This invention relates to a marine propulsion and steering system and, more particularly, is directed to an improved inboard-outboard engine. A conventional inboard engine is located forward and uses a fixed propeller in combination with a rudder for steering. In comparison with an outboard engine, a conventional inboard engine has the disadvantages of steering with wide turns and of requiring constant perfect shaft alignment to avoid excessive vibration. An inboard engine does, however, offer the advantage of convenient and safe accessibility, optimum weight location, minimum vulnerability to collision and docking damage, minimum likelihood of fishing line entanglement, holding a trim more easily, less sensitivity to waves and wind, ability to carry more freeboard or height at the stern, ability to drive more tonnage at high speed, and, finally, fuel economy. While a conventional outboard engine, on the other hand, lacks these numerous advantages, it has the important advantage of ability to turn in small circles for better maneuverability and of being more easily installed on a boat.

To combine the advantages of these two conventional types, various inboard-outboard engines have been developed, each of which comprises an inboard engine with an outboard-style propeller drive system that is rotatable for efficient short radius steering by propeller thrust. It is characteristic of the prevailing types of inboard-outboard engines that the drive shaft extends through the transom and is geared to a second downwardly extending drive shaft in a rotatable outboard housing.

One problem encountered in constructing such an inboard-outboard engine is to achieve simplicity and structural economy, the usual arrangement being of complicated costly construction. One reason for the complications that characterize the usual arrangement is that the outboard housing is subject to a heavy torque in reaction to the power delivered through the downwardly extending drive shaft, and if the outboard housing is rotatable for steering, this reaction torque seriously affects the steering by creating excessively hard steering in one direction and excessively soft steering in the opposite direction. The present invention is directed primarily to the solution of these two problems, i.e., the problem of providing a simple relatively inexpensive rotatable outboard driving unit, and the problem of making such a rotatable unit as steerable and free from torque interference as a conventional outboard engine.

With reference to structural simplicity and economy, a feature of the invention is the concept of mounting an inboard engine in position with its drive shaft extending substantially vertically downward through an opening in the bottom of the boat. The drive shaft extends into a downwardly extending outboard housing under the boat that carries the propeller and is mounted in the bottom opening of the boat in a rotary manner for steering by propeller thrust. This lower outboard housing has an extensive upward extension that telescopes into a similar cylindrical extension of the engine to insure and maintain accurate alignment of the drive shaft and to form a rotary joint with the engine. In addition, the assembly of engine and outboard drive may be tilted adjustably about the bottom opening of the boat as a fulcrum for optimum inclination of the propeller axis relative to the boat.

The invention makes a new approach to the problem of reaction torque and does so with important advantages. Instead of ignoring the torque reaction of the outboard housing or of seeking defensively to divert or neutralize the reaction torque, the invention takes advantage of the reaction torque by using it for power steering in one direction. For this purpose the invention provides a second opposed force for power steering in the opposite direction. Thus steering in the one direction is at least facilitated in a controlled manner by the reaction torque of the outboard housing and steering in the opposite direction is at least facilitated by controlled domination over the reaction torque by the second opposed force. The term "at least facilitated" is employed because within the scope of the invention the two opposed forces for power steering may be of minor magnitude with the steering accomplished largely by manual force, the two opposed forces merely facilitating manual steering or, on the other hand, the two opposed forces may be of relatively large magnitude, the applied manual force being merely to trigger the two opposed power steering forces.

A feature of the preferred practice of the invention is that the helmsman may utilize the two opposed forces to selected degrees as determined by the manner in which he manipulates the steering control. A further feature is that the steering control is fail-safe inasmuch as overriding manual control is always available.

These desirable features are provided by employing fluid-pressure-actuated means, either hydraulic or pneumatic, to dominate the torque reaction for changes in one steering direction and by employing a controlled dashpot means, either hydraulic or pneumatic, to yield to the torque reaction for changes in the opposite steering direction. In the preferred practice of the invention, the steering system is hydraulic and a single hydraulic chamber is employed both as power means to dominate the reaction torque and as dashpot means or fluid-metering means to retard the steering effect of the reaction torque.

To carry out this concept, a manually operable control member is movably mounted on the outboard housing for movement relative thereto in the two opposite steering directions and this control member has a neutral position between two normally closed valves that are fixedly mounted relative to the outboard housing. Manual movement of the control member in the opposite direction opens the corresponding valve to admit fluid to the power chamber to overcome the reaction torque for steering in the one direction. Manual movement of the control member in the opposite direction opens the other valve to release fluid from the power chamber in a controlled dashpot manner to permit the reaction torque to steer in the opposite direction.

The preferred practice of the invention is further characterized by the use of spring means to urge the control member to its neutral position at which it affects neither of the two normally closed valves. In practice, the necessity of providing special spring means for this purpose is avoided simply by using normally closed spring-loaded
3, valves. Manual movement of the control member relative to the outboard housing in either steering direction overcomes the spring pressure and progressively opens the corresponding valve. The advantage of this arrangement is that it gives the helmsman a certain "feel" or pressure indicative of the actuator resistance of the control member. At one extreme the manual steering force is relatively light, being merely sufficient to open the appropriate valve, the magnitude of the released power and the rate of steering change being determined by the degree to which the valve is opened. At the other extreme, manual steering force may be applied vigorously and abruptly to serve as the dominating steering force.

The use of hydraulic means both for overcoming the reaction torque for steering in one direction and for controlling the utilization of the reaction torque for steering in the opposite direction has the unexpected advantage of providing a hydraulic lock for automatically holding any selected steering position adjacent to the outboard housing. Thus if the operator releases the manual control or lets the spring resistance determine the position of the manual control, the manual control seeks its neutral position automatically at which position both of the two valves are closed to trap the hydraulic fluid in the power chamber.

Simplicity and structural economy are further achieved by utilizing the lubrication system of the engine itself to avoid the necessity of providing a special pump or the like for feeding pressurized fluid to the power steering chamber. For this purpose the normally closed inlet valve for the power chamber is connected to the oil pump or high pressure region of the lubrication system and the normally closed outlet valve for the power chamber is connected to the sump or low pressure region of the lubrication system. The temperature of the lubricant varies widely with different operating conditions with corresponding wide changes in the viscosity of the hydraulic fluid, but the changes in viscosity merely require corresponding changes in the degrees to which the two valves must be opened for given steering effects.

The features and advantages of the invention may be understood from the following detailed description and the accompanying drawing.

In the drawing, which is to be regarded as merely illustrative:

**FIG. 1** is a fragmentary view partly in elevation and partly in section showing an installation of the presently preferred embodiment of the invention; and

**FIG. 2** is a view that is partly diagrammatic and partly in section, the section being taken along the line 2—2 of **FIG. 1** and the diagram indicating the construction of the hydraulic system.

In **FIG. 1** of the drawing illustrating the selected embodiment of the invention, an inboard engine, generally designated 10, is mounted inside a boat generally designated 12, which boat has a circular bottom opening 14. The inboard engine 10 is mounted and braced above the opening 14 with the drive shaft 15 of the engine extending downward through the bottom opening into an outboard housing, generally designated by the numeral 16, the outboard housing carrying a propeller 18 on a transverse shaft 20. In a manner illustrated, an upper beveled gear 22 and a lower beveled gear 24, both freely rotatable on the drive shaft 15, mesh with a third beveled gear 25 that is fixedly mounted on the propeller shaft 20. A conventional ratchet collar 26 that is slidingly keyed to the drive shaft 15 is moveable selectively into engagement with the two beveled gears 22 and 24 to key the two beveled gears selectively to the drive shaft 15 for rotating the propeller 18 selectively in opposite directions, the ratchet collar being controlled in a well manner by a manually operated push-pull control rod 28.

In the construction shown, the engine 10 has a downward cylindrical extension 30, the lower end of which is formed 31 so as to simulate the chamfer of a conventional spherical cup with a curved rim 32 that seats advantageously in a similarly curved bearing plate 34 that surrounds the bottom opening 14. It is apparent that this construction provides a ball-type universal joint which permits the engine 10 to be tilted adjustably about the opening 14 as a fulcrum. Thus the engine may be tilted to suit the angle of inclination of the propeller shaft 20 relative to the boat.

The outboard housing 16 has an axial tubular extension 35 which rotatably telescopes into the cylindrical extension 30 of the engine 10, the tubular extension being suitably held against axial movement relative to the cylindrical extension of the engine and being sealed with respect to the cylindrical extension by suitable seal means. The outer cylindrical extension 30 of the engine has a circumferentially extending slot 36 and a rigid arm 38 of the inner tubular extension 35 extends radially outward through the slot to control the rotary position of Outboard housing 16. The rigid arm 38 may be in the form of a substantially horizontal metal plate, as shown.

Assuming that the reaction torque transmitted to the outboard housing 16 by the drive shaft 15 is counterclockwise as viewed in **FIG. 2**, a suitable hydraulic means is connected to the arm 38 to oppose the counterclockwise rotation, the hydraulic means comprising a single acting cylinder 40 that is connected to the arm by a pivot 42. A piston 44 in the cylinder 40 has a piston rod 45 which is pivotally connected to a fixed portion 46 of the boat by a suitable pivot 48. The cylinder 40 forms a power chamber 50 with a single port which is connected by a flexible hose 52 to an inlet valve 54 and is connected by a second flexible hose 55 to an outlet valve 56. The two valves 54 and 56 are fixedly mounted on the arm 38 on the opposite sides of a manually operable control member 58, the control member being mounted on the arm 38 by a pivot 60 to swing relative to the arm 38 in the two opposite steering directions. The two valves 54 and 56 are spring-loaded normally closed valves having operating plungers 62 which are directed towards the control member 58 on opposite sides of the control member. The usual springs incorporated in the two valves 54 and 56 to urge the valve to closed positions serve to yieldingly urge the two operating plungers 62 to their outermost positions whereby the two plungers cooperate in a yielding manner to urge the control member towards its normal position shown in **FIG. 2**.

It is apparent that if the control member 58 is rotated clockwise relative to the arm 38 about the pivot 60, the control member depresses the plunger 62 of the inlet valve 54 to open the inlet valve for admitting hydraulic fluid under pressure to the power chamber 50 to cause the power chamber to move the arm 38 and the outboard housing 16 clockwise about the axis of the drive shaft 15. On the other hand, if the control member 58 is swung counter-clockwise about the pivot 60 relative to the arm 38, the control member depresses the plunger of the outlet valve 56 to release fluid from the power chamber 50, the fluid being expelled with retarding dashpot effect by the reaction torque of the outboard housing 16. Two steps 70 are provided on the face of a control member 58 to limit the swinging motion of the control member against the operating plungers of the two valves 54 and 56.

The two valves 54 and 56 are connected to the lubrication system of the engine 10. As indicated diagrammatically in **FIG. 2**, there is a low pressure region which includes a sump 64 and a fluid passage 65 connected to the intake side of an oil
The output side of the oil pump 66 in the high pressure region of the lubrication system is connected to a fluid passage 70 which distributes the lubricant to various parts of the engine. The inlet valve 54 of the hydraulic steering system is connected by a flexible hose 72 to the high pressure region of the lubrication system, i.e., to the pump through the pipe 70 and the outlet valve 56 is connected by a flexible hose 73 to the low pressure region of the lubrication system, i.e., to the sump 64 through the pipe 65.

The pivoted control member 58 may serve as a tiller and may be provided with a handle for this purpose. In this particular embodiment of the invention, however, the operating member 58 is connected by a pair of opposed cables 74 to a remote wheel (not shown) in a well-known manner, the opposed cables being routed to the remote wheel by suitable guide pulleys including two guide pulleys 75.

The manner in which the invention serves its purpose may be readily understood from the foregoing description. It is apparent that the control member 58 normally seeks its neutral position since any swinging movement out of its neutral position is opposed by the spring action of the two springlimiting orifices 89 and 90. When the control member 58 is in its normal neutral position, both of the valves 54 and 56 are closed to trap the fluid in the power chamber whereby the power chamber serves as a hydraulic lock to maintain the outboard housing 16 at whatever steering position it may be adjusted.

If the control member 58 is turned clockwise as viewed in FIG. 2 by the remote wheel acting through one of the cables 74, the inlet valve 54 is opened to admit the high pressure lubricant to the power chamber 59 wherein the power chamber 59 overcomes the reaction torque of the outboard housing 16 to swing the outboard housing counterclockwise. When the control member 58 is turned counterclockwise as viewed in FIG. 2 by the remote wheel acting through one of the cables 74, the outlet valve 56 opens to release the fluid from the power cylinder 59 to permit the reaction torque of the outboard housing 16 to rotate the outboard housing counterclockwise. The counterclockwise movement being retarded by the dashpot action involved in the expelling of fluid from the power chamber. In this dashpot action the outlet valve 56 functions as a variable orifice for varying the resistance to the fluid discharge. If desired, an orifice fitting 76 may be inserted in the flexible hose 73 to serve this purpose.

It is apparent that if the control member 58 is swung forcibly against either of the two stops 78 the manual force will be transmitted directly to the arm 38 and the consequent steering movement will be largely manually operated. On the other hand, if the applied manual force is insufficient to cause the control member 58 to move against one of the stops 78, the steering movement of the outboard housing is power actuated except for the manual force indirectly transmitted by the springs of the two valves. It is the spring resistance of the two valves that gives the helmsman the desired rudder feel. In the event that the power steering system fails, overriding manual force may be used to steer the outboard housing.

My description in specific detail of the selected embodiment of the invention will suggest various changes, substitutions and other departures from my invention within the spirit and scope of the appended claims. I claim:

1. In an outboard drive for a boat having an inboard engine, the combination of:
   an outboard housing extending from the hull of the boat;
   a propeller carried by said housing to drive the boat, said housing being rotatable relative to the boat to vary the orientation of the propeller relative to the boat for steering the boat by the thrust of the propeller;
   transmission means extending from the engine downward through said housing to drive said propeller; with consequent reaction torque on the housing tending to turn the housing in one steering direction; and
   a single remotely controlled fluid-pressure-actuated ram connected to said housing eccentrically thereof to oppose said reaction torque to turn the housing in the other steering direction and to yield to said reaction torque with a dashpot action to permit the reaction torque alone to turn said housing in said one steering direction.

2. A combination as set forth in claim 1 in which said fluid-pressure-actuated means includes normally closed valve means to trap fluid in the ram to lock said housing against rotation in said one steering direction.

3. In an outboard drive for a boat having an inboard engine wherein the engine has a lubrication system with a low pressure region and a high pressure region, the combination of:
   an outboard housing extending from the hull of the boat;
   a propeller carried by said housing to drive the boat, said housing being rotatable to vary the orientation of the propeller relative to the boat for steering the boat by the thrust of the propeller;
   transmission means extending from the engine through said housing to drive said propeller with consequent reaction torque on the housing tending to turn the housing in one steering direction;
   a single hydraulic means operatively connected to said housing to exert force in a single direction to oppose said reaction torque; and
   control means operable in one respect to cut off the hydraulic means from said low pressure region of the lubrication system and to place the hydraulic means in communication with the high pressure region to receive lubricant therefrom to overcome said reaction torque for turning said housing in the opposite steering direction, said control means being operable in the opposite respect to cut off the hydraulic means from the high pressure region and to place the hydraulic means in communication with the low pressure region for metered return of the lubricant to the lubrication system to permit the reaction torque to turn the housing in said one steering direction.

4. A combination as set forth in claim 3 in which said control means is operable in a third respect to cut off the hydraulic means from the lubrication system for hydraulically locking said housing against rotation at selected steering positions of the housing.

5. In an outboard drive for a boat having an inboard engine, the combination of:
   an outboard housing extending downward from the boat;
   a propeller carried by said housing to drive the boat, said housing being rotatable relative to the boat to steer the boat by the thrust of the propeller;
   transmission means extending from the engine through said housing to drive said propeller with consequent reaction torque on the housing tending to turn the housing in one steering direction;
   control means connected to said housing and movable relative thereto in the two opposite steering directions of the housing;
   a fluid-pressure-actuated system operatively connected to said housing and including a power chamber for expansion to turn said housing in the opposite steering direction;
   a normally closed inlet valve in said system to admit pressurized fluid to said power chamber to overcome said reaction torque to turn said housing in the opposite steering direction, said inlet valve being mounted on one of said housing and control means for opening operation by the other of said housing and control means in response to movement of the control means relative to the housing in said opposite steering direction; and
3,148,657

7

a normally closed outlet valve in said system to release fluid from said power chamber to permit said reaction torque to turn the housing in said one direction at a rate retarded by the frictional resistance to flow of the released fluid, said outlet valve being mounted on one of said housing and control means for opening operation by the other of said housing and control means in response to movement of the control means relative to the housing in said one steering direction.

6. A combination as set forth in claim 5 in which said control means has freedom to take a neutral position at which both of the two valves are closed to trap fluid in the power chamber to lock the housing against rotation at selected steering positions of the housing.

7. A combination as set forth in claim 6 which includes yielding means acting between the housing and the control means to yieldingly urge said control means towards its neutral position.

8. In an outboard drive for a boat having an inboard engine, the combination of:

an outboard housing extending downward from the boat;
a propeller carried by said housing to drive the boat, said housing being rotatable relative to the boat to steer the boat by the thrust of the propeller;
transmission means extending from the engine through said housing to drive said propeller with consequent reaction torque on the housing tending to turn the housing in one steering direction;
a control means connected to said housing and movable relative thereto from a neutral position in the two opposite steering directions of the housing;
a fluid-pressure-actuated system connected to said housing and including a power chamber for expansion to turn said housing in the opposite steering direction;
an inlet valve in said system to admit pressurized fluid to said power chamber to overcome said reaction torque to turn said housing in the opposite steering direction, said inlet valve being mounted on one of said housing and control means for opening operation by the other of said housing and control means in response to movement of the control means relative to the housing in said opposite steering direction;
an outlet valve in said system to release fluid from said power chamber to permit said reaction torque to turn the housing in said one direction at a rate retarded by the frictional resistance to flow of the released fluid, said outlet valve being mounted on one of said housing and control means for opening operation by the other of said housing and control means in response to movement of the control means relative to the housing in said one steering direction; and
yielding means to urge both of said valves to their closed position thereby to urge said control means to its neutral position.

9. In an outboard drive for a boat having an inboard engine wherein the engine has a lubrication system with a low pressure region and a high pressure region, the combination of:

control means connected to said housing and movable relative thereto in the two opposite steering directions of the housing;
a fluid-pressure-actuated system operatively connected to said housing and including a power chamber for expansion to turn said housing in the opposite steering direction;
a normally closed inlet valve included in said fluid-pressure-actuated system to place said power chamber in communication with said high pressure region to admit pressurized lubricant to the power chamber to overcome said reaction torque to turn said housing in the opposite direction, said inlet valve being mounted on one of said housing and control means for opening operation by the other of

8

said housing and control means in response to movement of the control means relative to the housing in said opposite steering direction; and

a normally closed outlet valve included in said system to release lubricant from said power chamber to said low pressure region to permit said reaction torque to turn the housing in said one direction at a rate retarded by the frictional resistance to flow of the released lubricant, said outlet valve being mounted on one of said housing and control means for opening operation by the other of said housing and control means in response to movement of the control means relative to the housing in said one steering direction.

10. A combination as set forth in claim 9 in which said control means is movable to a neutral position at which both of said valves are closed and which includes spring means to oppose movement of the control means out of its neutral position.

11. In a system for propelling and guiding a boat, the combination of:
an engine inside the boat;
an opening in the bottom of the boat;
an outboard housing extending downward from said opening, said housing being connected with the opening in a fluid-tight manner, and being rotatable relative to the opening;
a propeller carried by said housing for rotation on an axis extending laterally of the axis of rotation of the housing for propelling the boat in directions determined by the rotary position of the housing;
means to transmit power from the engine to the propeller including drive means extending from the engine through said opening into said housing whereby the drive means applies a reaction torque to said housing for rotation of the housing in one steering direction; and

10

a single manually controlled fluid-pressure-actuated means inside the boat connected to the boat and to said housing to exert force in a single direction to oppose said reaction torque and to yield to said reaction torque with dashpot action to cause the reaction torque to turn said housing in said one steering direction.

12. A combination as set forth in claim 11 in which said fluid-pressure-actuated means includes normally closed valves to lock said outboard housing against rotation at selected steering positions of the housing.

13. In a system for propelling and guiding a boat, the combination of:
an engine inside the boat, said engine having a lubrication system with a low pressure region and a high pressure region;
an outboard housing extending downward from said opening, said housing being connected with the opening in a fluid-tight manner, and being rotatable relative to the opening;
a propeller carried by said housing for rotation on an axis extending laterally of the axis of rotation of the housing for propelling the boat in directions determined by the rotary position of the housing;
means to transmit power from the engine to the propeller including means to connect the drive means extending from the engine through said opening into said housing whereby the drive means applies a reaction torque to said housing for rotation of the housing in one steering direction;
hydraulic means inside the boat connected to the boat and to said housing to oppose said reaction torque; and

10

control means operable in one respect from a neutral position to cut off the hydraulic means from the low pressure region of the lubrication system and to place the hydraulic means in communication with the high pressure region to receive lubricant therefrom to overcome said reaction torque for turning said
housing in the opposite steering direction, said control means being operable in the opposite respect to cut off the hydraulic means from the high pressure region and to place the hydraulic means in communication with the low pressure region for metered return of the lubricant to the lubrication system to permit the reaction torque to turn the housing in said one steering direction, said control means being operable in a third respect to cut off the hydraulic means from both of said regions of the lubrication system for hydraulically locking said outboard housing against rotation at selected steering positions of the outboard housing.

14. A combination as set forth in claim 13 which includes yielding means to oppose operation of said control means out of its neutral position.

References Cited in the file of this patent

UNITED STATES PATENTS

2,486,049 Miller ---------------- Oct. 25, 1949
2,545,502 Troester ----------------- Mar. 20, 1951
2,936,730 Patty ------------------- May 17, 1960
2,976,836 Fageol ------------------- Mar. 28, 1961
2,981,222 Cunefare ---------------- Apr. 25, 1961
3,094,967 Willis ------------------- June 25, 1963