends in a direction orthogonal to an axis of the ball screw nut 82 (a direction orthogonal to the sheet of FIG. 7). The sector shaft 84 is rotatably supported by the housing 80 through a bearing (not shown).

[0051] The sector gear 85 is integrally rotatably provided on the sector shaft 84. Teeth 85a of the sector gear 85 mesh with the rack teeth 82a of the ball screw nut 82. An upper end portion of the sector shaft 84 is exposed outside the housing 80. The steering bracket 23 is coupled at an end thereof on the opposite side from the pivot shaft 22 to the upper end portion of the sector shaft 84 through the lever 48 and the link 49 (see FIG. 2).

[0052] An inside of the housing 80 is divided by the ball screw nut 82 and the closing member 86 into a first fluid chamber 87 and a second fluid chamber 88. The first fluid chamber 87 is located on the side of the control valve 72 with respect to the ball screw nut 82. The second fluid chamber 88 is located on the opposite side from the control valve 72 with respect to the ball screw nut 82.

[0053] The first fluid chamber 87 and the second fluid chamber 88 are supplied with the hydraulic fluid through the control valve 72. As the hydraulic fluid from the electrically powered pump 61 is selectively supplied to one of the first fluid chamber 87 and the second fluid chamber 88 through the control valve 72, a difference in pressure occurs between the first fluid chamber 87 and the second fluid chamber 88. The ball screw nut 82 and the closing member 86 are pressed along their respective axial directions according to this difference in pressure, so that the ball screw nut 82 and the closing member 86, functioning as pistons, move along the ball screw shaft 81. As the ball screw nut 82 moves, the sector gear 85 swings leftward or rightward around the sector shaft 84. As the sector gear 85 swings, the sector shaft 84 rotates in the same direction as the direction of swinging of the sector gear 85.

[0054] Next, the configuration of the control valve 72 will be described in detail. As shown in FIG. 7, the control valve 72 has a housing 90. The housing 90 is coupled to the housing 80 of the steering mechanism 71. Inside the housing 90 are provided a hollow input shaft 91, a torsion bar 92, an inner valve 93, and an outer valve 94.

[0055] The input shaft 91 extends through the housing 90. The input shaft 91 is rotatably supported by the hous-

ing 90 through a bearing 95. A first end (a left end in FIG. 7) of the input shaft 91 is inserted into a recess 81a that is provided as an insertion portion at the second end (the right end in FIG. 7) of the ball screw shaft 81, such that the input shaft 91 can rotate relatively to the ball screw shaft 81. A rotation angle sensor 34 is provided at a second end (a right end in FIG. 7) of the input shaft 91.

[0056] The torsion bar 92 extends through the input shaft 91. The torsion bar 92 is fixed at a first end thereof (a left end in FIG. 7) to a bottom of the recess 81a provided at the second end (the right end in FIG. 7) of the ball screw shaft 81. The torsion bar 92 is fixed at a second end thereof (a right end in FIG. 7) to the second end (the right end in FIG. 7) of the input shaft 91.

[0057] The inner valve 93 is provided inside the housing 90, on an outer circumference of the input shaft 91. The outer valve 94 is provided on an inner circumference of the housing 90. The torsion bar 92 is twisted according to a torque applied to the input shaft 91, and the positional relationship (relative angle) between the inner valve 93 and the outer valve 94 in a rotation direction changes according to this twisting of the torsion bar 92. By using this change in the positional relationship between the inner valve 93 and the outer valve 94 in the rotation direction, the control valve 72 switches a flow passage of the hydraulic fluid. Further, by forming a constriction according to the difference between a rotation angle of the input shaft 91, i.e., the inner valve 93, and a rotation angle of the outer valve 94 (a valve operating angle), the control valve 72 adjusts the flow rate of the hydraulic fluid supplied to the first fluid chamber 87 and the second fluid chamber 88.

[0058] The hydraulic fluid supplied from the electrically powered pump 61 through the discharge pipe 64 is distributed to one of the first fluid chamber 87 and the second fluid chamber 88 according to a shift in the relative angle between the inner valve 93 and the outer valve 94. Here, the electrically powered pump 61 and the first fluid chamber 87 communicate with each other when the input shaft 91 rotates in a clockwise direction as seen from an axial direction of the input shaft 91. On the other hand, the electrically powered pump 61 and the second fluid chamber 88 communicate with each other when the input shaft 91 rotates in a counterclockwise direction as seen from the axial direction of the input shaft 91.

[0059] For example, when the hydraulic fluid is supplied to the second fluid chamber 88, the ball screw nut 82 and the closing member 86 move toward the first fluid chamber 87 under the pressure of the hydraulic fluid. As the ball screw nut 82 moves, the hydraulic fluid inside the first fluid chamber 87 is pushed out of the first fluid chamber 87. The hydraulic fluid pushed out of the first fluid chamber 87 is discharged to the reservoir tank 62 through the discharge pipe 65.

[0060] When the hydraulic fluid is supplied to the first fluid chamber 87, the ball screw nut 82 and the closing member 86 move toward the second fluid chamber 88 under the pressure of the hydraulic fluid. As the ball screw

nut 82 moves, the hydraulic fluid inside the second fluid chamber 88 is pushed out of the second fluid chamber 88. The hydraulic fluid pushed out of the second fluid chamber 88 is discharged to the reservoir tank 62 through the discharge pipe 65.

[0061] In this way, supply or discharge of the hydraulic fluid to or from the first fluid chamber 87 and the second fluid chamber 88 is controlled according to the torque applied to the input shaft 91, i.e., the rotation of the input shaft 91. The input shaft 91 rotates in conjunction with manipulation of the steering wheel 14. The following configuration is an example of configurations employed to transmit power from the steering wheel 14 to the input shaft 91.

[0062] As shown in FIG. 8, a drive pulley 101 is integrally rotatably provided on the steering shaft 16. An idler pulley 102 is integrally rotatably provided on the input shaft 91 of the control valve 72. The drive pulley 101 and the idler pulley 102 are coupled together by two manipulating cables 103, 104. As the drive pulley 101 rotates, the idler pulley 102 and also the input shaft 91 rotate in conjunction with the drive pulley 101.

[0063] First end portions of the two manipulating cables 103, 104 are led out in a direction intersecting an axis of the drive pulley 101 in a state where the first end portions are fixed to two side surfaces of the drive pulley 101 that face each other in an axial direction of the drive pulley 101, and in a state where the manipulating cables 103, 104 are wound along a spiral groove, provided in an outer circumferential surface of the drive pulley 101, in directions toward each other.

[0064] As with the first end portions of the two manipulating cables 103, 104, second end portions of the manipulating cables 103, 104 are led out in a direction intersecting an axis of the idler pulley 102 in a state where the second end portions of the manipulating cables 103, 104 are fixed to two side surfaces of the idler pulley 102 that face each other in an axial direction of the idler pulley 102, and in a state where the manipulating cables 103, 104 are wound along a spiral groove, provided in an outer circumferential surface of the idler pulley 102, in directions toward each other.

[0065] To turn the boat 10, the steering wheel 14 is manipulated, and the drive pulley 101 rotates in conjunction with manipulation of the steering wheel 14. As the drive pulley 101 rotates, one of the two manipulating cables 103, 104 wound around the drive pulley 101 is pulled while the other one is loosened. Thus, rotation of the drive pulley 101 is transmitted to the idler pulley 102. As the idler pulley 102 rotates, the input shaft 91 of the control valve 72 rotates in conjunction with the idler pulley 102, and as the input shaft 91 rotates, the sector gear 85 swings. This swinging of the sector gear 85 is transmitted to the pivot shaft 22 through the sector shaft 84, the lever 48, the link 49, and the steering bracket 23, so that the outboard motor 12 is steered.

[0066] Thus, the second embodiment can offer the same advantages as the advantages (1) to (3) of the first

embodiment. Further, the electrically powered pump 61 is used as the hydraulic pump. Therefore, the second embodiment can also offer the same advantage as the advantage (4) of the first embodiment, although it is necessary to provide the hull 10a with hydraulic piping.

Other Embodiments

[0067] The first and second embodiments may be implemented with the following changes made thereto. In the first embodiment, the controller 15 is provided at an appropriate position in the hull 10a, but the controller 15 may instead be integrally provided with the motor 33.

[0068] In the first embodiment, the worm speed reducer having the worm 53 and the worm wheel 52 is used as the speed reducer 32, but instead of this worm speed reducer, a belt transmission mechanism may be used. Specifically, as shown in FIG. 10, the motor 33 is mounted on the housing 50 of the speed reducer 32 in such a posture that the output shaft 33a thereof is parallel to the shaft 51 of the speed reducer 32. A drive pulley 111 is integrally rotatably provided on the output shaft 33a of the motor 33. An idler pulley 112 is integrally rotatably provided on the shaft 51 of the speed reducer 32. An endless belt 113 is wrapped around both the drive pulley 111 and the idler pulley 112. Rotation of the motor 33 is transmitted to the shaft 51 and further to the ball screw shaft 41 through the drive pulley 111, the belt 113, and the idler pulley 112.

[0069] In the second embodiment, the drive pulley 101, the idler pulley 102, and the two manipulating cables 103, 104 are used as the configuration for transmitting power from the steering wheel 14 to the input shaft 91 of the control valve 72, but a motor may be used instead of these parts. In this case, the output shaft of the motor may be integrally rotatably coupled to the input shaft 91, or may be coupled to the input shaft 91 through a speed reducer, such as a worm speed reducer or a belt transmission mechanism, so as to be able to transmit a torque to the input shaft 91. The controller 15 controls power supply to the motor according to the steering angle θ that is detected through the rotation angle sensor 17. Since the motor is used only to rotate the input shaft 91, a smaller, lower-power motor can be adopted.

[0070] In the first and second embodiments, the controller 15 may control not only the steering actuators 13, 60 but also the engine 12a of the outboard motor 12. In the first and second embodiments, rotation of the sector shaft 44 is transmitted to the steering bracket 23 through the lever 48 and the link 49, but the following configuration may instead be employed as the power transmission mechanism between the sector shaft 44 and the steering bracket 23.

[0071] As shown in FIG. 9, an interlocking shaft 44a is provided at a position near a tooth 45a in an upper surface of the sector gear 45 (a surface on the near side in the sheet of FIG. 9). The interlocking shaft 44a is parallel to the sector shaft 44. The interlocking shaft 44a swings

leftward and rightward around the sector shaft 44 in conjunction with the sector gear 45. An upper end of the interlocking shaft 44a extends through the housing 40 or 80 and is exposed outside the housing 40 or 80. The upper end of the interlocking shaft 44a is slidably engaged in a long hole 23a that is provided in the steering bracket 23. Therefore, the steering bracket 23 swings leftward or rightward around the interlocking shaft 44a in conjunction with the sector gear 45. As a result, the outboard motor 12 is steered leftward or rightward around the pivot shaft 22. Thus, the lever 48 and the link 49 can be omitted from the configuration of the steering actuator 13, and the configuration thereof can be thereby simplified.

[0072] In the first and second embodiments, the steering actuators 13, 60 are applied to the boat 10 that is equipped with the outboard motor 12, but may instead be applied, for example, to a boat 10 that has an inboard motor. As shown in FIG. 11, an engine 12a as an inboard motor is provided inside a hull 10a. Output of the engine 12a is transmitted to a propeller 12b through a propeller shaft 121 that extends from the engine 12a toward the stern. An end of the propeller shaft 121 on the opposite side from the engine 12a extends through a bottom of the hull 10a and is located outside the hull 10a. The propeller 12b is integrally rotatably coupled to the end of the propeller shaft 121 on the opposite side from the engine 12a. A rudder 122 is rotatably supported at the stern of the hull 10a through a support shaft 123. A steering actuator 13 or 60 is provided near the stern of the hull 10a. A lever 48 of the steering actuator 13 or 60 is coupled to the support shaft 123 through two links 124, 125. The link 124 extends in a left-right direction relative to an advancing direction of the boat 10. The link 125 extends along a front-rear direction of the hull 10a. The link 124 is rotatably coupled at a first end thereof to the lever 48. The link 124 is rotatably coupled at a second end thereof that is an end on the opposite side from the lever 48 to a first end of the link 125. The link 125 is fixed at a second end thereof to the support shaft 123 of the rudder 122. Thus, swinging of the lever 48 leftward or rightward around a sector shaft 44 or 84 is converted into rotation of the support shaft 123 through the two links 124, 125. As the rudder 122 swings leftward or rightward around the support shaft 123, the advancing direction of the boat 10 changes.

[0073] Alternatively, the steering actuators 13, 60 may be applied to a boat 10 that is equipped with an inboard-outdrive engine. In an inboard-outdrive engine, an engine and a drive unit are integrated. In the drive unit, an outboard propeller and a mechanism that transmits output of the engine to the propeller are integrated. The engine is provided onboard, near the stern. The drive unit is provided at the stern so as to protrude to an outside of the boat. The drive unit is capable of swinging leftward and rightward relatively to the hull 10a and functions also as the rudder of the boat 10. The drive unit can be steered by transmitting rotation of the sector shaft 44 or 84 of the

steering mechanism 31 or 71 of the steering actuator 13 or 60 to the drive unit as a steering force for steering the drive unit.

[0074] In the first embodiment, the steering gear for a boat is implemented as the steering actuator 13 of steer-by-wire type in which power transmission between the steering wheel 14 and the outboard motor 12 is isolated, but the steering gear may instead be implemented as a power steering device that assists manual operation of the outboard motor 12. In this case, the boat 10 can employ a configuration from which the steering wheel 14, the steering shaft 16, and the rotation angle sensor 17 are omitted. As indicated by the long dashed double-short dashed line in FIG. 2, a handle 12d extending toward a front side of the hull 10a is integrally provided on the case 12c of the outboard motor 12. A steerer manipulates the handle 12d leftward or rightward to steer the outboard motor 12. The outboard motor 12 or the handle 12d is provided with a torque sensor that detects a steering torque applied to the handle 12d. The controller 15 controls power supply to the motor 33 according to the steering torque detected through the torque sensor. A torque from the motor 33 is transmitted to the pivot shaft 22 as an assisting force through the speed reducer 32 and the steering mechanism 31 and assists steering of the outboard motor 12 through the handle 12d. Alternatively, the steering actuator 60 of the second embodiment can be implemented as a power steering device. In this case, the controller 15 controls power supply to the electrically powered pump 61 according to the steering torque that is detected through the torque sensor.

Claims

1. A steering gear for a boat (10), the steering gear **characterized by** comprising:

a steering mechanism (31, 71) that moves a rudder provided at a stern of the boat (10); and
a driving source of the steering mechanism (31, 71), wherein

the steering mechanism (31, 71) has: a housing (40, 80) that is fixed to a hull (10a); an output shaft (44) that is rotatably supported by the housing (40, 80); a first conversion mechanism that is provided inside the housing (40, 80) and converts power from the driving source into rotation of the output shaft (44); and a second conversion mechanism that is provided outside the housing (40, 80) and converts rotation of the output shaft (44) into motion of the rudder.

2. The steering gear according to claim 1, **characterized in that** the first conversion mechanism has: a ball screw shaft (41, 81) that is rotatably supported inside the housing (40, 80) and rotates as the driving source operates; a ball screw nut (42, 82) that is

screwed on the ball screw shaft (41, 81) through a plurality of balls (43, 83) and has rack teeth (42a, 82a) provided on an outer circumferential surface along an axial direction; and a sector gear (45, 85) that is integrally rotatably coupled to the output shaft (44) and meshes with the rack teeth (42a, 82a) of the ball screw nut (42, 82) so as to swing around the output shaft (44) as the ball screw nut (42, 82) moves in the axial direction.

3. The steering gear according to claim 1 or 2, **characterized in that** the driving source is a motor (33).

4. The steering gear according to claim 2, **characterized in that**:

the driving source is a motor (33); and
the steering gear has a speed reducer (32) that reduces speed of rotation of the motor (33) and transmits the rotation at a reduced speed to the ball screw shaft (41, 81).

5. The steering gear according to claim 2, **characterized by** further comprising a control valve (72) that, on the assumption that the driving source is an electrically powered pump (61) that discharges a hydraulic fluid, and that the ball screw nut (82) is slidably provided in the housing (80), with an inside of the housing (80) being divided by the ball screw nut (82) into two fluid chambers, controls supply or discharge of the hydraulic fluid to or from the two fluid chambers, wherein the control valve (72) moves the ball screw nut (82) as a piston along the axial direction by selectively supplying the hydraulic fluid discharged from the electrically powered pump (61) to one of the two fluid chambers according to manipulation of a steering wheel (14) that is manipulated to change a direction of the hull (10a).

6. The steering gear according to any one of claims 1 to 5, **characterized in that** the rudder is an outboard motor (12) that is provided as a propulsion unit of the boat (10) on an outer side of the stern so as to be able to rotate around a pivot shaft (22) and functions also as the rudder of the boat (10) by rotating around the pivot shaft (22).

7. The steering gear according to any one of claims 1 to 5, **characterized in that** the rudder is provided separately from a propulsion unit of the boat (10) on an outer side of the stern so as to be able to rotate around a support shaft (123).

8. The steering gear according to any one of claims 1 to 7, **characterized in that** power transmission between the rudder and a steering wheel (14) that is manipulated to change a direction of the hull (10a) is isolated.

9. The steering gear according to any one of claims 1 to 7, **characterized in that:**

the rudder is coupled to a steering wheel (14)
that is manipulated to change a direction of the
hull (10a); and
the driving source generates an assisting force
that assists in moving the rudder through ma-
nipulation of the steering wheel (14).

10

15

20

25

30

35

40

45

50

55

१७६

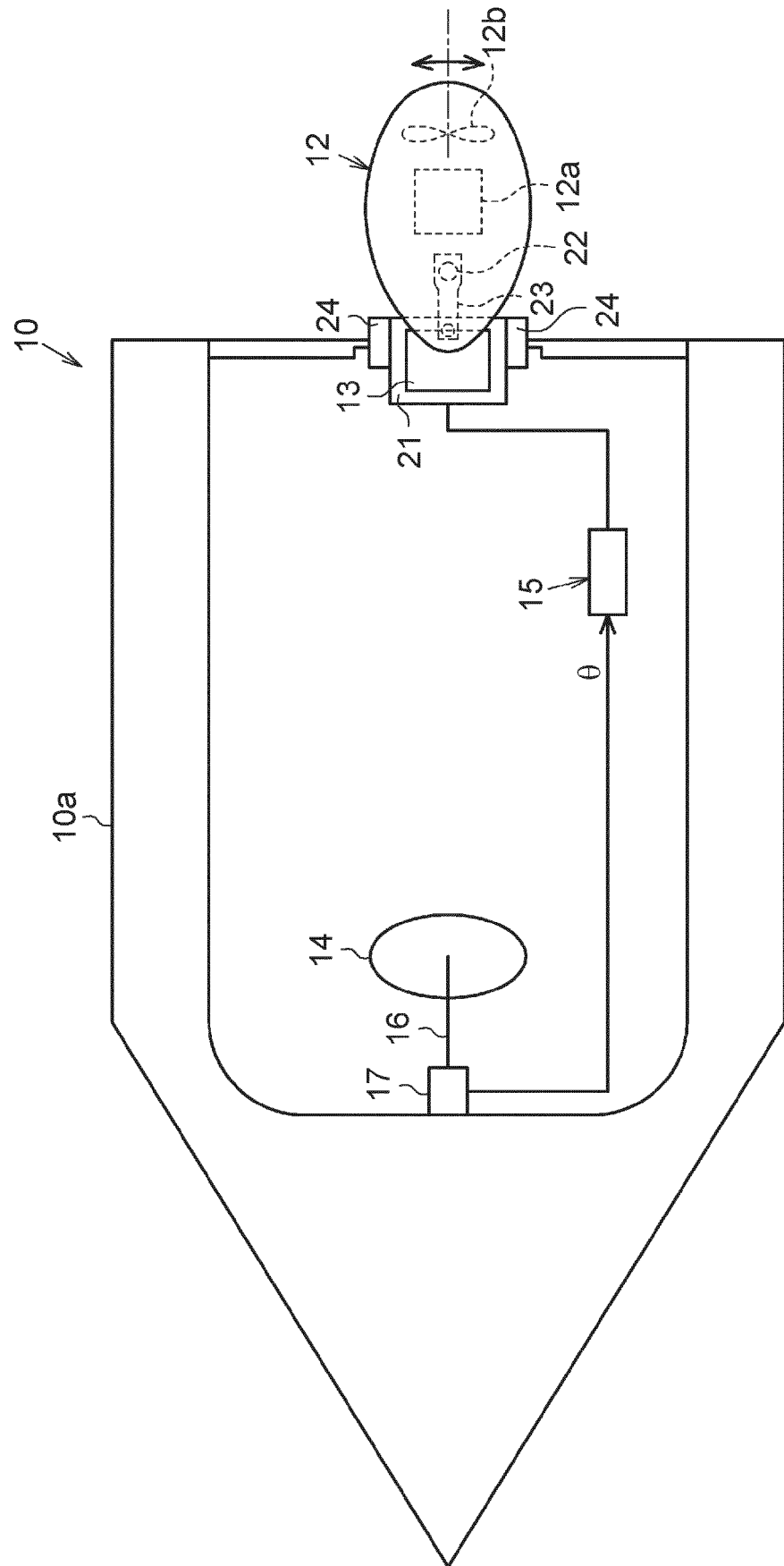


FIG. 2

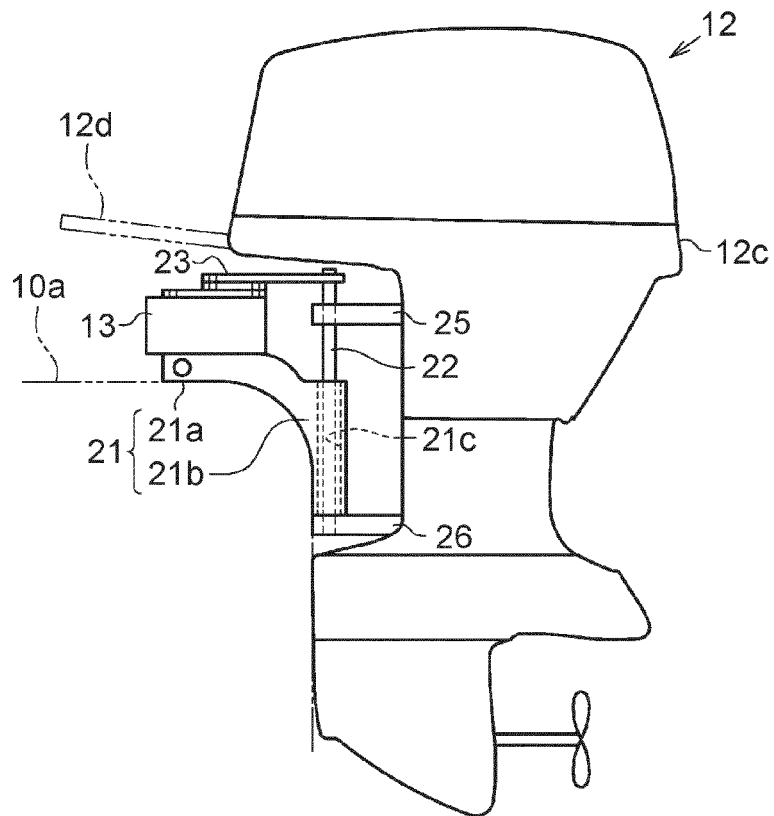
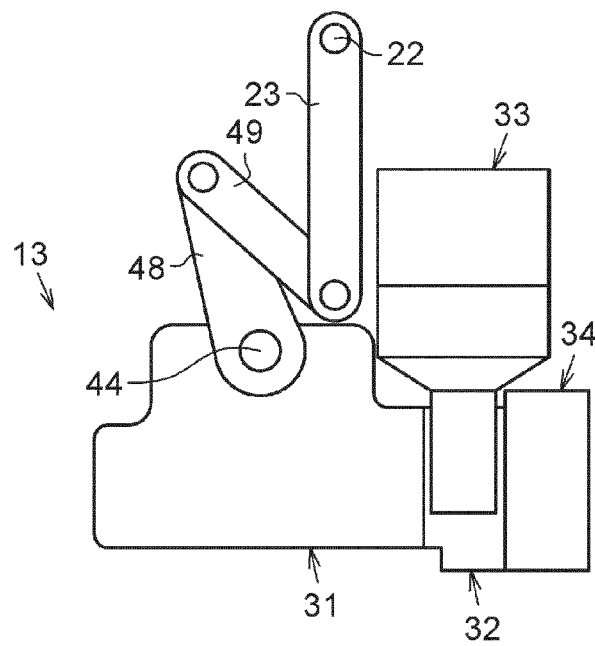


FIG. 3



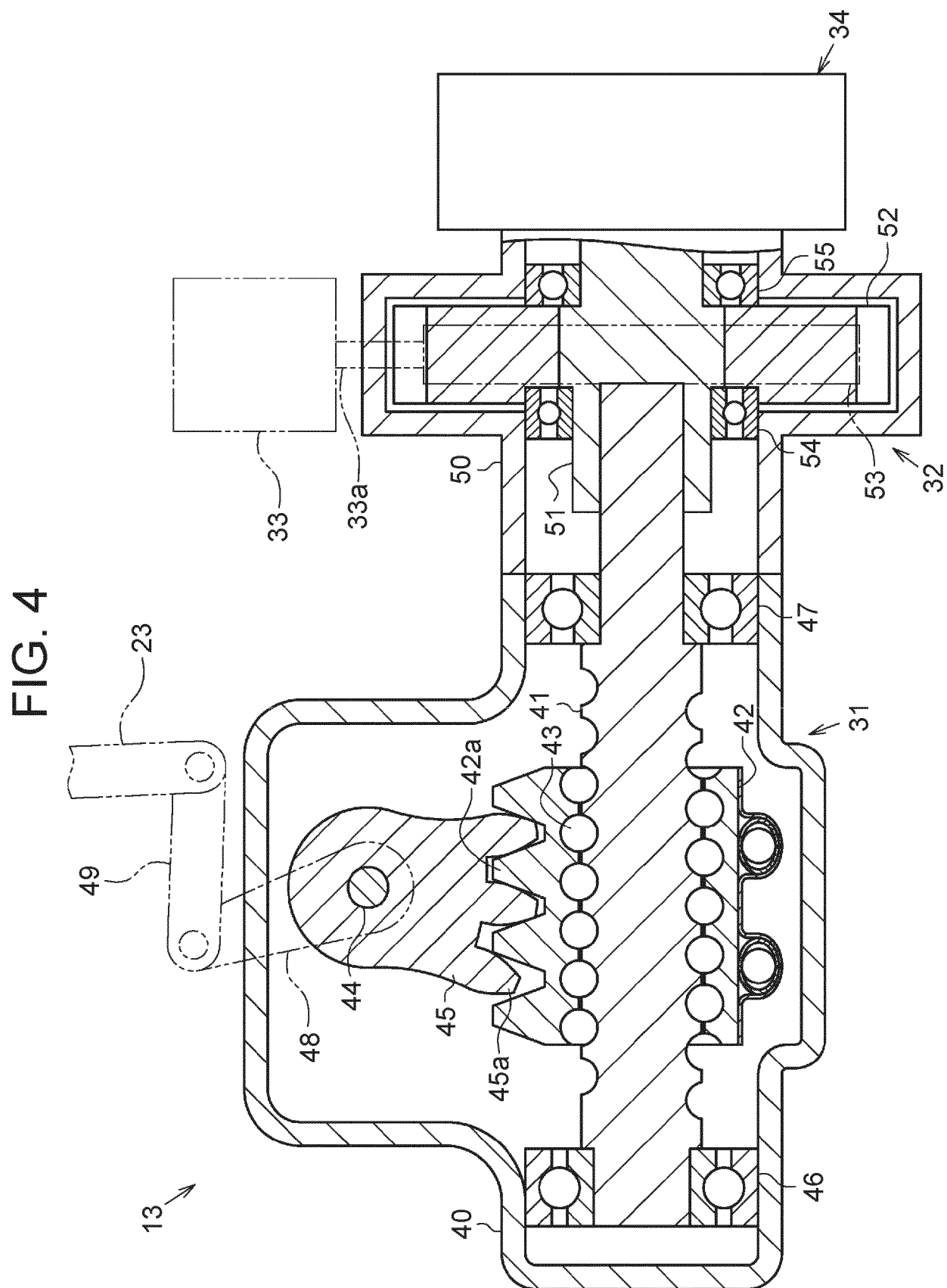


FIG. 5

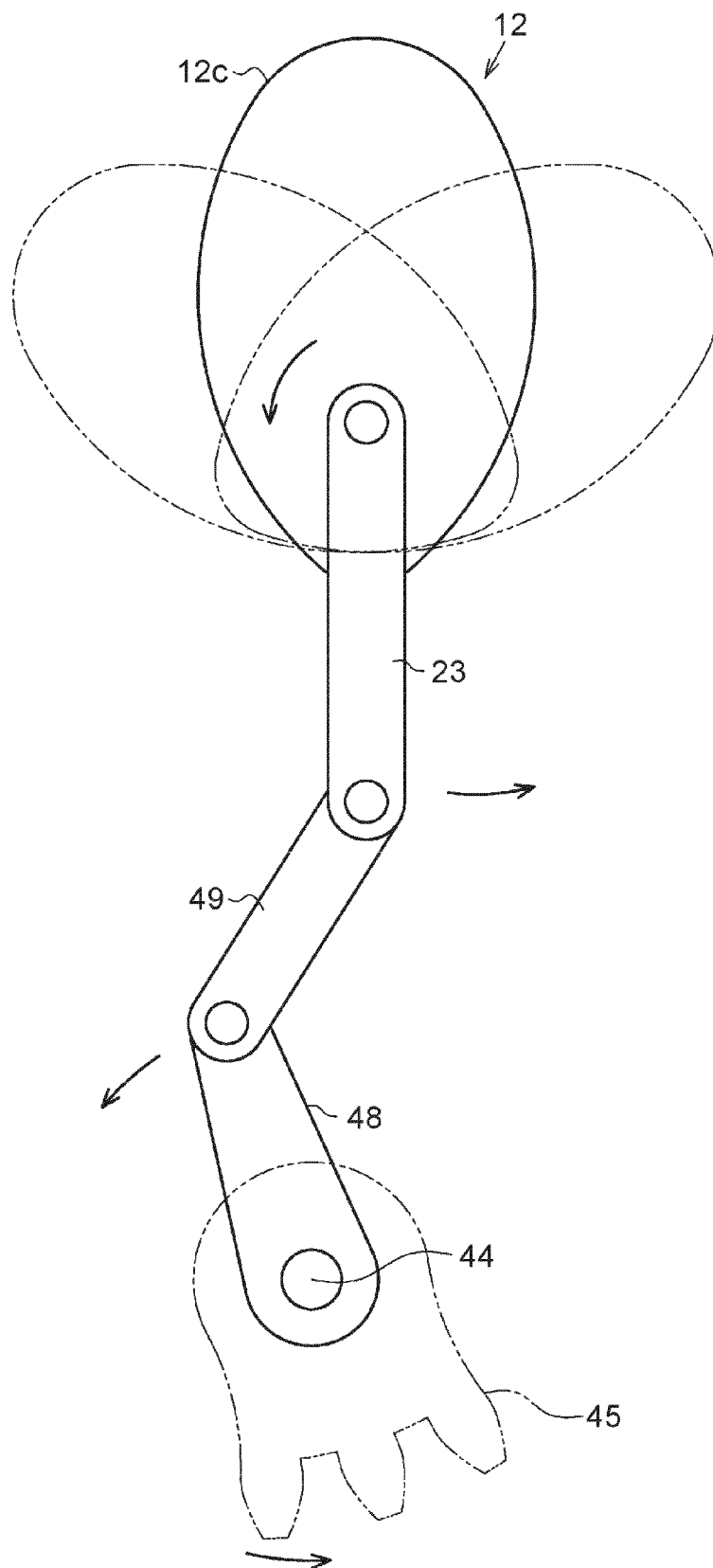


FIG. 6

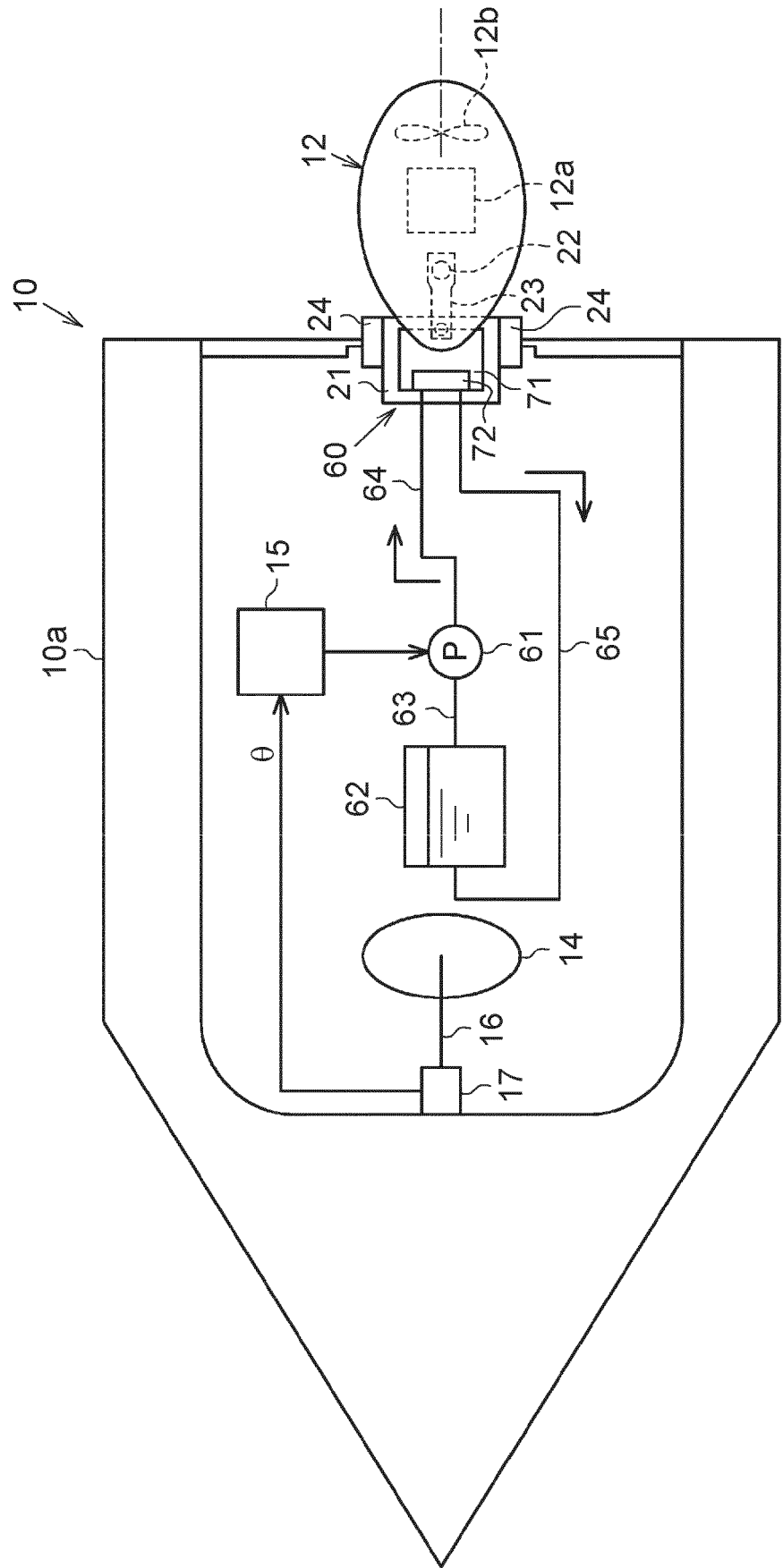


Fig. 7

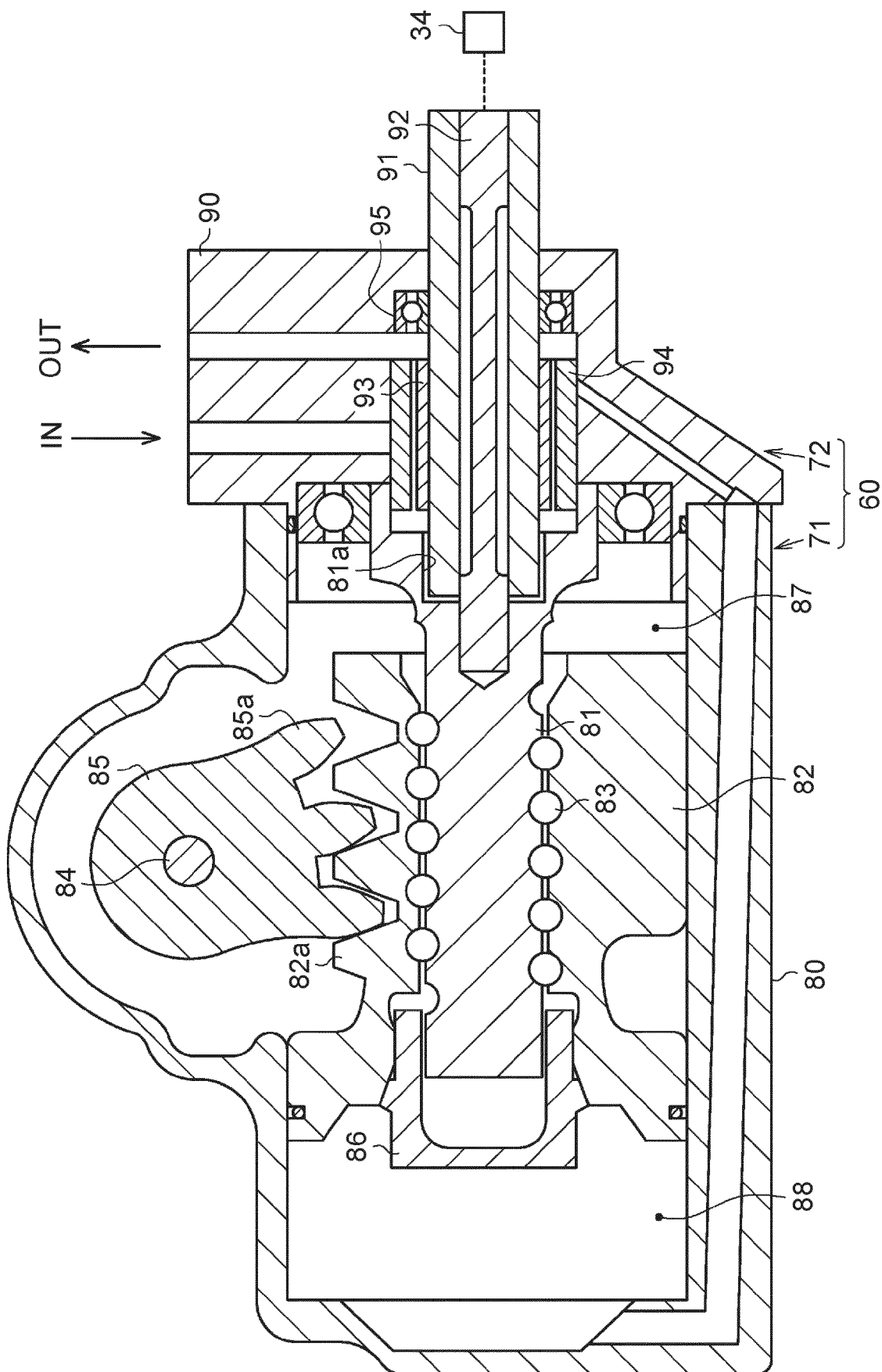


FIG. 8

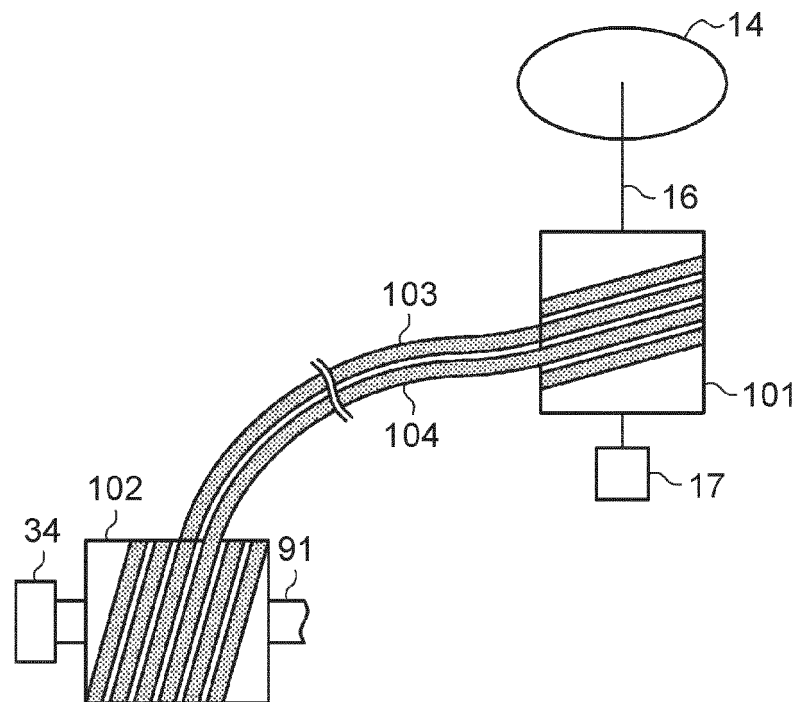


FIG. 9

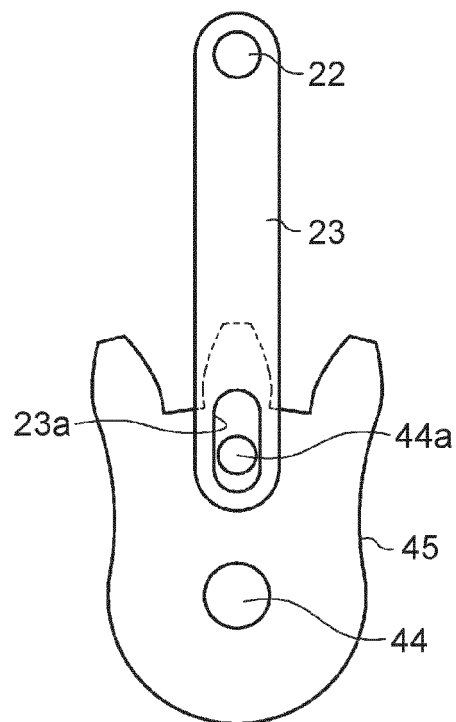


FIG. 10

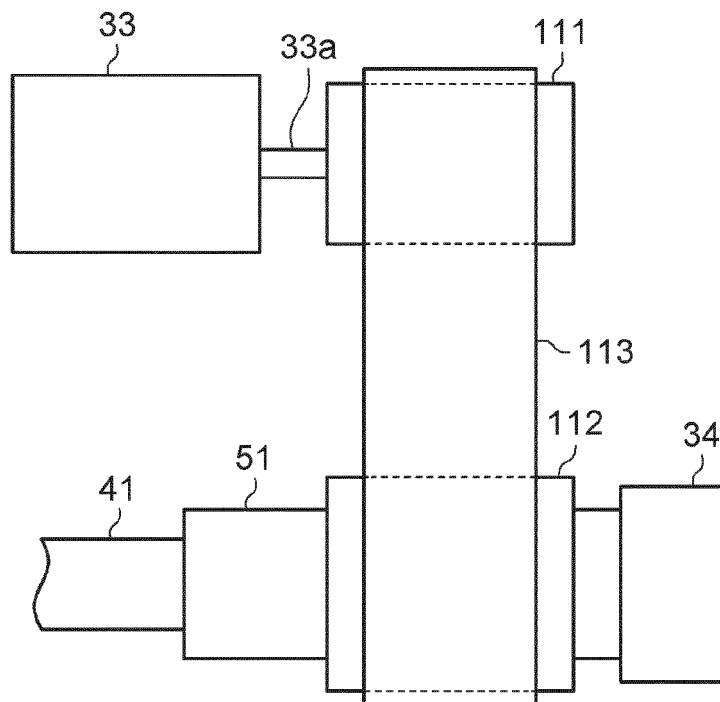
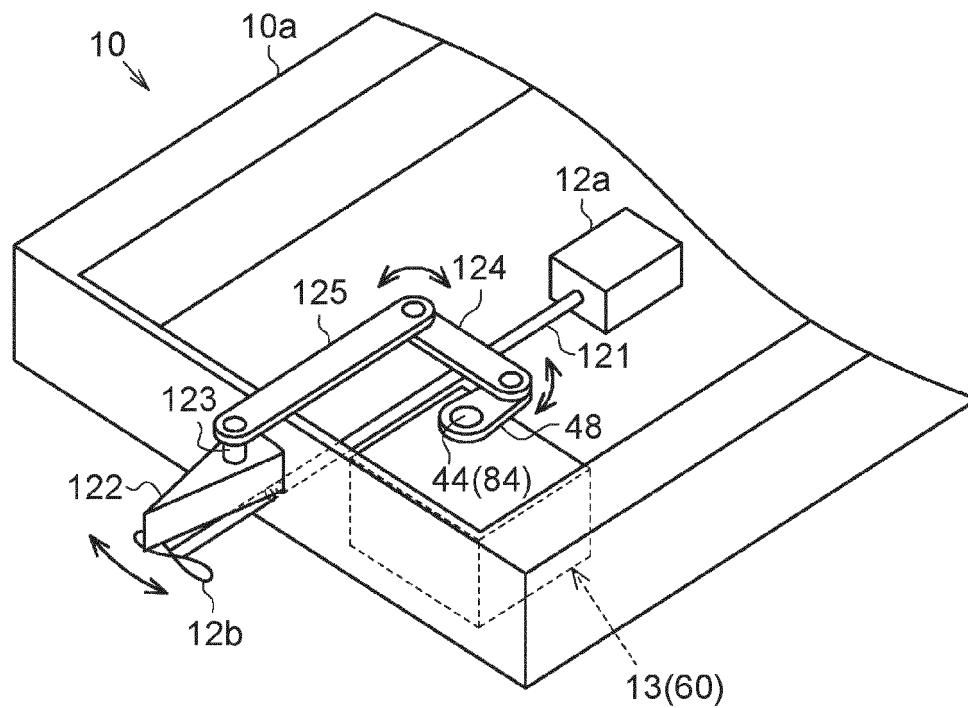


FIG. 11





EUROPEAN SEARCH REPORT

 Application Number
EP 20 20 1067

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP S49 19590 A (UNKNOWN) 21 February 1974 (1974-02-21) * figures 1, 4 *	1,2,7-9	INV. B63H20/12 B63H25/10
X	US 2017/106962 A1 (WEBER JOHN E [US] ET AL) 20 April 2017 (2017-04-20) * paragraph [0014] - paragraph [0016]; figure *	1,3,7-9 4	
X	US 2004/139903 A1 (WATABE HIROSHI [JP] ET AL) 22 July 2004 (2004-07-22) * paragraph [0035] - paragraph [0040]; figure 4 *	1,3,4,6	
X	US 2008/200080 A1 (MIZUTANI MAKOTO [JP]) 21 August 2008 (2008-08-21) * paragraph [0014] * * paragraph [0037] - paragraph [0039]; figure 3 *	1,3,4,6	
X	US 3 613 624 A (STAUFFER JOHN G) 19 October 1971 (1971-10-19) * figures *	1,3,6	TECHNICAL FIELDS SEARCHED (IPC) B63H
X	US 2012/094559 A1 (TAKASE HIROAKI [JP] ET AL) 19 April 2012 (2012-04-19) * paragraph [0080] - paragraph [0083]; figure 10 *	1-4,6	
X	US 2004/121665 A1 (MIZUGUCHI HIROSHI [JP] ET AL) 24 June 2004 (2004-06-24) * paragraph [0123] - paragraph [0126]; figures 16,17 *	1-3,5,6	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 2 March 2021	Examiner Schmitter, Thierry
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 20 1067

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

02-03-2021

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP S4919590 A	21-02-1974	NONE	
US 2017106962 A1	20-04-2017	NONE	
US 2004139903 A1	22-07-2004	CA 2455755 A1 US 2004139903 A1	17-07-2004 22-07-2004
US 2008200080 A1	21-08-2008	JP 2008049990 A US 2008200080 A1	06-03-2008 21-08-2008
US 3613624 A	19-10-1971	NONE	
US 2012094559 A1	19-04-2012	JP 2012081900 A US 2012094559 A1	26-04-2012 19-04-2012
US 2004121665 A1	24-06-2004	CA 2453087 A1 US 2004121665 A1	16-06-2004 24-06-2004

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2010143413 A [0002] [0006]