Feb. 2, 1954 A. W. KUMPF ET AL 2,667,746

STEERING APPARATUS

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FIG. 1.

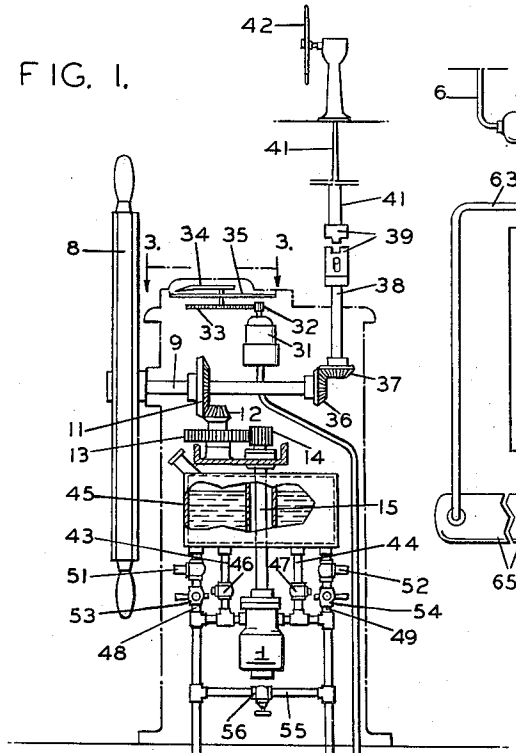
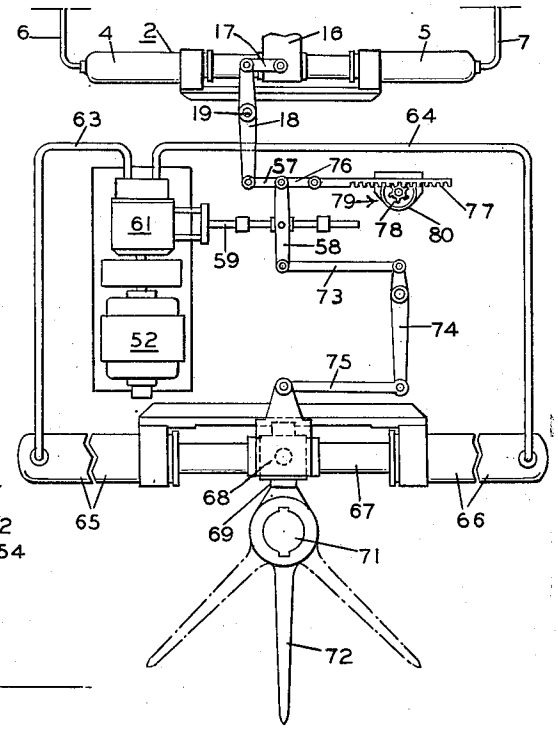


FIG. 2.



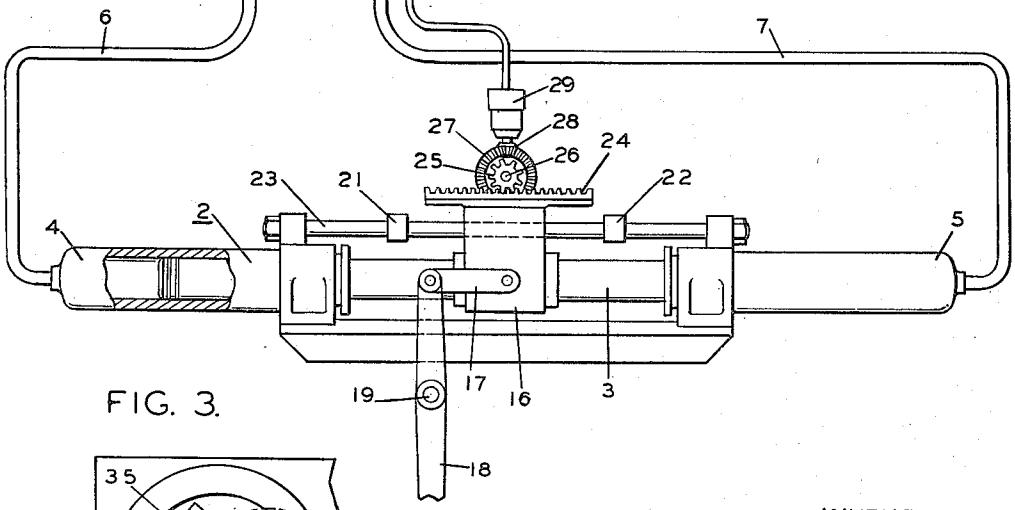
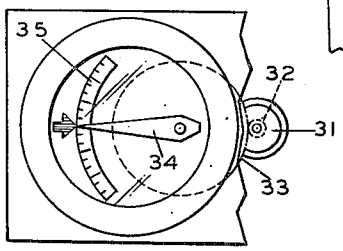


FIG. 3.



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STEERING APPARATUS

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6 Claims. (Cl. 60—52)

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This invention relates to improvements in hydraulic telemotor mechanisms and in steering systems employing such mechanisms.

A principal object of the invention is to provide a hydraulic telemotor mechanism of improved characteristics, the use of which for remote control purposes confers upon the asociated steering system improved characteristics as hereinafter set forth.

More specifically an object of the invention is to provide a telemotor system that will afford finger-tip steering, that is to say a minimum torque at the steering wheel.

Another object of the invention is to provide a telemotor mechanism which avoids necessity for use of electrical solenoids, switches, equalizing valves, and special devices for maintaining a synchronized relationship between the transmitter and receiver elements of the telemotor mechanism.

Still another object of the invention is to provide a telemotor mechanism which is immune to the effects of leakage or of introduction of air into the system.

A further object of the invention is to provide a telemotor mechanism which affords a continuous synchronized relationship with an independent and alternative electrical steering control with which the system may be associated, whereby the system may be switched from the normal manual control to the alternative control or vice versa at any time and without reference to the actual or relative positions of the transmitter and receiver elements of the mechanism.

Still another object of the invention is to provide a hydraulic telemotor mechanism wherein means is provided for continuously indicating the position of the actuated member of the receiver element as well as the position of the aforesaid independent electric steering control.

The invention will be more readily understood by reference to the drawing wherein:

Figure 1 is a diagrammatic elevational and partial sectional view illustrating a telemotor mechanism made in accordance with the invention;

Figure 2 is a diagrammatic view showing the manner in which the receiver of the telemotor mechanism is associated with the control elements of the steering apparatus, and

Figure 3 is a sectional view on the line 3—3, Figure 1.

With reference to the drawing, the telemotor mechanism therein illustrated comprises essen-

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tially a rotary pump 1 of the positive reversible discharge type; and an hydraulic motor 2 which consists of a plunger 3 having reciprocatory movement over a predetermined limited path, as hereinafter described, and which in accordance with the invention is free for unrestrained movement over the full extent of said path under action of hydraulic pressure imposed by the pump. In the present instance the opposite ends of the plunger 3 are operatively associated with cylinders 4 and 5 respectively, the outer ends of these cylinders being connected by pipes 6 and 7 respectively with opposite sides of the pump 1. In normal operation, therefore, the linear movements of the plunger 3 will be directly proportional to the angular movements of the pump 1 and the direction of movement of the plunger will be determined by the direction of rotation of the pump.

Means is provided for operatively connecting the pump 1 with a steering member which in the present instance takes the form of a conventional wheel 8. The hub of this wheel is attached to a shaft 9 which carries a bevel gear 11, and this gear is connected through a bevel pinion 12 with a spur gear 13 which in turn meshes with a spur pinion 14 at the upper end of the shaft 15 of pump 1. The plunger 3 has a cross head 16 which in the present instance is connected through a link 17 with one end of a lever 18 mounted on a fixed pivot 19. As hereinafter set forth this lever constitutes an element of a transmission by means of which the plunger 3 is operatively connected to steering apparatus hereinafter described. The travel of the piston 3 is limited in the present instance by a pair of stops 21 and 22 which are adjustable longitudinally of a supporting rod 23 and which are located in the path of the cross head 16 so as to form abutments for the latter. Also in accordance with the invention, the cross head 16 is provided with a rack 24 which meshes with a pinion 25 on a shaft 26, this shaft carrying also a bevel gear 27 which meshes with a pinion 28 on the shaft of a synchronous electric motor 29. This motor is operatively connected with a corresponding motor 31 which is connected through a pinion 32 and a gear 33 with the pointer 34 of an indicator 35 located adjacent to the wheel 8 so as to be visible to the steersman. This device affords the steersman a continuous indication of the position of the plunger 3 in its path of travel between the stops 21.

The shaft 9 is also connected by gears 36 and 37 with a shaft 38 which, through the medium

of a suitable clutch 39, may be connected at will to a shaft 41 which extends to a second steering wheel 42 at a station remote to the wheel 8 for optional use as required.

The pipes 6 and 7 are respectively connected at points immediately adjoining the pump 1 and by means of pipes 43 and 44 with a tank 45 which constitutes a reservoir for the oil or other hydraulic medium. Each of the pipes 43 and 44 contains a pressure relief valve, 46 and 47 respectively, these valves permitting movement of liquid from the pipes 6 and 7 to the tank under predetermined excessive pressures in the hydraulic system. Each of the pipes 6 and 7 is also connected to the tank 45 by a pipe 48 and 49 respectively, each of which contains a replenishing check valve 51 and 52 and a vent cock 53 and 54 respectively. The latter cocks afford a means for bleeding the hydraulic system of accumulations of air when filling and purging the hydraulic system, and the replenishing check valves 51 and 52 provide for automatic transfer of liquid from the tank 45 to the system as required.

The pipes 6 and 7 are also connected by a valve-controlled bypass 55 through which the pump 1 may be short circuited to permit free flow of fluid through the pipes 6 and 7 independently of the pump. When the operation of the system is by way of the wheel 8 the valve 56 of this bypass will be closed, but if it be desired to operate the steering apparatus by the aforesaid independent electrical steering control, provision for which is made as hereinafter described, the valve 56 will be opened so as to permit free movements of the plunger 3 in the pistons 4 and 5 under operation of the said independent controls.

With reference to Figure 2 it will be noted that in the present instance the lever 18 is connected by a link 57 with a floating lever 58 pivotally supported on a pump control rod 59. This rod constitutes a means for adjusting the direction and rate of discharge of a positive displacement pump 61, preferably of the type disclosed in U. S. Patent Number 1,932,892, this pump being driven continuously by an electric motor 62. The pump 61 is connected through pipes 63 and 64 with the outer ends of a pair of cylinders 65 and 66 which constitute elements of a reciprocatory hydraulic motor, this motor comprising a plunger 67, the ends of which are operatively associated respectively with the cylinders 65 and 66. The plunger 67 carries a cross head 68 which is connected through an arm 69 with the steering post 71 of a rudder 72. The connection between the piston and rudder is such that a movement of the piston in one direction will cause the rudder to move in an opposite direction toward one of the extreme positions indicated in broken lines, a reverse movement of the piston effecting a movement of the rudder in the opposite direction. The floating lever 58 is also connected through a link 73, a lever 74, and a second link 75 with the cross head 68, this connection providing for the usual "follow up" which with any adjustment of the pump control rod 59 resulting from actuation of the lever 18 will tend to return the rod to its original position thereby interrupting the operation of the pump 61 which was initiated by the original adjustment through the lever 18. The mode of operation of steering apparatus of this character is well understood in the art.

It is to be understood that the hydraulic telemotor in accordance with the invention is not limited in its applications to steering apparatus of the electro-hydraulic type or to "follow up"

mechanisms of the floating lever type described in the foregoing, but is also applicable to steering apparatus and follow up mechanisms of other constructions, well understood in the art, having available means of mechanical connection to the input end of the follow up mechanism.

With further reference to Figure 2 it will be noted that the floating lever 58 is connected through a link 76 with a rack 77, this rack meshing with a pinion 78 on the shaft of a synchronous motor 80 constituting an element of an independent electric control device indicated generally by the reference numeral 79. As previously set forth the pump 61 may be actuated selectively from the wheel 8, through the associated telemotor mechanism, and through the independent electrical control device 79. When the telemotor is employed, the bypass 55 will be closed by the valve 56 to render the hydraulic telemotor system operative. When the independent control 79 is employed the valve 56 will be opened so that piston 3 will be free to move with adjustments of the lever 18 by the said independent control. The independent control 79 is such that it may remain permanently geared through the rack 77 and pinion 78 with the floating lever 58 so that the synchronized relationship between the control device 79 and the rudder 72 remains constant and unchanged.

There are several material advantages in a telemotor mechanism of this kind as compared with those employing transmitters of the reciprocating plunger type. Regardless of whether the telemotor transmitter employs reciprocating plungers or a rotary pump, the motion of the plungers of the receiver and of the steering control mechanism connected thereto is, in the absence of leaks, bypassing, or air inclusions in the hydraulic circuit, proportionate to the angular motion of the steering wheel. The receiver unit aft is therefore synchronized with the transmitter unit forward, and an indicator geared to the steering wheel shaft will report in effect, the position of the receiver plungers, and also the position to which the rudder is moved as the steering gear responds to its control mechanism. Inequality of liquid between the two sides of the hydraulic system, however, due to leaks, bypassing, or air in the system, results in loss of synchronism between transmitter and receiver. Since in plunger type transmitters the rotation of the steering wheel is limited by the travel of the plungers of the transmitter in their cylinders it is necessary with this type of transmitter to provide equalizing and re-centering features to restore the transmitter and receiver to synchronism, both in order to maintain accuracy of indication and to prevent continued or progressive limitation of travel of the receiver.

With some types of telemotors employing plunger type transmittters for example equalization and replenishing are accomplished by automatically opening both sides of the hydraulic system to an atmospheric tank when the transmitter is at, or very close to the "amidship" position, whereupon springs on the receiver recenter the receiver plungers in their "amidship" position. While these springs thus perform an important function for this type of telemotor, they require an effort on the wheel to compress them, which effort increases as the helm angle is increased. Another plunger transmitter type of telemotor uses a series of electrical limit switches in control of a solenoid operated valve to resynchronize the transmitter and receiver.

In the rotary pump type telemotor, of the type forming the subject of the present invention, the rotation of the wheel is not limited by the travel of transmitter plungers in their cylinders, and the repeat-back indicator shows the position of the receiver regardless of the position of the steering wheel relative to that of the receiver. There is no necessity therefore for equalizing and re-centering. In the event of small leaks or air inclusions in the system during operation, it is only necessary to turn the steering wheel an additional amount until the indicator shows the desired rudder position.

The pressure relief valves and replenishing check valves for both sides of the system, headed into the atmospheric tank 45, afford protection against thermal expansion and against excessive wheel effort in the event the telemotor receiver is driven hard against its stops or the connected control mechanism is jammed. Pressure relief and liquid replenishing are accomplished without loss of indication.

It will be noted also that, except during periods of pressure relief and replenishing, the hydraulic system is a closed circuit, affording sensitive response to the wheel in all positions and eliminating the periods of "dead helm" (in which movement of the wheel does not produce movement of the receiver plungers) encountered when plunger-type transmittters are opened to atmosphere or are bypassed for equalizing and re-centering. As compared with telemotors employing re-centering springs, the wheel effort required by the rotary pump type telemotor of the present invention is low, and the operating pressures in the hydraulic system are correspondingly low.

We claim:

1. Steering apparatus comprising in combination a hydraulic steering motor, a positive displacement pump connected to said motor, control means for the pump, a manual steering member, a rotary pump having a driving connection with said member, a second hydraulic motor operatively connected to the said pump control means as an actuator for the latter and connected to the rotary pump for transmitting hydraulically to said control means the movements of the said steering member, means for limiting the travel of said second motor, and said second motor except for its connection with said control means being free for unrestrained movement over the full extent of said travel.

2. Steering apparatus according to claim 1 including a second and independent actuator for the pump control means in permanent connection with the latter.

3. Steering apparatus according to claim 2 wherein means is provided for short circuiting the rotary pump so as to afford free movements of the second motor independently of the rotary pump.

4. Steering apparatus comprising in combination power-driven means for imparting rotative motion to a steering device, follow up control means for said power-driven means, a manual steering member, a rotary pump having a driving connection with said member, a hydraulic motor operatively connected to the said follow up control means as an actuator for the latter and connected to the rotary pump for transmitting hydraulically to said follow up control means the movements of the said steering member, means for limiting the travel of the said hydraulic motor, and said hydraulic motor except for its connection with said control means being free for unrestrained movement over the full extent of said travel.

5. Steering apparatus according to claim 4 including a second and independent actuator for the follow up control means in permanent connection with the latter.

6. Steering apparatus according to claim 5 wherein means is provided for short circuiting the rotary pump so as to afford free movements of the hydraulic motor independently of the pump.

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