

Nov. 27, 1962

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3,065,740

PUMP MULTIPOSITION PRESET CONTROL

Filed Oct. 16, 1959

4 Sheets-Sheet 1

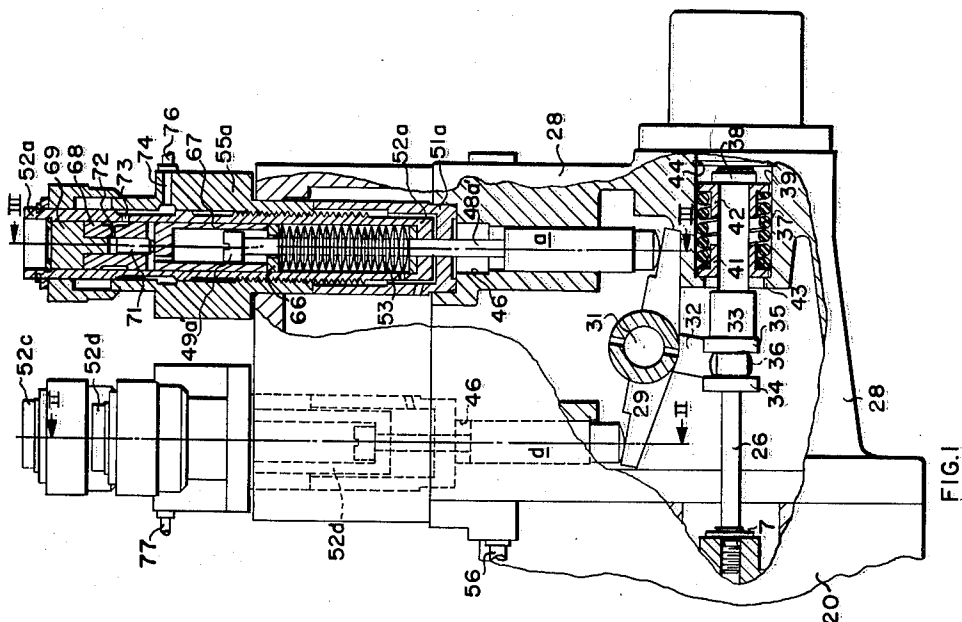


FIG. 1

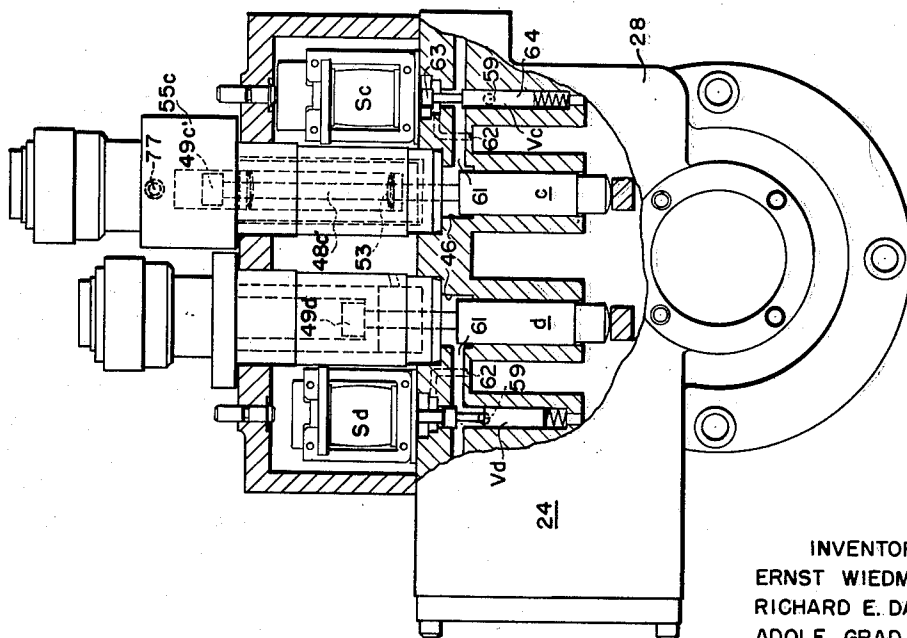


FIG. 2

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4 Sheets-Sheet 2

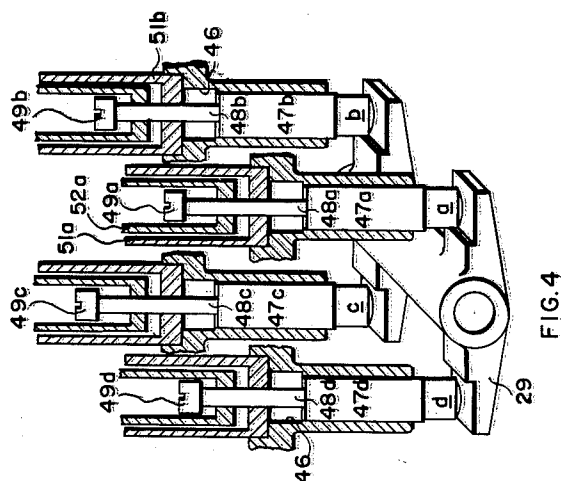


FIG. 4

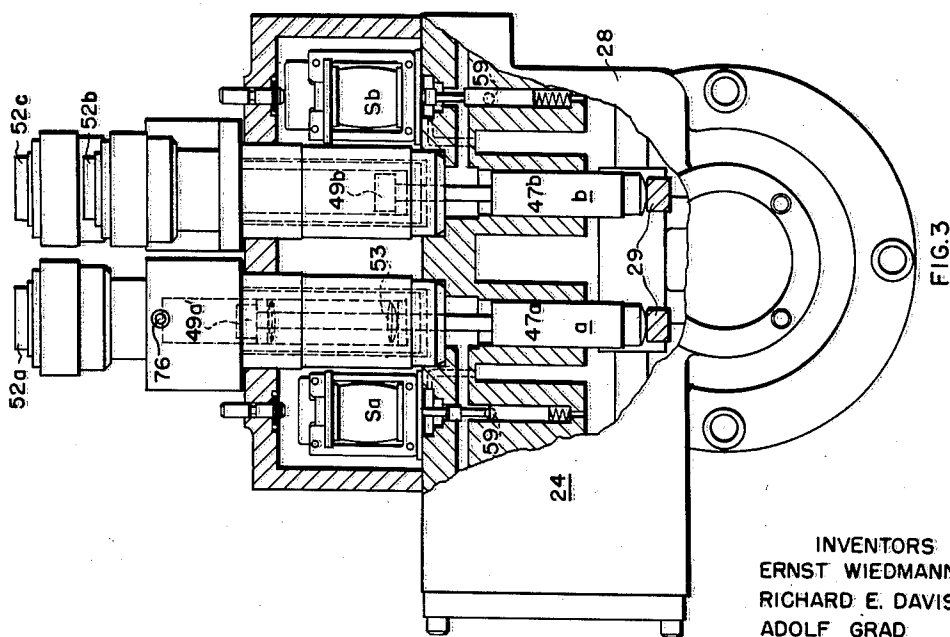


FIG. 3

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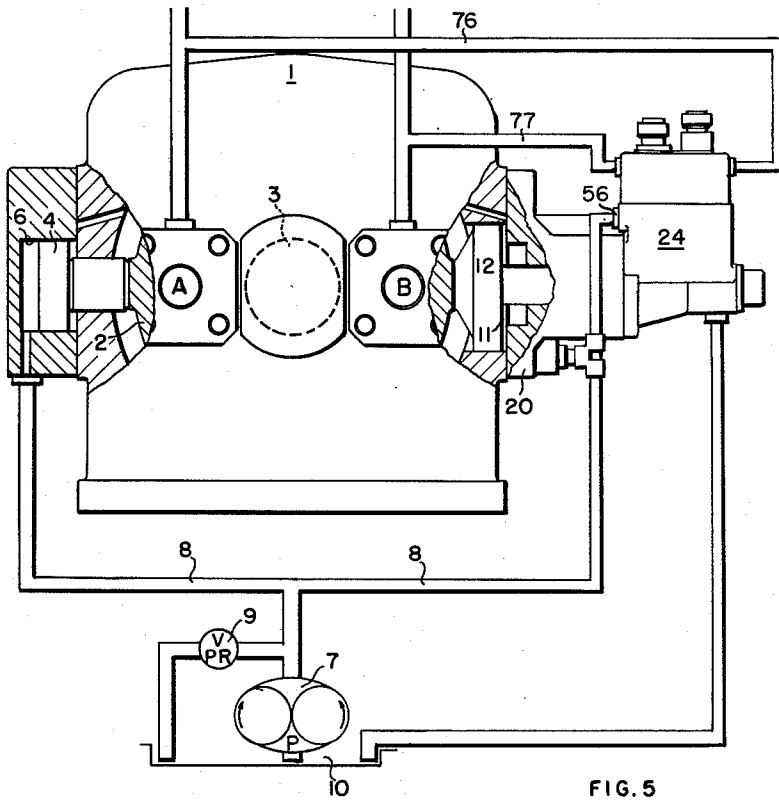


FIG. 5

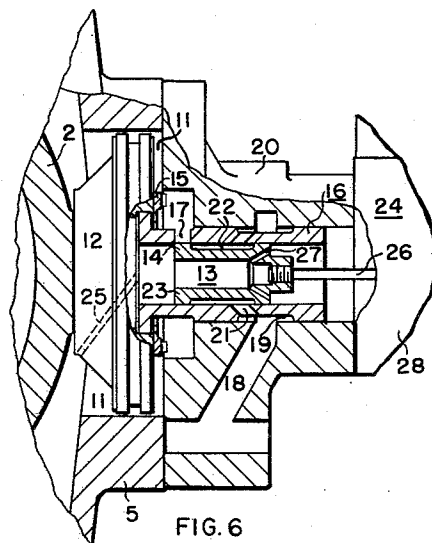


FIG. 6

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Filed Oct. 16, 1959

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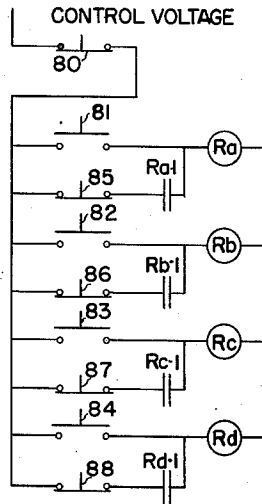


FIG. 7

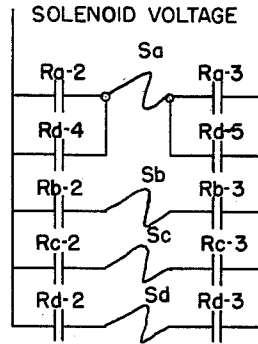


FIG. 8

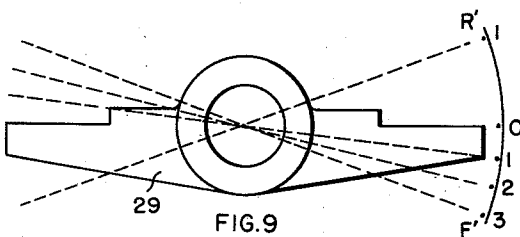


FIG. 9

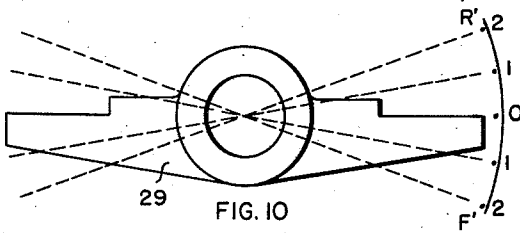


FIG. 10

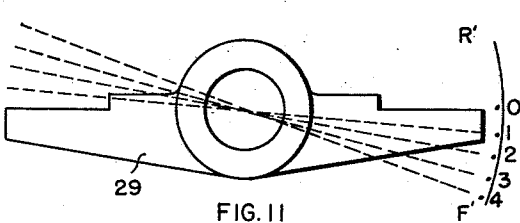


FIG. 11

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PUMP MULTIPOSITION PRESET CONTROL

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Filed Oct. 16, 1959, Ser. No. 846,900

5 Claims. (Cl. 121—120)

This invention relates to preset positioning control of a displacement member of a variable stroke hydraulic pump and more particularly it relates to a multiposition preset hydraulic operator acting through a hydraulic power amplifier to effect predetermined stroking of a piston type pump.

A hydraulic transmission for driving a device such as a machine tool may have a motor that is required to operate at a multitude of forward and reverse speeds including bringing the machine tool to a working position and return and working in one or both directions. The pump for such a transmission is provided according to the present invention with a fast acting control for the pump displacement member that quickly and accurately moves the displacement member to preset command positions so that the pump provides the required power to the hydraulic motor as demanded by the machine tool operation. The pump stroke is therefore varied by the position control to provide predetermined rates of pump discharge in either direction. The control is further constructed and arranged to provide stroke change to give slip compensation when the control commands a preset position for a working cycle of the driven device. Such slip or stroke compensation is provided by a pressure sensitive adjustment of the preset position.

According to the invention, a displacement member of a pump is activated by a bias piston and a control piston supplied with fluid under pressure controlled by a servo valve positioned by a hydraulically operated multiposition operator. The operator includes a lever biased to a neutral position corresponding to pump neutral. Pistons disposed on opposite sides of the pivot axis of the lever are selectively operable to rotate the lever to different angular positions as determined by preset limits to the stroke of the lever actuating pistons. Such preset limits are made adjustable, and for a "working" pump stroke the limit position is automatically adjusted in response to variations in pump discharge pressure so as to provide greater pump displacement with increase in pump discharge pressure.

It is an object of this invention to provide a variable displacement hydraulic pump with a multiposition preset stroke control.

Another object of the invention is to provide hydraulic preset positioning of a pump displacement member that is fast acting and repeatedly accurate.

Another object of the invention is to provide the multiposition preset stroke control with automatic increase of a preset "work" command stroke with increase in pump discharge pressure.

Another object of the invention is to obtain fast changing of a pump stroke to several predetermined preset positions by means of a remotely operable hydraulic control.

Another object of the invention is to provide a pump stroke positioning hydraulic operator having two oppositely acting pistons to command preset pump stroking on opposite sides of neutral or to cooperate to command two preset pump stroking positions on one side of neutral.

Another object of the invention is to provide a multiple position hydraulic operator for preset stroking of a hydraulic pump with pump pressure compensating adjustment for the preset "work" stroke command positions of the hydraulic operator.

Other objects and advantages will be apparent upon a

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reading of the following description with the accompanying drawings, in which:

FIG. 1 is an elevational view partly in section of a hydraulic operator for preset position control of the displacement member of a hydraulic pump embodying the present invention;

FIGS. 2 and 3 are views taken along lines II—II and lines III—III, respectively, in FIG. 1;

FIG. 4 is a perspective view of a portion of an operator such as shown in FIGS. 1, 2 and 3, to show the relative positions of its cylinders and lever actuating pistons with the lever in a neutral position and the pistons operable to position the lever to two positions on each side of neutral;

FIG. 5 is an elevational view of a hydraulic pump with a portion broken away and in section and including the hydraulic operator of FIGS. 1, 2 and 3 and a schematic illustration of its hydraulic circuit;

FIG. 6 is an enlarged view of the stroke controlling servo motor of the pump in FIG. 5;

FIGS. 7 and 8 are electric wiring diagrams for the solenoid operated valves for the operator of FIGS. 1, 2, and 3;

FIGS. 9, 10, and 11 show the lever of the operator in a neutral position and indicate some other possible preset positions with FIG. 9 representing the operator of FIG. 1; FIG. 10 representing the operator of FIG. 4, and FIG. 11 representing a further preset control of the lever by the same actuating pistons.

Referring to the drawing, a reversible variable displacement pump 1, is illustrated in FIG. 5, and is a rotating cylinder piston pump, such as a radial piston type having a displacement member or slide block 2 disposed coaxially of a pintle 3 and movable transversely of pintle 3 in opposite directions to stroke the pump for delivery from either port A or port B.

The slide block 2 is normally urged in one direction by a constant force provided by a bias piston 4 whose cylinder 6 is supplied with fluid at a fixed pressure from a gear pump 7 whose discharge pressure into a supply channel 8 is regulated by a pressure relief valve 9 disposed between channel 8 and a reservoir 10. Pump slide block 2 is urged in an opposite direction by a hydraulic motor comprising a control cylinder 11 and a control piston 12. A hydraulic servo motor 13 includes a valve 14 reciprocable in a sleeve 16 movable with piston 12 for operatively connecting cylinder 11 to the source of control pressure supplied by gear pump 7. The valve sleeve 16 has an end flange secured in a counterbore of piston 12 by an annular plate 15 fastened to the face of the piston 12 so that the valve sleeve moves axially with the control piston 12. Valve sleeve 16 has a port 17 open to cylinder 11 for admitting fluid thereto and exhausting fluid therefrom in accordance with the relative axial positions of the valve sleeve 16 and its valve 14.

Valve sleeve 16 is disposed in a bore in an end head 20 of cylinder 11 which has a supply passage 18 connected to channel 8 and which opens into an axially extending annular chamber 19 in the outer periphery of the valve sleeve 16. A hole 21 through the valve sleeve opens to an axially extending annular pressure chamber 22 in valve 14. Chambers 19, 22 are axially extended to maintain the pressure chamber 22 in constant connection with the source of pressure fluid during control movement of valve 14 and follow-up movement of valve sleeve 16 with piston 12.

A land 23 of valve 14 overlies port 17 in the valve sleeve 16 and has edges normally aligned with edges of the port 17 so that relative movement between the valve and the valve sleeve will connect port 17 either to the pressure chamber 22 or to drain provided by the interior of the pump case via the interior of the valve

sleeve which is open to a bore in control piston 12 and a drain hole 25 through the piston 12. The interior of the pump case 5 may serve as reservoir 10 which is schematically illustrated as outside of the pump in FIG. 5. The follow-up action of the valve sleeve 16 causes the control valve 14 to modulate the force applied to control piston 12. Since only a relatively small force is required to move valve 14 and a large force is required to move the slide block 2, the force applied to the slide block by pistons 6 and 12 is referred to as an amplified force of that applied to the valve 14 and the combination is a power amplifier for a hydraulic operator 24 which positions the valve 14.

Thus it is seen that both valve elements 14 and 16 and axially movable, valve element 14 being positioned by the hydraulic operator 24, and valve sleeve 16 being secured to and therefore positioned by piston 12. Since pressure chamber 22 in valve element 14 is always supplied with gear pump pressure, any movement of valve element 14 to the left or any movement of sleeve 16 to the right in FIG. 6 will cause land 23 to uncover port 17 and admit pressure fluid to cylinder 11 from pressure chamber 22. Contra, any movement of valve element 14 to the right in FIG. 6 or any movement of valve sleeve 16 to the left will uncover port 17 and connect cylinder 11 to the space at the end of valve element 14 which space is connected by drain passage 25 for return to reservoir.

The hydraulic operator 24, FIGS. 1 to 4, comprises a lever formed by a rocker plate 29 having a longitudinally extending central pivot member 31 and having a crank arm 32 for effecting reciprocable movement of plunger 26. A sleeve 33 secured to the plunger provides a pair of spaced flanges 34, 35 which form a clevis in sliding engagement with a rod or cylindrical member 36 mounted on the end of the crank arm 32 so that the plunger 26 is actuated by the rocker plate without lost motion therebetween.

The plunger 26 is suitably supported in the housing 28 for reciprocable movement. A caged spring 37 is mounted in a bore 39 coaxially of the plunger 26, in a well known manner, between the sleeve 33 and an adjustable nut 38, on the end of the plunger to apply the tension of the caged spring 37 to the plunger to urge the plunger to a predetermined position at which the pump control valve 14 commands zero stroke or neutral positioning of the pump displacement member 2. The spring 37 has end guides or collars 41, 42 that are urged by the spring against a stop 43 provided by a flanged end of the spring housing bore 39 and a stop 44 provided by a snap ring disposed in the spring receiving bore 39. Guide collars 41, 42 are subject to abutment respectively with the end of sleeve 33 and the adjustable nut 38 on the plunger upon axial movement of the plunger compressing the caged spring against one or the other stop 43, 44.

The caged spring 37 is confined under a predetermined force so that it is effective to urge the plunger to a neutral position at which the control valve 14 commands the pump displacement member to zero stroke or neutral position; and when the plunger is in the neutral position the rocker plate is in a corresponding neutral position which would be a horizontal position in FIGS. 1 and 4.

Actuating means for selectively rotating the rocker plate 29 to different predetermined positions against the force of the caged spring 37 comprise hydraulic motors *a*, *b*, *c*, and *d* symmetrically arranged so that two are disposed on each side of the pivot axis 31 of the rocker plate, as better seen in FIG. 4. The reference characters for corresponding parts of these hydraulic motors are similar except for the inclusion where necessary of the letter subscript corresponding to that of its motor. Hydraulic motor "*a*" comprises a cylinder 46 having a single acting piston 47*a*.

A hook-stop structure limiting the stroke of piston 47*a* comprises a connecting rod 48 of predetermined length having a T shaped head 49*a*. The rod 48*a* extends through the bottom of a tube shaped end head 51*a* for cylinder 46*a* and the bottom of another tube 52*a* disposed within end head tube 51*a*. The T shaped head 49*a* is free to move axially within tube 52*a* except for abutment with its bottom end which serves as a stop limiting the downward stroke of the piston 47*a* in accordance with the axial spacing between the bottom of tube 52*a* and the T shaped head 49*a* when the rocker plate is horizontal at neutral.

The hydraulic motors of FIG. 4 are arranged so that diagonally opposite motors *a* and *c* provide predetermined strokes in opposite directions and motors *b* and *d* provide intermediate strokes in opposite directions, and such predetermined preset positions for the rocker plate 29 are illustrated in FIG. 10.

Referring again to FIG. 1, the hook-stop structure is shown as being adjustable. The stop providing tube 52*a* extends in threaded engagement through a support 55*a* and may be screwed therein for raising or lowering the tube 52*a* relative to its support.

The hook-stop structure of hydraulic motors *a* and *c*, which represent the greater stroke positioning of the rocker plate in opposite directions, include slip or pressure compensating compression springs made up of a series of stacked Belleville type dished spring washers 53 disposed on the rods 48*a*' and 48*c*' between their T shaped heads 49*a*' and 49*c*' and the bottom of their stop providing tubes 52*a* and 52*c*, respectively, FIGS. 1, 2 and 3.

The arrangement of the hook-stop structures for the hydraulic motors *a*, *b*, *c* and *d* of FIGS. 1, 2 and 3 is such as to provide the various preset positions for the rocker plate 26 indicated in FIG. 9 which shows a Zero or neutral position, three positions of forward stroke on one side of neutral and one position of reverse stroke on the opposite side of neutral.

The hook-stop for piston 47*a* limits its actuation of the rocker plate clockwise to a predetermined position indicated as index position F-3 in FIG. 9. The hook-stop for piston 47*b* limits the clockwise actuation of the rocker plate to an intermediate position indicated as index position F-2 in FIG. 9. A smaller angular clockwise rotation of the rocker plate to index position F-1, in FIG. 9, is effected by actuation of piston 47*d* to hold it against its hook stop and also by actuation of piston 47*a* which rotates the rocker plate clockwise into abutment with piston 47*d*, whereby the combination of oppositely acting pistons 47*a* and 47*d* are employed to provide an additional preset position of the rocker plate on the forward side of neutral. The hook-stop for piston 47*c* limits its actuation of the rocker plate counterclockwise to a predetermined position indicated as index position R-1 in the reverse direction in FIG. 9.

FIG. 11 shows that the rocker plate 29 may be actuated by the pistons 47*a* to 47*d* to four positions on one side of its neutral or biased position, and this preset positioning is effected by adjustment of the hook-stop structure for piston 47*c* in the manner of that for piston 47*d*, FIG. 1, so that piston 47*c* can serve as a stop limiting clockwise rotation of rocker plate 29 to another intermediate position between neutral and that normally provided by actuation of piston 47*a*.

Control pressure for the hydraulic operator 24 is supplied by gear pump 7 through a branch supply channel 8 which is connected to a passage 56 in the operator body 28. Passage 56 includes branches, not shown, that connect to each of the ports 59 opening into the valve bores of the solenoid operated valves *Va*, *Vb*, *Vc* and *Vd*. Passages 61 connect the cylinders 46 of the hydraulic motors *a*, *b*, *c* and *d* to these valve bores and passages 62 which are connected to drain within the operator housing also open to these valve bores. Each of the solenoid valves has a lower land 64 that normally blocks the control pressure supply ports 59 and an upper land 63 that normally is

positioned so that the valve bore establishes communication between the cylinder passage 61 and the drain passage 62. The interior of the operator housing drains through pump control valve passages 27 into the pump casing.

When a solenoid valve is actuated its upper land 63 moves down to interrupt communication between cylinder passage 61 and drain 62 and the lower land 64 uncovers port 59 so that it supplies control pressure to cylinder passage 61 and thereby to the associated cylinder 46 and its rocker plate actuating piston.

Stroke compensators are built into the hydraulic operator for the preset positioning actuator motors *a* and *c* which determine the forward and return working strokes of a load device for which it is desired to maintain constant speed. The stroke compensator that varies the command stroke for the pump is subject to the discharge pressure of the pump so as to vary the pump stroke therewith and thereby compensate for slip so as to maintain a constant rate of pump discharge. The compensators comprise hydraulic means for compressing the compensator springs 53, in response to increases in pump discharge pressures. The compensator described for actuator motor "*a*" comprises the yielding stop abutment provided by the compression springs 53, a washer 66 on the springs for abutment with T-head 49a, a spacer tube 67 telescoping the T-head 49a for axial movement relative thereto, a high pressure cylinder disposed above the spacer tube 67 within tube 52a and formed by a bushing 68 closed at its upper end by a plug 69, and a piston 71 reciprocable in bushing 68 and adapted to be urged against spacer tube 67 for compressing the springs 53a. The bushing 68 is supplied with fluid from pump port A so that the piston 71 compresses springs 53a with a force that varies with the pressure at pump port A. A port in bushing 68 is provided by a radial hole 72 therein which connects to a radial hole 73 through tube 52a through an annular groove in bushing 68. Hole 73 in tube 52a opens to an annular groove in the outer periphery of tube 52a for connection to a passage 74 through the supporting flange 55a. Passage 74 is connected by a channel or conduit 76 to pump port A.

A stroke compensator for actuator motor *c* is indicated by its compression springs 53c, and its bushing cylinder, not shown, which is externally connected at flange 55c through a conduit 77 to pump port B. Thus when the pump discharges from port B pump discharge pressure is applied to its compensating piston acting on the compression springs 53c to vary the hook-stop position for actuator motor *c* and vary the stroke of the pump with changes in discharge pressure above a predetermined value. And when the pump discharges from port A its discharge pressure acts on compensator piston 71 to compress springs 53a to effect a compensating change in the pump stroke with changes in pressure at port A.

FIGS. 7 and 8 show an electric wiring circuit for remote control operation of the solenoid valves of the hydraulic operator arranged for operation as illustrated in FIGS. 1 and 9. These circuits show that the solenoids *Sa*, *Sb*, *Sc* and *Sd* are selectively connected across a solenoid supply voltage through normally open relay contacts which are closed upon actuation of their associated relays *Ra*, *Rb*, *Rc* and *Rd*, respectively. These relays are energized by a control voltage upon closing of their respective normally open starting switches 81, 82, 83 and 84 and deenergized upon opening of a main switch 80 or of their associated normally closed stop switches 85, 86, 87 and 88. A holding circuit is provided for each relay and comprises a normally open contact of the associated relay connected in series with the stop switch across the starting switch for that relay.

Thus solenoid *Sa* is energized upon closing of start switch 81 which causes operation of relay *Ra* and closing of contacts *Ra-1*, *Ra-2* and *Ra-3*; and solenoid *Sa* is deenergized upon opening of stop switch 85 which causes

deenergization of relay *Ra* and opens its contacts. Solenoid *Sb* is energized by closing of switch 82 which operates relay *Rb* to close its contacts *Rb-1*, *Rb-2*, *Rb-3*; and solenoid *Sb* is deenergized upon opening of its stop switch 86. Solenoids *Sc* and *Sd* are similarly selectively energized, respectively, upon closing of their start switches 83 and 84 to energize their relays *Rc* and *Rd*. Relay *Rd*, however, has additional contacts *Rd-4* and *Rd-5* which connect solenoid *Sa* to its supply voltage upon energization of relay *Rd* so that both solenoids *Sa* and *Sd* are energized upon closing of start switch 84.

The pump control is normally at neutral as provided by the action of the caged spring 37 in the hydraulic operator. The pump is commanded to one of the preset strokes by closing one of the start switches, such as start switch 81 which causes operation of solenoid valve *Va* which rotates rocker plate 26 to position F-3, FIG. 9. The pump discharges from port A and its pressure is applied to the pressure compensator piston 71. The pump is returned to neutral upon opening of stop switch 85 to deenergize relay *Ra*.

The intermediate preset pump stroke in the same direction indicated by rocker plate position F-2, FIG. 9, is obtained by energization of relay *Rb*. A second intermediate preset pump stroke in the same direction indicated by rocker plate position F-1, FIG. 9, is obtained by energization of relay *Rd* which causes operation of both solenoid valves *Va* and *Vd* so that actuator piston 47d serves as a stop limiting the displacement of the rocker plate by actuator piston 47a, as illustrated in FIG. 1.

The stroke of the pump may be reversed and brought to a position indicated by rocker plate position R-1 in FIG. 9 upon energization of relay *Rc* to operate valve *Vc*. Pump discharge is then from port B and pump discharge pressure is applied to the pressure compensator of actuator *c*.

The invention of a pump control shown and described having a hydraulic operator normally providing selected preset pump strokes on opposite sides of neutral, and adapted to provide all or more of the preset strokes on one side of neutral, with built-in pressure compensation for a working stroke, may be changed and modified within the teaching herein and the scope of the appended claims.

We claim:

1. A hydraulic operator adapted for preset command positioning of servo control means for obtaining predetermined rates of discharge from a reversible variable displacement hydraulic device, said operator comprising a support, a lever rotatably mounted on a pivot axis in said support, a caged spring mounted on said support and urging said lever to a neutral position, four single acting cylinder and free piston assemblies mounted for longitudinal adjustment in said support, first and second said assemblies positioned on one side of said pivot axis and operative to rotate said lever in one direction to first and second preset positions, respectively; third and fourth said assemblies positioned on the opposite side of said pivot axis and normally operative to rotate said lever in an opposite direction to third and fourth preset positions, respectively; and means adjusting the longitudinal position of said third assembly so that the third piston when operated remains spaced from said lever in its neutral position so as to serve as a stop limiting movement of said lever in said one direction so as to re-establish said third preset position upon operation of both said third piston and one of the opposed said first or second pistons, and means for simultaneously operating both said third piston and one of said opposed pistons.

2. A hydraulic operator as defined in claim 1 in which said first piston has a compression spring normally limiting the travel of the first piston, an auxiliary cylinder and piston responsive to said hydraulic device pressure

for opposing said compression spring to vary said first predetermined lever position.

3. A hydraulic operator as defined in claim 1 in which said first piston has a first compression spring normally limiting the travel of said first piston, said fourth piston has a fourth compression spring normally limiting the travel of the fourth piston, a first auxiliary cylinder and piston operable to oppose said first compression spring in response to pressure at a first port of said hydraulic device to vary the limit of travel of said first piston, a fourth auxiliary cylinder and piston operable to oppose said fourth compression spring in response to pressure at a second port of said hydraulic device to vary the limit of travel of said fourth piston.

4. A hydraulic operator adapted for connection to a control valve for effecting selected preset stroking of a hydraulic device, said operator comprising a lever supported on a pivot axis, spring means opposing rotation of said lever in either direction from a neutral position, a first single acting cylinder having a free piston operable to urge said lever in one direction, a compression spring normally limiting the travel of said free piston to provide a first preset angular position for said lever, a first valve means operable to connect said first cylinder to a source of pressure fluid, an auxiliary cylinder and a piston therein responsive to said hydraulic device pressure for opposing said compression spring and varying said first preset position of said lever, a second single acting cylinder having a second free piston operable to a limit position short of engagement with said lever in neutral position to provide a stop limiting rotation of said lever in said one direction by said first free piston to an intermediate position, a second valve means operable to connect said second cylinder to said source of pressure fluid, and control means to selectively operate said first valve means and both said first and second valve means.

5. A hydraulic operator adapted for preset command

positioning of control means for a hydraulic device, said operator comprising a support, a lever rotatably mounted on pivot axis in said support, spring means opposing rotation of said lever in either direction from a neutral position, a first single acting cylinder mounted in said support and having a free first piston operable to rotate said lever in one direction to a first forward preset position, a second single acting cylinder mounted in said support and having a second free piston independently operable to normally rotate said lever in an opposite direction to a first reverse preset position determined by a stop means for said second piston, means for adjusting said stop means for said second piston so that said second piston is operable to serve as a stop limiting the rotation of said lever in said one direction to a second forward preset position intermediate said first forward preset position and neutral upon operation of both said first and second pistons, a compression spring providing a variable stop for said first piston for said first forward preset position of said lever, and a pressure compensating cylinder having a piston responsive to a pressure of the controlled device for opposing said spring so as to vary said first preset position of said lever.

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