

April 21, 1953

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2,635,428

CONTROL MEANS FOR HYDRAULIC PUMP AND MOTOR SYSTEMS

Original Filed Aug. 14, 1946

2 SHEETS—SHEET 1

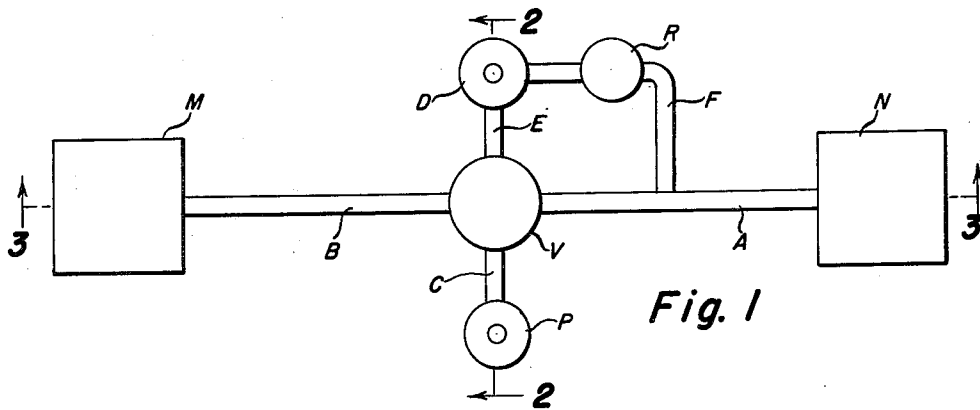


Fig. 1

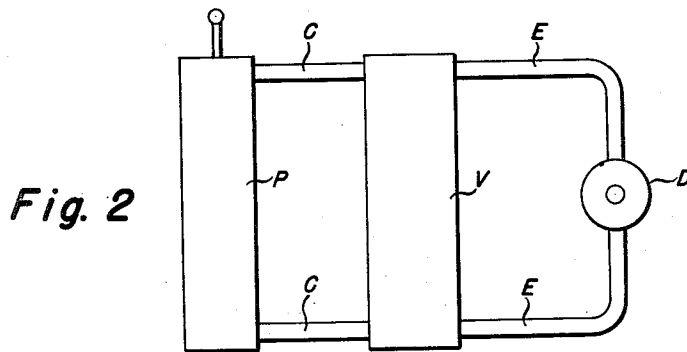


Fig. 2

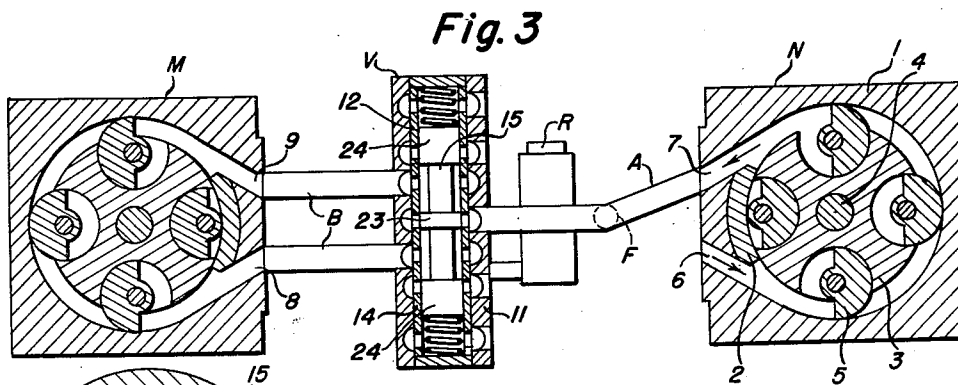


Fig. 3

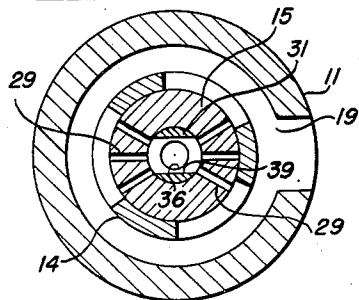


Fig. 5

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CONTROL MEANS FOR HYDRAULIC PUMP AND MOTOR SYSTEMS

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2 SHEETS—SHEET 2

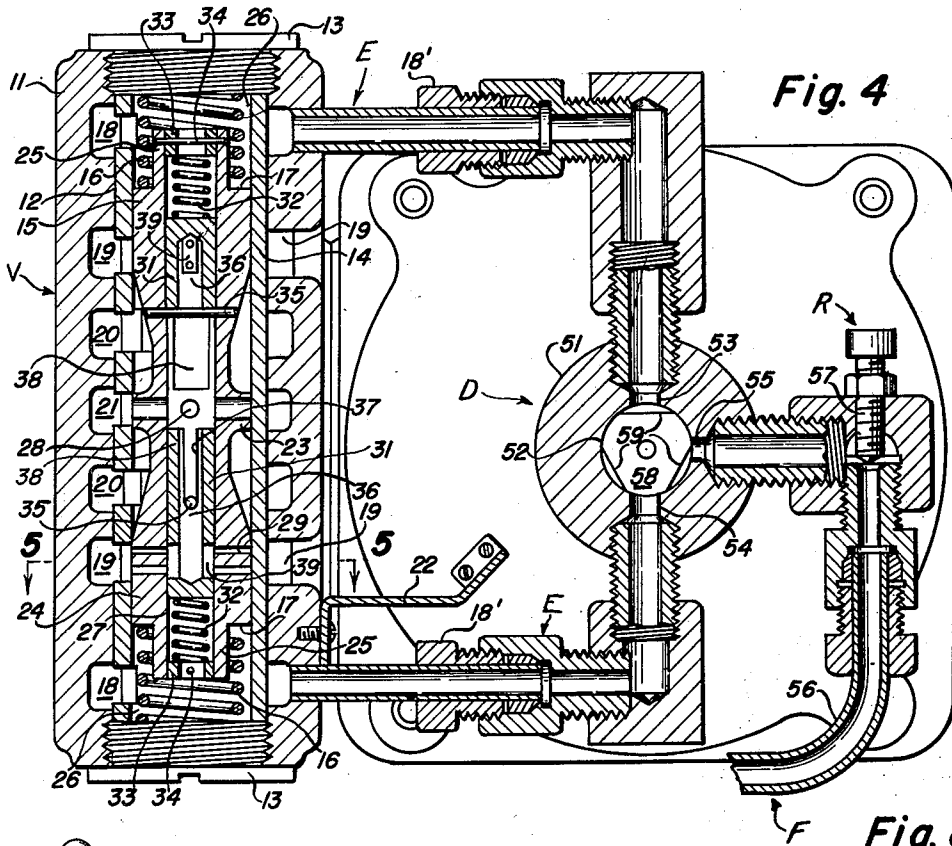


Fig. 4

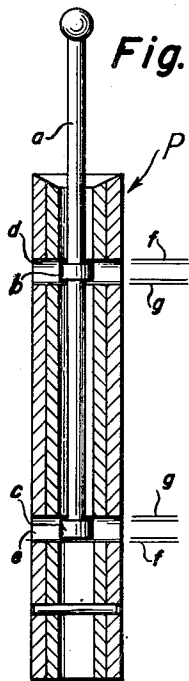


Fig. 7

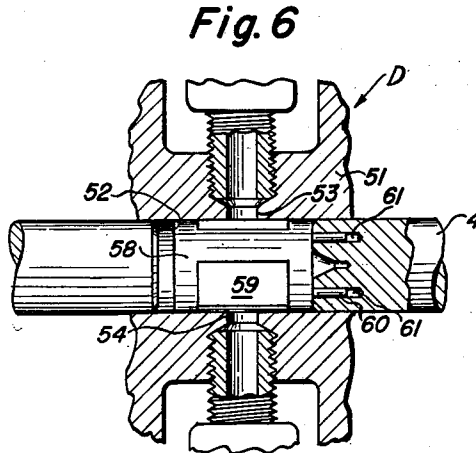


Fig. 6

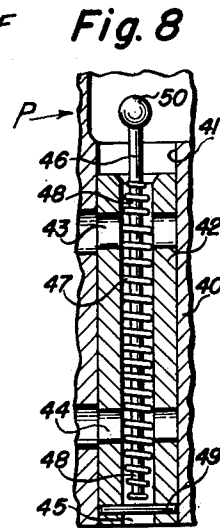


Fig. 8

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2,635,428

CONTROL MEANS FOR HYDRAULIC PUMP
AND MOTOR SYSTEMS

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Substituted for abandoned application Serial No.
690,574, August 14, 1946. This application Au-
gust 9, 1948, Serial No. 43,324

17 Claims. (Cl. 60—53)

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This invention relates to control means for hydraulic apparatus and more particularly to simple and efficiently operating means for controlling the transmission of hydraulic fluid from a constant displacement pump to a motor to drive the latter at a predetermined speed with a minimum loss of energy. The present application is substituted for application S. N. 690,574, filed August 14, 1946, now abandoned, which in turn is a continuation-in-part of an abandoned application S. N. 504,130, filed September 28, 1943.

It is one of the principal objects of the invention to provide a novel valve mechanism connected between a constant displacement pump and fluid motor, whereby all or any part of the fluid discharged from the pump may by-pass the motor so that only that portion of the fluid pressure will be utilized, which is required to drive the motor at a predetermined speed.

It is another object of our invention to provide a valve mechanism having a symmetrical porting arrangement whereby the direction of operation of the motor may be reversed at will.

A further object of the invention is to provide control means for the hydraulic motor which will be effective to hydraulically lock the motor when the latter is not in operation.

It is an additional object of the invention to provide a novel combination and arrangement of auxiliary by-pass valves within a main valve and controlling the effective fluid pressure supplied to the motor.

Another object of the invention resides in the provision of a control valve assembly and connections between said assembly and the pump and motor, whereby the main control valve and the auxiliary by-pass valves are operated by fluid pressure.

A further object of the invention resides in the provision of a pilot valve of novel construction having means providing for the introduction of gradual intake, exhaust and stabilizing clearances to effect smoother operation of the control valve elements.

It is also one of the objects of the invention to provide means in the control system driven by the motor to produce a slight pulsatory action of the fluid in the valve mechanism which will materially augment the sensitive response of the movable valve elements to the fluid pressures.

With the above and other objects in view, the invention comprises the improved control means for hydraulic apparatus and the construction and relative arrangement of its several parts as will hereinafter be more fully described, illustrated in

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the accompanying drawings and subsequently incorporated in the subjoined claims.

In the drawings, wherein we have illustrated one practical embodiment of the invention, similar reference characters designate corresponding parts throughout the several views.

Figure 1 is a diagrammatic plan view illustrating one arrangement of the principal control units in the fluid transmission connections between the pump and motor.

Figure 2 is a similar diagrammatic view taken at section 2—2 of Figure 1 in elevation showing the connections between the pilot valve and the main control valve.

Figure 3 is a semi-diagrammatic sectional view on the line 3—3 of Figure 1 illustrating the connections between the main control valve and the pump and motor.

Figure 4 is a vertical sectional view on an enlarged scale illustrating the main valve assembly with the valve elements in neutral or normal position and showing the dither valve connected with said main valve assembly and with the pressure regulating unit.

Figure 5 is a horizontal sectional view taken substantially on the lines 5—5 of Figure 4.

Figure 6 is a detail view partly in section, showing the dither valve connected to the pump shaft.

Figure 7 is a sectional view illustrating a conventional type of pilot valve.

Figure 8 is a similar view showing our improved pilot valve construction.

Referring in further detail to the drawings, in Figures 1 and 2 thereof, we have illustrated the principal units of our control means connected in the fluid transmission system between the pump N and hydraulic motor M. These units comprise a main valve assembly V having an inlet connection A with the discharge side of the pump and supply and discharge connections B with the ports of motor M; the pilot valve P connected by conduits C with fluid pressure chambers at opposite ends of the main valve; a dither valve unit D also connected by conduits E with said pressure chambers of the main valve; and a regulator valve unit R interposed in the bleed line connection F between the pump discharge conduit A and the dither valve D.

For purposes of illustration, we have shown the pump and motor as identical hydraulic mechanisms which may be used interchangeably as a pump or motor. Therefore, the same reference numerals have been applied to corresponding parts of these two mechanisms. As shown in

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Figure 3, the pump and motor are of the constant displacement type and comprise a housing 1 supporting a division plate 2 between spaced fluid inlet and outlet ports thereof. A cylindrical rotor 3 is keyed to a shaft 4 suitably journaled in the end walls of housing 1. Semi-cylindrical vanes 5 are journaled in the rotor and are rotated by a gear system so arranged that the flat surfaces of the vanes remain always parallel and thus have the proper clearance over the division plate 2. Because of the symmetry of these mechanisms, operation in either direction is inherently optional. In the system illustrated the pump rotates counter-clockwise so that port 6 is the intake and port 7 the discharge. The direction of operation of the motor depends upon which of the ports 8 or 9 receives the fluid from the pump. Fluid may be supplied to the intake port of the pump from a sump or reservoir. Further detail description of the pump and motor are not required for the purposes of this present explanation, for which reference may be had to Patent No. 2,274,206 issued February 24, 1942, to Walter H. Marsh.

The pump N is driven from an external power source and, assuming that the rotor 3 is rotated in anti-clockwise direction, the port 6 is the intake port while port 7 is the discharge port with which transmission conduit A is connected.

The main valve assembly V includes the cored manifold 11 suitably attached to both the pump and motor and so cored as to provide a fluid channel connecting the manifold bore 12 with pump outlet conduit A and the two motor ports 8 and 9. The opposite ends of bore 12 are threaded to receive suitable closure or cover members 13. The pump intake port 6 may open directly into the sump through an opening provided in valve manifold 11.

Mounted in the manifold bore 12 is a machined valve sleeve 14. The main valve 15 is axially slidable in this sleeve and is normally urged to a central or neutral position by means of coil springs 16 compressed between the closure members 13 and suitable shoulders 17 formed on the ends of valve member 15.

The manifold 11 and the valve sleeve 14 are provided with a series of axially spaced registering ports which includes control ports 18 at opposite ends of the valve unit, a central port 21 directly connected with pump outlet conduit A and intermediate motor connecting ports 20 and exhaust ports 19 respectively. Ports 19 open through the manifold directly into the sump or fluid supply reservoir. Preferably a baffle plate 22 is mounted directly below the lower exhaust port 19 to prevent the fluid from taking the shortest path through the sump back into the pump intake port 6. This baffle has a marked effect on lowering the temperature of the fluid, when space limitations require the use of a minimum volume of fluid.

The main valve member 15 is of generally cylindrical shape and provided with a central land 23 and two end lands 24. The reduced cylindrical terminal bosses 25 of the valve member are received within the springs 16 and also serve to limit axial movement of the valve member by contact with the covers 13. The spaces between the end lands 24 of the valve member and covers 13 constitute fluid pressure chambers 26 which respectively open into the upper and lower control ports 18. From the outer surface of each land 24 the periphery of valve member 15 gradually tapers inwardly to a small

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diameter section adjoining the center land 23, for a purpose which will become apparent from the following description.

The main valve 15 has an axial bore 27 intersected by a plurality of spaced radial holes 28 drilled through the center land 23. Also small diameter radial holes or apertures 29 are drilled radially through each of the end lands 24 at its inner end portion and in diametrically opposite sides thereof. The openings 28 and 29 provide flow ports for the fluid to and from the axial bore 27 and are so located as to permit partial or total blocking of the fluid flow through bore 27 by the unbroken surfaces of the main valve sleeve 14 upon movement of the valve member 15. In the preferred construction of this valve member, the center land 23 is of slightly less diameter than the end lands 24 to avoid any possibility of binding between the edges of the central land and the edges of the central slots or ports in the sleeve 14. The end chambers 26 are each connected through the upper and lower control ports 18 and couplings 18' to the dither valve D and also through the connecting conduits C to the pilot valve P. The two motor ports 20 are connected by transmission conduits B with the motor ports, while as above noted, the central port 21 is in fluid communication with the pump discharge port 7.

An auxiliary by-pass valve is positioned in each end of the axial bore of the main valve member 15. Each of these auxiliary by-pass valves includes the member 31 which is axially urged in one direction to normal position by spring 32 interposed between one end of said valve member and a tubular plug 33 secured in the end of the valve member 15 by a pin 34 extending transversely through the boss 25.

The axial travel of valve member 31 under the pressure of spring 32 is limited by a transverse pin 35 fixed in valve member 15 and extending across the axial bore 27 thereof through diametrically opposed slots 37 and the axial bore 36 of valve member 31. The tubular stops 33 permit equalization of fluid pressure between the chambers 26 and the outer ends of valves 31 and prevent hydraulic locking of said valves in fixed position with respect to the main valve 15. The two legs 38 formed by slots 37 coacting with pin 35 restrain the valve member 31 against rotative movement relative to valve member 15. The bore 36 in spaced relation from the outer end of the valve member is intersected by diametrically opposite openings 39 in said member which are in axial alignment with the respective groups of openings 29 in the valve member 15 for movement into and out of registration therewith. By this construction, the passage of fluid through the openings 29 in the main valve may be controlled not only by movements of the main valve with respect to sleeve 14 but also by the relative movement of the auxiliary valves 31. It will thus be apparent that any fluid entering the bore of the main valve 15 through the openings 28 must flow axially along the bores of the two valve members and through the openings 39 in the valve members 31 before it can be exhausted through the openings 29 in the main valve and the exhaust ports 19.

The pilot valve assembly P is shown in a preferred embodiment thereof in Figure 3 of the drawing. This valve, which controls the operations of the main valve assembly, includes the housing 40 having a cylindrical bore 41 into which a sleeve 42 is pressed, an upper port 43

and lower port 44 of said sleeve being respectively connected to the end chambers 26 of the main valve assembly V by the conduits C. Bore 45 of sleeve 42 is open at its upper and lower ends to the sump or fluid supply reservoir.

An axially adjustable pilot valve member 46 is mounted within the bore of the sleeve 42. This valve member is provided substantially for its full length with the thread 47, the intermediate convolutions of which are in contact with the wall of bore 45. The opposite end portions of the thread 47 gradually decrease in diameter as indicated at 48 in successively increasing radially spaced relation from the wall of bore 45 to the terminal convolutions. A pin 49 is diametrically disposed across the lower end of bore 45 in sleeve 42 to limit the downward axial movement of valve member 46 therein. Suitable means 50 is provided at the upper end of the valve member by which it may be readily shifted in the bore 45 either manually or by a suitable mechanical connection therewith.

In order that the operational advantages of the pilot valve 46 may be clearly understood and for purposes of comparison, we have shown a conventional type of pilot valve in Figure 7 of the drawing. This valve comprises a cylindrical rod *a* having two lands *b* and *c* axially spaced apart to coincide with the inlet ports *d* and *e* respectively. The width of these lands is slightly less than that of the ports *d* and *e*. Therefore, when the valve is in a central or neutral position, there are slight clearances as indicated at *f* and *g* between the lands and the upper and lower sides of the respective ports. These clearances may be referred to as exhaust and stabilizing clearances respectively. It will be seen that any fluid entering one of the ports *d* or *e* when the pilot valve is centrally positioned, will have several possible paths of escape. Thus, the fluid may flow through the upper exhaust *f* into the surrounding sump, or through the upper stabilizing clearance *g* into the space between the lands *b* and *c* and hence, through the opposite stabilizing clearance *g* into the conduit connection which leads to the other end chamber 26 of the main valve, or mainly around the land *c* and into the surrounding sump.

Normally, the clearances *f*—*f* provide relief for the pressures in valve chambers 26. If however, the valve member *a* is given an axial movement so that the exhaust clearance *f* of one land is closed simultaneously with the closing of the stabilizing clearance *g* of the other land, then the full pressure developed by the regulator unit R will bear on that end of the main valve member 15 corresponding to the port of the pilot valve whose exhaust clearance is closed. For smooth and efficient action, such an hydraulic locking at one end of the main valve may be prevented. This type of pilot valve has the additional undesirable feature that in the axial movement of the valve member one of the stabilizing clearances may be entirely closed, which can result in an unstable operation of the main valve member.

Our new pilot valve construction will avoid the difficulties above mentioned, since in the operation thereof, none of the clearances is ever entirely reduced to zero. When the pilot valve member 46 and main valve member 15 are in the central or neutral position, the fluid pressure in the end chambers 26 of the main valve will become equalized as the fluid may readily flow through the conduit connections C and ports 43 and 44 between the convolutions of the thread 47

and into the sump or reservoir and the rate of flow may be varied by movement of the pilot valve member 46 so as to change the number of convolutions between ports 43 and 44 and the sump or reservoir. The variation in flow due to movement of pilot valve member 46 may be increased by tapering the end threads 47 so that when one of the tapered portions is opposite to the associated inlet port, there will be a larger flow of fluid from the corresponding end chamber 26 of the main valve into the sump or reservoir while the fluid pressure regulator R will build up pressure in the other end chamber 26, notwithstanding the continued relatively small flow of fluid from the latter chamber through the other inlet port between the full diameter convolutions of the thread 47 opposed to the latter part. The clearances *f* and *g* above referred to in connection with conventional type of pilot valve are represented in the valve of Figure 8 not only by the space between the thread convolutions but also upon sufficient movement of the valve by the space developed between the tapering portions of the valve and the bore of the valve sleeve, it being noted that the increase or decrease of such clearances occurs gradually in the shifting of the valve, resulting in a smooth operation of the main valve mechanism.

The dither valve assembly is shown in Figures 4 and 6. This valve is mounted in the axial bore 52 of a housing 51. This bore is intersected by three radial openings 53, 54 and 55 respectively spaced apart 90°. The openings 53 and 54 are outlet ports connected by the couplings 18' to the respective end chambers 26 of the main valve assembly, while opening 55 is an intake port connected with the outlet of pressure regulator R by the conduit 56 which is preferably provided with a suitable type of needle valve 57 by means of which the volume of fluid flow to the dither valve may be regulated.

The dither valve 58 is preferably driven from the shaft 4 of the pump and comprises a short steel cylinder having three flat, symmetrically arranged peripheral surfaces 59 formed thereon. Into one end of this valve member 58 two pins 60 are fixed in longitudinally projecting relation therefrom to fit into registering longitudinal bores 61 provided in one end of the pump drive shaft 4. Thus, the valve member 58 will revolve in the bore 52 at the same speed as the pump rotor. By the provision of the flattened surfaces 59 on the valve member, the rotation thereof results in a rapid succession of fluid impulses or pulsations which are transmitted through the ports 53 and 54 and couplings 18' to the end chambers 26 of the main valve assembly V. Thus, static positioning of the valve elements is avoided with a more sensitive and rapid response of said elements to relative movement under the control of the pilot valve P. The effective value of the pulsations from the movement of the valve 58 may be altered by adjustment of valve 57 to change the rate of flow to the dither valve, as well as by the modification of the structural design of the valve member.

In the operation of the above described mechanisms, assuming first that the main valve 15 and pilot valve 46 are in neutral position as shown in the drawing, the entire output of the pump N, with the exception of the small portion entering the intake of the regulator unit R which is delivered under predetermined pressure through the dither valve unit D to the end chambers 26 of the main valve assembly V, enters the intake port

21 of the main valve assembly. Fluid flow into the sleeve 14 is substantially entirely blocked by the central land 23 of the valve member 15. Thus, the fluid must pass through the radial openings 28 into the axial bore 27 of valve member 15 and then axially in each direction through said bore and the bores 36 of auxiliary valve member 31 where, in this neutral position, the fluid will flow through the holes 39 in the latter valve member and holes 29 in the main valve 15 and into the sump or fluid reservoir through the exhaust ports 19 in the main valve manifold.

The fluid pressures supplied through regulator R and dither valve assembly D to the end chambers 26 of the main valve assembly are equalized, since there is a continual equal leakage of fluid from these end chambers through the pilot valve P to the sump or reservoir. Thus, the main valve 15 will remain in its hydraulically balanced neutral position.

Since all of the fluid except the small portion in the control passage-ways is by-passed through the main valve assembly, the motor unit M is not operated and no effective work is done. In fact, the motor is substantially hydraulically locked in a stationary position since a small volume of fluid will pass the center land 23 of the main valve into the upper and lower motor ports 20.

Referring now to Figure 3 of the drawing, assuming that it is desired to drive the motor in anti-clockwise direction, the pilot valve 46 is moved vertically upward to position the lower tapering convolutions of the thread 47 with respect to port 44, thus exhausting fluid from the lower chamber 26 of the main valve assembly in greater volume to rapidly reduce the pressure thereof. The relatively higher fluid pressure in the upper chamber 26 is then effective to move the main valve member 15 downwardly, uncovering the port 21 in the valve sleeve so that the fluid may flow upwardly into upper port 20 and into the port 9 of the motor. The lower port 20 of the valve assembly is simultaneously connected with the lower exhaust port 19 so that the fluid will be exhausted through the motor port 8 and port 19 of the valve assembly to the sump or reservoir. This downward movement of main valve 15 also results in a decrease in the by-pass flow of fluid through openings 29 into the exhaust port, thereby increasing the fluid pressure within the bore of valve member 15 which can force the auxiliary by-pass valve members 31 outwardly with respect to the main valve member, moving the openings 39 thereof wholly or partially out of registration with the openings 29 in valve member 15 and thus further decreasing the by-pass flow of fluid to exhaust port 19 which results in a secondary increase of the fluid pressure supplied to the motor port 9 to compensate for a sudden increase in resisting torque of the motor. Thus, by proper adjustment of the pilot valve member 46 and auxiliary by-pass springs 32 to control the release of pressure from the lower valve chamber 26 and the axial movement of valve members 15 and 31, the motor may be driven at any selected speed from zero to maximum over a broad range of motor resisting torques.

Obviously, owing to the symmetrical porting arrangement of the main valve assembly, the motor may also be driven in the reverse or clockwise direction at any selected speed by moving the pilot valve member 46 downwardly from its neutral position to release the fluid pressure from the upper chamber 26 of the main valve assembly so that the main and auxiliary valve will function

as above described to connect the port 21 with the lower motor port 20 while the fluid is exhausted through motor port 9 and returned through the upper exhaust port 19 to the sump or reservoir.

From the foregoing description, it will be seen that we have provided simple and reliably functioning means for establishing variable fluid pressures and rates of flow in the main valve mechanism which control and determine the movement of the valve members relative to each other and to the ports or passages in the valve manifold. Thus, through a single control valve unit, the motor or other apparatus may be driven at any selected speed between zero and maximum, and in either direction; while, when the motor is idle and the pump is in continuous operation, substantially the entire output of the pump is by-passed around the motor through the valve mechanism with little pressure drop, and hence small loss of energy. Also, as above noted, by maintaining pulsatory or fluctuating fluid pressures in the end chambers of the valve manifold, a static condition of the movable valve parts is avoided so that they will be sensitively responsive to any adjustment of the primary or pilot control valve 46. It will of course, be understood that the above description of the pump and motor is merely suggestive, and that our improved valve control mechanism may be employed in connection with similar units of well known mechanical construction.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. In combination with hydraulically operated apparatus and a source of fluid pressure, a fluid distributing system comprising fluid transmission channels to and from said apparatus and pressure source, and valve mechanism interconnected with said transmission channels, said mechanism comprising a manifold having a central inlet port and fluid supply and exhaust ports connected with the apparatus at each side of said inlet port together with a chamber at each end of the manifold connected with the fluid pressure source, a main valve in said manifold, a by-pass valve subject to inlet fluid pressure mounted in each end of said main valve, said main and by-pass valves having coacting means to by-pass fluid to the pressure source, and a control valve connected with said end chambers to hydraulically balance the main valve in neutral position and interrupt fluid flow through said mechanism to the apparatus, said control valve being operable to selectively exhaust pressure fluid from said end chambers and reverse the direction of operation of the apparatus at will.

2. The combination defined in claim 1, together with spring means biasing said by-pass valves to normal position to by-pass substantially the entire volume of fluid from the inlet port to the fluid pressure source.

3. In combination with hydraulically operated apparatus and a volumetrically constant source

of fluid pressure; a fluid distributing system comprising fluid transmission channels to and from said apparatus and pressure source, and valve mechanism including a main valve operative in response to differential fluid pressures to distribute fluid from said constant volume source in variable volume to said apparatus and from the apparatus to the pressure source, relatively movable auxiliary valves mounted at opposite ends of the main valve, said main valve having a passageway in fluid communication with the pressure source and means controlling the volumetric flow of fluid from the pressure source to the apparatus and return flow to the pressure source, said main valve having a by-pass at each end, said auxiliary valves being operable by fluid pressure in the said passageway and each having means cooperating with the respective by-passes of the main valve to control the volume of by-passed fluid and modify the fluid pressure supplied to the apparatus.

4. The combination defined in claim 3, wherein the auxiliary valves and the flow transmitting connections between the main valve and the apparatus are arranged with respect to the connection between said valve and the fluid pressure source for the controlled operation of said apparatus in reverse directions.

5. The combination defined in claim 3, together with a pilot valve in fluid communication with the main valve and the fluid pressure source and operable to create differential fluid pressures in said main valve to actuate the main and auxiliary valves as a unit in each direction.

6. The combination defined in claim 3, together with differential pressure producing means connecting the fluid supply source with the main valve to selectively move said valve and the auxiliary valves as a unit in each direction, and a power driven dither valve connected with the main valve and operative to pulsate the fluid medium and prevent static positioning of the relatively movable valve parts.

7. The combination defined in claim 3, together with a pressure regulating valve and means connecting said valve with the main valve and with the constant fluid pressure source, and a power driven dither valve interposed in the connecting means between the main and regulating valves to produce a pulsatory movement of the fluid medium and the main and auxiliary valves.

8. In combination with a hydraulic motor and a constant fluid pressure supply pump, fluid flow control means between the pump and motor comprising a valve assembly including main and auxiliary reciprocating valve members operative respectively to produce a primary modification of fluid pressure supplied to the motor by said pump and a secondary modification of fluid pressure to compensate for varying loads on the motor, said auxiliary valves being subjected on one side to the fluid pressure from said pump, means forming pressure chambers at each end of said main valve and the other side of said auxiliary valves, said pressure chambers being hydraulically connected to said pump, and pilot valve means connected with said pressure chambers and operable to control the pressure in said chambers and thereby the effective operation of said main and auxiliary valves.

9. The combination defined in claim 8, together with means operatively connected with a driven part of the pump operable to control the supply of fluid to said pressure chambers to produce pulsatory fluid pressures in said pressure cham-

bers acting upon said main and auxiliary valve members.

10. The combination defined in claim 8, together with a pressure regulating valve in fluid communication with said chambers and with the discharge side of the pump, said pilot valve in fluid communication with said chambers comprising spaced means constructed to control the exhaust of fluid pressure from the respective chambers and to maintain stabilizing pressures therein when the exhaust is fully closed.

11. In combination with a hydraulic motor and a constant fluid pressure supply pump, fluid flow control means between the pump and motor, comprising a valve manifold having an inlet port connected with the discharge side of the pump, a port at each side of said inlet port connected respectively to inlet and discharge ports of the motor, exhaust ports to discharge fluid from the respective last named manifold ports to the intake side of the pump, and a fluid pressure chamber at each end of the manifold; a main reciprocating valve in said manifold having a bore and a port variably controlling the distribution of fluid between said manifold inlet port, the motor ports thereof and said valve bore, said bore being in fluid communication with said end chambers, auxiliary valve members reciprocating in opposite ends of said bore and actuated by fluid pressure therein, means connected with said chambers operative to create differential fluid pressures in said end chambers and move the main and auxiliary valves as a unit in one direction, said main and auxiliary valves having co-acting by-pass means connecting said bore with the exhaust ports to variably modify the fluid pressure supplied to the motor under the control of said main valve.

12. The combination defined in claim 11, in which said means connected with the end chambers of the valve manifold comprises a pilot valve having means to selectively control the exhaust of pressure fluid from said chambers and to maintain a stabilizing pressure therein in all positions of said pilot valve.

13. The combination defined in claim 11, in which baffle means is interposed between the manifold exhaust ports and the intake side of the pump, together with additional means connecting each of said end chambers with the discharge side of the pump including a power driven dither valve operative to produce a pulsatory movement of the fluid medium and the main and auxiliary valves.

14. In combination with hydraulically operated apparatus, a volumetrically constant source of fluid pressure and fluid distributing means connected between said apparatus and pressure source, including a valve mechanism, fluid pressure means for operating said valve mechanism, a pressure regulating valve connecting the pressure source and said fluid pressure means, and primary control means including a valve casing having spaced exhaust ports in fluid communication with said fluid pressure means and a pilot valve operable within said casing having adjustable means constructed to cooperate with said exhaust ports of said casing to control the exhaust of fluid pressure from said fluid pressure means while maintaining stabilizing pressures therein in all positions of said pilot valve.

15. In combination with hydraulically operated apparatus, a volumetrically constant source of fluid pressure, fluid distributing means connect-

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ed between said apparatus and pressure source, including a valve mechanism, fluid pressure means for controlling said valve mechanism, a pressure regulating valve connecting the pressure source and said fluid pressure means, and primary control means for said fluid pressure means including a valve casing having spaced exhaust ports in fluid communication with said fluid pressure means, a pilot valve operable within said casing having means constructed to cooperate with the exhaust ports of said casing to control the exhaust of fluid from said fluid pressure means while maintaining stabilizing pressures therein in all positions of said pilot valve, said pressure source comprising a constant volume pump having an intake in communication with a fluid containing sump in which the pilot valve casing is immersed with its bore in fluid communication with the sump, and wherein said pilot valve is reciprocable in said casing and said control means thereof comprises spaced helical threads on said valve having tapering end portions of progressively decreasing diameter to the terminals thereof and cooperating with the respective ports of said casing to exhaust fluid in variable volume from said fluid pressure mechanism and to maintain stabilizing clearances between the pilot valve and casing in all positions of said valve.

16. In combination, a source of fluid pressure, a reversible fluid motor having two ports, valve means connecting said source and said two ports, said valve means including a member movable to

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connect either of said ports to said source and vary the volume of fluid entering the connected port, a pressure chamber at each end of said valve means for moving said member, each of said pressure chambers having separate inlet and outlet connections, means for introducing fluid under pressure from said pressure source into the inlet connections of both pressure chambers, and control means independent of said fluid introducing means for regulating the relative proportions of flow of fluid in said outlets.

17. The combination defined in claim 16 in which the control means comprises a pilot valve, means for connecting both outlets to said pilot valve, a member movable in said pilot valve to regulate the relative proportions of flow of fluid from said outlets and means for positioning said member in any intermediate position between its two limiting positions.

WALTER H. MARSH.
WILLIAM I. SMITH.

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