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(71) Applicant: **Honda Motor Co., Ltd.**
Tokyo 107-8556 (JP)

(72) Inventors:

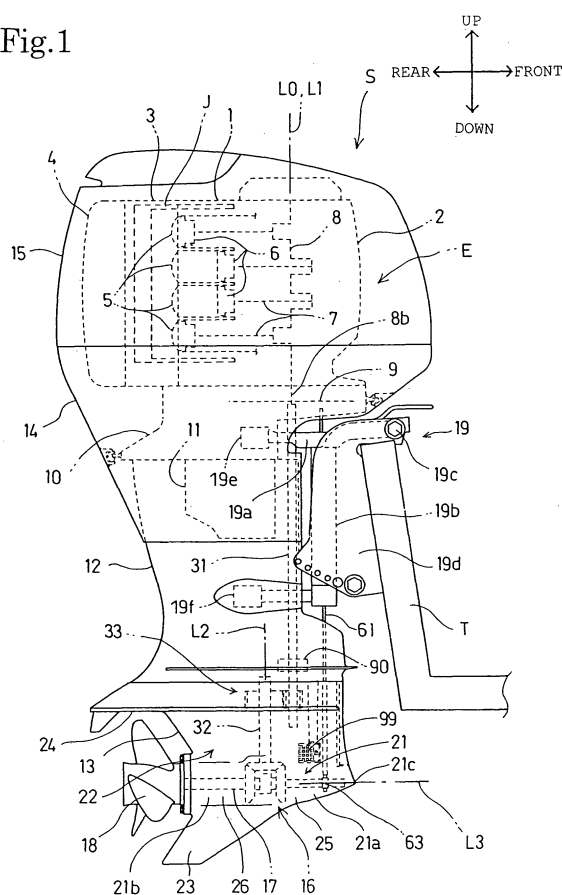
- Ide, Shinichi
Wako-shi
Saitama, 351-0193 (JP)
- Kubota, Mitsuaki
Wako-shi
Saitama, 351-0193 (JP)
- Akiyama, Masahiro
Wako-shi
Saitama, 351-0193 (JP)

(74) Representative: **Trossin, Hans-Jürgen et al**
Weickmann & Weickmann,
Postfach 860 820
81635 München (DE)

(54) **Marine propulsion machine having drive shaft**

(57) An outboard motor S has: a first drive shaft 31 interlocked with an internal combustion engine, a second drive shaft 32 interlocked with the first drive gear 31, an output gear mechanism 50 driven by the second drive shaft 32, a propeller shaft 17, and a gear case 13 holding the output gear mechanism 50 and the propeller shaft 17 and having a normally submerged gearing holding portion 21. The second drive shaft 32 is disposed rearward of the first drive shaft 31 with respect to a longitudinal direction. The gearing holding portion 21 has a tapered part 21a extending forward from a position corresponding to the second drive shaft 32 and having a front end 21c. The tapered part 21a is tapered toward the front. The disposition of the second drive shaft 32 rearward of the first drive shaft 31 enables forming the gear case 13 in a small size and reduces underwater resistance to the gear case 13.

Fig.1



Description

BACKGROUND OF THE INVENTION

5 Field of the Invention

[0001] The present invention relates to a marine propulsion machine including a vertical drive shaft rotatively driven by an engine, an output gear mechanism driven by the drive shaft, a propeller shaft rotatively driven by the output gear mechanism, and a normally submerging gear case containing the output gear mechanism and the propeller shaft.

10 Description of the Related Art

[0002] Marine propulsion machines are disclosed in, for example, JP-A 5-52107 and JP-A 63-97489. The known marine propulsion machine has a gear case holding therein an output gear mechanism driven by a drive shaft rotatively driven by an engine, and a propeller shaft rotatively driven by the output gear mechanism. In this marine propulsion machine, the drive shaft has a first drive shaft interlocked with the engine, and a second drive shaft driven by the first drive shaft to transmit power to the output gear mechanism, and the second drive shaft is disposed on the rear side of the first drive shaft.

[0003] The normally submerging gear case has a gearing holding portion holding the output gear mechanism and the propeller shaft, and a support portion extending upward from the gearing holding portion and connected to a case overlying the gear case and having a cross-sectional shape resembling a cross section of a wing. The gearing holding portion has diameter gradually increasing from its front end toward its rear end. If the area of the cross section of the gearing holding portion in a plane perpendicular to a longitudinal direction parallel to a direction in which water flows relative to the ship when the ship moves forward, increases sharply toward the rear, the form drag (hereinafter referred to as "underwater resistance") resulting from the shape of the gear case while the ship is cruising forward is high, a low-pressure region develops due to the disturbance of water currents when the ship cruises at high cruising speed, and cavitation is liable to occur around a propeller disposed rearward of the gear case.

[0004] When an interlocking mechanism included in an operating mechanism for reversing the rotating direction of the propeller shaft is disposed on the front side of the drive shaft in the gear case, and an operating member and an actuating member included in the interlocking mechanism are a pin and a cam eccentric to the center axis of the operating member, the eccentricity of the eccentric pin and the height of the lobe of the cam are determined so as to correspond to a necessary moving distance along the center axis of the propeller shaft. Therefore, the interlocking mechanism has a large dimension with respect to transverse directions, namely, directions perpendicular to the center axis of the propeller shaft in a plane. Consequently, the transverse dimension of a part of the gear case holding the interlocking mechanism is large and the form drag (hereinafter referred to as "underwater resistance") increases.

SUMMARY OF THE INVENTION

[0005] The present invention has been made under such circumstances and it is therefore an object of the present invention to provide a marine propulsion engine including a first drive shaft rotatively driven by an engine, a second drive shaft interlocked with the first drive shaft and disposed at a distance rearward of the first drive shaft, and a comparatively small gear case on which a comparatively low underwater resistance acts.

[0006] Another object of the present invention is to provide a marine propulsion machine including an operating mechanism, for operating a reversing mechanism, including an interlocking mechanism formed in a small size to use a gear case having a small transverse dimension and subject to a low underwater resistance.

[0007] A marine propulsion machine in a first aspect of the present invention includes: an engine, a first drive shaft interlocked with the engine; a second drive shaft disposed rearward of the first drive shaft and interlocked with the first drive shaft; the first and second drive shafts being disposed with axes thereof vertically extended, an output gear mechanism driven by the second drive shaft; a propeller shaft having a longitudinal center axis and driven by the output gear mechanism; and a normally submerged gear case having a gearing holding portion holding the output gear mechanism and the propeller shaft; wherein the gearing holding portion has a tapered part extending forward from a position corresponding to the second drive shaft with respect to a longitudinal direction to an front end of the gearing holding portion and tapered toward the front end of the gearing holding portion.

[0008] Suppose that a comparative marine propulsion machine is provided with a single drive shaft disposed at the position of the first drive shaft of the marine propulsion machine in the first aspect of the present invention, and provided with a comparative gear case. Then, the longitudinal distance between the second drive shaft and the front end of the gearing holding portion of the marine propulsion machine of the present invention is longer than that between the single drive shaft and the front end of the comparative gear case of the comparative marine propulsion machine because the

second drive shaft is at a distance rearward of the first drive shaft. Consequently, the radius of the gearing holding portion can be more gently increased from the front end to a part of the gearing holding portion corresponding to the second drive shaft than the radius of the gearing holding portion of the comparative gear case. Since the sharp increase of the sectional area of the tapered part from the front end rearward can be avoided, underwater resistance acting on the tapered part can be reduced, water currents are not excessively disturbed during high-speed cruising, and cavitation around the gear case can be suppressed.

[0009] Preferably, the marine propulsion machine is provided with a shift rod for reversing the driving direction of the output gear mechanism, and the longitudinal distance between the front end of the gearing holding portion and the shift rod is not shorter than the outside diameter of a part of the tapered part corresponding to the shift rod with respect to the longitudinal direction.

[0010] Since the longitudinal distance between the front end of the gearing holding portion and the shift rod is not smaller than the outside diameter of a part of the tapered part corresponding to the shift rod, the second drive shaft is at an enlarged distance from the front end of the gearing holding portion and, consequently, the outside radius of the tapered part increases gently from the front end toward the rear, which enhances the effect of the present invention still more.

[0011] Preferably, the second drive shaft is disposed substantially at a middle part of the gearing holding portion with respect to a longitudinal direction.

[0012] Then, the outside radius of the tapered part increases gently, and the increase of frictional resistance exerted by water on the tapered part due to an excessively long distance between the front end to the second drive shaft can be suppressed.

[0013] A marine propulsion machine in a second aspect of the present invention includes: a drive shaft disposed with a center axis thereof vertically extended and driven by an engine; an output gear mechanism driven by the drive shaft; a propeller shaft rotatively driven by the output gear mechanism; a reversing mechanism for reversing rotation of the propeller shaft; an operating mechanism for operating the reversing mechanism; and a gear case having a gearing holding portion holding the output gear mechanism and the propeller shaft; wherein the operating mechanism includes an operating member supported for turning and an actuating member operated through an interlocking mechanism by the operating member to operate the reversing mechanism, the interlocking mechanism disposed on the front side of the drive shaft in the gear case; the interlocking mechanism includes a pinion mounted on the operating member, and a rack formed parallel to the propeller shaft in the actuating member and meshed with the pinion.

[0014] In the marine propulsion machine in the second aspect of the present invention, the interlocking mechanism included in the operating mechanism includes the pinion mounted on the operating member, and the rack formed in the actuating member. Whereas the interlocking mechanism including an eccentric pin and a cam mechanism makes transverse motions, the interlocking mechanism used in the second aspect of the present invention does not make any transverse motions, and the actuating member can be moved in a wide range by turning the operating member. Therefore, a part of the gear case corresponding to the interlocking mechanism can be formed in a small outside diameter and hence underwater resistance to the gear case is low.

[0015] In the marine propulsion machine in the second aspect of the present invention, it is preferable that the gear case has a gearing holding portion holding the output gear mechanism, the propeller shaft and the interlocking mechanism, and the longitudinal distance between the center axis of an input part of the drive shaft in engagement with the output gear mechanism and the center axis of the operating member is greater than the outside diameter of a part of the gearing holding portion corresponding to the center axis of the input part of the drive shaft.

[0016] Since the longitudinal distance between the center axis of the input part of the drive shaft and that of the operating member is greater than the outside diameter of the part of the gearing holding portion corresponding to the center axis of the input part of the drive shaft, a front part of the gearing holding portion extending forward on the front side of the center axis of the input part of the drive shaft can be formed in a long, narrow shape. Thus the diameter of the gearing holding portion can be gently increased from its front end toward the rear to reduce underwater resistance.

[0017] In the marine propulsion machine in the second aspect of the present invention, it is preferable that the drive shaft is a second drive shaft interlocked with a first drive shaft interlocked with the engine by a reduction gear mechanism to transmit power of the first drive shaft to the output gear mechanism.

[0018] Thus the rotational speed of the first drive shaft is reduced to the rotating speed of the second drive shaft by the reduction gear mechanism, and the output gear mechanism is driven by the second drive shaft rotating at the reduced rotational speed. Therefore, the reduction ratio of the output gear mechanism may be low and hence the gear case may be small.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a schematic side elevation of an outboard motor in a preferred embodiment of the present invention taken from the right side of the outboard motor;

Fig. 2 is a sectional view of an essential part of the outboard motor shown in Fig. 1 taken in a plane containing the respective center axes of first and second drive shafts;

Fig. 3 is an enlarged view of a part shown in Fig. 2;

Fig. 4 is a sectional view taken on the line IV-IV in Fig. 2;

Fig. 5A is a sectional view taken on the line V-V in Fig. 2;

Fig. 5B is a sectional view taken on the line a-a in Fig. 5A;

Fig. 6 is a sectional view taken on the line VI-VI in Fig. 2;

Fig. 7A is a view, corresponding to Fig. 2, of a modification of the outboard motor embodying the present invention; and

Fig. 7B is a view, corresponding to Fig 5B, of a part of the modification shown in Fig. 7A.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Preferred embodiments of the present invention will be described with reference to Figs 1 to 7B.

[0021] Referring to Fig. 1, an outboard motor S, namely, a marine propulsion machine, embodying the present invention has a propulsion device and a mounting device 19 for mounting the propulsion device on a hull T. The propulsion device includes an internal combustion engine E, a propulsion unit provided with a propeller 18 driven by the internal combustion engine E to generate thrust, an oil pan 11, cases 12 and 13, and covers 14 and 15.

[0022] The internal combustion engine E is a vertical, water-cooled, multicylinder 4-stroke internal combustion engine. The internal combustion engine E is provided with a crankshaft 8 disposed with its center axis L0 vertically extended, and an overhead-camshaft valve train. The internal combustion engine E has an engine body including a cylinder block 1 integrally provided with four cylinders arranged in a row, pistons 6 fitted in the cylinders for reciprocation, a crankcase 2 joined to the front end of the cylinder block 1, a cylinder head 3 joined to the rear end of the cylinder block 1, and a head cover 4. The crankshaft 8 is rotatably supported on the cylinder block 1 and the crankcase 2. The pistons 6 are interlocked with the crankshaft 8 by connecting rods 7, respectively. The pistons 6 are driven by the pressure of combustion gas produced in combustion chamber 5 formed in the cylinder head 3 to drive the crankshaft 8 for rotation through the connecting rods 7.

[0023] In this specification and appended claims, vertical directions are parallel to the center axes of drive shafts 31 and 32 shown in Figs. 1 and 2, and a longitudinal directions and transverse directions are in a horizontal plane perpendicular to the vertical directions. In a horizontal plane, the transverse directions are perpendicular to the center axis of a propeller shaft. In this embodiment, vertical directions, longitudinal directions and transverse directions correspond to vertical directions, longitudinal directions and transverse directions with respect to the hull.

[0024] The internal combustion engine E is joined to the upper end of a mount case 10. The oil pan 11 and the extension case 12 surrounding the oil pan 11 are joined to the lower end of the mount case 10. The gear case 13 is joined to the lower end of the extension case 12. A lower part of the internal combustion engine E, the mount case 10 and an upper part of the extension case 12 are covered with an under cover 14. An engine cover 15 is joined to the upper end of the under cover 14 so as to cover the internal combustion engine E. The under cover 14 and the engine cover 15 define an engine compartment for containing the internal combustion engine E.

[0025] A first drive shaft 31 is connected to a lower end part 8b of the crankshaft 8 through a flywheel 9 coaxially with the crankshaft 8. The first drive shaft 31 has a vertical center axis L1 aligned with the center axis of the crankshaft 8. The first drive shaft 31 is driven for rotation by the crankshaft 8. The first drive shaft 31 extends downward from the lower end part 8b of the crankshaft 8 through the mount case 10 and the extension case 12 into the gear case 13. A second drive shaft 32 is supported in a vertical position on the gear case 13. The second drive shaft 32 has a vertical center axis L2 parallel to the center axis of the first drive shaft 31. The second drive shaft 32 is connected through a reversing mechanism 16 to a propeller shaft 17 holding the propeller 18, namely, a thrust generating means. The reversing mechanism 16 is capable of changing the input speed to provide an output speed. The power of the internal combustion engine E is transmitted from the crankshaft 8 through the drive shafts 31 and 32, the reversing mechanism 16 and the propeller shaft 17 to the propeller 18 to drive the propeller 18 for rotation.

[0026] The propulsion unit includes the drive shafts 31 and 32, the reversing mechanism 16, the propeller shaft 17 and the propeller 18.

[0027] The mounting device 19 for mounting the outboard motor S on the stern of a hull T has a swivel shaft 19a fixed to the mount case 10 and the extension case 12, a swivel case 19b supporting the swivel shaft 19a for turning thereon, a tilting shaft 19c supporting the swivel case 12 so as to be turnable in a vertical plane, and a bracket 19d holding the tilting shaft 19c and attached to the stern of the hull T. The swivel shaft 19a has an upper end part fixed through a mount rubber 19e to the mount case 10, and a lower end part fixed through a mount rubber 19f to the extension case 12. The mounting device 19 holds the outboard motor S so as to be turnable on the tilting shaft 19c in a vertical plane relative to the hull T and so as to be turnable on the swivel shaft 19a in a horizontal plane.

[0028] Referring to Figs. 1 and 2, the gear case 13 has a gearing holding portion 21 defining a gear chamber 20 (Fig. 2) for containing the reversing mechanism 16 and the propeller shaft 17, a support portion 22 extending upward from the gearing holding portion 21 and connected to the extension case 12, a skeg 23 extending downward from the gearing holding portion 21, and an anticavitation plate 24 horizontally extending from an upper part of the support portion 22. While the ship is cruising, the anticavitation plate 24 is substantially at the level of the water surface, and the gearing holding portion 21 and the support portion 22 are beneath the water level. The gearing holding portion 21 has a streamline shape resembling an artillery shell. The support portion 22 has a cross section having a streamline shape resembling a cross section of a wing, in a horizontal plane perpendicular to the respective center axes L1 and L2 of the drive shafts 31 and 32.

[0029] The first drive shaft 31 is supported in a vertical position in bearings 36 and 37 on the support portion 22. The second drive shaft 32 is supported in a vertical position in bearings 38 and 39 on the support portion 22. An oil pump 70 is built in the support portion 22. The support portion 22 is provided with a bore 69 for receiving a shift rod 61, a suction passage 97 for carrying water to a water pump 90, and a pressure bore 27 for measuring water pressure to determine cruising speed. The water pump 90 sucks cooling water and supplies the cooling water by pressure to water jackets J formed in the cylinder block 1 and the cylinder head 3 of the internal combustion engine E.

[0030] Referring to Figs. 2 and 3, the first drive shaft 31 has an upper end part connected to the crankshaft 8 (Fig. 1). The second drive shaft 32 is interlocked with the first drive shaft 31 by an intermediate gear mechanism 33. The second drive shaft 32 transmits the power of the first drive shaft 31 to an output gear mechanism 50. The second drive shaft 32 is disposed behind the first drive shaft. The center axis L1 of the first drive shaft 31 is aligned with the center axis L0 of the crankshaft 8 of the internal combustion engine E. The center axis L2 of the second drive shaft 32 is parallel to the center axis L1 of the first drive shaft 31 and is separated longitudinally rearward from the center axis L1 of the first drive shaft 31 by a distance δ . The second drive shaft 32 is disposed substantially at the middle of the gearing holding portion 21; that is, the center axis L2 of the second drive shaft 32 is nearer to a vertical line bisecting the length W (Fig. 2), namely, the longitudinal dimension, of the gearing holding portion 21 than the center axis L1 of the first drive shaft 31. The second shaft 32 extends downward beyond a vertical position corresponding to the lower end of the first drive shaft 31. The center axes L1 and L2 are contained in a vertical plane containing the center axis L3 (Figs. 1 and 3) of the propeller shaft 17.

[0031] The first drive shaft 31 provided with the water pump 90 is wetted with water. Therefore, the first drive shaft 31 is made of a highly corrosion-resistant material, such as a stainless steel. The second drive shaft 32 is exposed to oil and an oil-containing atmosphere. Therefore, the second drive shaft 32 is made of a material less corrosion-resistant than the material of the first drive shaft 31. The second drive shaft 32 is made of a low-cost ferrous material, such as a machine-structural carbon steel, for example, SCM415, Japan Industrial Standards. Thus the second drive shaft 32 can be manufactured at low cost.

[0032] The intermediate gear mechanism 33, namely, an interlocking mechanism, includes a drive gear 34 mounted on the first drive shaft 31 and interlocked with the first drive shaft 31 by splines, and a driven gear 35 mounted on the second drive shaft 32, meshed with the drive shaft 34 and interlocked with the second drive shaft 32 by splines.

[0033] The first drive shaft 31 extending through the extension case 12 has a lower part 31c extending in the support portion 22. The drive gear 34, namely, a driving interlocking member, is mounted on the lower end part 31c. A lower end part 31b of the first drive shaft 31 extends downward from the drive gear 34. The lower end part 31b extends substantially in a middle part of a vertical range between the propeller shaft 17 and the water pump 90 or substantially in a middle part of the support portion 22. The first drive shaft 31 is supported in the bearing 36 on the upper side of the boss 34a of the drive gear 34 and the bearing 37 on the lower side of the boss 34a of the drive gear 34.

[0034] The upper bearing 36 is a roller bearing. The lower part 31c of the first drive shaft 31 is supported through an upper part of the boss 34a by the upper bearing 36. The upper bearing 36 is held immediately above a toothed part 34b of the drive gear 34 on the support portion 22 by a bearing holder 41. The lower bearing 37 is a taper roller bearing. The lower part 31c of the first drive shaft 31 is supported by the lower bearing 37 through a lower part of the boss 34a. The lower bearing 37 is held immediately below the toothed part 34b on the support portion 22.

[0035] The second drive shaft 32 is substantially entirely contained in the support portion 22. The second drive shaft 37 has an upper end part 32a extending upward from the boss 35a of the driven gear 35, namely, a driven interlocking member, and a lower end part 34b extending in the gear chamber 20. The lower end part 34b of the second drive shaft 32 is the input member of the output gear mechanism 50. The second drive shaft 32 is supported only in the bearings 38 and 39 disposed on the upper and the lower side, respectively, of the driven gear 35 with respect to the vertical direction.

[0036] The upper bearing 38 is a double-row taper roller bearing with vertex of contact angles outside of the bearing and is capable of sustaining both upward and downward axial loads. An upper end part 32a of the second drive shaft 34 extending upward from the region of the driven gear 35 is supported in the upper bearing 38. The upper bearing 38 is held immediately above the boss 35a of the driven gear 35 by a bearing holder 42 joined to an upper end part 22a of the support portion 22. The lower bearing 39 is a needle bearing. The lower bearing 39 supports the second drive shaft 32 and is held on the support portion 22 at a position immediately above the lower end part 32b of the second drive shaft 34.

[0037] The upper bearing 38, the boss 34a of the drive gear 34 and the toothed part 34b are substantially at the same vertical position with respect to the vertical direction in which the second drive shaft 34 extends. The upper bearing 38 and the cylindrical toothed part 35b of the driven gear 35 are substantially at the same vertical position with respect to the vertical direction. The upper bearing 38 is disposed in a cylindrical space 43 extending between the upper end part 32a and the toothed part 35b and surrounded by the toothed part 35b. The lower bearing 39 is put on a part of the lower end part 32b extending above an input gear 51 mounted on the lower end part 32b.

[0038] As shown in Fig. 2, the propeller shaft 17 is rotatably supported by a bearing holder 29 in the gearing holding portion 21 with its center axis L3 longitudinally extended. The propeller shaft 17 is driven for rotation by power transmitted thereto by the output gear mechanism 50. The propeller shaft 17 has a front part 17a extending in the gearing holding portion 21 or the gear chamber 20, and a rear part 17b extending to the outside of the gearing holding portion 21 and holding the propeller 18.

[0039] As best shown in Fig. 3, the reversing mechanism 16 includes the output gear mechanism 50 and a clutch 54 for changing the rotational direction of the propeller shaft 17.

[0040] The output gear mechanism 50 driven by the second drive shaft 32 is disposed in the gear chamber 20. The gear chamber 20 is a sealed space filled with oil. The output gear mechanism 50 includes an input gear 51 mounted on the lower end part 32b of the second drive shaft 32, a forward gear 52 and a reverse gear 53. The forward gear 52 and the reverse gear 53 are on the rear side and the front side, respectively, of the clutch 54. The output gear mechanism 50 is a bevel gear mechanism. In this embodiment, the output gear mechanism 50 is a standard rotation type gear mechanism. The forward gear 52 is supported by bearings 46 and 47 on the front part 17a at a position behind the center axis L2 aligned with the center axis of the input gear 51 and the center axis of the lower end part 32b. The reverse gear 53 is supported by bearings 48 and 49 on the front part 17a at a position in front of the center axis L2.

[0041] The intermediate gear mechanism 33 and the output gear mechanism 50 are a primary reduction gear mechanism and a secondary reduction gear mechanism, respectively, of a transmission system including the first drive shaft 31, the second drive shaft 32 and the propeller shaft 17. The reduction ratio of the intermediate gear mechanism 33 is higher than that of the output gear mechanism 50. For example, the reduction ratio of the intermediate gear mechanism 33 is between 1.6 and 2.5, while that of the output gear mechanism 50 is between 1.0 and 1.4. Therefore, the reduction ratio of the output gear mechanism 50 may be low as compared with a reduction ratio required when the intermediate gear mechanism 33 is omitted. Thus the respective diameters of the forward gear 52 and the reverse gear 53 are small, the diameter of the gearing holding portion 21 may be small and hence the gear case 13 may be small.

[0042] Referring to Figs. 4, 5A and 5B, the clutch 54 includes a shifter 55 fitted in an axial bore formed in the front part 17a so as to be axially slidable in directions parallel to the center axis L3 of the propeller shaft 17, a cylindrical clutch element 56 put on the front part 17a, and a connecting pin 57 retained in place by a coil spring 58 to connect the shifter 55 and the clutch element 56.

[0043] The shifter 55 is moved in directions A (Fig. 3) parallel to the center axis L3 by operating the shift rod 61. The shifter 55 has a connecting part 55a connected to an operating rod 62 so as to be rotatable and movable in the directions A, and a detent mechanism 55b, namely, a positioning mechanism, for retaining the shifter 55 of the clutch mechanism 54 at a neutral position, a forward position or a reverse position. As shown in Fig. 3, the connecting pin 57 is passed through a pair of slots 59 formed in the front part 17a and parallel to the center axis L3. The connecting pin 57 has opposite end parts connected to the clutch element 56. The clutch element 56 is interlocked with the front part 17a by splines so as to be slidable in the directions A on the front part 17a. The clutch element 56 is a movable member of a dog clutch. The clutch element 56 has a forward interlocking part 56a provided with teeth capable of being engaged with teeth formed on the forward gear 52 formed on one end thereof and a reverse interlocking part 56b provided with teeth capable of being engaged with teeth of the reverse gear 53 formed on the other end thereof.

[0044] When the shifter 55 is positioned at the neutral position by operating the shift rod 61, the clutch element 56 is not interlocked with either of the forward gear 52 and the reverse gear 53, and hence any power is transmitted through the first drive shaft 31 and the second drive shaft 32 to the propeller shaft 17. When the shifter 55 is positioned at the forward position, the clutch element 56 is interlocked with the forward gear 52. Consequently, power is transmitted through the first drive shaft 31, the second drive shaft 32, the forward gear 52 and the clutch element 56 to the propeller shaft 17 to propel the ship forward by rotating the propeller 18 in the normal direction. When the shifter 55 is positioned at the reverse position, the clutch element 56 is interlocked with the reverse gear 53. Consequently, power is transmitted through the first drive shaft 31, the second drive shaft 32, the reverse gear 53 and the clutch element 56 to the propeller shaft 17 to propel the ship rearward by rotating the propeller 18 in the reverse direction.

[0045] Referring to Figs. 1 to 3 and 5A, a clutch control mechanism for controlling the clutch mechanism 54 includes the shift rod 61, namely, an operating member, to be turned by a drive mechanism, not shown, operated by the operator, and the operating rod 62 to be driven through an interlocking mechanism 63 by the shift rod 61 to control the clutch mechanism 54.

[0046] The shift rod 61 held in the bore 69 of the gear case 13 lies in front of the first drive shaft 31 and vertically extends through the support portion 22 into the gearing holding portion 21 (Fig. 1). The shift rod 61 has a lower end part

61b extending in the gear chamber 20 (Fig. 2). A lowermost part 61b1 of the shift rod 61 is slidably and rotatably supported on the gearing holding portion 21. A pinion 63a is mounted on the lower end part 61b.

[0047] The operating rod 62 has a front end part 62a slidably and rotatably fitted in a bore formed in a part of the gearing holding portion 21 near the front end 21c of the gearing holding portion 21, and a rear end part 62b connected to the connecting part 55a of the shifter 55. The operating rod 62 has a slotted middle part 62d provided with a slot 62e opening in vertical directions, and extending between the front end part 62a and the rear end part 62b. The slotted middle part 62d is provided in the inside surface of one of the longitudinal side parts thereof with a rack 63b (Fig. 5A). The pinion 63a is in mesh with the rack 63b.

[0048] The interlocking mechanism 63 includes the pinion 63a, namely, a driving member, and the rack 63b, namely, a driven member.

[0049] When the shift rod 61 is turned, the pinion 63a turns to move the rack 63b forward or rearward (in either of the directions A parallel to the center axis L3). Thus the operating rod 62 moves the shifter 55 in an axial direction to place the shifter 55 selectively at the neutral position, the forward position or the reverse position. More concretely, the shifter 55 is at the neutral position in Figs. 3 and 5A. When the shift rod 61 is turned to turn the pinion 63a clockwise in the state shown in Fig. 5A, the operating rod 62 provided with the rack 63b is moved rearward to position the shifter 55 at the forward position. When the shift rod 61 is turned to turn the pinion 63a counterclockwise in the state shown in Fig. 5A, the operating rod 62 provided with the rack 63b is moved forward to position the shifter 55 at the reverse position.

[0050] A recessed part 62c (Fig. 5B) of the operating rod 62 allows the operating rod 62 to be connected to the connecting part 55a at two different angular positions of the operating rod 62 around its axis L3. Therefore, the rack 63b can be disposed either on the right side or on the left side of the pinion 63a. Therefore, change of the twisting direction of the blades of the propeller 18 or the reversing of the rotating direction of the first drive shaft 31 or the second drive shaft 32 can be dealt with by changing the mode of connection of the operating rod 62 to the shifter 55 and hence the forward cruising and reverse cruising of the ship can be controlled without changing the turning directions of the shift rod 61 respectively for forward cruising and reverse cruising.

[0051] Referring to Figs. 1 and 2, the gearing holding portion 21 is divided into a tapered part 21a and a cylindrical part 21b substantially by a vertical plane which contains the center axis L2 and is perpendicular to the center axis L3. The tapered part 21a extends forward from the region of the second drive shaft 32 to the front end 21c of the gearing holding portion 21. The cylindrical part 21b extends rearward from the region of the second drive shaft 32 to the rear end of the gearing holding portion 21. Referring to Figs. 4 and 5, the tapered part 21a has a generally tapered shape and has diameter decreasing with distance in a direction from the second drive shaft 32 toward the front end 21c, and the cylindrical part 21b has a generally cylindrical shape and has a fixed diameter.

[0052] In this specification, "generally tapered" signifies that the tapered part 21a is substantially tapered and may include local irregularities, and "generally cylindrical" signifies that the cylindrical part 21b is substantially cylindrical and may have local irregularities. Joints (merging parts) between the gearing holding portion 21 and the support portion 22 and between the gearing holding portion 21 and the skeg 23 are excluded from the tapered part 21a and the cylindrical part 21b.

[0053] More concretely, the radii e (Fig. 4) of parts on the intersection of the outside surface 25 of the tapered part 21a and a plane at an angle θ from a vertical plane containing the center axis L3 (a datum plane), namely, distances from the center axis L3 to parts on the intersection of the outside surface 25 of the tapered part 21a and a plane at an angle θ from a vertical plane containing the center axis L3 (a datum plane), farther forward from the center axis L2 are smaller. The greatest radius e_1 among the radii e of the tapered part 21a is substantially dependent on the size of the output gear mechanism 50 held in the gearing holding portion 21, namely, the diameters of the gears 51 to 53. Therefore, a part of the outside surface 25 of the tapered part 21a corresponding to the center axis L2 has the greatest radius e_1 . The radii e of parts of the tapered part 21a extending in front of the second drive shaft 32 including the radius e_3 of a part corresponding to the center axis L1 of the first drive shaft 31 aligned with the center axis of the connecting pin 57 at the neutral position, and the radius e_2 of a part corresponding to the center axis L4 of the shift rod 61 decrease toward the front end 21c. In Fig. 4, the circumference of the outside surface 25 in a vertical plane containing the center axis L1 of the first drive shaft 31 and perpendicular to the center axis L3 is indicated by a two-dot chain line. Cross sections of the tapered part 21a excluding that of a part corresponding to the input gear 51 are circles.

[0054] The cross section is a section in a plane perpendicular to the longitudinal direction, namely, a direction in which water flows when the ship cruises straight. A cross-sectional area is the area of a cross section.

[0055] Thus the distance from the front end 21c to the part having the greatest radius e_1 of the tapered part 21a of the gear case 13 of the outboard motor S in this embodiment is longer than that from the front end to a part having the greatest radius of the gear case (comparative gear case) of an outboard motor having a single drive shaft at a position corresponding to that of the first drive shaft 31. In other words, the distance from the front end 21c to the part having the greatest radius e_1 is longer than that in the case of the comparative gear case by the distance δ by which the center axis L2 of the second drive shaft 32 is separated longitudinally rearward from the center axis L1 of the first drive shaft 31. Therefore, the tapered part 21a of the gear case 13 has a taper ratio smaller than that of the tapered part of the

comparative gear case. Thus the tapered part 21a is tapered in a small or gentle taper. The radius e of the tapered part 21a increases more gradually from the front end 21c toward the part corresponding to the second drive shaft 32 than that of the tapered part of the comparative gear case, and hence the cross-sectional area of the tapered part 21a increases gradually from the front end 21c toward the part corresponding to the second drive shaft 32. Thus, it is possible to provide a low "shape resistance" (hereinafter referred to as "underwater resistance") resulting from the shape of the gear case 13 while the ship is cruising forward.

[0056] In this specification, the term "taper ratio" is the ratio of the axial distance f_1 between the front end 21c and the center axis L2 of the second drive shaft 32 corresponding to the part having the greatest radius e_1 , to the greatest radius e_1 , i.e. f_1/e_1 .

[0057] Referring to Fig. 5A, the shape of the tapered part 21a is defined by the following expressions.

$$R2 = f2/f1$$

$$R3 = f3/f1$$

$$R4 = f4/f1$$

$$R5 = e_2/e_1$$

$$R6 = e_3/e_1$$

where f_1 is the axial distance between the front end 21c and the center axis L2 of the second drive shaft 32 corresponding to the part having the greatest radius e_1 , f_2 is the axial distance between the front end 21c and the center axis L4 of the shift rod 61, f_3 is the axial distance between the front end 21c and the center axis L1 of the first drive shaft 31, f_4 is the axial distance between the center axis L4 of the shift rod 61 and the center axis L1 of the first drive shaft 31, e_1 is the greatest one of the radii e of the tapered part 21a, and e_2 is the radius of the part corresponding to the center axis L4 of the shift rod 61. The axial distance f_2 satisfies an inequality: $20\% \leq R2 \leq 45\%$, preferably, $R2 = 34\%$. The radius e_2 satisfies an inequality: $58\% \leq R5 \leq 69\%$, preferably, $R5 = 63\%$.

[0058] The axial distance f_3 satisfies an inequality: $60\% \leq R3 \leq 80\%$, preferably, $R3 \approx 68\%$ (when the axial distance satisfies that condition, the axial distance f_4 satisfied $R4 \approx 36\%$). The radius e_3 of the part corresponding to the center axis L1 satisfies an inequality: $89\% \leq R6 \leq 97\%$, preferably, $R6 = 93\%$.

[0059] The distance between the center axis L3 to an optional part on the outside surface 26 (Fig. 1) of the cylindrical part 21b is approximately equal to the greatest radius e_0 . A cross section of the cylindrical part 21b has a circular shape.

[0060] In the gearing holding portion 21 holding the output gear mechanism 50, the propeller shaft 17 and the interlocking mechanism 63, the axial distance between the center axis L2 of the second drive shaft 32 having the lower end part 32b in engagement with the output gear mechanism 50, and the center axis L4 of the shift rod 61 is greater than the outside diameter d_1 (Fig. 5A) of a part of the gearing holding portion 21 corresponding to the center axis L2. The outside diameter d_1 of the part corresponding to the center axis L2 is the greatest one of those of the tapered part 21a.

[0061] As best shown in Fig. 5A, the decreasing rate of the radius e in an axial range between the center axis L1 of the first drive shaft 21 and the front end 21c is higher than that at which the radius e decreases in an axial range between the center axis L2 of the second drive shaft 32 and the center axis L1 of the first drive shaft 31.

[0062] The axial distance f_2 between the front end 21c and the center axis L4 of the shift rod 61 is not smaller than the diameter d_2 of a part of the tapered part 21a corresponding to the center axis L4 ($2e_2$) and not greater than $2.5e_2$.

[0063] Since the second drive shaft 32 is separated rearward from the first drive shaft 31, the axial distance between the second drive shaft 32 and the front end of the support portion 22 is long relative to the outside diameter as compared with the corresponding axial distance in the comparative gear case. Thus the support portion 22, similarly to the gearing holding portion 21, can be formed in a tapered shape, the support portion 22 is gradually tapered toward its front end and hence the cross-sectional area of the holding part 22 increases gradually from the front end rearward.

[0064] Referring to Fig. 2, the gear case 13 is turned around the shift rod 61 for steering. Therefore a part of the gear

case 13 extending forward from the center axis L4 of the shift rod 61 to the front ends 21c and 22c is a front overhang. The shape of the front overhang has a significant influence on the high-speed cruising performance of the ship and response to steering operations. The overhang extending slightly below the anticavitation plate 24 is designed such that the axial distance f2 between the front end 21c and the center axis L4 of the shift rod 61 is in a range between a distance equal to the axial distance f5 between the center axis L4 and the front end 22c of the support portion 22 and a distance about twice the distance f5. The front ends 21c and 22c are shaped such that the front end 22c is connected by a substantially straight line to the front end 21c when the distance f2 is equal to the distance f5 or by a continuous curve when the distance f2 is longer than the distance f5.

[0065] A lubricating system for lubricating the moving parts disposed in the gear case 13 and requiring lubrication including the bearings 36, 37, 38 and 39 and the intermediate gear mechanism 33 will be described with reference to Figs. 2 and 3.

[0066] The lubricating system includes the oil pump 70, namely, a first oil pump, driven by the first drive shaft 31, a screw pump 71, namely, a second oil pump, and oil passages. The oil pump 70 is a trochoid pump. The oil pump 70 is disposed at a vertical position substantially coinciding with that of the screw pump 71 between the output gear mechanism 50 and the intermediate gear mechanism 33 with respect to a vertical direction

[0067] The oil pump 70 includes a pump body 72 fixedly held in the support portion 22 and having a recess opening downward, a rotor unit disposed in the recess of the pump body 72 and including an inner rotor 74a and an outer rotor 74b, a pump cover 73 seated on a shoulder 22d formed in the support portion 22 so as to cover the rotors 74a and 74b, and a pump shaft 75 connected to a lower end part 31b of the first drive shaft 31 and the inner rotor 74a. The pump cover 73 and the pump body 72 contiguous with the pump cover 73 are fastened to the shoulder 22d with bolts 79. The pump cover 73 and the pump body 72 are provided with a suction port 76 and a discharge port 77, respectively.

[0068] The oil passages include a suction passage 80 formed in the support portion 22 to carry oil from the gear chamber 20 to the suction port 76, a discharge passage 81 formed in the first drive shaft 31 and connected to the discharge port 77, an oil chamber 82 defined by the support portion 22 and the bearing holder 41 and holding the upper bearing 36 therein, an oil passage 83 formed in the bearing holder 41, an oil chamber 84 formed in the bearing holder 41, an oil chamber 85 defined by the bearing holders 41 and 42 and holding the upper bearing 38 therein, two return passages 87 and 88 formed in the support portion 22 to carry oil to the oil chamber 20, and an oil passage 86 formed in the second drive shaft 32 to carry part of the oil contained in the oil chamber 84 to the screw pump 71.

[0069] An uppermost part 32a1 of the upper end part 32a of the second drive shaft 32 is inserted into the oil chamber 84. The oil passage 86 opens into the oil chamber 84. The screw pump 71 is disposed between the driven gear 35 and the lower bearing 39 and is driven by the second drive shaft 32. The screw pump 71 has a cylindrical rotor provided in its outer surface with a helical grooves twisted so as to move the oil downward when the cylindrical rotor rotates. Oil level OL of the oil contained in the gear case 13 is below the intermediate gear mechanism 33 and near the vertical position of the oil pump 70 so that the oil pump 70 can suck the oil.

[0070] When the internal combustion engine E operates and the first drive shaft 31 and the second drive shaft 32 rotate, the oil pump 70 sucks the oil through the suction passage 80 and discharges the oil through the discharge port 77 into the discharge passage 81. The oil flowing in the discharge passage 81 is pressurized by centrifugal force exerted thereon when the first drive shaft 31 rotates and is forced into the oil chamber 82 to lubricate the upper bearing 36. The oil flows downward from the oil chamber 82 to lubricate the drive gear 34, the driven gear 35 and the lower bearing 37, and then flows through an oil passage, not shown, into the return passage 87. The oil flows from the oil chamber 82 through the oil passage 83 into the oil chamber 84. Then, the oil flows from the oil chamber 84, flows through a gap between the bearing holder 41 and the upper end part 32a of the second drive shaft 32 into the oil chamber 85 to lubricate the upper bearing 38 and the driven gear 35, and then flows into the return passage 87. The screw pump 71 sucks part of the oil contained in the oil chamber 84 into the oil passage 86. The screw pump supplies the oil by pressure. Part of the oil supplied by the screw pump 71 lubricates the lower bearing 39 and returns into the gear chamber 20 and another part of the oil flows into the return passage 88. Thus the entire second drive shaft 32 is in the oil and an oil-containing atmosphere.

[0071] The water pump 90 is driven by the first drive shaft 31. The water pump 90 is held on the gear case 13 by the bearing holder 41. The water pump 90 includes a pump housing 91 fixed to the upper end of the bearing holder 41, and an impeller 93 placed in a pump chamber 92 defined by the pump housing 91. The impeller 93 is mounted on the first drive shaft 31. Water is sucked through an inlet port 95 formed in a gasket 94 into the pump chamber 92. Then, the impeller 93 sends out the water by pressure through an outlet port 96. Then, the water flows through a water supply passage including a conduit and pores formed in the mount case 10 into the water jackets J (Fig. 1) of the internal combustion engine E.

[0072] Referring also to Fig. 6, suction passages 97 are formed in the support portion 22 and the bearing holder 41 to carry cooling water to the inlet port 95. A pair of water intakes 98 are formed in the opposite side surfaces 25 of the support portion 22. Only the water intake 98 formed in the right-hand side surface 25 is shown in Fig. 6. The suction passages 97 are connected to the water intakes 98, respectively. Screens 99 are attached to the water intakes 98 to

screen out foreign matters. As shown in Fig. 3, the oil pump 70 and at least a part of each of the water intakes 98 covered with the screens 99 are located between the first drive shaft 31 and the output gear mechanism 50 with respect to a vertical direction, and between the first drive shaft 31 and the shift rod 61 with respect to the longitudinal direction.

[0073] The lower end part 31b of the first drive shaft 31 is at a height level substantially corresponding to that of a middle part of the second drive shaft 32. Therefore, the water intakes 98 are disposed in a space extending between the first drive shaft 31 and the output gear mechanism 50 with respect to a vertical direction on the front side of the second drive shaft 32 disposed rearward of the first drive shaft 31. The upper ends 98c of the water intakes 98 are at a height level below the lower end part 31b, and at least a part of the lower end 98d of each water intake 98 is on the front side of the reverse gear 53 of the output gear mechanism 50, i.e., on the front side of the input gear 51 and the forward gear 52 of the output gear mechanism 50, and is at a vertical position substantially coinciding with that of the input gear 51.

[0074] The longitudinal dimension of the water intakes 98 is equal to or greater than the vertical dimension of the same. The front ends 98a of the water intakes 98 are at a distance equal to the distance δ from the center axis L1 of the first drive shaft 31 toward the front. The rear ends 98b of the water intakes 98 are on the rear side of the bearings 36 and 37.

[0075] The operation and effect of the outboard motor S in the preferred embodiment will be described.

[0076] The gearing holding portion 21 has the tapered part 21a extending forward from the second drive shaft 32 disposed rearward of the first drive shaft 31 to the front end 21c of the gearing holding portion 21. The tapered part 21a is coaxial with the center axis L3 of the propeller shaft 17, extends forward from a position corresponding to the second drive shaft 32 and is tapered toward the front end 21c. Therefore, the longitudinal distance between the front end 21c of the gearing holding portion 21 and the second drive shaft 32 is longer than the distance between the front end of the gearing holding portion of the comparative gear case and the drive shaft by a distance corresponding to the distance between the first drive shaft 31 and the second drive shaft 32. Since the tapered part 21a is tapered toward the front end 21c, the radius e of the outside surface 25 of the tapered part 21a can be more gently increased toward the rear than that of the tapered part of the comparative gear case. Thus the sharp increase of the sectional area of the tapered part 21a toward the rear can be prevented. The tapered part 21a of such a shape can reduce underwater resistance. While the ship is cruising at high cruising speed, water currents are not disturbed excessively and cavitation around the gear case 13 and the propeller 18 disposed rearward of the gear case 13 can be suppressed.

[0077] The longitudinal distance between the front end 21c and the shift rod 61 is not smaller than the outside diameter d_2 of a part of the tapered part 21a corresponding to the shift rod 61. Therefore, the longitudinal distance between the front end 21c and the second drive shaft 32 is long, the tapered part 21a can be tapered in a small taper so that the outside diameter of the tapered part 21a decreases gently toward the front. Thus underwater resistance can be effectively reduced and cavitation can be effectively suppressed.

[0078] The second drive shaft 32 is at a substantially middle part of the gearing holding portion 21 with respect to a longitudinal direction. Therefore, the tapered part 21a can be tapered gradually and increase in frictional resistance of water to the tapered part 21a resulting from an excessively long longitudinal distance between the front end 21c and the second drive shaft 32 can be suppressed.

[0079] The second drive shaft 32 is disposed approximately in the middle of the longitudinal length of the gearing holding portion 21, so that the radius e of the outside surface 25 of the tapered part 21a can be increase gently, while increase in the friction resistance between the tapered part 21a and the water due to excessively large longitudinal distance from the front end 21c to the second drive shaft 32 can be suppressed.

[0080] The second drive shaft 32 is supported only by the upper bearing 38 and the lower bearing 39 disposed on the upper and the lower side, respectively, of the driven gear 35. The upper bearing 38 supporting the upper end part 32a extending upward from the driven gear 35 is at a vertical position substantially coinciding with that of the drive gear 34. The lower bearing 39 supports the lower end part 32b of the second drive shaft 32 on which the input gear 51 of the output gear mechanism 50 is mounted. Thus the second drive shaft 32 is supported by only the upper bearing 38 and the lower bearing 39, and the upper bearing 38 is at the vertical position substantially coinciding with that of the drive gear 34. Therefore, the second drive shaft 32 can be made short and light. Since the second drive shaft 32 is supported by the upper bearing 38 above the driven gear 35, and the lower bearing 39, the upper bearing 38 can be easily installed in place. The number of component parts is small and assembling work for assembling the outboard motor S is small as compared with those needed by an outboard motor having a second drive shaft corresponding to the second drive shaft 32 and supported by three or more bearings.

[0081] The intermediate gear mechanism 33 is a reduction gear mechanism. The upper bearing 38 is at a vertical position substantially coinciding with that of the toothed part 35b of the driven gear 35; that is, the upper bearing 38 is disposed in a cylindrical space 43 surrounded by the toothed part 35b of the driven gear 35. Since the upper bearing 38 is disposed in the cylindrical space 43 defined by the driven gear 35, the length of an upper end part of the second drive shaft 31 projecting upward from the driven gear 35 is short and hence the overall length of the second drive shaft 32 is short and hence the second drive shaft 32 is short. The driven gear 35 having a diameter greater than that of the drive gear 34 defines the cylindrical space 43. Therefore, the large driven gear 35 has a small weight.

[0082] The upper bearing 38 is a double-row taper roller bearing capable of sustaining both upward and downward axial loads. Since the upper bearing 38 is capable of sustaining both upward and downward axial load, the second drive shaft 32 can be surely supported.

[0083] The oil pump 70 disposed in the gear case 13 is driven by the first drive shaft 31 and is separated from the intermediate gear mechanism 33. Therefore, the freedom of determining the capacity of the oil pump 70 is high as compared with a case in which the intermediate gear mechanism 33 serves also as an oil pump. Thus an oil pump having a desired discharge capacity can be easily selected.

[0084] Since the oil pump 70 is driven by the first drive shaft 31 that rotates at a rotational speed higher than that of the second drive shaft 32, the oil pump 70 having a desired discharge capacity is made small, and hence the gear case 13 may be small.

[0085] The oil pump 70 disposed at the vertical position lower than that of the intermediate gear mechanism 33 and sucks up the oil contained in the gear case and having its surface at the oil level OL below the intermediate gear mechanism 33. Therefore, the resistance of the oil to stirring is low and the loss of power of the first drive shaft 31 and the second drive shaft 32 is small.

[0086] The first drive shaft 31 is provided with the discharge passage 81 for delivering the oil discharged from the oil pump 70 to the parts requiring lubrication including the bearings 36, 37, 38 and 39 and the intermediate gear mechanism 33. Since the discharge passage 81 for delivering the oil to the parts requiring lubrication is formed in the first drive shaft 31, the gear case 13 does not need to be provided with any discharge passage and hence the gear case 13 can be formed in a small size.

[0087] The interlocking mechanism 63 of the operating mechanism for operating the clutch 54 includes the pinion 63a mounted on the shift rod 61, and the rack 63b formed integrally with the operating rod 52, extending parallel to the propeller shaft 17 and meshed with the pinion 63a. The interlocking mechanism 63 does not move transversely like an interlocking mechanism including an eccentric pin and a cam mechanism. The operating rod 62 can be moved in a wide range according to the turning angle of the shift rod 61. Therefore, the outside diameter of a part of the gear case 13 around the interlocking mechanism 13 may be small and hence the underwater resistance to the gear case 13 is low.

[0088] The gear case 13 has the gearing holding portion 21 holding the output gear mechanism 50, the propeller shaft 17 and the interlocking mechanism 63. The axial distance between the center axis L2 of the lower end part 32b of the second drive shaft 32 engaged with the output gear mechanism 50 and the center axis L4 of the shift rod 61 is greater than the outside diameter d1 of the part of the gearing holding portion 21 corresponding to the center axis L2. Therefore, the front part of the gearing holding portion 21 extending forward from the center axis L2 can be formed in a long and narrow shape, the outside diameter of the gearing holding portion 21 increases gently rearward from the front end 21c, which is effective in reducing underwater resistance.

[0089] The first drive shaft 31 is connected to the internal combustion engine E, and the second drive shaft 32 interlocked with the first drive shaft 31 by the intermediate gear mechanism 33 to transmit the power of the first drive shaft 31 to the output gear mechanism 50. The rotational speed of the first drive shaft 31 is reduced to the rotational speed of the second drive shaft 32 by the intermediate gear mechanism 33, and the output gear mechanism 50 is driven by the second drive shaft 32 rotating at the reduced rotational speed. Therefore, the reduction ratio of the output gear mechanism 50 may be low and hence the gearing holding portion 21 of the gear case 13 can be formed in a small size.

[0090] The first drive shaft 31 and the second drive shaft 32 are rotatably supported on the gear case 13, and the second shaft 32 extends downward beyond a vertical position corresponding to the lower end of the first drive shaft 31. The gear case 13 is provided with the water intakes 98 through which the water pump 90 sucks up water, and the water intakes 98 are formed in front of the second drive shaft 32 and between the first drive shaft 31 and the output gear mechanism 50 with respect to the vertical direction. Since the water intakes 98 are formed on the front side of the second drive shaft 32 disposed rearward of the first drive shaft 31 in spaces below the first drive shaft 31. The water intakes 98 enable the water pump 90 to pump water at a sufficiently high rate.

[0091] The axial distance between the front end 98a of each water intake 98 and the center axis L1 of the first drive shaft 31 is equal to the distance δ . Thus the water intakes 98 can be formed in a large size such that the front ends 98a thereof are at the distance δ to the front from the center axis L1 of the first drive shaft 31.

[0092] At least a part of the lower end 98d of each water intake 98 is on the front side of the reverse gear 53 of the output gear mechanism 50, i.e., on the front side of the input gear 51 and the forward gear 52 of the output gear mechanism 50, and is at a vertical position substantially coinciding with that of the input gear 51. Thus the lower end 98d of each water intake 98 opening in a necessary area can be lowered in a space extending on the front side of the reverse gear 53 to the vertical position substantially coinciding with that of the input gear 51. Therefore, the water intakes 98 appear rarely above the surface of the water, suction of air through the water intake 98 can be avoided and hence the internal combustion engine E can be properly cooled.

[0093] The water pump 90 is combined with the first drive shaft 31 and the second drive shaft 32 is engaged with the output gear mechanism 50 below the first drive shaft 31. Therefore, the length of the first drive shaft 31 is shorter than in a case in which the first drive shaft 31 is engaged directly with the output gear mechanism 50. Since the first drive

shaft 31 is made of an expensive corrosion-resistant material because the first drive shaft 31 is combined with the water pump 90, the short expensive first drive shaft 31 can be manufactured at low cost, and the second drive shaft 32 is made of an inexpensive, ordinary ferrous material. Thus the outboard motor S can be manufactured at low cost.

[0094] Modifications of the foregoing embodiment will be described.

[0095] The output gear mechanism 50 of the foregoing embodiment is of a standard rotation type. An output gear mechanism 150 of a counter rotation type will be described with reference to Fig. 7A. When two outboard motors are mounted on the hull, the respective propellers of the two outboard motors rotate in opposite directions, respectively. One of the two outboard motors is provided with an output gear mechanism of a standard rotation type and the other outboard motor is provided with an output gear mechanism of a counter rotation type.

[0096] The outboard motor in the modification is basically the same in construction excluding the output gear mechanism 150. In Figs. 7A and 7B, parts like or corresponding to those shown in Figs. 1 to 6 are designated by the same reference characters when necessary.

[0097] In the output gear mechanism 150, a forward gear 152 is supported in two bearings 46 and 47 on a front part 17a of a propeller shaft 17 at a position on the front side, with respect to a longitudinal direction, of the center axis L2 of an input gear 51 in a gearing holding portion 21. A reverse gear 153 is supported in bearings 48 and 49 on the front part 17a at a position on the rear side, with respect to the longitudinal direction, of the center axis L2 of the input gear 51.

[0098] As shown in Fig. 7B, a recessed part 62c (Fig. 5B) of an operating rod 62 is connected to a connecting part 55a in a transversely inverted position with respect to the output gear mechanism 150 of a standard rotation type. Thus a rack 63b is disposed at a transversely inverted position relative to a pinion 63a.

[0099] When a shift rod 61 is turned to turn the pinion 63a clockwise as viewed in Fig. 7A, the rack 63b and the operating rod 62 are moved forward, a shifter 55 is moved forward to set a clutch 54 in a forward position. When the shift rod 61 is turned to turn the pinion 63a counterclockwise as viewed in Fig. 7B, the rack 63b and the operating rod 62 are moved rearward, the shifter 55 is moved rearward to set the clutch 54 in a reverse position.

[0100] When the method of connecting the operating rod 62 to the shifter 55 is thus changed, the moving direction of the ship provided with the outboard engine of a counter rotation type can be controlled in the mode of operating the shift rod 61 of the outboard motor of a standard rotation type.

[0101] A device corresponding to the screw pump 71 shown in Fig. 2 may be omitted from a lubricating system for lubricating the bearings 36, 37, 38 and 39 and the intermediate gear mechanism 33 held in the gear case 13 as shown in Fig. 7A.

[0102] An oil pump 70, namely, a trochoid pump, may be omitted from the lubricating system, a screw pump 71 may be combined with a first drive shaft 31 or a second drive shaft 32, and the bearings 36, 37, 38 and 39 and the intermediate gear mechanism 33 may be lubricated with oil pumped by the screw pump 71.

[0103] The internal combustion engine may be a single-cylinder internal combustion engine, an in-line multicylinder internal combustion engine other than the in-line four-cylinder internal combustion engine, or a V-type internal combustion engine, such as a V-6 internal combustion engine. The marine propulsion machine may be an inboard motor.

[0104] An outboard motor S has: a first drive shaft 31 interlocked with an internal combustion engine, a second drive shaft 32 interlocked with the first drive gear 31, an output gear mechanism 50 driven by the second drive shaft 32, a propeller shaft 17, and a gear case 13 holding the output gear mechanism 50 and the propeller shaft 17 and having a normally submerged gearing holding portion 21. The second drive shaft 32 is disposed rearward of the first drive shaft 31 with respect to a longitudinal direction. The gearing holding portion 21 has a tapered part 21a extending forward from a position corresponding to the second drive shaft 32 and having a front end 21c. The tapered part 21a is tapered toward the front. The disposition of the second drive shaft 32 rearward of the first drive shaft 31 enables forming the gear case 13 in a small size and reduces underwater resistance to the gear case 13.

Claims

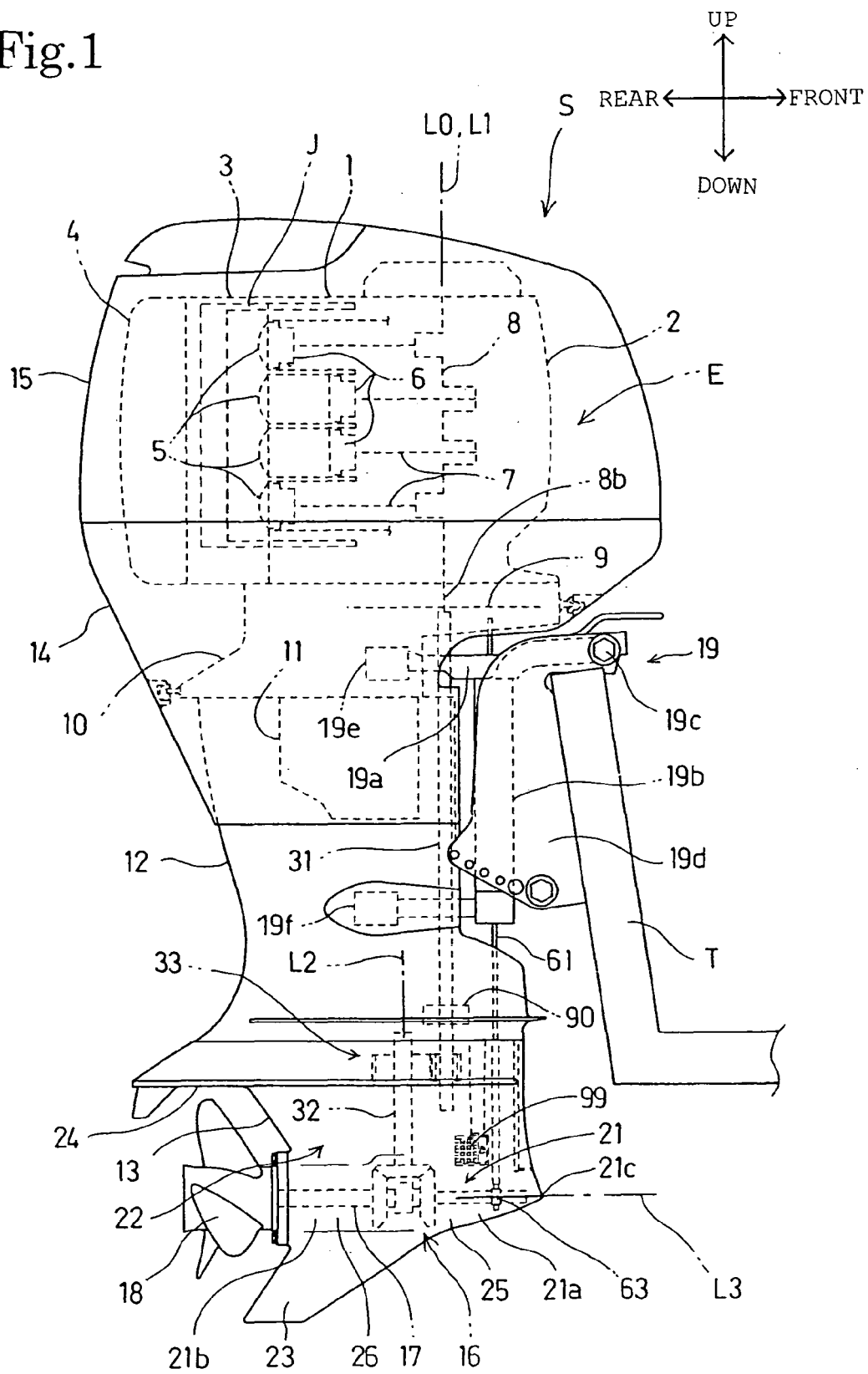
1. A marine propulsion machine comprising: an engine (E), a first drive shaft (31) interlocked with the engine (E); a second drive shaft (32) disposed rearward of the first drive shaft (31) and interlocked with the first drive shaft (31); the first and second drive shafts being (31) disposed with axes thereof vertically extended, an output gear mechanism (50) driven by the second drive shaft (32); a propeller shaft (17) having a longitudinal center axis and driven by the output gear mechanism (50); and a normally submerged gear case (13) having a gearing holding portion (21) holding the output gear mechanism (50) and the propeller shaft (17); **characterized in that:**

the gearing holding portion (21) has a tapered part (21a) extending forward from a position corresponding to the second drive shaft (32) with respect to a longitudinal direction to a front end (21c) of the gearing holding portion (21) and tapered toward the front end (21c) of the gearing holding portion (21).

2. The marine propulsion machine according to claim 1 further comprising a shift rod (61), for reversing the driving direction of the output gear mechanism (50), disposed in a vertical position in the gear case (13), and a longitudinal distance (f2) between the front end (21c) of the gearing holding portion (21) and the shift rod (61) is not shorter than an outside diameter of a part of the tapered part (21a) corresponding to the shift rod (61) with respect to the longitudinal direction.
3. The marine propulsion machine according to claim 1 or 2, wherein the second drive shaft (32) is disposed substantially at a middle part of the gearing holding portion (21) with respect to a longitudinal direction.
4. The marine propulsion machine according to claim 1, wherein a longitudinal distance between a center axis (L2) of the second drive shaft (32) and a center axis (L4) of the shift rod (61) is greater than an outside diameter (d1) of a part of the gearing holding portion (21) corresponding to the center axis (L2) of the second drive shaft (32).
5. The marine propulsion machine according to claim 1, wherein a reduction rate at which radius (e) of a part of the tapered part (21c) between the center axis (L1) of the first drive shaft (31) and the front end (21c) decreases toward the front is greater than that at which radius (e) of a part of the tapered part (21a) between a center axis (L2) of the second drive shaft (32) and a center axis (L1) of the first drive shaft (L1) decreases toward the front.
6. A marine propulsion comprising: a drive shaft (32) disposed with a center axis (L2) thereof vertically extended and driven by an engine (E); an output gear mechanism (50) driven by the drive shaft (32); a propeller shaft (17) rotatively driven by the output gear mechanism (50); a reversing mechanism (54) for reversing rotation of the propeller shaft (17); an operating mechanism (61,62) for operating the reversing mechanism (54) ; and a gear case (13) ; wherein the operating mechanism (61, 62) includes an operating member (61) supported for turning and an actuating member operated through an interlocking mechanism (63) by the operating member (61) to operate the reversing mechanism (54), the interlocking mechanism (63) disposed on a front side of the drive shaft (32) in the gear case (13); **characterized in that:**

the interlocking mechanism (63) includes a pinion (63a) mounted on the operating member (61), and a rack (63b) formed parallel to the propeller shaft in the actuating member (62) and meshed with the pinion (63a).
7. The marine propulsion machine according to claim 6, wherein the gear case (13) has a gearing holding portion (21) holding the output gear mechanism (50), the propeller shaft (17) and the interlocking mechanism (63), and a longitudinal distance between a center axis (L2) of an input part of the drive shaft (32) in engagement with the output gear mechanism (50) and a center axis (L4) of the operating member (61) is greater than an outside diameter (d1) of a part of the gearing holding portion (21) corresponding to the center axis (L2) of the input part of the drive shaft (32).
8. The marine propulsion machine according to claim 6 or 7, wherein the drive shaft (32) is a second drive shaft interlocked with a first drive shaft (31) interlocked with the engine by a reduction gear mechanism to transmit power of the first drive shaft (31) to the output gear mechanism (50).

Fig.1



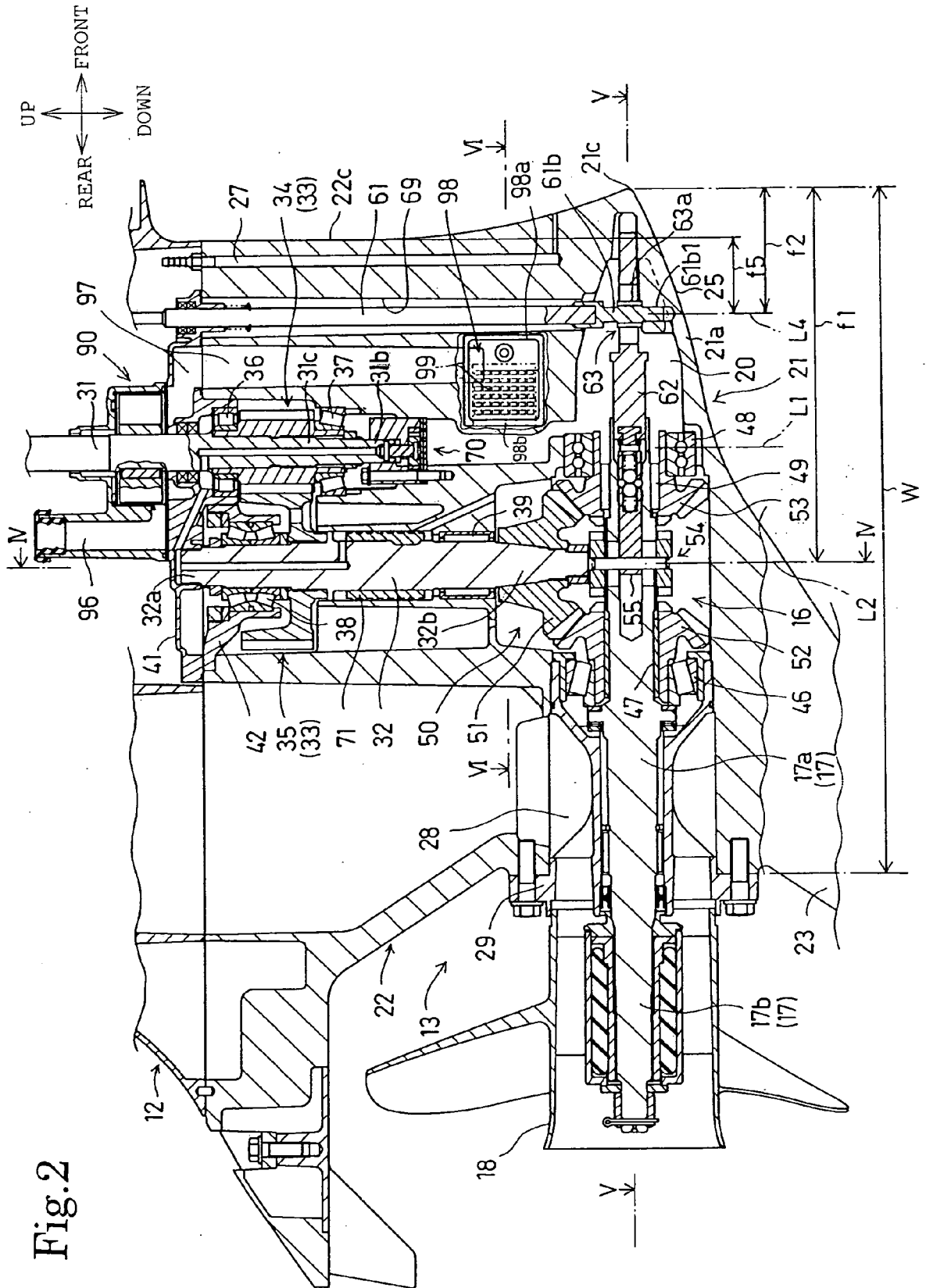


Fig.3

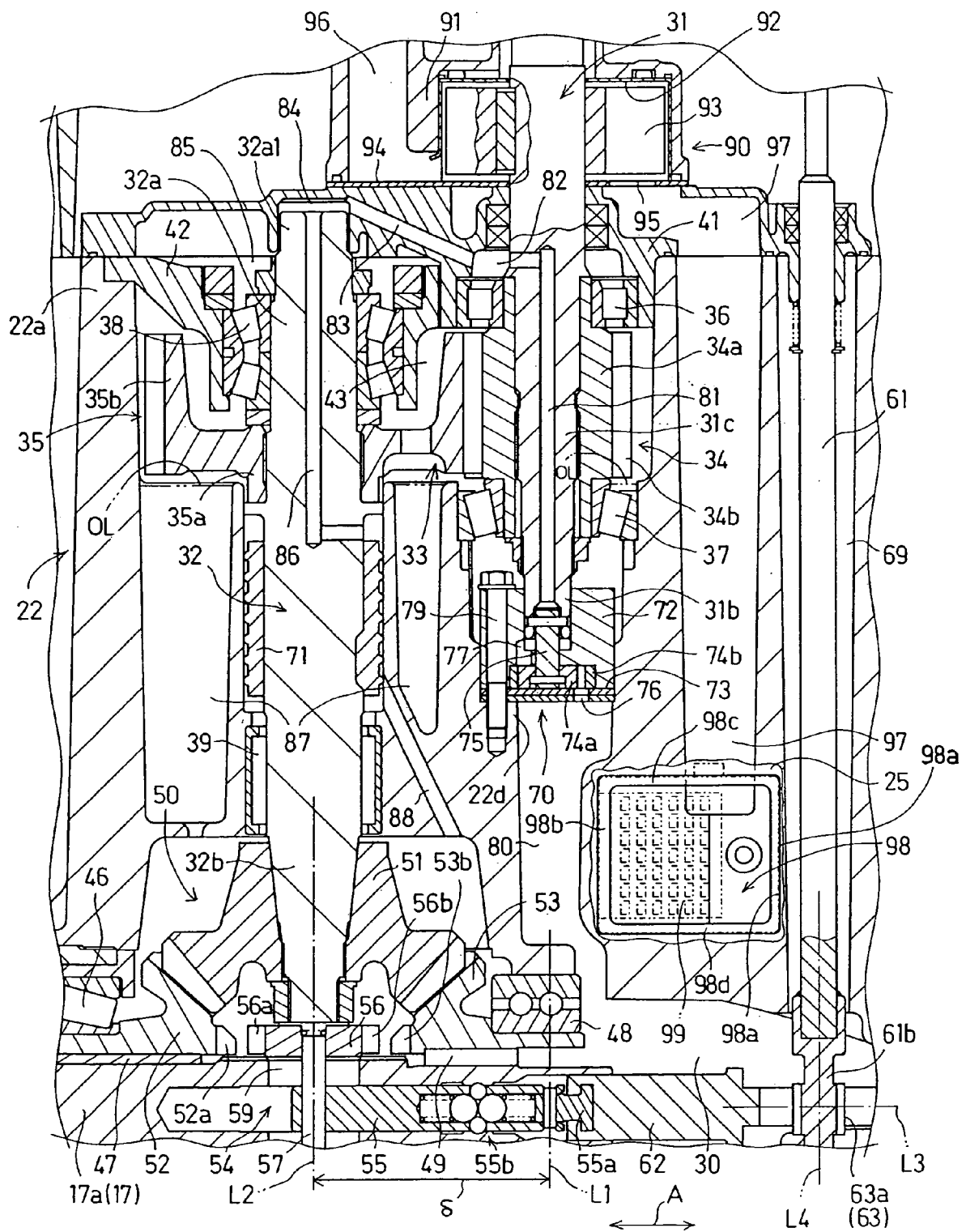


Fig.4

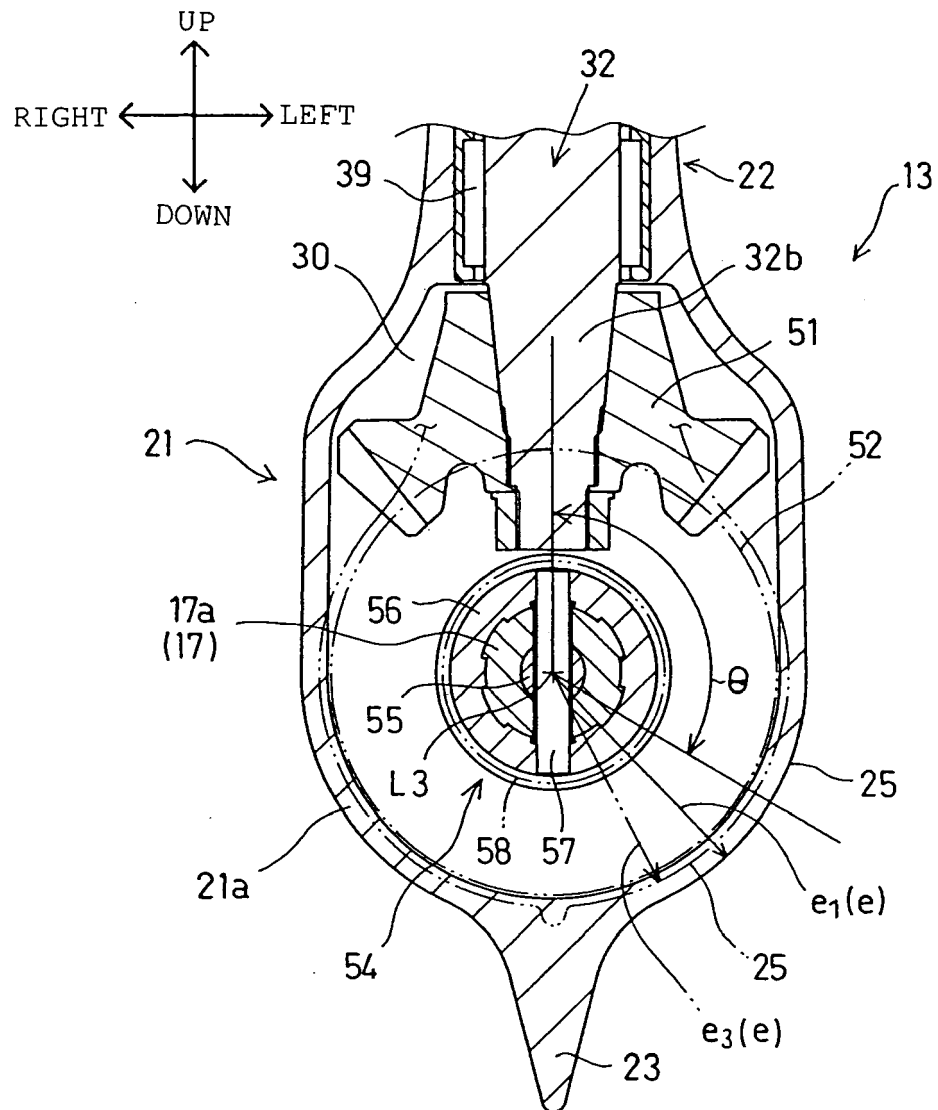


Fig.5B

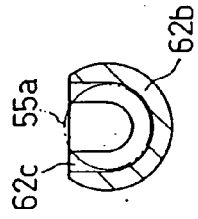


Fig.5A

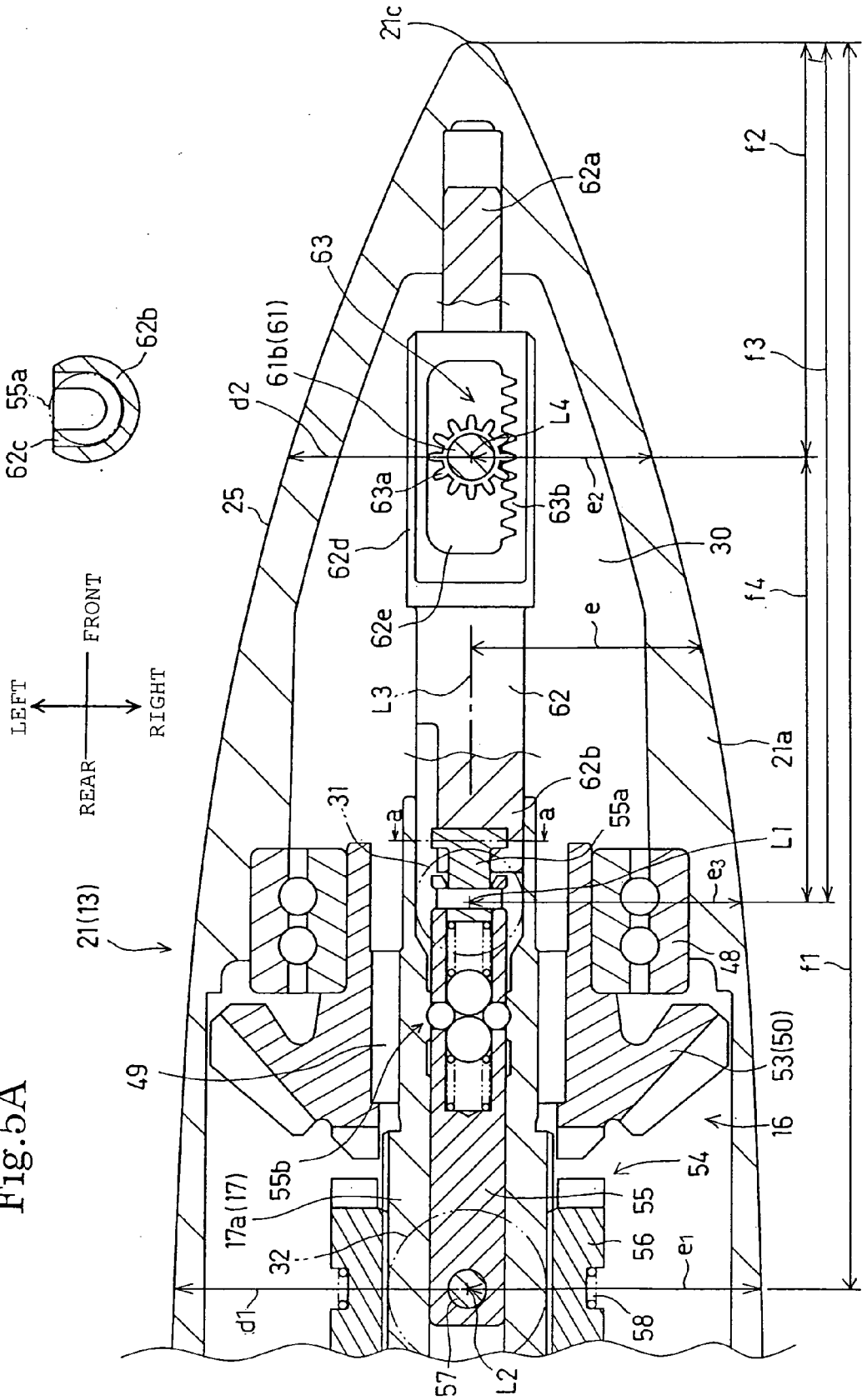


Fig.6

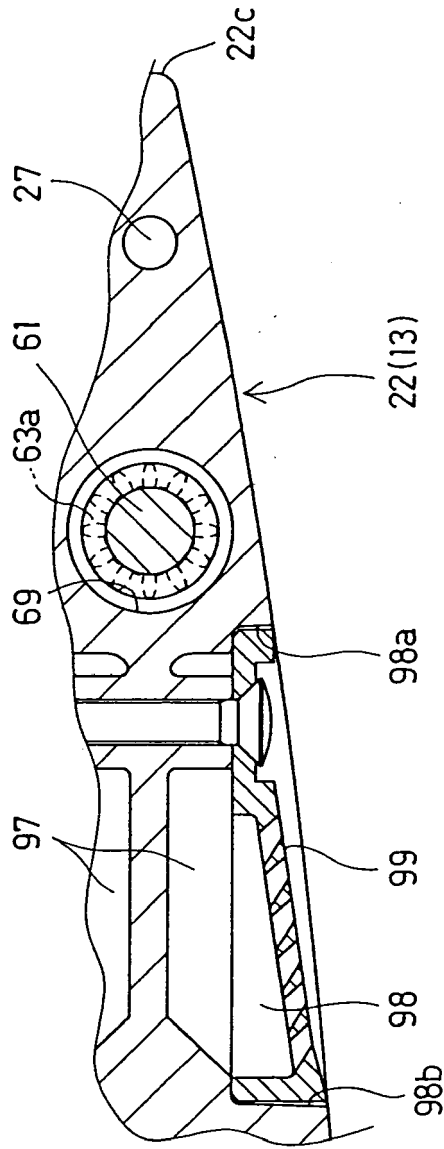


Fig. 7B

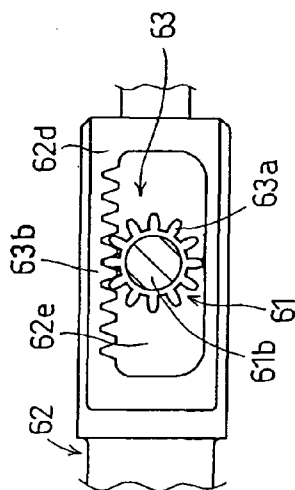
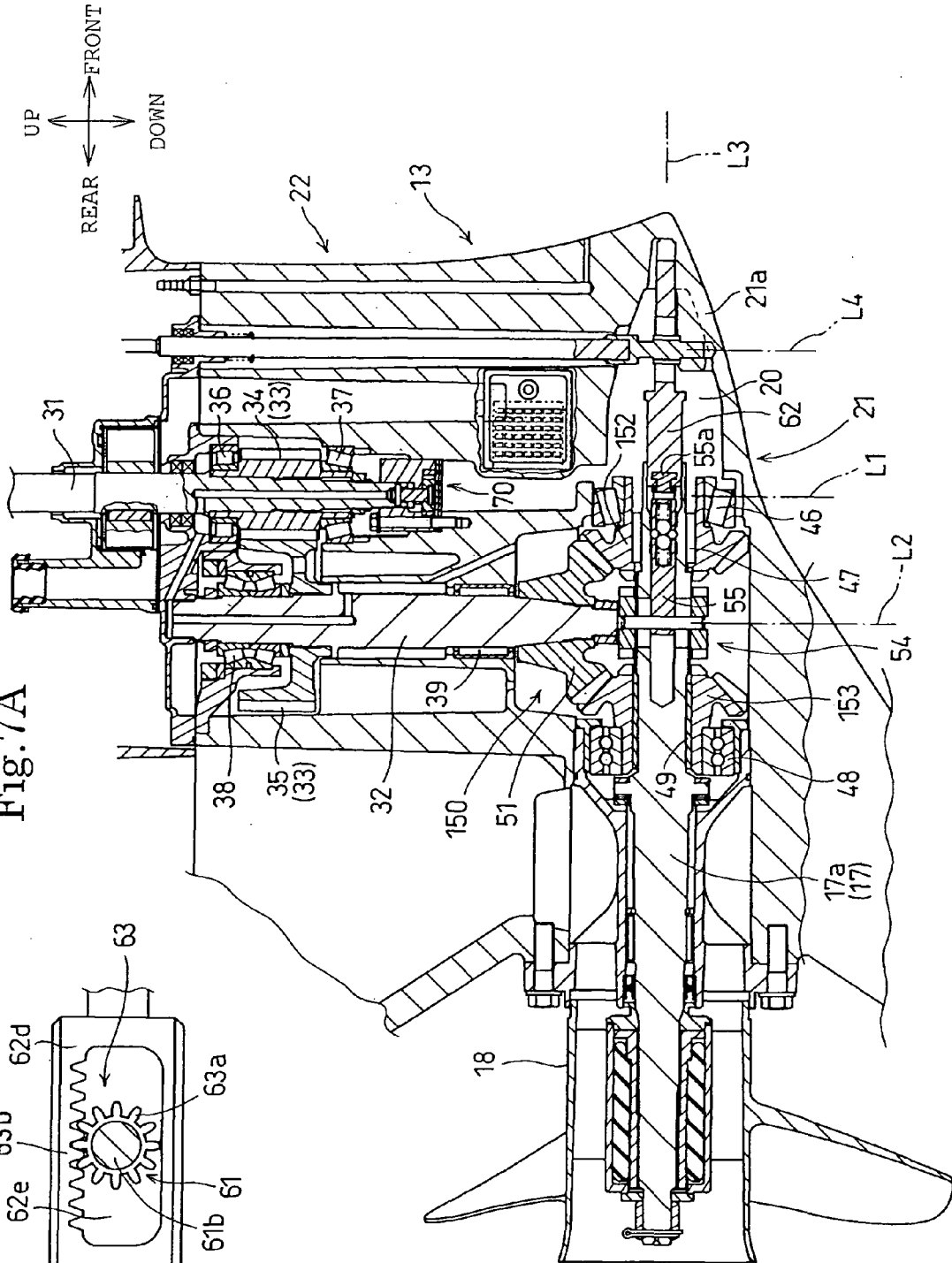


Fig. 7A





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EUROPEAN SEARCH REPORT

Application Number
EP 07 01 2396

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	US 3 368 420 A (ALEXANDER JR CHARLES F) 13 February 1968 (1968-02-13)	1-5	INV. F02B61/04
Y	* the whole document *	8	
X	US 2 718 792 A (KIEKHAEFER ELMER C) 27 September 1955 (1955-09-27)	6,7	
Y	* column 3, line 41 - line 60 *	8	
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D,A	JP 63 097489 A (YANMAR DIESEL ENGINE CO) 28 April 1988 (1988-04-28)	1	
D,A	JP 05 052107 A (SUZUKI MOTOR CO) 2 March 1993 (1993-03-02)	1	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 October 2007	Examiner Coniglio, Carlo
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			

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EPO FORM 1503 03.82 (P04C01)



European Patent
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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



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**LACK OF UNITY OF INVENTION
SHEET B**

Application Number
EP 07 01 2396

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-5

a marine propulsion machine with an alternative shape of the
gear holding portion

2. claims: 6-8

a marine propulsion machine with an alternative operating
mechanism for reversing rotation of the propeller shaft

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

EP 07 01 2396

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
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17-10-2007

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REFERENCES CITED IN THE DESCRIPTION

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