

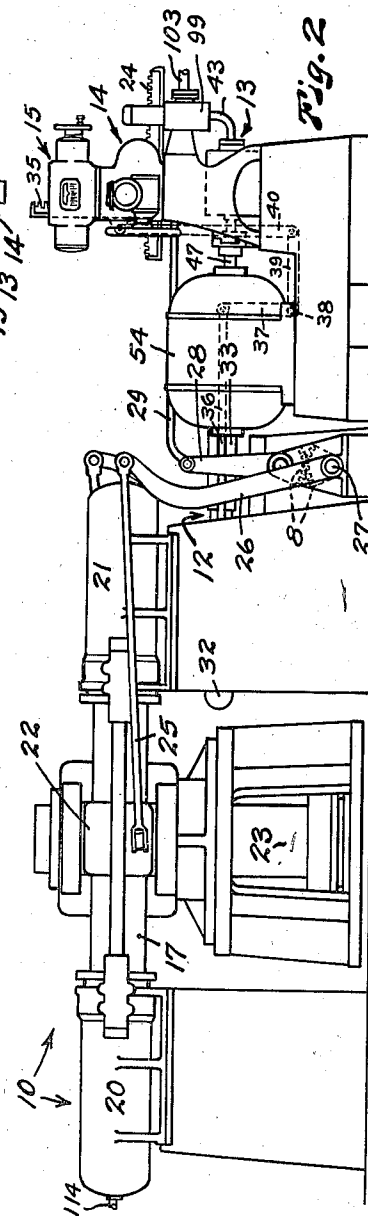
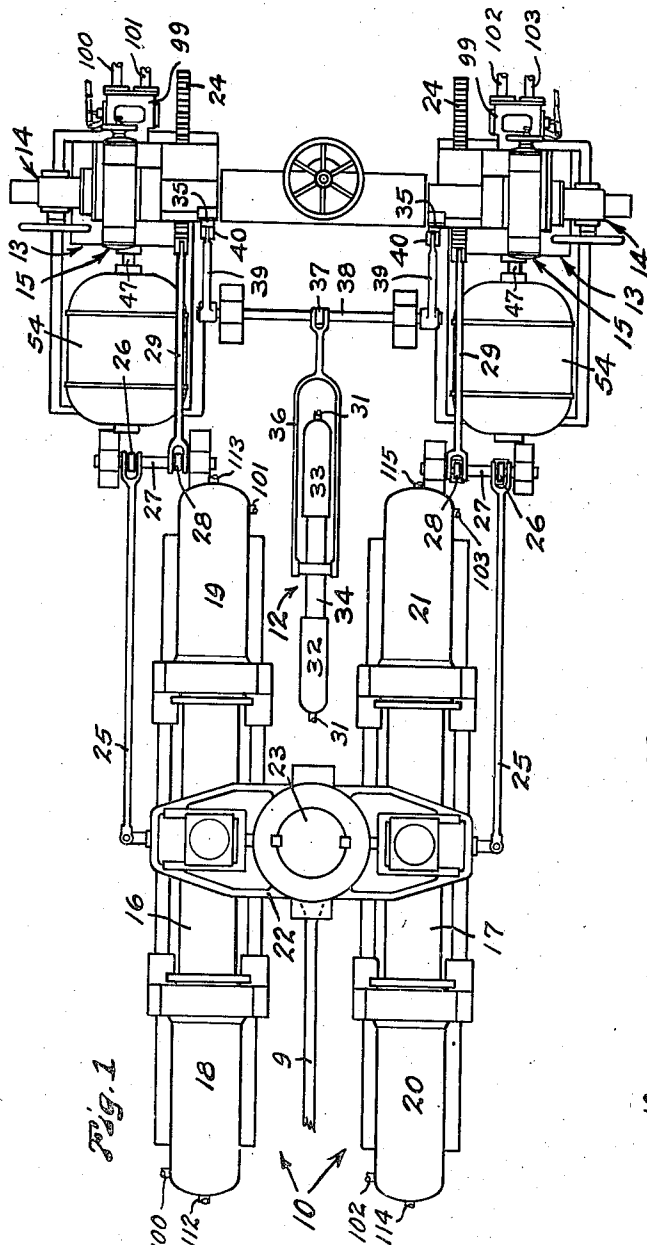
Nov. 30, 1948.

W. T. PRITCHARD
HYDRAULIC MARINE STEERING GEAR FOR
OPERATING THE RUDDERS OF SHIPS

2,455,090

Filed June 8, 1944

3 Sheets-Sheet 1



INVENTOR.
Wilmot T. Pritchard
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Arnold and Mathie
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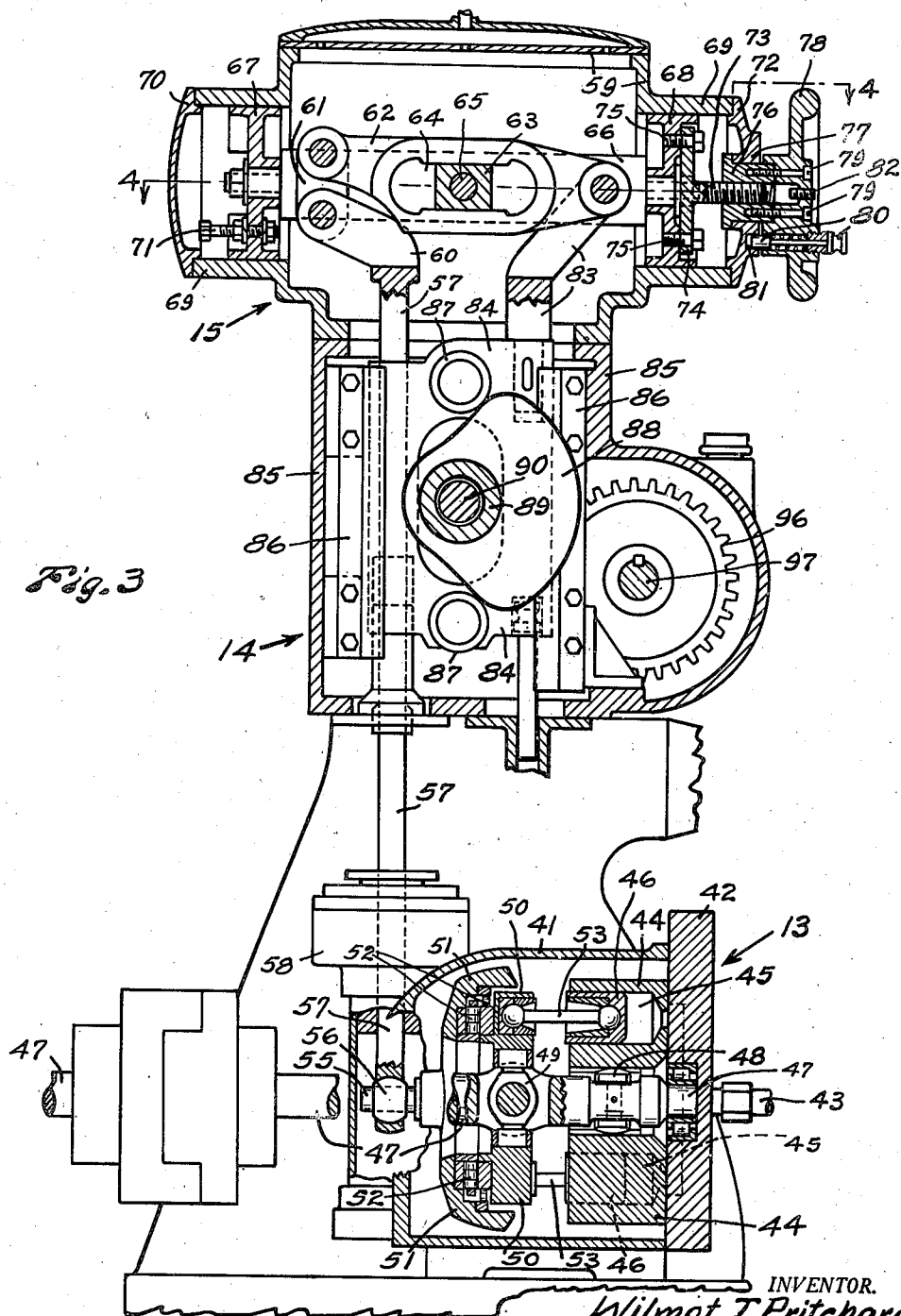
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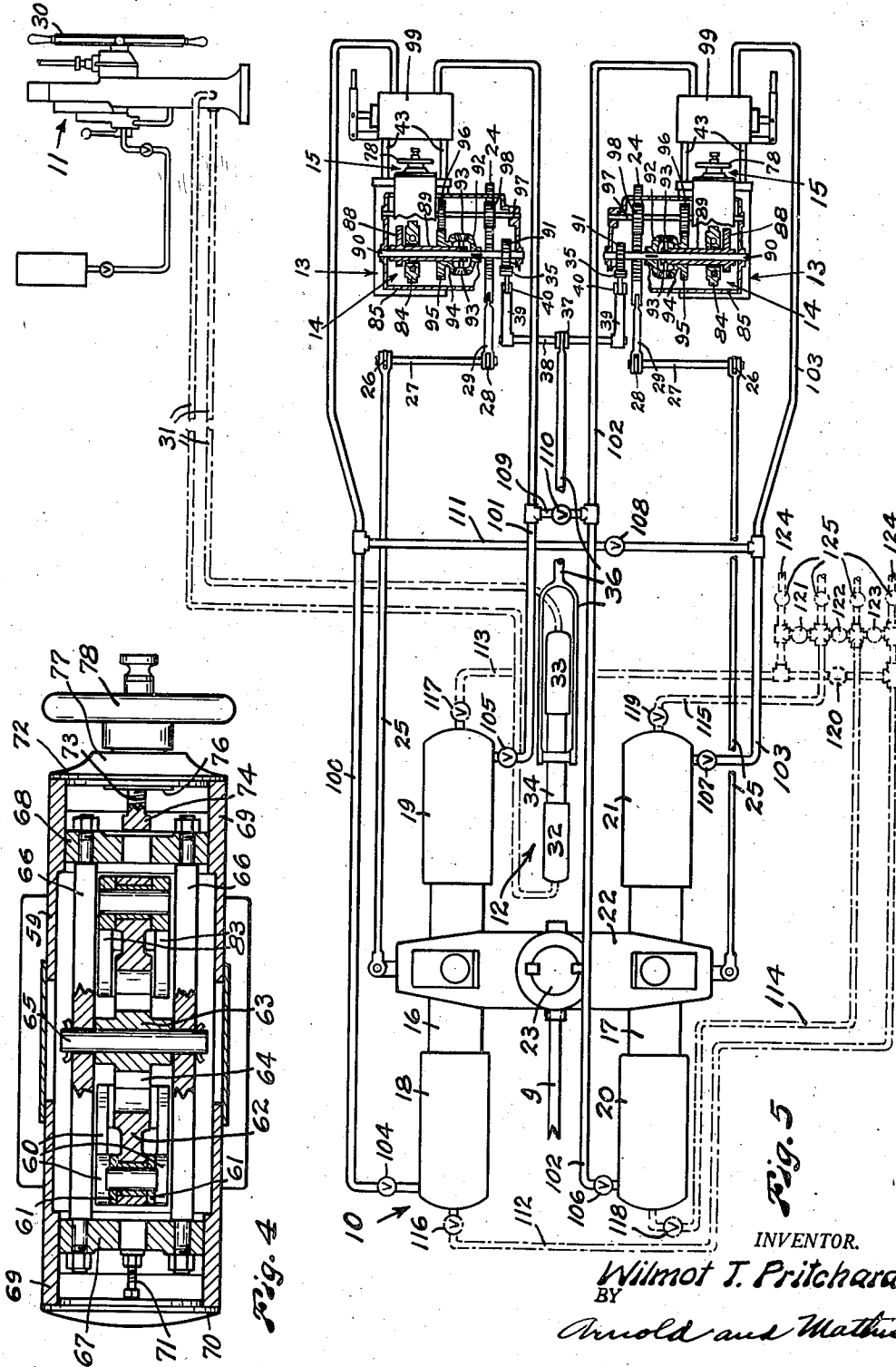
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UNITED STATES PATENT OFFICE

2,455,090

HYDRAULIC MARINE STEERING GEAR FOR
OPERATING THE RUDDERS OF SHIPS

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Application June 8, 1944, Serial No. 539,342

5 Claims. (Cl. 60—52)

1

My invention relates to hydraulic marine steering gear for operating the rudder of a ship.

More particularly my invention relates to providing in a hydraulic marine steering mechanism, for varying the speed of response of a ship's rudder to the pilot wheel, such varying being of a controlled, adjustable, and continuous character throughout a predetermined range of capacities of the pump as between 60% to 100%, and such varying being rendered possible without releasing the force operating at a given moment to maintain the rudder either in a given position or in motion. Also, my invention provides for varying of the character above described, the capacity of not only one pump but two pumps in combined operation when the rudder is in motion or without in any wise interfering with the steering.

In a ship having a hydraulic steering gear (sometimes called an engine) for operating the rudder, it will be understood the operation of the pilot wheel in the pilot house actually operates to pump oil in a cylinder assembly called the forward telemotor, which may be located close to the wheel or just beneath the wheel. This telemotor is hydraulically connected to an after telemotor. The plungers of the after telemotor are connected to gear mechanism called "differential," which in turn functions as control means for the swash plate in a variable delivery type of pump thereby determining the capacity of the variable delivery type of pump. From the foregoing, it will be understood that due to hydraulic connection from the forward to the after telemotor, any movement of the steering wheel will produce a proportional movement of the pump control and therefore movement of the rudder. At the same time connected means is set in motion to stop the rudder at the position determined by the wheel and to restore the swash plate to neutral position.

Such hydraulic steering gear for operating the rudder has the tiller mounted upon the rudder stock and has each end of the tiller connected to the center of a ram disposed to move in and out of cylinders, one cylinder for each end of the ram. Thus, as there are two rams, there would be four cylinders. To pump the oil into the four cylinders to actuate the ram, ordinarily there are two pumps, often referred to as the two-pump units.

Due to the necessity at times of maneuvering the ship while adhering closely to a given course and to the necessity of operating under routine conditions, and due to the necessity of providing for wear of parts, lost motion, leakage of hydraulic fluid, and due to the necessity at the same time for providing for emergency situations as naval engagements, storms, failure for mechanical reasons, maneuvering in tortuous narrow

2

channels, or transfer of oil or any transfer at sea to another ship where operation in unison is required, there develops a wide range of requirements as respects varying speeds of response of the rudder to the pilot wheel. Expressed in other words, this means varying the amount of power to be applied to the rudder or varying the capacity of the hydraulic pumps. A primary object of my invention is to provide for such range of requirements and particularly that such varying shall be of a controlled, adjustable, and continuous character throughout a predetermined range, as between 60% to 100% inclusive, of capacities of a variable capacity type pump. The object of my invention is to provide mechanism which shall render possible such varying of the capacity of the pump or pumps even while the rudder is moving. Be it particularly noted that the successful carrying out of operations, at sea and in the emergency situations above set forth, may depend wholly or in large part upon the steering mechanism being capable of changing the speed of rudder movement at all times. In short, I propose providing a steering mechanism having a rudder connected to a plurality of rams and cylinders hydraulically operated by a plurality of variable output pumps which mechanism is characterized by being capable of operating under a selectable predetermined maximum output of the pumps singly or jointly and at the same time having such output capable of change even while the rudder is moving. Thus when the ship is being steered in a zigzag course in dodging torpedoes not a second of time would be lost in causing response of the ship to the desired capacity of the pumps in applying the desired power to the rudder. I purpose providing for such varying of capacity of a continuous character not only of one pump operating singly but also of the two pumps of a dual installation operating in combination.

Since the utility of a ship depends in large measure upon its maneuverability and this in turn depends upon the proper and efficient operation of the rudder with respect to the speed of the ship, a primary object of my invention is (a) to provide for adjusting the capacity of the pump to minimum requirements, (b) to provide for increasing the power applied to the rudder by increasing the capacity of the pump in emergency when high activity of the rudder is necessary, and (c) to provide security obtained by having a wide range of selectivity of operation of parts of a dual unit mechanism.

As illustrating a situation where my invention solves a particularly difficult problem of maneuvering requiring, in an exceptionally high degree, exactness of steering, let it be noted in the transfer of oil at sea to another ship, known as oiling, the oiling ship which it will be assumed is equipped with my invention and the ship receiv-

ing the oil are required to run parallel while the oil is being pumped from the oiler to the other vessel with a plurality of heavy lines extending from one ship to the other. The ships are secured in spaced relation by heavy hausers but they must be close enough to permit the booms to swing the oil lines to the ship to be supplied with oil. The ships are then steering slightly apart to maintain the distance. Under such circumstances, the moving of the rudder at an exceedingly fast rate when in a rough sea and the ships are moving, there is required a particularly active rudder for successful carrying out of the transfer. The ship being supplied with the oil may have a very slow steering mechanism and therefore the steering mechanism of the oiler must provide the safety for both vessels. It will be understood that the vessels are proceeding at a relatively slow rate and this also is a feature which increases the requirement for an active rudder on the part of the oiler. My invention has been found successfully to solve this situation.

Also, a primary object of my invention is to provide in effect an adjustable cam which is subject to being moved by the pilot wheel.

Another primary object of my invention is to provide means for varying the discharge volume of a cam controlled pump to obtain greater or less speed of response of the rudder to the pilot wheel and at the same time not interrupt the operation of the pump or the force applied to the rudder which may be operating to hold it in a given position to which it has been or is being moved.

The above mentioned general objects of my invention, together with others inherent in the same, are attained by the mechanism illustrated in the following drawings, the same being a preferred exemplary form of embodiment of my invention, throughout which drawings like reference numerals indicate like parts:

Figure 1 is a somewhat diagrammatic view showing an hydraulic steering gear embodying my invention;

Fig. 2 is a side elevation of the same;

Fig. 3 is a vertical sectional view with parts in elevation and parts broken away, taken through the pump stroke adjusting means, differential control, and pump;

Fig. 4 is a view in longitudinal section with parts in plan through the pump stroke adjusting means taken substantially on broken line 4-4 of Fig. 3; and

Fig. 5 is a diagrammatic view showing pipes, valves and differential control means.

The most important units of mechanism that go to make up this steering gear are designated in a general way in the drawings by the following numerals: 10 is a hydraulic ram means connected with a ship's rudder; 11 is a steering control means or forward telemotor—such control means is usually manually operated as by a pilot wheel in the pilot house but may be operated automatically by a Sperry unit; 12 is a hydraulically operated after telemotor; 13 is a constantly driven variable volume pump, two of which are used to provide alternate or combined operating means; 14 is a differential gear and cam unit forming part of the pump controlling means which means is connected to and is common to each pump; 15 is a pump volume adjusting unit herein referred to as a "stroke adjusting device," one being provided for each pump.

Preferably a pump unit 13, a differential gear and cam unit 14 and a stroke adjustment unit 15 are assembled into one piece of mechanism as

shown in Fig. 3, and two of these assemblies are used in each steering gear as shown in Figs. 1 and 5.

The hydraulic ram unit 10 comprises two reciprocable parallel plungers or ram members 16 and 17 having their end portions disposed respectively in four hydraulic cylinders 18, 19, 20 and 21. A tiller 22 extends crosswise of the ram members 16 and 17 and is operatively pivotally connected therewith for angular movement thereby. An upright rudder post or stock 23 is keyed to the tiller 22 intermediate the length of said tiller. A rudder 9, shown fragmentarily in Figs. 1 and 5, is secured to the stock 23. When either of the two ram members 16 or 17 is longitudinally moved the tiller 22 and the rudder 9 connected therewith will be angularly moved to steer the ship. Power may be applied to either or both ram members 16 and 17 and when one ram member is moved in one direction the other ram member will necessarily be moved in the opposite direction. Fluid under pressure is supplied to the cylinders 18, 19, 20 and 21 through suitable pipes hereinafter described. To provide two-way rudder actuating means, the cylinders 18, 19, 20 and 21 are operated in pairs and opposed relation.

Angular movement of the tiller 22 also transmits a follow up motion to two horizontal gear racks 24 in order to stop the movement of the rudder 9 at the position predetermined by the movement of a pilot wheel 30. Said gear racks are moved by means such as rods 25, upright levers 26, shafts 27, upright levers 28, and links 29. The rods 25 are pivotally connected with the end portions of the tiller 22 and the links 29 are pivotally connected with the gear racks 24.

The gear racks 24 transmit follow up movement to the differential gear and cam unit 14 through which the pump is controlled as hereinafter described. In order to provide for simultaneous movement of the racks 24 in the same direction, gear segments 8 shown diagrammatically in Fig. 2, are provided in the means connecting one of said racks 24 with the tiller 22.

The steering control unit or forward telemotor 11 is of standard construction, is usually located in the pilot house of the ship and is provided with the usual manually operated pilot wheel 30. This steering control unit 11 has a hydraulic connection through pipes 31 with the after telemotor 12.

The after telemotor 12 may comprise two hydraulic cylinders 32 and 33 operatively receiving the end portions of a ram or plunger 34. The plunger 34 has an operating connection with two upright gear racks 35 by means, such as a forked member 36, lever arm 37, shaft 38, lever arms 39, and links 40. The gear racks 35 transmit movement to the differential gear and cam unit 14 through which the pump is controlled as hereinafter described.

Each pump unit 13 is of a rotary, variable delivery or displacement type with axially disposed reciprocable pistons operated by swash plate means. In the drawings 41, Fig. 3, is a pump housing and 42 is a front valve or manifold plate connected with inlet and discharge conduits means 43. 44 is a cylinder block having cylinders 45 for the reception of pistons 46. A suitable number of pistons 46 and cylinders 45 may be provided and said pistons and cylinders are arranged at spaced intervals around the axis of the pump and substantially parallel with said axis. 47 is a motor driven main shaft that is connected by key means 48 with the cylinder barrel or block and by uni-

versal type joint means 49 with swash plate means 50. 51 is an angularly adjustable receptacle or tilting box within which the swash plate means 50 is rotatively supported by bearing means 52. 53 are connecting rods that connect the pistons 46 with the swash plate means 50. Each pump shaft 47 is connected with an electric motor 54. Fig. 1 and 2, by which the pump is driven constantly when in use.

When the tilting box 51 and swash plate means 50 are positioned at right angles to the shaft 47, as shown in Fig. 3, rotary motion of the swash plate 50 and the cylindrical barrel 44 will not produce any longitudinal movement of the pistons 46 and no liquid will be pumped. If the tilting box 51 and swash plate means 50 are inclined relative to the axis of shaft 47 then rotary movement of these parts and the barrel 44 will reciprocate the pistons 46. The amount of inclination imparted to the tilting box 51 and swash plate means 50 will determine the stroke of the pistons 46. The direction of inclination of these parts 51 and 50 will determine which of the conduits 43 is an inlet and which is an outlet conduit. Thus the direction of flow of the liquid that is being circulated by a pump unit 13 may be varied, neutralized, or reversed by angular adjustment of the tilting box 51 and swash plate means 50. The above mode of operation of the pump is that which characterizes this type of variable delivery pump.

Let it be noted that instead of the axially disposed piston type of variable delivery pump above described, the radially disposed piston type of variable delivery pump may be substituted or employed.

The means for tilting the box 51 comprises a rearwardly extending stub shaft 55 rigidly connected with said box 51 to one side of the center thereof (i. e., shaft 55 lies behind main shaft 47 in Fig. 3—main shaft 47 being broken away to reveal shaft 55). Stub shaft 55 is connected by ball and socket joint means 56 with a longitudinally movable pump adjusting rod 57.

The rod 57 extends upwardly out of the pump housing through bearing and packing means 53. The upper end portion of said rod 57 is positioned within the housing 59 of the pump stroke adjustment unit 15, Figs. 3 and 4, and is provided with a forked portion 60 that is connected by links 61 with one end portion of a lever arm 62.

The lever arm 62 is fulcrumed on adjustable pivot means comprising a block 63 movable in a slot 64 in said lever arm 62. The block 63 is fulcrumed on an adjustable pivot pin 65 that is carried by two spaced apart parallel pivot carrying bars 66. The respective end portions of the pivot carrying bars 66 are secured to two head slides 67 and 68 that are supported for movement in tubular extensions 69 at the two ends of the housing 59. A cover plate 70 is secured to the tubular extension 69 that houses the head slide 67 and said head slide 67 is preferably provided with an adjustable stop bolt 71 adapted to engage with the cover plate 70 to limit adjustment in one direction of the pivot carrying means.

Another cover plate 72 is secured to the tubular extension 69 that houses the head slide 68. An adjusting screw 73 has a base portion 74 that is secured as by cap screws 75 to the head slide 68. The adjusting screw 73 is threaded through a nut member 76 that is rotatively held in a hub 77 in the cover plate 72. An adjusting wheel 78 is secured to the nut member 76 by cap screw 79. A readily retractable spring pressed locking plunger 75a is

is carried by the adjusting wheel 78 and adapted to lock into a recess 81 in the cover plate 72 to prevent any but desired movement of the wheel 78. An adjustable stop screw 82 is provided in the adjusting wheel 78 for limiting movement to the right, Fig. 2, of the adjusting screw 73. Turning the adjusting wheel 78 will turn the nut member 76 and adjust the position of the pivot pin 65 longitudinally as respects the lever 62.

The end portion of the lever 62, shown at the right in Figs. 3 and 4, is pivotally connected with a forked rod 83. The rod 83 extends downwardly and is fixedly secured to a plate or crosshead 84 that is vertically movable in the housing 85 of the differential gear and cam unit 14. Means such as guide members 86 slidably support the edge portions of the plate or crosshead 84. The plate 84 carries two cam rollers 87 that are positioned in engagement with a cam 88 fixedly secured for purposes of operation on a sleeve 89. Rotary movement of the cam 88 will slidably move the plate or crosshead 84 and this will move the forked rod 83 and angularly move the lever arm 62 about the adjustable fulcrum pivot 65. Angular movement of the lever 62 will vertically move the pump adjusting rod 57 and change the angular position of the tilting box 51 and swash plate 50 in the pump unit 13 thus adjusting or varying the piston stroke of the pump. Manifestly, shifting of the fulcrum pivot 65 varies the length of the lever arms on each side of said pivot whereby the amount of throw of pump adjusting rod 57 is varied. Obviously such shifting or adjusting of the fulcrum pivot 65 may be done while the mechanism is in operation and force is being applied to the rudder 9.

A shaft 90, Figs. 3 and 5, is disposed within the sleeve 89, that carries the cam 88. Each shaft 90 has a fixedly secured gear wheel 91, Fig. 4, thereon that is engaged by one of the upright racks 95 whereby each shaft 90 may be rotatively moved in response to movement of the after telemotor 12 through forked link 36 and connecting means. Each shaft 90 and the sleeve 89 thereon are connected with each other by differential gear means comprising a bevel gear 92 that is fixedly secured to the shaft 90 and meshes with other bevel gears 93 which are carried by and fixed to the sleeve 89. The bevel gears 93 also mesh with another bevel gear 94 that is rotatively mounted on the sleeve 89. The bevel gear 94 is secured to a gear wheel 95 that meshes with another gear wheel 96 on a counter-shaft 97. The counter-shaft 97 has a gear wheel 98 that is engaged by one of the horizontal gear racks 24 which is connected with the hydraulic ram unit 10.

Due to said differential mechanism and tiller connections through rods 25 the cam 88 will always be restored to its neutral position shown in Fig. 3 after movement of the pilot wheel 30 has been brought to rest at any desired position. When the after telemotor 12 moves the upright racks 35 in response to force communicated from the pilot wheel 30 each shaft 90 will be rotatively moved thereby. This will transmit rotary motion in one direction to the cam 88 through sleeve 89 and bevel gears 92 and 93. This motion of the cam 88 will be communicated to the pump units 13 through parts 87, 84, 83, 62, 61, and 57 and will angularly move the swash plates 50 thereof into desired oil-delivery position. Either one or both of the pumps will be affected, depending on whether one or both pumps are in use. Usually in normal operation of the ship

only one pump will be in use. The delivery of oil or hydraulic fluid under pressure to the ram 10 operates said ram. Movement of said ram, communicated through tiller 22, rods 25, and associated connecting means, will move gear racks 24. Gear racks 24 will actuate gear wheels 98, counter-shaft 97, gear wheels 96 and 95, bevel gears 94 and 93, and sleeve 89 back to the cam 88. Thus movement of the ram means 10 automatically functions to return the cam 88 to its original neutral position. When the ram has traveled a predetermined distance proportional to the distance the pilot wheel 30 has been moved, the cam 88 will be brought back to the neutral or inoperative position. Usually an indicator (not shown) is provided in connection with the pilot wheel 30 and the hereinabove described mechanism operates so that the ship's rudder 9 will always be angularly moved the number of degrees indicated on this indicator in the direction indicated by said indicator, and thus the rudder position is determined.

Two pumping assemblies capable of separate and independent operation as well as combined operation are used in connection with each ram. Each of these assemblies comprises a pump 13, a differential gear and cam unit 14 and a stroke adjustment unit 15. A control valve 99 of standard construction is connected with each pump unit 13 by the two conduits 43.

The control valve 99 that is connected with the uppermost pump unit 13 shown in Fig. 5 is connected by main supply pipes 100 and 101 with the outer end portions of the respective ram cylinders 18 and 19. Similarly, the control valve 99 that is connected with the lowermost pump unit 13, shown in Fig. 5, is connected by main supply pipes 102 and 103 with the outer end portions of the respective ram cylinders 20 and 21.

Valves 104, 105, 106 and 107 are provided in the respective pipes 100, 101, 102 and 103 preferably near the locations where these pipes connect with their respective cylinders.

A cross pipe 111 provided with a valve 108 is connected between the pipes 100 and 103 and a similar cross pipe 109 with valve 110 is provided between pipes 101 and 102.

Four by-pass pipes 112, 113, 114 and 115 are also connected with the outer end portions of the hydraulic cylinders 18, 19, 20 and 21 and are respectively provided with valves 116, 117, 118 and 119 preferably positioned near the cylinders.

The by-pass pipes 112, 113, 114, and 115 are interconnected as shown in the lower portion of Fig. 5 and provided with valves 120, 121, 122, and 123 by which by-passing of liquid between different cylinders may be selectively controlled. Any suitable arrangement of liquid supply tanks and reservoirs may be connected with the by-pass pipes 112, 113, 114 and 115 by pipes 124 having valves 125 therein.

The conduits 100, 101, 102, 103, 109 and 111, Fig. 5, are high-pressure conduits. All of the remaining conduits shown in Fig. 5 are low pressure conduits. As Fig. 5 is a diagrammatic view the low pressure conduits are therein shown by dot and dash lines to distinguish them, in this figure, from the high pressure conduits which are shown by full lines.

In the operation of this ship's steering gear, movement of the wheel 30 of steering control unit 11 will produce movement of the ram member 34 of the after telemotor 12. This movement of ram member 34 will be transmitted through parts 36, 37, 38, 39, 40, 35, 91, 90, 93, and 89 to

the cam 88. Rotary movement of cam 88, Fig. 3, will act through rollers 87 to vertically move the crosshead 84. This will vertically move the forked member 83 and angularly move lever arm 62. The angular movement of lever arm 62 will vertically move pump adjusting rod 57 and thus adjust the position of the swash plate 50. The pump 13 is driven continuously while in use and the position of the swash plate 50 determines the stroke of the pump pistons 56 as hereinbefore fully explained. The cam 88 is designed to provide for relatively rapid movement of the crosshead 84 between the position shown in Fig. 3, in which the pump unit 13 is neutral and the piston stroke is zero, and a position of full or maximum pump stroke in which one cam roller 87 will ride the larger diameter of the cam 88. Cam 88 and stroke adjusting means 15 move swash plate 50 or tilting box 51.

The mode of operation of my invention is set forth in part in giving the technical description above. The following will supplement the above.

Recognized specification covering steering gears provide that such must be designed to move the rudder from hard over to hard over through 70° within 30 seconds when the ship is traveling at full speed ahead at the maximum designed ship horse power without the hydraulic pressure of the steering mechanism exceeding the rated pounds per square inch when a single pump is operating at not over 90% of full stroke and without exceeding the rated horse power of the pump motor specified.

The mode of operation of my invention is characterized by providing an infinite number of pump volume or capacity adjustments as between 60% and 100% inclusive, thus rendering the varying of the pump capacity continuous in character within said range. The magnitude of the throw of the cam 88 is designed to move the swash plate 50 of the pump from neutral position or zero capacity of delivery to the desired specified maximum, 90%, capacity of the pump to which it is connected when the performance of said pump is as above specified. By providing the shiftable fulcrum pump stroke adjusting mechanism 15, Fig. 3, my invention provides for the swash plate 50 or tilting box 51 to be caused to move and respond to the movement of the cam 88 through an infinite number of adjustments, that is, through a continuously varying capacity of each pump with its cam acting singly in the range of 60% to 100% inclusive or the combined capacities of said pumps and their cams when said pumps are operated in combination. For example, when it is desired to have the power of both pumps available to insure desired rudder activity, both pumps may be put under load by employing the desired combined capacities of said pumps ranging from their combined minimum output to their combined maximum output. My invention provides this continuous varying adjustment of capacity of each pump or the combined pumps while at the same time without releasing the force which at the moment may be operating to maintain the rudder in a given position or in motion. This adjustment is accomplished in my invention by shifting the fulcrum 65 through the screw 73 and associated mechanism connected to hand wheel 78.

This adjustment provides the infinite number of adjustments because it may continuously vary the fulcrum 65 of the pivotally mounted pump adjusting means by reason of its slidably mounted fulcrum 65—said fulcrum 65 being thus mounted to

pass through all points within the range of its movement by screw—and associated parts. This “continuously” varying is subject at all times to control by the wheel 78, so that we have a “controllable continuously increasing and decreasing means” as respects pump capacity.

In the event that the magnitude of the throw of the cam 83 is designed to move the swash plate 50 of the pump from neutral or zero capacity of delivery to less or more than the 90% stroke capacity, then obviously my invention may be employed to increase or decrease respectively the effective throw of the cam 83 by suitable shifting of the fulcrum 65 by operation of adjusting wheel 78. Where parts become worn or there is minor leakage of hydraulic fluid from normal wear, my invention provides for correcting these situations and providing for full steering gear efficiency even when the ship is at sea by merely turning wheel 78 to adjust the capacity above that at which it has been working. As an example, while the pump initially may be designed to give a required degree of service at 90% of its capacity, when parts become worn or small leakages develop it may be necessary to adjust the pump above said 90%.

It will be understood that the cylinders 18, 19, 20, and 21 with their connecting pipes, both high pressure and bypassing pipes, are filled with hydraulic fluid, as oil. When oil is pumped under pressure to cylinders 19 and 20 as one pair, cylinders 18 and 21 as another pair, the oil under pressure therein will exert pressure on both rams 16 and 17. When a ram 16 or 17, as 17, is not in use and two cylinders, as 20 and 21, are bypassed by the oil, then the oil under pressure in cylinder 18 or 19 will be exerted on ram 16. Similar operation occurs as to ram 17 when cylinders 20 or 21 are subjected to oil under pressure and cylinders 18 and 19 are bypassed. Each pump has a capacity to operate both rams 16 and 17. By providing for a continuing varying capacity of the pumps and this while the force is being maintained on the rudder 9 to hold it in whatever position it may be then occupying, through the stroke adjusting unit 15 interposed between cam 83 and the swash plate 50, it is obvious that a great range of selectivity of the number of cylinders as well as the capacity under which said cylinders are to be operated is provided by my invention without in any wise interfering with the normal operation of the pilot wheel or other parts of the steering mechanism.

The stroke adjusting unit 15 operates between the cam 83 and the tilting box 51 or swash plate 50 to vary the effective stroke of the cam, i. e., to vary the amount of angular movement that a predetermined constant throw of the cam 83 will impart to the swash plate 50. As such adjustment is made by moving the pivot or fulcrum 65 of lever 62 toward and away from the pivot member that connects the forked arm 83 with the lever 62 the pump adjusting rod 57 and tilting box 51 and swash plate 50 will always be returned to the same neutral position irrespective of how much they have been moved by a full stroke of the cam 83.

The arrangement of conduits and valves shown in Fig. 5 makes it possible to use either one or both of the adjustable pump units 13 to supply fluid under pressure to predetermined ram cylinders. When fluid under pressure is being supplied to one ram cylinder then fluid is always exhausting from an opposed ram cylinder. The term opposed cylinders refers to any two ram cylinders in which ram members are moving in opposed relation, i. e., one to admit fluid and the other

to exhaust or discharge fluid, at the same time. Thus opposed cylinders would be cylinders 18 and 19, or 20 and 21, or 18 and 20, or 19 and 21.

The rams 16 and 17 always move in opposite directions due to their interconnection by the tiller 22 and irrespective of whether force is applied to one or both of said rams. Also, whenever these rams are moving, two cylinders will always be exhausting or by-passing fluid either back to a pump or from one cylinder to another. When any two cylinders are idling, i. e., are not communicatively connected with a pump that is in operation, then it becomes necessary to interconnect said cylinders through the by-pass conduits 112, 113, 114 and 115. One way to use both pumps to supply fluid under pressure to both rams is to open valves 104, 105, 106 and 107 and close all other valves. When this is done the two pump units will be independently connected one with the two cylinders 18 and 19 and the other with the two cylinders 20 and 21. If valves 108 and 110 are opened along with valves 104, 105, 106 and 107 then the circulation systems formed by conduits 100, 101, 102 and 103 will be communicatively connected with each other and the two pump units can be used jointly to supply fluid under pressure in both rams. If the use of one of the adjustable pump units is discontinued while valves 104, 105, 106, 107, 108 and 110 are open and all by-pass valves are closed then the other adjustable pump unit alone can be used to supply fluid under pressure to both rams. Thus, when a pump unit, with its associated piping, is operating, it will always take care of the exhaust fluid from the cylinders opposed to those to which it is supplying fluid under pressure.

Also, both adjustable pump units or either adjustable pump unit may be used to supply fluid under pressure to only one cylinder at a time. Thus, by opening high pressure valves 104, 105, 108, 110, and low pressure valves 116, 119 and 122 and closing all other valves both adjustable pump units may be used jointly to apply power through the ram member 16 while the ram member 17 idles. Also with the same valve arrangement just described either pump unit may be stopped or rendered inoperative and the other pump unit used alone to apply power to the ram member 16. Similarly if high pressure valves 106, 107, 108 and 110 and low pressure valves 116, 117 and 120 are opened and all other valves closed, then both adjustable pump units may be used jointly to apply power through ram member 17 while ram member 16 idles or either of said adjustable pump units may be so used if the other pump unit is not operating.

It is also possible to use the two opposed cylinders 19 and 21 as operating cylinders in connection with both or either of the adjustable pump units by opening high pressure valves 105, 107, 108 and 110 and low pressure valves 116, 118 and 123 and closing all other valves.

In a similar manner it is possible to use the two opposed cylinders 18 and 20 as operating cylinders in connection with both or either of the adjustable pump units by opening high pressure valves 104, 106, 108 and 110 and low pressure valves 117, 119 and 121 and closing all other valves.

Obviously when the uppermost adjustable pump unit shown in Fig. 5 is being used to apply power only to the ram member 16 then the valves 108 and 110 may be closed. Similarly these valves 108 and 110 may be closed when power is being

applied to the ram member 17 only by the lowermost adjustable pump unit shown in Fig. 5.

From the foregoing description it will be seen that the two adjustable pump units can be used jointly in connection with all of the ram cylinders or in connection with any two opposed ram cylinders or either of said pump units can be used singly in connection with all of the ram cylinders or in connection with any two opposed ram cylinders. Thus, in the event parts of the steering gear are damaged or become inoperative it will always be possible to operate the steering gear successfully as long as one pump unit and two opposed cylinders and the connections therebetween remain in condition for operation.

The use of the various above combinations of cylinders is possible with my invention without even momentarily interrupting the steering operation or normal operation of the rudder due to the fact that change in pump capacities may be made without interrupting the force being applied to the rudder and thereby no loss of control of the maneuvering of the ship at any time results.

In the use of the two pump units independently, i. e., with both pumps operating and the two valves 108 and 109 closed, the pump adjusting unit 15 provide a means for quickly and accurately adjusting either or both of said pumps while the steering gear is in operation so that each pump will do its share of the work and neither pump will be a drag on the other.

Obviously, changes may be made in the forms, dimensions, and arrangement of the parts of my invention, without departing from the principle thereof, the above setting forth only a preferred form of embodiment.

I claim:

1. In a hydraulically operated marine steering gear mechanism for selectively varying the rate of angular movement of a ship's rudder in response to a ship's pilot wheel, the combination of a motion transfer cam-like-means movable in response to a ship's pilot wheel; and adjustable control means for varying the effective throw of said cam-like-means comprising a lever, a slidably mounted fulcrum for said lever, and means for controllably sliding said fulcrum relative to the end portions of said lever, whereby the length of the lever arms of said lever may be varied; and adjustable power means for moving a ship's rudder controlled by said cam-like-means.

2. A hydraulically operated marine steering gear mechanism for selectively varying the rate of angular movement of a ship's rudder in response to a ship's pilot wheel comprising, a motion transfer cam-like-means movable in response to a ship's pilot wheel; rollers to engage said cam-like-means; slidable cross head mounting means for said rollers; hydraulic operating means connectable to a ship's rudder; a variable output pump for hydraulically operating said hydraulic operating means; a lever having one end portion connected to said cross head and the other end portion connected to said pump; a slidably mounted fulcrum for said lever; and controllable means for sliding said fulcrum toward and away from the respective ends of said lever to adjust the effective throw of said cam-like-means.

3. A hydraulically operated marine steering gear mechanism for selectively varying the rate of angular movement of a ship's rudder in re-

sponse to a ship's pilot wheel comprising, a motion transfer cam-like-means movable in response to a ship's pilot wheel; hydraulically operated ram means connectable to a ship's rudder; a variable output pump for hydraulically operating said hydraulic ram means; a lever having one end portion operatively connected to said cam-like-means and the other end portion to said pump; a slidably mounted fulcrum for said lever; and controllable means for sliding said fulcrum toward and away from the respective ends of said lever to adjust the effective throw of said cam-like-means.

4. A hydraulically operated marine steering gear mechanism for selectively varying the rate of angular movement of a ship's rudder in response to a ship's pilot wheel comprising a motion transfer cam-like-means movable in response to a ship's pilot wheel; hydraulically operated ram means connectable to a ship's rudder; a variable output pump delivering liquid under pressure to said ram means; a cam-like-means operable by a ship's pilot wheel; follow-up means connecting said ram means with said cam-like-means; a lever having one end portion operatively connected with said cam-like-means and the other end portion with said pump; a slidably mounted fulcrum for said lever; and controllable means for sliding said fulcrum toward and away from the respective ends of said lever to adjust the effective throw of said cam-like-means.

5. A hydraulically operated marine steering gear mechanism for selectively varying the rate of angular movement of a ship's rudder in response to a ship's pilot wheel comprising, a motion transfer cam-like-means movable in response to a ship's pilot wheel; two ram members connectable with a ship's rudder; cylinders in which the ram members respectively operate; two variable output pumps; conduit and valve means operatively connecting said pumps to said cylinders; two cam-like-means operable by a ship's pilot wheel; two differential means each connected with one of said cam-like-means and connectable with a ship's rudder; two levers, each having one end portion operatively connected with one of said cam-like-means and the other end portion with one of said pumps; a slidably mounted fulcrum for each of said levers; and controllable means for sliding each of said fulcrums toward and away from the respective ends of said lever to adjust the effective throw of said cam-like-means.

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