HYDRAULIC TRIM/TILT SYSTEM FOR OUTBOARD PROPULSION UNITS

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UNITED STATES PATENTS
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ABSTRACT
A hydraulic system for trimming and tilting outboard drives for boats. The system comprises a pump adapted to deliver fluid pressure to a double acting cylinder-piston assembly, which is connected to the tiltable outboard drive unit and to a stationary part of the boat. A valve selects between two modes of operation of the cylinder. In one mode the chambers of the cylinder are interconnected to provide rapid tilt operation. In the other mode, one chamber is connected to the pump and the other is connected to the fluid sump to provide relatively less rapid trimming with greater force.

6 Claims, 3 Drawing Figures
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BACKGROUND OF THE INVENTION

In tilting and trimming outboard drives, two main requirements are to be met. In one case, the tilt movement, when the boat lies still and when no propeller thrust acts on the drive, a wide range of tilting is to be performed in a short time. Under this condition, only a relatively small force is needed. In the second case, the trimming movement, when the boat is driven and the drive is subjected to the propeller thrust, a relatively greater force is needed to achieve the trimming movement. On the other hand the trim angle is small and a low speed of the trimming movement is desirable to permit accurate setting of the trim angle.

It is known, for example from U. S. Pat. No. 3,548,777 — Bergstvedt, to fulfill the above named requirements by utilizing one hydraulic cylinder with a relatively small piston area for tilting and a second cylinder with a relatively large piston area for trimming. By this arrangement it is possible to achieve both the quick tilting movement and the slow trimming movement with one pump with constant capacity.

It is, of course, preferred for economy, simplicity and space considerations to use one, rather than two cylinders for trimming and tilting.

It is an object of the present invention to provide a hydraulic system with which it is possible to achieve the above named trimming and tilting functions by using only one cylinder. This is accomplished by a valve unit in the hydraulic system which is adjustable between a first position, in which the chamber at the piston rod end of the cylinder is connected to the chamber at the piston end of the cylinder, and a second position, in which the chamber at the piston rod end of the cylinder is connected to the sump tank.

In the first position of the valve unit, in which it provides a short circuit between the two chambers of the cylinder, the fluid pressure delivered by the pump to the cylinder will act on the difference between the piston areas of the two chambers of the cylinder, i.e., on the cross-sectional area of the piston rod. Since this area is much smaller than the total piston area exposed to the chamber at the piston end of the cylinder, the fluid will cause a fast movement of the piston and little force, which is desired during tilting.

It is preferred that the cylinder-piston assembly is arranged, as in said U. S. Pat. No. 3,548,777, so that an outward movement of the piston rod causes an upward tilting of the drive unit.

In the second position of the valve unit the chamber at the piston rod end of the cylinder is drained by a connection to a sump tank. When fluid pressures is then delivered to the piston area, it causes a slow motion of the piston rod with great force which results in a slow upward swinging of the drive with a force which is able to overcome the propeller thrust when trimming during forward driving of the boat.

As the propeller thrust must be overcome when trimming underway, the pressure delivered by the pump must be much higher than during tilting. A preferred embodiment of the invention uses this pressure difference and is characterized by the fact that the valve unit comprises pressure sensitive means which automatically adjusts the valve unit from said first position to said second position in response to the higher pressure built up in the system during trimming the drive unit against the propeller thrust.

The pressure sensitive means is adapted to adjust the valve unit to said first position in response to a relatively low pressure in the system caused by a low load on the piston rod when the boat is not being driven forward.

The hydraulic system according to the invention will be fully understood from the following description which refers to the accompanying drawings.

FIG. 1 is a side view of an inboard-outboard drive unit for a boat embodying the invention;

FIG. 2 is a schematic view of a previous known hydraulic trim/tilt system with two cylinders; and

FIG. 3 is a schematic view of the hydraulic system according to the invention, with an automatically adjustable valve unit.

This invention contemplates an outboard drive unit for a boat, such as the inboard-outboard unit shown in FIG. 1 as comprising an outboard leg 60 mounted for tilting on a pivot 61 to the boat transom 62. The leg is arranged for steering, for example, as shown in U. S. Pat. No. 3,605,677 — Bergstvedt, and is provided with a cylinder 63 rockably connected to a fixed portion 64 of the boat or drive unit and with an extensible piston rod 35 pivotally connected to the leg, whereby extension of the rod causes rearward trimming or tilting movement of the leg about pivot 61. A control cable or rod linkage 56, 58 leads from a housing 65 which may form an integral part of the cylinder and in which control valves of the system are contained. A pump and fluid sump schematically shown at P is connected by means of fluid conduits schematically represented at 66 to supply pressure fluid to and receive return fluid from the control system.

The known hydraulic system showed in FIG. 2 comprises a reversible pump 1 which can deliver fluid in both directions, and it is therefore connected to the sump tank 6 over two lines 2 and 3 with back pressure valves 4 and 5. The pump is also connected to the sump tank via lines 7 and 8 with respective safety relief valves 9 and 10. The lines 2 and 3, of which one acts as a suction line and the other as a pressure line depending on the pump direction of the pump 1, connect the pump to two regulating valve units 11 and 12, of which the first one 11 communicates, via the lines 13 and 14, with the chamber 16 at the piston end of a double acting tilt cylinder 17 and also with a single acting trim cylinder 19 in order to regulate the fluid flow to and from these cylinders. The other regulating valve unit 12 communicates, via the line 15, with the chamber 20 at the piston rod end of the double acting cylinder 17. Both valve units 11 and 12 also communicate with the sump tank via respective return lines 21 and 22. Units 11 and 12 comprise respective piston means 25 and 26, which are influenced by the pressure in lines 3 and 2 and which are spring biased by respective compression springs 23 and 24 against the pressure in the respective lines. The piston means 25 controls the communication between sump return line 21 and lines 13 and 14 depending on the pressure in line 3, while piston means 26 controls the communication between sump return line 22 and line 15 depending on the pressure in line 2.

The hydraulic system further comprises a lock valve 27, which is manually adjustable and is interposed in the line 15 which communicates with the chamber 20 in cylinder 17. The system also comprises a safety relief
valve 29 in a short circuit line 28 connecting between lines 13 and 15.

Another safety relief valve is disposed in a channel in the piston 32, said channel connecting chambers 16 and 20 of the double acting cylinder to each other.

Finally, the system also comprises a line 33, which via a relief valve 48 connects line 13 to the sump tank.

The described system suffers of very little, actually negligible, leakage and keeps the pistons 32 and 34 of the cylinders 17 and 19 in their adjusted positions.

The hydraulic cylinders are adapted to act between a stationary part of the boat and the tiltable part of the drive unit in such a way that an outward movement of the respective piston rods 35 and 36 causes an upward swinging movement of the drive. This arrangement, being well known in the art, is therefore not further shown in the drawings.

When the angular position of the drive unit is to be adjusted, for upward or downward tilting or trimming, the pump is actuated and connected in the desired direction until the desired position of the drive unit is achieved.

When the drive unit is to be tilted from drive position when the boat is lying still or is not being driven forward, the function of the system is as follows:

The pump is actuated and connected in a direction which makes the line 3 constitute a suction line and the line 2 a pressure line. The pressure in line 2 opens a spring biased back pressure valve 37 in the regulating valve unit 11, whereupon the fluid under pressure is delivered to chambers 16 and 18 in the cylinder 17 and 19 via lines 13 and 14.

Simultaneously, the pressure in line 2 causes the piston 26 in the regulating valve unit 12 to move to the right as seen in FIG. 2 and thus opens back pressure valve 38 in the valve unit 12, whereupon chamber 20 in the cylinder 17 communicates with the sump tank 6 via the line 15 and the return line 22. The trimming cylinder has a relatively short stroke. As the piston 32 of cylinder 17 has a smaller area than the piston 34 of cylinder 19 and as the same pressure prevails in the cylinder chambers 16 and 18, a fast outward movement of the piston rod 35, and thus a fast tilting of the drive, is achieved after the piston 34 has reached its limit. As seen in U.S. Pat. No. 3,548,777, the rod 36 is so arranged that the outboard leg swings away therefrom beyond the trim range.

For downward tilting of the drive the pump is actuated in the opposite direction, so that line 3 constitutes a pressure line and line 2 a suction line. It will be apparent that the direction of rotation of the pump may be reversed to provide pressure to line 3 and to draw fluid from line 2 or that merely the input and output connections to the pump may be reversed to provide this result without reversing the actual direction of rotation of the pump itself. Via a spring biased back pressure valve 39 in the regulating valve unit 12 fluid is delivered to chamber 20 in the cylinder 17. Simultaneously, the pressure in line 3 causes piston 25 in the valve unit 11 to open a spring biased back pressure valve in the valve unit 11, whereupon the cylinder chambers 16 and 18 communicate with the tank 6 via the line 13, the back pressure valve 40 and the return line 21. In this case an inward movement of the piston 32 and finally of both pistons 32 and 34 and a downward movement of the drive are achieved.

When the boat is propelled, whereby the piston rods 35 and 36 are exposed to the force caused by the propeller thrust which tends to press the pistons inward, the cylinder 17, due to its small piston area, is not able to produce an outwardly directed force which is enough to overcome the propeller force and accomplish a short movement of the drive for trimming. At trimming, whereby the fluid flow corresponds to the above described one for tilting, the short movement of the drive is instead accomplished primarily by the cylinder 19 with the piston 34 which has a larger piston area, assisted to some extent by the lesser force of piston 32.

It shall be mentioned in this connection that the cylinder 19 is preferably positioned so that a relatively long moment arm is obtained, which is made possible by the fact that only a relatively short swinging motion is needed for trimming compared with tilting. The cylinder 17, however, is positioned so that a relatively short moment arm is obtained, in order to get a fast and wide swinging movement.

Of the other valves 27, 29 and 30 which are comprised in the hydraulic system, the valve 27 works as a lock valve which is manually adjustable together with the gear mechanism of the drive in order to block the drainage from the cylinder chamber 20. In this way it is ensured that the drive will not be tilted by the rearwardly directed propeller force during reverse drive. The valve 29 is a safety release valve which permits drainage of the chamber 20 if the drive is exposed to an extreme rearwardly directed force, for example upon impact with a submerged or floating object. Valve 30 has the same function when the lock valve 27 is in its locking position.

The hydraulic system according to the invention will hereunder be described with reference to FIG. 3 in which the components corresponding to those in FIG. 2 have been given the same number as in FIG. 2. The system shown in FIG. 3 corresponds in most parts to the system in FIG. 2, the difference being that the valve 12 is replaced by a regulating valve unit 41 and that the hydraulic cylinder 19 is abolished. The hydraulic cylinder 63 is designed similarly to cylinder 17 of FIG. 2 but with larger dimensions.

The regulating valve unit 41 includes, like valve 12 of FIG. 2, a piston 26 influenced by the pressure in line 2. The piston is spring biased by a spring 42 and controls the back pressure valve 38 in the connection line between line 15 and the return line 22. The system further comprises a back pressure valve 39 in the connection between the regulating valve unit 41 and the line 3. Besides this, the valve unit 41 has a second piston 44 which is also influenced by the pressure in line 2 and which controls a valve 45 connected to line 15 via a further valve 46.

When the drive is to be tilted up as earlier described, the function of the system of FIG. 3 is as follows:

When fluid is delivered to chamber 16 of cylinder 63 via line 2, valve 37 in the regulating valve unit 11 and the line 13, a pressure is built up in the system due to the counter force on the piston 32. This pressure, which is relatively low when the boat lies still, i.e. when no propeller thrust acts on the piston rod, is also transmitted to the chamber 47 of the regulating valve unit 41 and acts on the two pistons 26 and 44. The tensions of the compression springs 42 and 43 acting on the two pistons are selected or adjusted so that the control pis-
ton 44 opens the valve 45 at said relatively low pressure, while the control piston 26 is held back in its inactive position by the spring 42 so that the valve 38 is kept closed.

The return fluid, which is pressed out from the chamber 20 at the piston rod end of cylinder 63 by the downward movement of the piston 32, will then be transmitted to the chamber 16 at the piston end of the cylinder via line 15, back pressure valve 46, the open valve 45, chamber 47, line 2 and line 13. Fluid is thus delivered to chamber 16 both from the pump 1 and from the cylinder chamber 20. The effective area on which the fluid pressure from the pump acts, then, is equal to the difference between the areas on both sides of the piston 32, i.e. the piston rod area. As this area is relatively smaller than the area of the piston exposed to chamber 16, a quick outward movement of the piston rod 35 is achieved with a small force fitted to the low load at the upward tilt.

Downward tilting of the drive is carried out in the same course as with the system according to FIG. 2, pressure fluid passing through line 3, valve 39, line 15 and valve 27 to chamber 20, and return fluid passing from chamber 16 through open valve 40 and thence to the sump 6 through line 21.

When trimming underway, when a forwardly directed propeller thrust acts on the piston rod 35, a higher pressure must be built up in the system in order to overcome the counter force. The spring 42 is adjusted to yield for such higher pressure on the control piston 26 thereby to cause the valve 38 to open. Now when the piston 32 moves downwardly for trimming the drive, the fluid pressed out from the chamber 20 will return to the sump tank via the open valve 38 and line 22. The communication between the chamber 47 and the line 15 through the open valve 45 is interrupted or blocked by valve 46. It will be seen that, as the pressure against control piston 44 increases, the spring 43 urging valve 46 toward closed position is increasingly compressed. When the system pressure in chambers 16 and 47 is above the pressure at which valve 38 is opened, the fluid from line 15, accordingly, passes freely through valve 38 and does not force open valve 46. Fluid is therefore delivered by the pump 1 to chamber 16 only, whereby the pressure acts on the whole piston area exposed to chamber 16 and a slow piston movement with great force is achieved. The spring 42 acting on the control piston 26 is preferably adjustable by well known means for varying the opening pressure of the valve 38, although adjusting means are omitted from the drawing for the sake of clarity.

With the described system there is provided an automatic adjustment between quick piston movement with little force and slow piston movement with great force depending on the pressure in the system.

U. S. Patents having some pertinence in connection with the present invention include No. 3,003,724 — Kiechhafer; No. 3,434,448 — Woodfill; No. 3,653,270 — Bergstedt; and No. 3,581,702 — Moberg, in addition to No. 3,548,777 identified above.

While the invention has been described with respect to certain specific embodiments, it will be appreciated that many modifications and changes may be made by those skilled in the art without departing from the spirit of the invention. It is intended, therefore, by the appended claims to cover all such modifications and changes as fall within the true spirit and scope of the invention.

What is claimed as new and what it is desired to secure by Letters Patent of the United States is:

1. A hydraulic system for trimming and tilting of outboard drive units for boats, comprising pump means adapted to deliver fluid under pressure from a fluid sump to a double acting cylinder-piston assembly, said cylinder-piston assembly being arranged between said tiltable drive unit and the boat or a stationary part of the drive, characterized by a valve unit, said valve unit being adjustable between a first position in which the chamber at the piston rod end of the cylinder is disconnected from communication with said sump and connected to communicate with the chamber at the piston end of the cylinder, and a second position in which said chamber at said piston rod end of said cylinder is disconnected from communication with said chamber at said piston end of said cylinder and connected to communicate with said sump.

2. In a hydraulic system for trimming and tilting an outboard drive leg for boats about a horizontal tilt axis comprising a hydraulic fluid sump, a double acting hydraulic cylinder-piston assembly including a piston rod and having a cylinder with a piston therein dividing the space in the cylinder into a first chamber at the piston end and a second chamber at the piston rod end of said cylinder, means connecting said cylinder-piston assembly between said leg and said boat and spanning said axis, and a source of pressure fluid connected to said first chamber, valve means connected to said sump and to each of said chambers adjustable between two positions in the first of which said valve means closes connection between said second chamber and said sump and opens a connection between said chambers and in the second of which it closes connection between said chambers and opens a connection from said second chamber to said sump.

3. A hydraulic system according to claim 2, characterized in that said valve means comprises pressure sensing means for automatic adjustment of said valve means from said first to said second positions in response to a pressure in the system in excess of a predetermined pressure.

4. A hydraulic system according to claim 3, characterized in that the pressure sensing means is operative to adjust said valve means to said first position in response to said system pressure being less than said predetermined pressure which is characteristic of a low load on the piston rod, fluid being delivered to said first chamber partly from said source and partly from said second chamber when said valve is in said first position, and to adjust said valve means to said second position in response to such system pressure being in excess of said predetermined pressure which is characteristic of a relatively higher load on the piston rod, fluid being delivered to said first chamber only from said source and fluid displaced from said second chamber being returned to said sump when said valve is in said second position.

5. A hydraulic system according to claim 4, characterized in that said pressure sensing means comprises two spring biased control pistons disposed in a housing of said valve means, one of said control pistons being operative to establish communication between said chambers in response to said pressure below said predetermined pressure, the other of said control pistons
7 being operative to establish communication between said second chamber and said sump in response to an increase of said pressure to above said predetermined pressure, said valve means comprising a back pressure valve for interrupting the communication between said first chamber and said second chamber in response to such increase of the pressure.

8 6. A hydraulic system according to claim 5, characterized in that the spring biasing said second piston is adjustable for adjustment of said predetermined pressure at which the communication between said second chamber of the cylinder and said sump is established.

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