June 4, 1940. R. C. LAMOND 2,203,097

HYDRAULIC CONTROL MECHANISM

Filed April 15, 1937 2 Sheets-Sheet 1

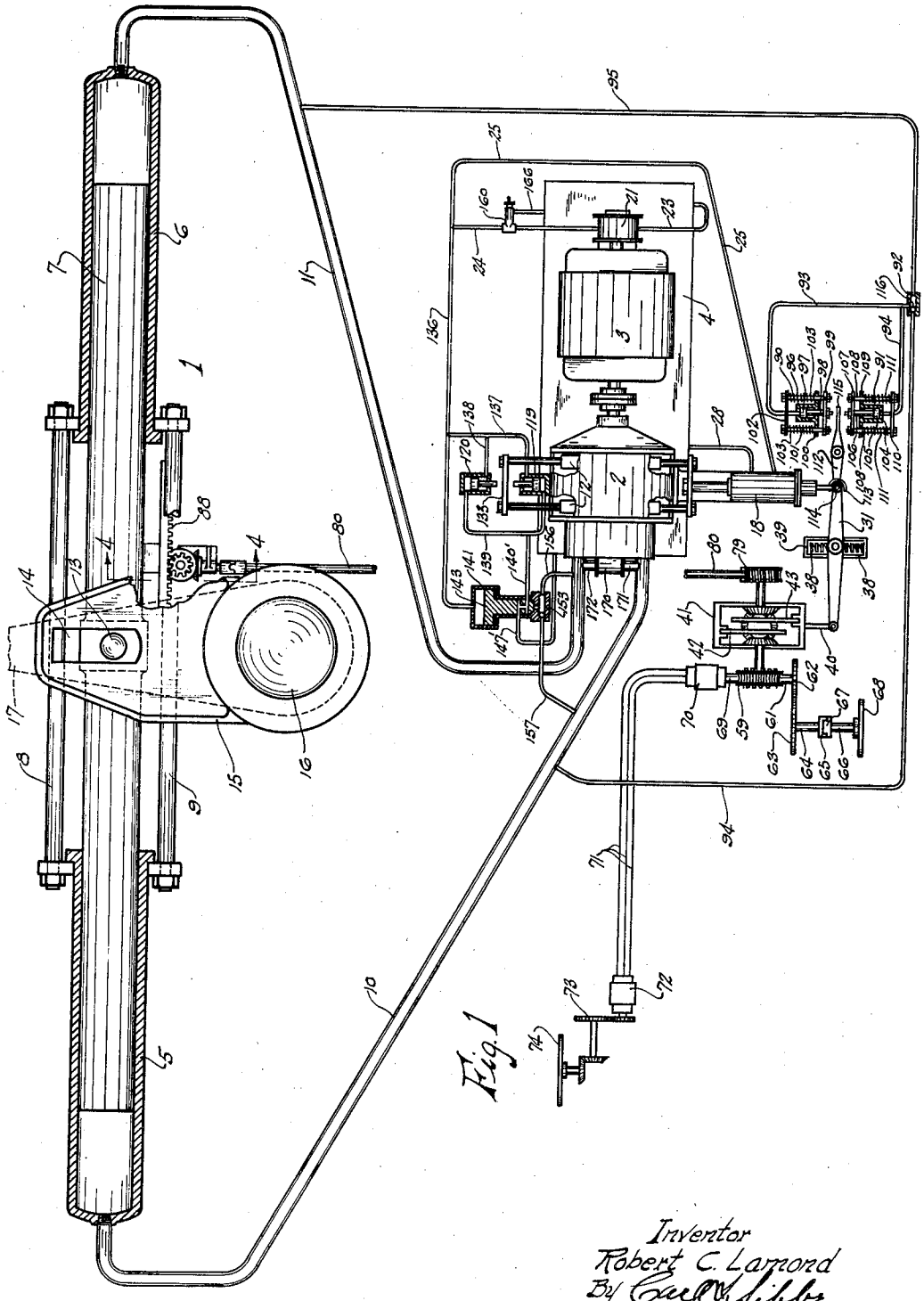


Fig. 1

Inventor
Robert C. Lamond
By Carl W. Gibbs
Attorney

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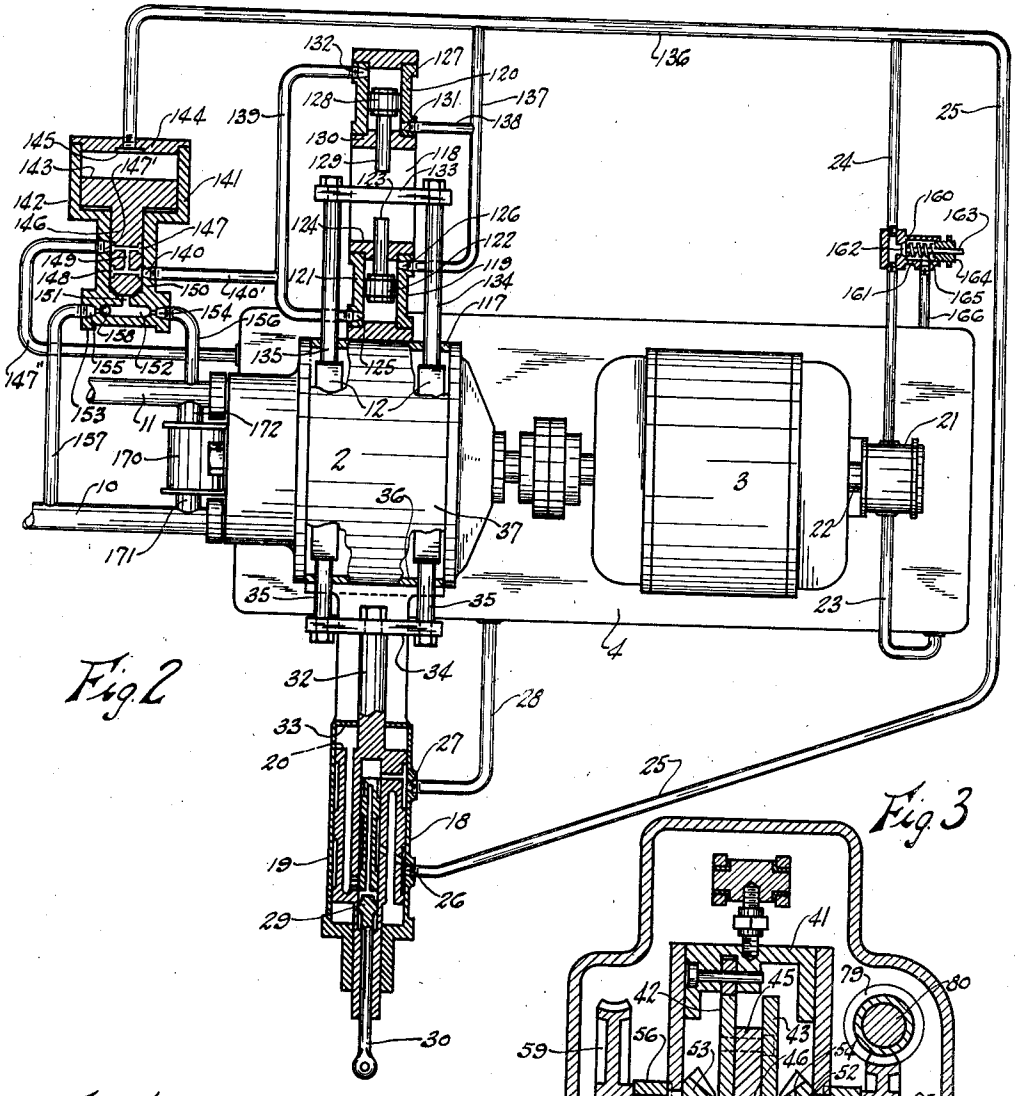


Fig. 2

Fig. 3

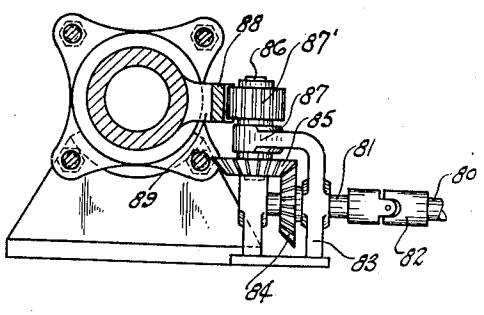


Fig. 4

Inventor
Robert C. Lamond
By Carl R. Libbe
Attorney

Patented June 4, 1940 2,203,097

UNITED STATES PATENT OFFICE

2,203,097

HYDRAULIC CONTROL MECHANISM

Robert C. Lamond, Philadelphia, Pa., assignor to American Engineering Company, Philadelphia, Pa., a corporation of Pennsylvania

Application April 15, 1937, Serial No. 137,051

6 Claims. (Cl. 60—52)

This invention relates to control mechanisms for hydraulic transmissions, especially those employed in steering devices for ships. In steering mechanisms of this character a reciprocating motor is employed to move the rudder to various positions of adjustment. The motor is driven by a reversible discharge pump which in turn, in most instances, is driven by an electric motor. Suitable controls are also provided to control the stroke and direction of discharge of the pump. During the operation of such devices, in the event the driving motor for the pump should become disabled, while the pump is on stroke, an hydraulic lock occurs in the system which retains the pump in that position. Upon reconditioning of the driving apparatus it is seen that in order to continue the operation of the device it would be necessary to start the operation thereof under a heavy load.

The present invention has for its primary object the provision of a safety means, preferably in the form of fluid motors connected to the pressure side of the system which function in the event the driving mechanism should become disabled for any reason, to return the stroke controls of the pump to neutral position. The driving mechanism for the pump may then be started up under practically no load, and damage to the windings or the apparatus in general is prevented.

Other and further objects will become apparent as the description of the invention progresses.

Of the drawings:

Fig. 1 is a diagrammatic view partly in section, showing the invention applied to a steering mechanism for ships.

Fig. 2 is an enlarged plan view partly in section, showing the pump end of the transmission and the control mechanism associated therewith.

Fig. 3 is a sectional view showing the differential mechanism for adjusting the control valve of the stroke adjusting motor, and

Fig. 4 is a detail view partly in section, taken substantially along line 4—4 of Fig. 1.

Referring to the drawings, the numeral 1 designates generally a fluid motor driven in the present instance by a variable stroke reversible discharge pump 2, which in turn may be driven by an electric motor 3, or by any other suitable driving mechanism. Pump 2 and motor 3 are mounted upon a makeup tank 4 from which fluid may be drawn into the system through connections hereinafter described. Pump 2 is of the general type shown and described in United States Patent No. 1,077,979 to which reference may be had for a complete description thereof.

Fluid motor 1 comprises a pair of spaced, axially aligned cylinders 5 and 6, having a ram 7 operating therein. Cylinders 5 and 6 are rigidly connected by a pair of tie rods 8 and 9. The outer ends of cylinders 5 and 6 are respectively connected to pump 2 by pipes 10 and 11. Pump 2, as is well known in the art, is of such a construction that when the sliding blocks 12 thereof are adjusted in one direction from a neutral position, pressure is delivered to pipe 11 and suction to pipe 10, causing the ram 7 to move to the left and when the sliding blocks 12 are actuated in the reverse direction from a neutral position, pressure is delivered to pipe 10 and suction to pipe 11, causing the ram 7 to move to the right. Extending vertically from ram 7 intermediate the ends thereof is a projection 13, which operates in a slot 14, provided near the free end of an arm 15 secured to a rudder post 16. A rudder 17, shown in dotted lines in Fig. 1, is secured to the lower end of post 16. It therefore is seen that upon actuation of ram 7 in the manner just described, rudder 17 is adjusted accordingly.

The stroke adjusting elements 12 of pump 2 are adjusted by means of a servo motor 18 which may be of the type shown and described in United States Patent No. 1,986,640. As shown more particularly in Fig. 2, servo motor 18 comprises a cylindrical casing 19 having a piston 20 operating therein. Fluid is supplied to servo motor 18 by a small pump 21, mounted in the present instance on motor 3 and driven by the armature shaft 22 thereof. Fluid is drawn into pump 21 from makeup tank 4 through a pipe 23, and is discharged therefrom through pipe 24. A branch pipe 25 connects pipe 24 with the inlet port 26 provided in the casing 19 of servo motor 18. Fluid at the low pressure end of servo motor 18 discharges to makeup tank through a port 27 also provided in casing 19 and pipe 28. The operation of piston 20 is controlled by a valve 29, the stem 30 of which extends through the outer end of casing 19 and has pivotally connected to the free end thereof one end of a lever 31. Piston 20 has secured thereto a rod 32 which extends through a suitable bearing provided in the inner wall 33 of casing 19, the outer end of which being secured to a crosshead 34. The opposite ends of crosshead 34 have secured thereto the outer ends of a pair of rods 35 which extend through suitable bearings provided in the end wall 36 of the casing 37 of pump 2, while the inner ends of these rods are secured to the sliding

blocks 12 of said pump. It therefore is seen that upon actuation of piston 20 of servo motor 18 the sliding blocks 12 are actuated accordingly to vary the stroke and direction of discharge of pump 2.

As shown in Fig. 1, lever 31 is mounted intermediate the ends thereof on a pair of coil springs 38 provided in a casing 39 and has pivotally connected to the left end thereof a rod 40. Rod 40 is secured to a cam follower 41 which in the present instance is actuated by a pair of cams 42 and 43. Cams 42 and 43 are adjusted by differential gearing indicated generally by the numeral 44. Cams 42 and 43 are secured to the vertical extension 45 of an operating element 46. The lower end of operating element 46 has secured thereto a bearing stud 47 upon which a bevel gear 48 is rotatably mounted. Operating element 46 is also provided with a pair of laterally extending bearing elements 49 and 50 which extend respectively into the inner central bores 51 and 52 provided in a pair of axially aligned bevel gears 53 and 54 which mesh with bevel gear 48. Bevel gear 53 has integral therewith a hub portion 55 which extends through a suitable bearing 56 provided in the inner vertical wall 57 of the casing 58 for differential gear 44. The outer end of hub 55 has secured thereto a worm wheel 59 which meshes with a worm gear 60 secured to a shaft 61. One end of shaft 61 has secured thereto a spur gear 62 which meshes with a pinion 63 secured to a shaft 64 having a clutch element 65 provided thereon. A second shaft 56 mounted in any suitable manner in axial alignment with shaft 64 is provided with a complementary clutch element 67, and has a hand wheel 68 secured to the outer end thereof. The other end of shaft 61 is secured in any suitable manner to the armature shaft 69 of a synchronous receiver 70, which in turn is connected by suitable conductors 71 to a synchronous transmitter 72. Synchronous transmitter 72 may be located at some remote point on board ship, such as on the bridge thereof, and is connected by gearing 73 to a steering wheel 74. It therefore is seen that worm gear 60 may be actuated either by hand wheel 68 or by the synchronous transmitter 70, as desired.

Bevel gear 54 also has provided thereon an extended hub portion 75 which extends through a suitable bearing 76 provided in a second interior wall 77 of casing 58. The free end of hub 75 has secured thereto a worm wheel 78, which meshes with a worm gear 79 mounted on a followup shaft 80. Shaft 80, as shown more particularly in Figs. 1 and 4, is secured to a second shaft 81 by a universal coupling 82. Shaft 81 is rotatably mounted in a bracket 83 and has secured intermediate the ends thereof a bevel gear 84, which meshes with a second bevel gear 85 secured to the lower end of a shaft 86 mounted in a second bearing 87. The upper end of shaft 86 has secured thereto a gear 87' which meshes with a rack 88 integrally secured to ram 7 in any suitable manner, such as by a connecting element 89.

The various mechanisms hereinbefore described are of the general type shown and described in the pending application of Albert R. Kuzelewski, Serial No. 714,960, filed March 10, 1934, issued March 22, 1938 as Patent No. 2,111,594, to which reference may be had for a more detailed description thereof. However, from the foregoing description it is seen that upon movement of hand wheel 68 or 74, rotary movement is imparted to worm wheel 59, and bevel gear 53 which in turn actuates bevel gear 48. However, at this time inasmuch as bevel gear 54 is held stationary through its connection with worm gear 79, bevel gear 48 will roll thereon thereby swinging operating element 46, and consequently cams 42 and 43. By operation of cams 42 and 43 in this manner movement is imparted to cam follower 41, which in turn swings lever 31 in one direction about its flexible pivot. This movement of lever 31 is imparted to valve 29 of servo motor 18, which properly conditions the servo motor for operation. When this occurs fluid from pump 21 will flow to the proper end of cylinder 19, depending upon the direction of movement of hand wheel 68 or 74, causing piston 20 to actuate the sliding blocks 12 accordingly, thereby placing pump 2 on stroke. Let us assume that pump 2 has been so adjusted as to deliver pressure to pipe 11 and suction to pipe 10. Under these conditions ram 7 will move to the left, carrying rack member 88 with it. This motion is imparted to worm gear 79 through gears 87, 85, 84, and shafts 81 and 80. By this action worm wheel 78 will actuate bevel gear 54 to return bevel gear 48 and actuating element 46 to normal position. This movement is again imparted to valve 29 through lever 31, causing piston 20 to return the stroke controls of pump 2 to neutral position. Ram 7, and consequently the rudder 17 actuated thereby, will thus remain in adjusted position until hand wheels 68 or 74 are again operated.

Referring to Fig. 1, mechanism has also been provided to adjust valve 29 toward neutral position to thereby condition servo motor 18 to effect adjustment of sliding block 12 of pump 2 to reduce the stroke thereof in the event the pressure in the system exceeds a predetermined value. This mechanism consists of a pair of fluid motors 90 and 91 which are connected to a shuttle valve 92 by pipes 93 and 94 respectively. One end of shuttle valve 92 is connected to pipe 10 by a pipe 94, while the other end thereof is connected to pipe 11 by a second pipe 95. Motor 90 consists of a cylinder 96 having a piston 97 operating therein. Piston 97 has a rod 98 secured thereto, which extends through the inner end of cylinder 96 and is secured to a crosshead 99 at the free end thereof. Crosshead 99 has secured to the opposite ends thereof a pair of rods 101, which extend through guide bearings provided in the flange 100 of cylinder 96. The other ends of rods 101 extend through apertures provided in a rigid cross member 102. A pair of springs 103 encircle rods 101 and extend between cross member 102 and flange 100.

Motor 91 is of similar construction and also consists of a cylinder 104 having a piston 105 operating therein. The free end of piston rod 106 is secured to a crosshead 107 having secured to the opposite ends thereof a pair of rods 108. Rods 108 extend through guiding apertures provided in the flange 109 of cylinder 104, and also through guiding apertures provided in a rigid cross member 110. A pair of springs 111 encircle rods 108 and extend between flange 109 and rigid member 110. A lever 112 pivoted intermediate its ends has provided at one end thereof a yoke 113 adapted to engage a stud 114 projecting from valve stem 30. The other end 115 of lever 112 extends between and is adapted to be engaged by the free ends of piston rods 98 and 106.

It therefore is seen that should the pressure in pipe 10 exceed a predetermined safe value, the ball 116 of shuttle valve 92 will be actuated to the right (Fig. 1), thereby establishing communication between motors 90 and 91 and said pipe, and at the same time preventing fluid from dis-

charging from pipe 94 to pipe 95. When this pressure exceeds the pressure of springs 103 and 111 associated with motors 90 and 91 respectively, pistons 97 and 105 will move inwardly to actuate lever 112 toward a central position. Lever 112 in turn through its connection with valve stem 30 will then adjust valve 29 toward neutral position. When this occurs piston 20 will also be actuated toward a neutral position to effect adjustment of the sliding blocks 12 of pump 2 toward neutral position and thereby reduce the stroke of the pump. The same is true in the event the pressure in pipe 11 should exceed a predetermined safe value. When this occurs the ball 116 of shuttle valve 92 will be adjusted to the position shown in Fig. 1, thereby establishing communication between pipe 11 and motors 90 and 91, which in turn actuate lever 112 toward a central position. Piston 20 of servo motor 18 now effects adjustment of sliding blocks 12 of pump 2 toward neutral position, to again reduce the stroke of the pump and thus relieve the pressure in the system.

Referring to Figs. 1 and 2, it will be observed that pump 2 has secured to the end wall 117 thereof a bracket 118. Bracket 118 has mounted therein a pair of spaced, axially aligned fluid motors 119 and 120. Motor 119 comprises a cylinder 121 having a piston 122 operating therein. A rod 123 secured to piston 122 extends through a suitable bearing provided in the end wall 124 of cylinder 121. Cylinder 121 is provided with ports 125 and 126 at the opposite ends thereof. Motor 120 also comprises a cylinder 127 in which operates a piston 128. A rod 129 extends through a suitable bearing provided in the end wall 130 of cylinder 127. Cylinder 127 also has provided therein a pair of ports 131 and 132. Extending between the ends of piston rods 123 and 129 is a crosshead 133, to the opposite ends of which are secured a pair of rods 134 and 135. These rods extend through suitable bearings provided in the end wall 117 of pump 2 and are secured at their inner ends to sliding blocks 12.

It therefore is seen that when pistons 122 and 128 are actuated toward each other, crosshead 133 and consequently sliding blocks 12 will be actuated to neutral position to place the pump on neutral stroke. Port 126 of motor 119 is connected to a pipe 136 by means of a pipe 137. Port 131 of motor 120 is connected to pipe 137 by a branch pipe 128, while pipe 136 is connected to pipe 24, and therefore receives fluid from pump 21. Pistons 122 and 128, it therefore will be observed, are normally actuated away from each other and are held in that position by the pressure of pump 21. Ports 125 and 132 of motors 119 and 120 respectively, are connected by means of a pipe 139. Pipe 139 is connected to a port 140 of a control valve 141 by a pipe 140'. Control valve 141 comprises a substantially T-shaped casing 142 having a piston 143 operating therein. The outer wall 144 of casing 142 has an inlet port 145 provided therein, to which the end of pipe 136 is connected. Piston 143 therefore is constantly subjected to the pressure delivered by pump 21. Piston 143 has integral therewith a reduced portion 146 having provided intermediate the ends thereof a pair of transverse passages 147 and 148 connected by a third passage 149. The lower end of the reduced portion of the casing 150 has provided therein a port 151 which communicates with the chamber 152 of a shuttle valve 153. The opposite ends of shuttle valve 153 have provided therein ports 154 and 155, the former of which is connected by a pipe 156 to pipe 11, while the latter is connected to pipe 10 by a second pipe 157. Valve 153 comprises a ball valve 158 adapted to be actuated by pressure from one extreme end of chamber 152 to the other. When valve 141 is in the position shown in Figs. 1 and 2 passage 147 registers with an exhaust port 147' provided in the casing 142 thereof which in turn is connected to tank 4 by a pipe 147''. Thus, when the valve is in normal position fluid from the head ends of motors 119 and 120 drains to exhaust through pipes 139, 140', passages 148, 149 and 147, and pipe 147''. Any fluid leakage past piston 143 also flows to exhaust through port 147' and pipe 147''.

From the foregoing description it is seen that for normal operations of the apparatus as a whole, the piston rod ends of pistons 122 and 128 are constantly subjected to the pressure delivered by pump 21. Pistons 122 and 128 are thus actuated away from each other, and retained in that position by this pressure. It is also seen that the outer end of piston 143 is also constantly subjected to the pressure delivered by pump 21, and therefore is retained in the position shown in Figs. 1 and 2. Now let us assume, for example, that pump 2 has been so adjusted as to deliver pressure to pipe 10 and suction to pipe 11. Fluid pressure from pump 2 now flows to the left hand end of cylinder 5 causing ram 7, and consequently rudder 17, to move to the right. Ball 158 of shuttle valve 153 will move to the right hand end of chamber 152, thereby preventing the passage of fluid from pipe 157 to pipe 156, and consequently the inner end of piston 143 will be subjected to the pressure in pipe 10. When the parts have been so adjusted, let us assume that the electric power is shut off, or that driving motor 3 should for any other reason become disabled and thereby come to rest. Under these conditions, due to the pressure in pipe 10 pump 2 will be driven as a motor and will rotate motor 3, as well as pump 21, in the opposite direction. Pump 21 then draws fluid from valve 141, the piston rod ends of motors 119 and 120, as well as from servo motor 18. This obviously reduces the pressure operating on these elements. Also, when auxiliary pump 21 comes to rest, a certain leakage occurs in the system, and consequently the pressure at the outer end of piston 143, as well as that at connecting rod ends of motors 119 and 120, will be further reduced. If the ship is in motion, or in the event a wave should strike rudder 17, it will tend to move, depending upon the direction of application of the force. This force is transmitted to ram 7, which also tends to move in the direction of the application of the force, thereby tending to compress the fluid in pipes 10 or 11. Supposing the force is so applied that ram 7 tends to move to the left, thereby imposing pressure in pipe 10, the fluid pressure thus created will be communicated to the inner end of piston 143. This pressure communicated to pump 2 also tends to operate the same as a motor to cause pump 21 to withdraw fluid from the outer end of piston 143 and the piston rod ends of motors 119 and 120, as well as from servo motor 18, and to discharge the same to makeup tank 4 through pipe 23. Inasmuch as the outer end of piston 143 is now subjected to substantially no pressure, piston 143 will move outwardly to establish communication between pipe 10 and the head ends of motors 119 and 120. As pointed

out before, the connecting rod ends are subjected to substantially no pressure, and consequently the pressure communicated to the head ends of these motors will actuate the pistons 122 and 128 toward each other to thereby center crosshead 133, and consequently sliding blocks 12, thereby adjusting the pump to neutral position. Upon starting up of electric motor 3 it will be seen that inasmuch as pump 2 is on neutral stroke the motor 3 will be subjected to substantially no load. The same procedure follows in the event the application of the force on the rudder 17 should be in the opposite direction. Pressure will then be built up in pipe 11, causing ball 158 of shuttle valve 153 to move to the extreme left hand position, thereby preventing the passage of fluid from pipe 156 to pipe 157. The inner end of piston 143 will consequently be subjected to this pressure. Inasmuch as the upper end of piston 143 is subjected to substantially no pressure, the said piston will move outwardly to establish communication between the head ends of motors 119 and 120, and pipe 11. The pistons 122 and 128 of motors 119 and 120 respectively will now move toward each other to actuate the sliding blocks 12 of pump 2 to a central position, and thereby place the said pump on neutral stroke.

The pressure applied to the upper end of piston 143, the piston rod ends of motors 119 and 120, as well as that applied to servo motor 18 by pump 21, may be predetermined by means of a relief valve 160, mounted in pipe 24. Relief valve 160 comprises a casing 161 having a valve element 162 mounted therein. The stem 163 of valve element 162 extends through the central bore of a plug 164, which makes threaded engagement with the right hand end (Fig. 2) of casing 161. A coil spring 165 encircles valve stem 163 and extends between the valve head and the inner end of plug 164. Thus, by adjusting plug 164, the pressure of spring 165 may be varied. The casing 161 of valve 160 is also connected to makeup tank 4, by means of a pipe 166. During normal operation of the apparatus, when pistons 122 and 128 of motors 119 and 120, and piston 143 of control valve 141 have been actuated to their normal positions of adjustment, continued operation of pump 21 causes the pressure of the fluid to build up, and when this pressure exceeds the pressure of spring 165 of relief valve 160, valve element 162 will be actuated away from its seat to permit the fluid from pump 21 to bypass to makeup tank 4.

Fluid is drawn into the system for makeup purposes from tank 4 through a valve 170 and pipes 171 and 172, the latter of which being connected to pipes 10 and 11.

While the embodiment herein described is admirably adapted to fulfill the objects primarily stated, it is to be understood that the invention is not to be limited thereto, since it may be embodied in other forms, all coming within the scope of the claims which follow:

What is claimed is:

1. In a fluid system, the combination with a reversible discharge pump, of power means for operating said pump, a reciprocatory fluid motor, a rudder actuated by said fluid motor, stroke adjusting means for varying the stroke and direction of discharge of said pump, a pair of fluid motors adapted to actuate said stroke controls to neutral position, a valve for controlling the operation of said pair of fluid motors, means connecting one end of said valve to the pressure in said system, an auxiliary pump actuated by said power means, and means connecting the other end of said valve to said auxiliary pump, whereby when the pressure in the system imposed upon said valve exceeds that imposed upon said valve by said auxiliary pump, said valve is actuated to establish communication between one end of said pair of fluid motors and said system pressure, causing said stroke adjusting means to be actuated to neutral position.

2. In a fluid system, the combination with a reversible discharge pump, of power means for operating said pump, a reciprocatory fluid motor, a rudder actuated by said fluid motor, stroke adjusting means for varying the stroke and direction of discharge of said pump, a pair of fluid motors adapted to actuate said stroke controls to neutral position, a valve for controlling the operation of said pair of fluid motors, means connecting one end of said valve to the pressure in said system, an auxiliary pump, means connecting the other end of said valve to said auxiliary pump, whereby when the pressure in the system imposed upon said valve exceeds that imposed upon said valve by said auxiliary pump, said valve is actuated to establish communication between one end of said pair of fluid motors and said system pressure, causing said stroke adjusting means to be actuated to neutral position, and means connecting the other ends of said pair of fluid motors to said auxiliary pump, whereby the latter are normally retained in ineffective position.

3. In a fluid system, the combination with a reversible discharge pump, of power means for operating said pump, a reciprocatory fluid motor, a rudder actuated by said fluid motor, stroke adjusting means for varying the stroke and direction of discharge of said pump, a pair of fluid motors adapted to actuate said stroke controls to neutral position, a valve for controlling the operation of said pair of fluid motors, means connecting one end of said valve to the pressure in said system, an auxiliary pump, means connecting the other end of said valve to said auxiliary pump, whereby when the pressure in the system imposed upon said valve exceeds that imposed upon said valve by said auxiliary pump, said valve is actuated to establish communication between one end of said pair of fluid motors and said system pressure, causing said stroke adjusting means to be actuated to neutral position, means connecting the other ends of said pair of fluid motors to said auxiliary pump, whereby the latter are normally retained in ineffective position, and adjustable means for varying the pressure delivered by said auxiliary pump.

4. In a fluid system, the combination with a reversible discharge pump, of power means for operating said pump, a fluid motor operated by the discharge of said pump, a rudder operated by said fluid motor, stroke adjusting means for varying the stroke and direction of discharge of said pump, an auxiliary source of fluid pressure, means operated by said auxiliary source of fluid pressure for actuating said stroke adjusting means to different positions of adjustment, a pair of fluid motors adapted to actuate said stroke adjusting means to neutral position, a valve for controlling the operation of said pair of fluid motors, means connecting one end of said valve to the pressure in said system, means connecting the other end of said valve to said auxiliary source of pressure whereby when the pressure in the system imposed upon said valve exceeds that imposed upon said valve by said auxiliary source of

pressure, said valve is actuated to establish communication between one end of said pair of fluid motors and said system pressure whereby said stroke adjusting means are actuated to neutral position.

5. In a fluid system, the combination with a reversible discharge pump, of power means for operating said pump, a fluid motor operated by the discharge of said pump, a rudder operated by said fluid motor, stroke adjusting means for varying the stroke and direction of discharge of said pump, an auxiliary source of fluid pressure, means operated by said auxiliary source of fluid pressure for actuating said stroke adjusting means to different positions of adjustment, a pair of fluid motors adapted to actuate said stroke adjusting means to neutral position, a valve for controlling the operation of said pair of fluid motors, means connecting one end of said valve to the pressure in said system, means connecting the other end of said valve to said auxiliary source of pressure whereby when the pressure in the system imposed on said valve exceeds that imposed upon said valve by said auxiliary source of pressure, said valve is actuated to establish communication between one end of said pair of fluid motors and said system pressure whereby said stroke adjusting means are actuated to neutral position, and means connecting the other ends of said pair of fluid motors to said auxiliary source of pressure whereby said motors are normally retained in ineffective position.

6. In a fluid system, the combination with a reversible discharge pump, of power means for operating said pump, a fluid motor operated by the discharge of said pump, a rudder operated by said fluid motor, stroke adjusting means for varying the stroke and direction of discharge of said pump, an auxiliary source of fluid pressure, means operated by said auxiliary source of fluid pressure for actuating said stroke adjusting means to different positions of adjustment, a pair of fluid motors adapted to actuate said stroke adjusting means to neutral position, a valve for controlling the operation of said pair of fluid motors, means connecting one end of said valve to the pressure in said system, means connecting the other end of said valve to said auxiliary source of pressure whereby when the pressure in the system imposed upon said valve exceeds that imposed upon said valve by said auxiliary source of pressure, said valve is actuated to establish communication between one end of said pair of fluid motors and said system pressure whereby said stroke adjusting means are actuated to neutral position, means connecting the other ends of said pair of fluid motors to said auxiliary source of pressure whereby said motors are normally retained in ineffective position, and adjustable means for varying the pressure delivered by said auxiliary source of fluid pressure.

ROBERT C. LAMOND.