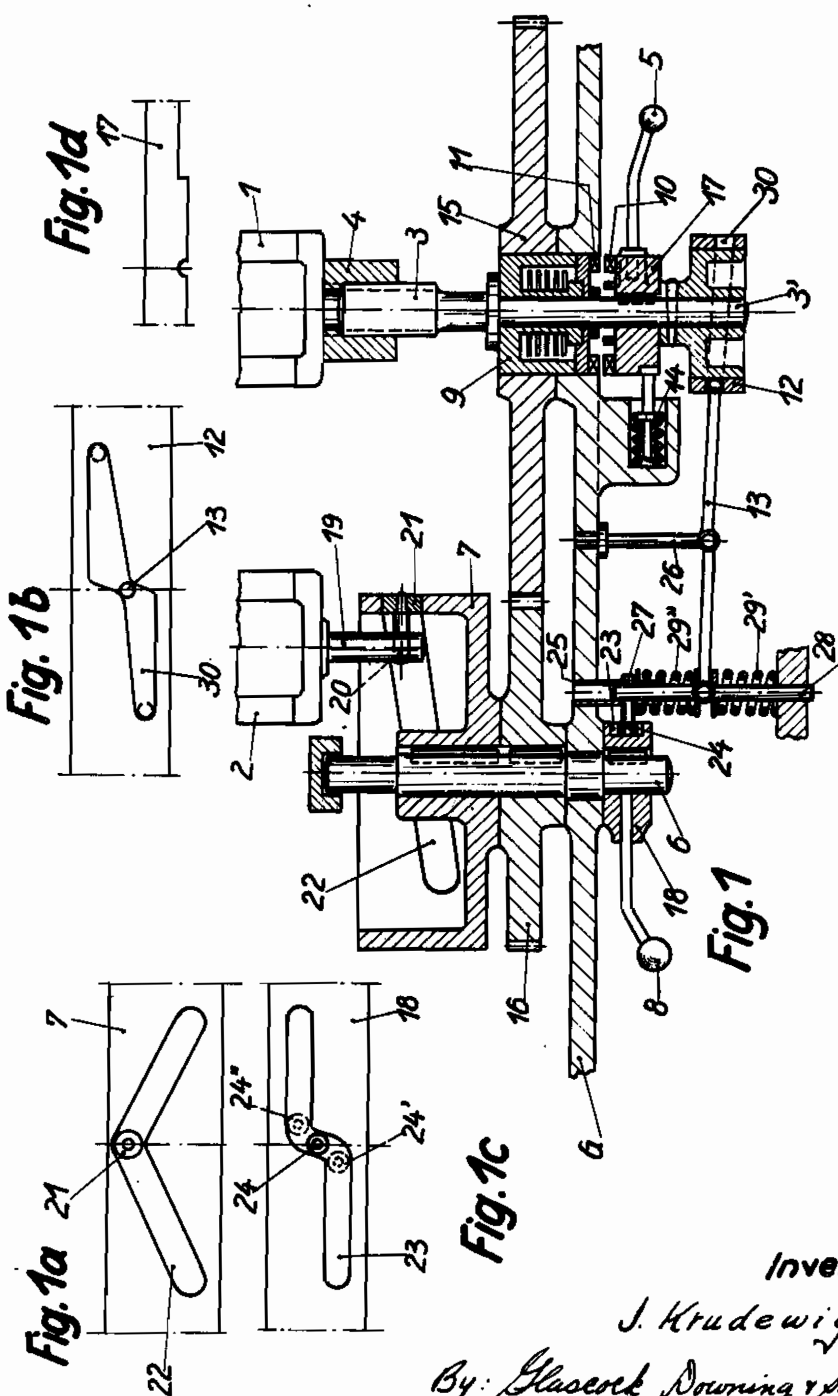
PUBLISHED
APRIL 27, 1943.
BY A. P. C.

J. KRUDEWIG
LIQUID CHANGE-SPEED GEARING
Filed Aug. 12, 1940

Serial No.
352,305
3 Sheets-Sheet 1



Inventor
J. Krudewig
By: Glascock Downing & Seebold
Attys.

PUBLISHED
APRIL 27, 1943.
BY A. P. C.

J. KRUDEWIG

LIQUID CHANGE-SPEED GEARING

Filed Aug. 12, 1940

Serial No.
352,305

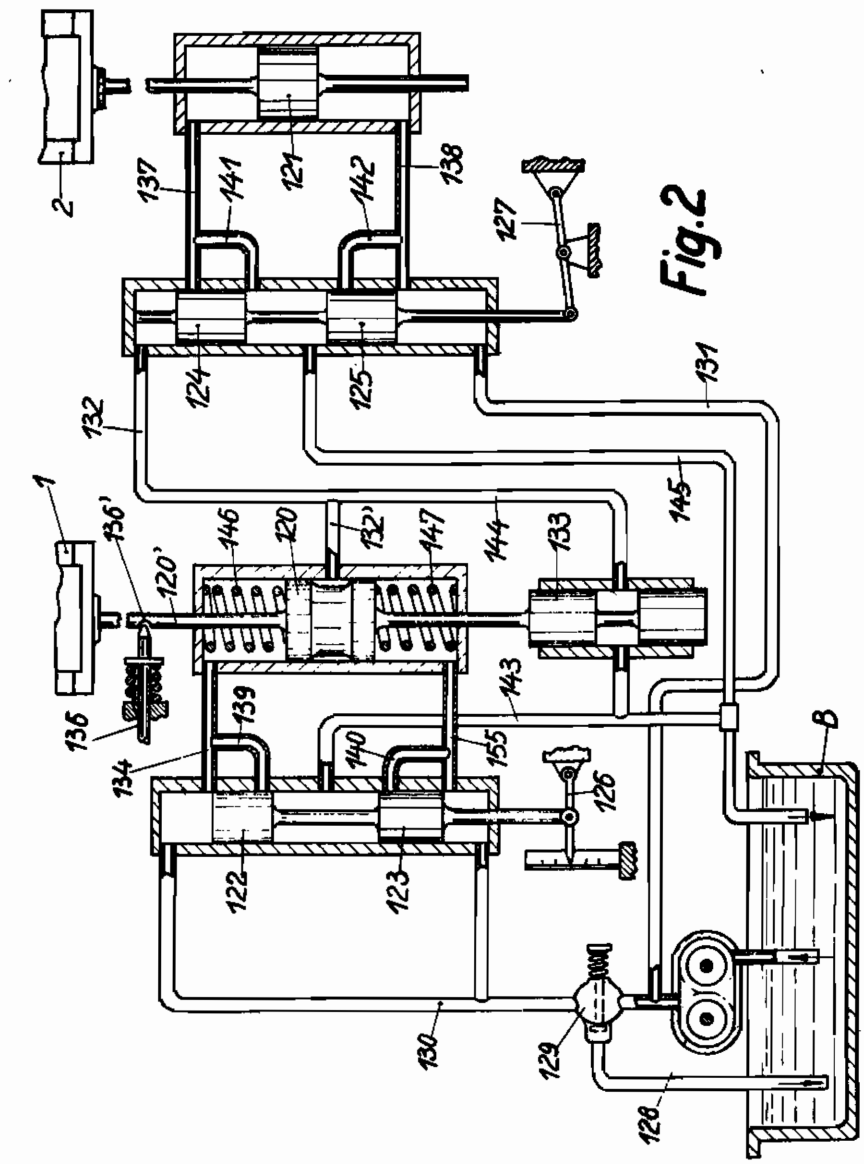


Fig.2

Inventor

J. Krudewig

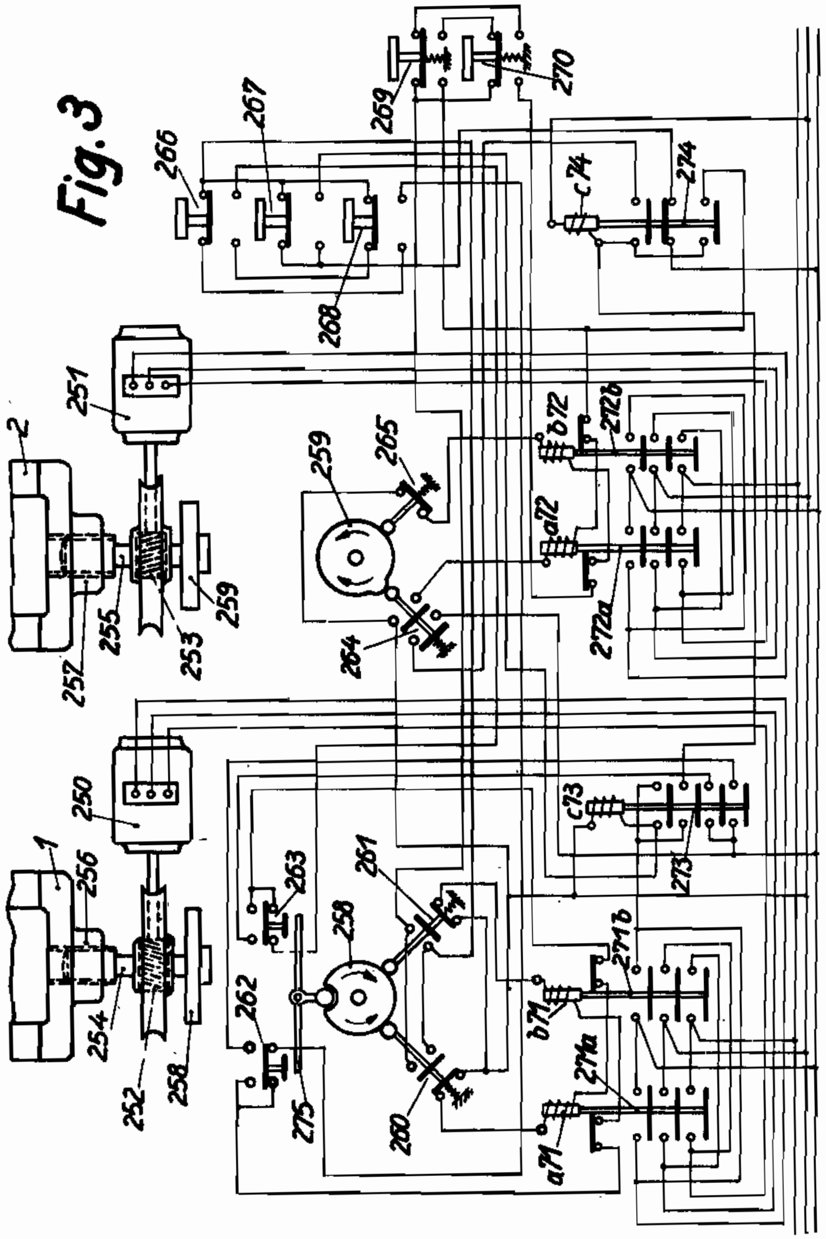
By: Glascock Downing & Seebold
Att'ys.

PUBLISHED
APRIL 27, 1943.
BY A. P. C.

J. KRUDEWIG
LIQUID CHANGE-SPEED GEARING
Filed Aug. 12, 1940

Serial No.
352,305
3 Sheets-Sheet 3

Fig. 3



Inventor
J. Krudewig
By: Glascock Downing & Seebold
Attys.

Published Apr. 27, 1943

Serial No. 352,305

ALIEN PROPERTY CUSTODIAN

LIQUID CHANGE-SPEED GEARING

Johannes Krudewig, Goppingen, Germany; vested in the Alien Property Custodian

Application filed August 12, 1940

The usual liquid gearings operating according to the displacement principle consist of a primary part (liquid pump) and a secondary part (liquid motor) which both can be regulated by the readjustment of certain members, for instance by eccentric shifting of the outer casing of an enclosed device. The readjustment of the respective members for the purpose of regulating the number of revolutions, as well as for exerting an influence upon the output or upon the turning moment can be effected either directly manually or indirectly with the aid of servo motors. The readjustment can, furthermore, be effected perfectly freely or in dependency of a service magnitude of the driving motor of the gearing or of the machine to be driven.

For solving the various problems connected with the regulation mentioned control gearings have been designed by means of which either the primary part and the secondary part are actuated by separate readjusting members or both said parts are regulated by a readjusting member common to them.

In very many cases in which liquid driving gears are used it has been found to be advantageous to drive them on the one hand with as low oil pressure as possible and on the other hand with as uniform efficiency as possible. With this manner of operation in view a control gearing operating with a common readjusting member for the liquid pump and for the liquid motor has already been suggested, this control gearing operating in such a manner that the volume of liquid which the pump delivers at the greatest absorption capacity of the motor is increased from zero, and the absorption capacity of the same is decreased only after the full pump output has been attained. This control gearing, assumed that it answers the purpose in view, presents, it is true, the advantage that the drive always starts with the greatest turning moment possible, but it presents nevertheless also two essential drawbacks as dealt with hereinafter.

In order to prevent the path of the operating member from becoming too long, it is necessary to resign such delicate regulation as otherwise customary with liquid driving gears. To stop the secondary part of the gearing, that is to say, to stop the driven machine, it is, first of all, necessary to regulate the absorption capacity of the liquid motor to its maximum, and only then the output of the pump is reduced whereby, as a matter of course, the stopping of the machine takes place correspondingly slowly which cannot be consented to in many cases.

The present invention aims at driving the machine to be driven with the greatest possible or available turning moment, but rendering it nevertheless possible to stop it very quickly without giving rise to faulty connections. The invention starts from the principle known with control gears having a common readjusting member for the liquid pump and the liquid motor to increase the output of the pump from zero at the greatest absorption capacity of the liquid motor, and to decrease the absorption capacity of the same only after the full output of the pump has been attained. The increase of the pump output from the zero output need not, of course, be continued until the full output has actually been reached, but need be driven only to a certain most favourable value, in that it is often times suited to the purpose in view to make use of the capacity of the pump at first only partly and to increase the output thereafter according to the increase of the number of revolutions.

The invention consists therein that the primary part and the secondary part are simultaneously readjusted back to their starting position when the gearing is stopped. Another characteristic feature of the invention is that, likewise for the purpose in view, a connection is established within the gearing members effecting the readjustment, said connection containing a yieldable member or an equivalent member capable of equalising the generally unequal readjustment of the pump and the motor. There is attained by this contrivance the further advantage that the regulation of the liquid motor can be rendered as delicate as desired.

The invention is illustrated diagrammatically and by way of example on the accompanying drawings on which Figure 1 is a horizontal section through the entire arrangement and combination of parts constituting my invention. Figures 1*a*, 1*b*, 1c and 1*d* show certain details more fully referred to hereinafter, Figure 2 is an illustration especially of the piping with its accessories, and Figure 3 is a wiring diagram, likewise with its accessories.

On the drawings, 1 (Fig. 1) denotes the readjustable part of the liquid pump, and 2 denotes the readjustable part of a liquid reversing gear not shown on the drawings pertaining to the present application but being shown and described in the USA Patent No. 2,049,092, dated July 28, 1936, which relates to a rotary piston engine, especially for fluid gears. The readjustable part of the pump is provided with a threaded tubular branch 4 engaged by a threaded spindle 3 turnable by manually movable lever 5. This lever is affixed to an annular member 17 connected by feather and groove with a shaft 3' forming an extension of the threaded spindle 3. The output of the pump from zero to the maximum can be regulated by turning the shaft 3' in the one or the other direction of the reversing gear according to the direction in which the readjustment is effected.

The readjustable part 2 of the motor is provided with a bolt 19 bearing a rotatory roll 21 on a transverse axle 20. This roll engages a guide slot 22 provided in the drum 7 which is firmly keyed to the shaft 6 to which, besides, is firmly secured an annular member 18 provided with a hand lever 8. The shaft 6 is supported in the stationary frame of the device in which also another parts are supported.

The shape of the guide slot 22 appears from Fig. 1*a* which shows a development of the drum 7. The roll 21 is shown in its normal position in said slot, this being the position in which the motor has its greatest absorption capacity, the lever 5 being locked in this position of the roll by means of certain members separately provided for that purpose, and the locking being maintained as long as the pump remains adjusted for zero output or for running idle. Said locking member is constituted by a drum 12 secured to the shaft 3' and provided with a control groove 30, the shape of which appears from Fig. 1*b* that shows a development of said drum 12. The control groove 30 is engaged by one end of a double-armed lever 13 supported on a pivot 26. The other end of this lever is coupled with a bolt 28 guided in a sleeve 25 and being surrounded with two helical compression springs 29 and 29' holding said lever in its middle position. A transverse pin 27 of the bolt 28 bears a guide roll 24 engaging a guide slot 23 provided in the annular member 18. The shape of the slot 23 appears from Fig. 1*c* in which is shown a development of the member 18. The roll 24 is here shown in its locking position.

The hand lever 5 is locked in its readjusted position in a certain particular manner hereinafter dealt with by means of a bolt 14 cooperating with a cam groove provided in the annular member 17. The profile of this groove appears from Fig. 15 which shows a development of said member 17. This latter is furthermore provided with clutch claws 10 engaging similar claws 11 of a counter clutch member 9 when this member is axially shifted. It is designed as a sliding coupling and supports a cog-wheel 18 which meshes with a cog-wheel 16 keyed to the shaft 6.

The manner of operation of the above-described device is as follows: In the position shown in Fig. 1 the device is in its no-load position in which the pump is adjusted to zero output and the motor to its greatest absorption capacity, whereas any readjustment is prevented by the locking members 13, 23 and 24. If now the hand lever 5 is moved by turning the shaft 3' so as to adjust the pump for a sufficiently large output, say for instance, the largest possible output, the locking having been effected up to then by the members 23 and 24, is broken across the lever 13 and the members 27 and 28 owing to the suitable shape of the guide slot 30, in such a manner, that at a certain distinct position of the hand lever 5 (for instance for running forward) this lever can be turned only in the appropriate one direction, whereas turning in the other direction cannot take place. When the lever is released for the other direction (for instance for rearward running) the former direction will be blocked. Simultaneously therewith the annular member 14 and, thus, also the hand lever 5 are locked by the bolt 14 in such a manner that this lever can be further moved either not at all or can be further moved only in the same direction. Now the absorption capacity of the motor is changed with the aid of the lever 8 across the shaft 8 and the cam drum 7, it being at the same time rendered possible to increase the output of the pump. The cam drum 7 has symmetrical shape so that the liquid motor can be readjusted for both directions of turning of the lever 8 from its position for greatest absorption capacity in the same direction. In order to stop the gearing the annular member 17 is shifted together with the lever 15, and the clutch 10, 11 is thrown into gear and simultaneously therewith the bolt 14 which locks only in one direction of motion of the lever 5 becomes inactive. The lever 5 can now be moved back into its former position, whereby the output of the pump will be reduced and simultaneously therewith the liquid motor will be brought to its greatest absorption capacity across the cogwheels 15 and 16.

The ratio of transmission is preferably so chosen that the longest operating path of the motor corresponds with the operating path of the pump. In order to prevent the motor from being again readjusted to a smaller absorption capacity by an erroneous connection after the pump has only partly been readjusted to its former output, without adjusting simultaneously therewith for a larger output, the bolt 14 prevents the disengagement of the clutch 10, 11 until the lever 5 has arrived in its zero position and the bolt 14 engages the cam groove or is locked. In the first case the bolt 14 must be released either prior to the restarting of the gearing or simultaneously therewith.

In Fig. 2 is illustrated a hydraulic control device designed according to this invention. The control piston valve 120 readjusts the pump 1 and the control piston valve 121 readjusts the liquid motor 2. The direction of the readjustment of the pump 1 is determined by the piston valves 122 and 123, and the direction of the readjustment of the motor is determined by the piston valves 124 and 125; the piston valves can be moved into the position necessary at the time being by means of the hand levers 126 and 127, whereby the admission of the liquid under pressure delivered by an auxiliary pump 128 to the slide valves 120 and 121 can be regulated. The liquid under pressure passes through an overcharge valve 129 and through pipes 130 and 131 directly to the piston valves 122 and 123, or 124 and 125 respectively, but it flows through the pipe 132 only after the readjusting piston valve 120 for the pump has been shifted from its middle position. The auxiliary slide valve 133 serves solely for equalising the pressure within the control gearing, which operates as follows:

In the no-load position of the gearing, that is to say, at zero output of the pump, the control piston valves 122, 123 and 124, 125 are in the position shown in Fig. 2. The liquid under pressure withdrawn from the receptacle B by the auxiliary pump 128 acts upon both sides of the piston 120 through the pipe 130 as well as through the pipes 134 and 135. The piston 120 is maintained in its middle position by two helical compression springs balancing one another, and by the spring-actuated bolt 138 which engages a recess 138′ of the piston rod 120.

The liquid pressure presses, furthermore, through the pipes 131 and 132 upon the front surface of the piston valve, in such a manner, that when this valve is in the position shown in Fig. 2, the liquid motor has its greatest absorption capacity. The excess of the liquid under pressure escapes into the receptacle B through the overcharge valve 129.

The piston valves 124, 125 cannot be readjusted by hand, if the pressure exerted upon the front surface of the piston 125 is sufficiently high, as the oppositely located surface of the piston 124 is connected with the receptacle B of the auxiliary pump.

In order to start the gearing for running in the one or the other direction the piston valves 122, 123 are readjusted forwardly or rearwardly by means of the hand lever 126 so that either the pipe 134 or the pipe 135 is closed and the pipe 139 or 140 respectively is opened. But then the pressure of the liquid acts only on the one face of the piston 120 which is now shifted, together with the readjustable part 1 and counter to the action of the springs 146, 147. The locking bolt 138 is either separately withdrawn or simultaneously with the described other operation by means of the lever 138, or it is automatically released with the aid of the piston 120. In this way the readjustable part 1 of the pump can be regulated up to a certain intended position, preferably with the aid of stationary abutment members, that position corresponding with the largest output.

In order to render it possible to drive the gearing also with any desired small outputs, the piston valves 122, 123 can be so designed that the piston 122 closes in one position the pipe 134, as well as the pipe 136 and the piston 123 closes in one position the pipe 123, as well as the pipes 140 and 135. After the piston 120 has covered a certain intended readjusting path, may be, for instance, the entire readjusting path, it opens the pipe 132′ and connects thereby the upper face of the piston 124 with the pressure pipe 130. Under the same circumstances it is suited to the object in view to provide two pipes 132′ in order to render it possible to adjust the piston paths independently from one another in both directions to which they are being opened. The pressure of the liquid upon the piston valves 124 and 125 is now equalised so that these valves can be moved forwardly by actuating the lever 127 manually and the pipes 136 and 141 are closed and the pipes 137 and 142 opened. Owing hereto, the front face of the piston valve 121 is relieved from the pressure and the rear face thereof subjected to the pressure so that the valve 121 is moved forwardly and the liquid motor is readjusted to a smaller absorption capacity. When the intended number of revolutions has been attained, the hand lever is actuated so as to move the piston valves into their middle position in which they shut the four pipes 137, 136, 141 and 142 whereby the piston valve 120 will be locked. The locking of this piston can, however, be dispensed with if, with the purpose of choosing already, preliminarily the highest number of revolution, abutment members for the readjustment of the liquid motor are provided, these members being then adjusted with respect to the intended highest number of revolutions. The pipes 143, 144 and 145 serve for discharging the pressureless liquid conveyed, while the piston valves are being moved, into the oil receptacle B or into the suction space of the auxiliary pump.

In order to stop the gearing the piston valves 122 and 123 are moved into their middle position by means of the lever 126 so that the liquid pressure exerted upon both faces of the piston 120 is of equal height and this piston is then moved back into its middle position by the springs 146 and 147. In this position the piston 120 shuts the pipe 132′, whereas the piston 133 opens the pipe 144. The rear face of the piston valve 124 is, thus, not subjected to pressure and the two piston valves 124 and 125 are, therefore, moved into their end-positions by means of the liquid under pressure arriving through the pipe 111 whereby the pipes 130 and 137 will be connected with one another and the pipe 137 will be shut. The piston 121 readjusts, therefore, the liquid motor to its greatest absorption capacity whereby the initial position is re-established.

Figure 3 shows an electric control device designed according to this invention. The readjustment of the part 1 of the pump and of the part 2 of the motor is effected, for instance, by an electromotor 250 or 251 respectively; driving a worm-gear 252, or 253 respectively, and moving thereby a nut 254, or 255 respectively, connected with the pump part and the motor part, whereby the eccentricity of these parts is changed. On said spindles 254 and 255 are cams or equivalent members 256, 259 which serve for operating switches 260, 261, 262, 263, 264, and 265 cooperating with push buttons 266, 267, 268, 269, and 270, whereby two reversing relays 271 and 272 for the motors 250, 251 as well as auxiliary relays 273 and 274 are to be controlled. The manner of operation of this control device is as follows:

In the initial position of the members, as shown, the output of the pump is zero and the motor has its greatest absorption capacity. All relay coils are currentless. To throw the gearing into gear either the push button 266 or the push button 268 is depressed according to the direction of rotation desired whereby either the coil *a71* of the relay 271*a* or the coil *b71* of the relay 271*b* acts upon the appertaining core, or armature. The operating procedures are equal for both directions of rotation. It will, therefore, suffice to describe in detail the operating procedures taking place with one direction of rotation. When the push button 266 is depressed the coil 71 is supplied with current across the switches 200 and 263 and across the auxiliary relay 274 whereby the reversing relay 271*a* will be actuated so that the motor drives the pump. At the same time a cam disk 256 has been turned by the rotating readjusting spindle 254 whereby the switch 262 will be switches off by means of the bridge 275. The liquid motor is now in that position in which its absorption capacity is greatest. It cannot at the time being be readjusted in that the coil *b72* of the reversing relay 272*b* remains currentless even if the push button 270 is depressed, as the appertaining circuit is broken at the switches 261 and 266. Only when the pump has attained its largest output and the reversing relay 271*a* and, thus, also the electromotor 250 have been disconnected, or switched off respectively, by means of the switch 260, the circuit for the coil *b72* can again be closed across the switches 265 and 260 by depressing the push button 270 and actuating the auxiliary relay 274.

It is, of course, possible to separate the two contacts of the switch 260 from one another in order to render it possible to operate the switching-on contact for the circuit of the coil *b12* over a shorter readjusting path of the pump part than over the switching-off contact for the circuit of the coil *a11*. The coil *b12* actuates the reversing relay 272*b* whereby the motor 251 is switches on and the liquid motor is readjusted during that period of time in which the push-button is kept depressed, or until the terminal switch 265 has been switched off by the cam disk 259 rotated together with the readjusting spindle 255, the circuit for the reversing relay is now interrupted. In the meantime the switch 264 has been switched on and now is it possible to effect an adjustment for any desired number of revolutions by operating the push button 269, or 270 respectively.

To stop the gearing the push-button 267 is depressed whereby first the coil *c13* of the auxiliary relay 274 so that the relay 273 is operated. This latter closed now the circuit for the coil *c14* which actuates the auxiliary relay 274 whereby the circuit for the coil *c13* is broken across the auxiliary relay 274. Simultaneously therewith the coil *b11* and with it the reversing relay 271*b* are switched on across the relay 273 and the switches 262 and 261, so that the coil *c13* remains switched on across this relay. Owing to the actuation of the reversing relay 171*b* the electromotor 160 runs in a direction reverse to that which existed when the gearing was switched on. It regulates the pump to zero output across the readjusting spindle. In the zero position the circuit for the coil *b11* is interrupted by the switch 262. In the meantime and simultaneously therewith the circuit for the coil *a12* has been closed across the switch 284 and the relay 273 for actuating the auxiliary relay 274. By actuating the reversing relay 272*a* the electromotor 251 readjusts the liquid motor to its greatest absorption capacity until the circuit for the coil *a12* is being broken by means of the switch 264 with the aid of the cam disk 259. In order to render possible that the liquid motor can be regulated as delicately as the invention aims at, a circuit for the coil *c14* is lead across the switch 254 whereby the relay 274 remains in operated state until the greatest absorption capacity of the liquid motor has been attained.

In order to prevent faulty connections the switches 262 and 263 are so designed that, after the pump has been switched on in the one direction, the readjustment in the other direction can be effected by depressing the push button 267. In order to secure the zero position of the pump there can be provided, by way of addition, a rest that is to be actuated by a magnet.

On the preceding pages a mechanical, a hydraulic and an electric control device for liquid variable speed gears able to run in both directions have been described in order to present examples for applications of this invention. It is a matter of course that the control devices designed according to the invention can be materially simplified if the gearing need run only in one direction as in such a case all control members requisite for the other direction can be dispensed with and besides the reciprocal locking of the control members can become simpler. A particular case of employing the invention exists if the regulation of the liquid gearing is effected by remote control, for one direction only. In order to render it possible to turn the working machine to be driven also in the other direction, an additional manually operable readjusting device can be provided, formed for instance in a particularly simple manner by a hand wheel adapted to be coupled with the shaft of the control motor of the pump and to be normally actuated after a stationary abutment member determining the zero postion of the pump has been disengaged. It is in this case suited to the purpose intended to provide a sliding clutch between the control motor and the readjusting spindle in order to render it possible to readjust the pump with the aid of the electromotor until it contacts with the abutment member and to disconnect the control motor only thereafter.

In the examples in question the primary and the secondary part are regulated by separate readjusting members. The fundamental principle of the invention to readjust while the gearing is thrown into engagement first solely the primary part at the greatest absorption capacity of the secondary part and to regulate this part only thereafter, whereas on disengaging the gearing said parts are readjusted in common, but I wish it to be understood that the invention can be used also in connection with so-called one-lever control devices although in such a case the advantage to obtain a sufficient delicacy of the regulation in the case of only short switching-on and switching-off paths must be given up in a certain degree.

JOHANNES KRUDEWIG.