

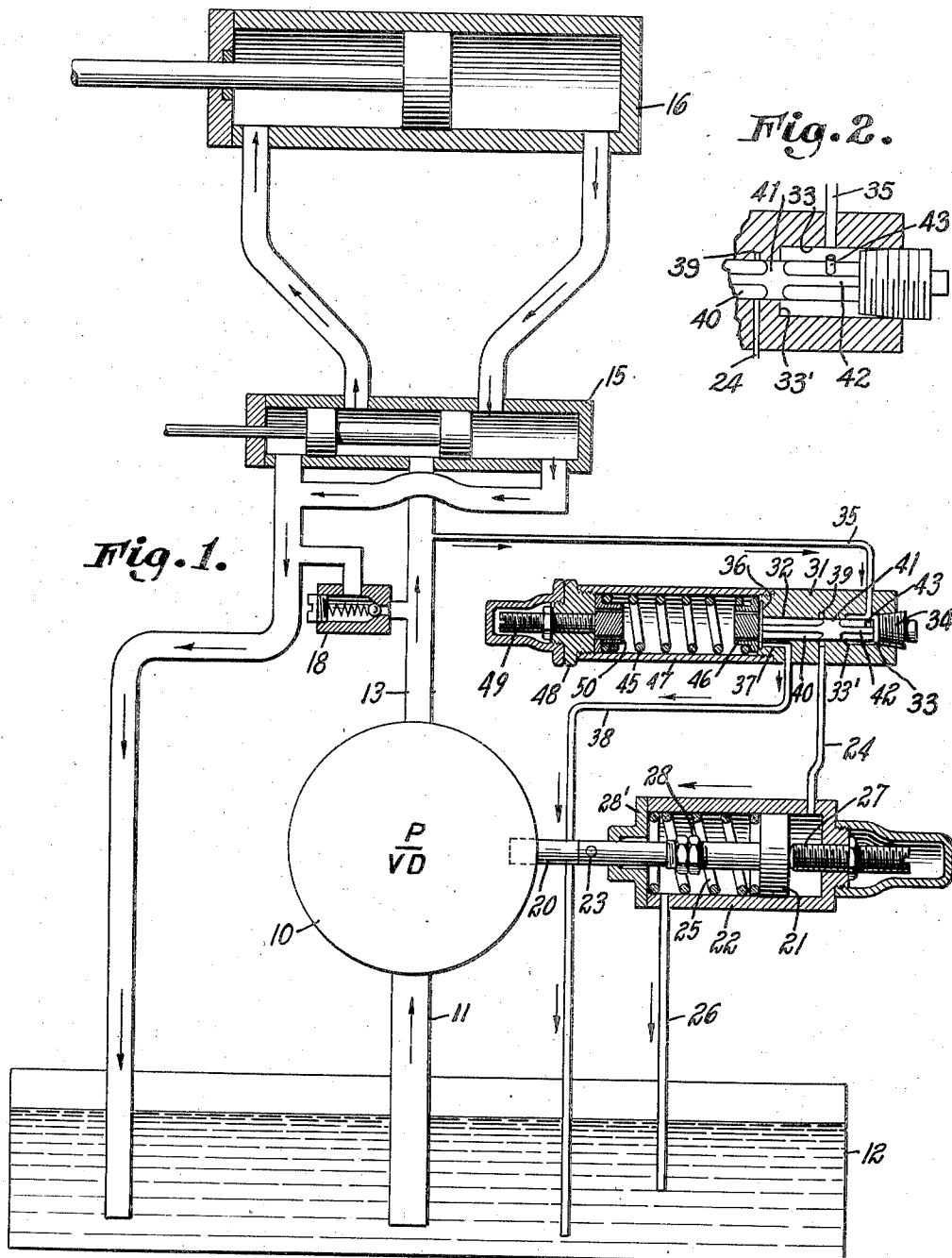
April 15, 1941.

C. M. KENDRICK

2,238,060

FLUID PRESSURE FEED AND RAPID TRAVERSE SYSTEM OF TRANSMISSION OF POWER

Filed Feb. 8, 1938



INVENTOR.
Charles M. Kendrick
BY
Bartlett & Scott
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,238,060

FLUID PRESSURE FEED AND RAPID TRAVERSE SYSTEM OF TRANSMISSION OF POWER

Charles M. Kendrick, New York, N. Y., assignor to Manly Corporation, Washington, D. C., a corporation of Delaware

Application February 8, 1938, Serial No. 189,362

6 Claims. (Cl. 60—52)

This invention relates to systems for the transmission of power by means of fluid under pressure and more particularly to such systems in which the driven member is actuated at relatively low speed by fluid under relatively high pressure, and at relatively high speed by fluid under relatively low pressure. The low-speed-high-pressure actuation of the driven member is frequently termed the "feed" or the "slow traverse movement" and the high-speed-low-pressure actuation is correspondingly termed "rapid traverse;" for convenience these terms will be employed in the description which follows and the system as a whole will be termed a "feed and rapid traverse system."

Systems of this general character have heretofore been proposed in which an excess fluid volume is pumped and by-passed during the feed or slow traverse, viz, systems in which two constant delivery, constantly operating, pumps are employed for supplying the fluid pressure, with the fluid furnished by one pump by-passed back to the source during the feed or slow traverse.

One object of the invention is a novel and improved fluid pressure feed and rapid traverse system in which a single pump, namely a single variable delivery pump, is employed as the source of fluid pressure both for the feed and for the rapid traverse strokes, and particularly such a system including a control for varying the delivery of the pump to meet the exact volume needs of the feed and rapid traverse strokes respectively without the necessity of pumping and by-passing excess fluid.

A further object of the invention is a system of the character indicated wherein the fluid volumes delivered for rapid traverse and for feed respectively are held steady with no surging or pulsation due to change in the pump's delivery, and, further, such a system wherein the delivered volume whether that for the rapid traverse or for the feed or slow traverse is unaffected by minor variations in operating pressure of the fluid.

A further object is to provide such a system which includes simple, novel and relatively inexpensive control valve mechanism for the variable delivery pump whereby the volumes of fluid delivered thereby are substantially restricted to the volumes required for feed or slow traverse and for rapid traverse respectively, the delivery of the pump changing from one to the other of these volumes substantially instantly and without interruption, thus limiting the delivery of all other volumes to those incident to this change.

Other objects will appear from the following description of an illustrative embodiment of the invention which is shown in the accompanying drawing, wherein—

Fig. 1 shows, in partly diagrammatic arrangement, an embodiment of a feed and rapid traverse system according to the present invention, certain of the control and power mechanism of which are shown in section, and

Fig. 2 is a detail view.

Referring now to the drawing, the preferred embodiment of the invention includes a variable delivery pump 10 receiving its supply of fluid through an inlet conduit 11 from a reservoir 12. The pump 10 is also provided with a discharge conduit 13 leading to and connecting with a directional valve 15 of conventional type which controls the direction of operation of the power cylinder 16. The discharge conduit 13 is also connected with a suitable pressure relief valve 18 which may be employed as a safeguard against excessive fluid pressure in the system or may be utilized to determine the working pressure of the fluid during feed or slow traverse.

The volume of fluid delivered by the pump 10 is controlled by the position of a laterally movable adjusting rod or volume determining element 20. The arrangement is such that movement of the adjusting rod 20 inward (or toward the left as viewed in the drawing) causes decrease in the delivered volume, while its movement outward (or toward the right) causes increase of the volume of fluid delivered.

Movement of the adjusting rod 20 is effected and its position controlled by power means in co-operation with control valve mechanism. In the embodiment here chosen for illustration, the power means is a fluid motor which includes an adjusting piston 21 reciprocable in an adjusting cylinder 22 and appropriately connected with the adjusting rod 20, as indicated at 23, for simultaneous movement therewith. The adjusting piston 21 is moved inward or in a delivery decreasing direction by pressure fluid admitted to the right hand end of the adjusting cylinder 22 through the pipe 24 but is preferably moved outward or in a delivery increasing direction by a spring 25. Movement of the adjusting piston 21, and hence its position, is entirely controlled by admission and exhaust of fluid to and from the right hand end of the adjusting cylinder 22, thus simplifying the fluid circuit and the necessary control mechanism as will be more fully explained presently. A return pipe 26 leads from the left hand end of the adjusting cylinder 22 to the reservoir

12 to permit the passage of any fluid leaking past the adjusting piston 21 from the right hand end of the adjusting cylinder 22.

Suitable means are also provided to determine the maximum and the minimum fluid volumes to be delivered by the pump 10. In the present instance these delivery determining means are shown as adjustable stops 27 and 28 respectively for the adjusting piston 21. The stop 27 limits the movement of the adjusting piston 21 and its attached adjusting rod 20 in an outward or delivery increasing direction and hence determines the maximum fluid volume delivered by the pump 10; it is accordingly set so that the maximum volume thus determined is the volume required for rapid traverse. Similarly, the stop 28 limits movement of the adjusting piston 21 and adjusting rod 20 in an inward or delivery decreasing direction and hence determines the minimum fluid volume which the pump 10 delivers; it is therefore set so that the minimum volume thus determined is the volume desired for feed or slow traverse. This stop 28 comprises a pair of adjustable nuts on a screw threaded part of the piston rod, and the movement of the piston and rod to the left is limited by the stop 28 engaging with the end wall 28' of the cylinder.

Admission and exhaust of fluid to and from the adjusting cylinder 22 through the pipe 24 are under control of control valve mechanism which includes a valve housing 31 in which is a valve bore 32 having an enlarged end 33 (for convenience hereinafter termed the "high pressure" end). The latter is connected as by a pipe 35 with the discharge conduit 13 from which it receives a supply of fluid under substantially the same pressure as that in said discharge conduit 13. The other end of the valve bore 32 (which for convenience will be hereinafter termed the "exhaust end") is connected with the reservoir 12 by means of a counterbore 36 on the end of the valve housing 31 which extends to and connects with a passage 37 to which the return pipe 38 is suitably connected. An annular cylinder port 39 is also formed in the valve bore 32 intermediate the ends thereof and is suitably connected with the pipe 24, whose other end is connected with the right hand end of the adjusting cylinder 22 as already stated.

A valve piston 40 is slidably mounted in the valve bore 32 and is made of such length that one of its ends at all times extends into the high pressure end 33 of the valve bore 32. The proportions are also such that the other end of the valve piston 40 is even with the exhaust end of the valve housing 31 when said piston 40 is in its extreme working position toward the right, as shown in the drawing. The piston 40 is formed intermediate its ends with a single valve head 41 which effectively cuts off communication between the portions of the valve bore 32 on either end thereof and which in the preferred arrangement is materially wider than the cylinder port 39, for example several times wider, as in the embodiment illustrated. In order to firmly guide the valve piston 40 and to prevent binding, a plurality of guiding surfaces 42 extend from the head 41 to the ends of the valve piston 40, suitable recesses being formed circumferentially between the guiding surfaces 42 to permit the passage of fluid. The guiding surfaces 42 and intermediate recesses are so arranged that the hydraulic forces acting in a radial direction on the valve piston 40 at any point are balanced, in the usual manner.

The end of the valve piston 40 which lies in the high pressure end 33 of the valve bore 32 is acted upon by pressure fluid therein which tends to move the valve piston 40 toward the left, as viewed in the drawing. Maximum movement of the valve piston 40 in this direction is limited by a stop 43, comprising a pin driven through said valve piston 40 near its end, which is adapted to strike the shoulder 33' formed by the inner end of the enlarged portion 33 of the valve bore 32. The arrangement is preferably made such that the stop 43 does not strike this shoulder until the valve piston 40 has moved a distance toward the left sufficient not only to connect the cylinder port 39 with the high pressure end 33 of the valve bore 32 but also to permit over-run of the valve head 41 a short distance (for example, $\frac{1}{8}$ "') beyond the point where this connection is established.

The force acting on the valve piston 40 in a direction tending to move it toward the left is opposed by a force exerted by a spring 45 acting on the opposite end of the valve piston 40, that is the end thereof which is in the exhaust end of the valve bore 32, and urging it toward the right. The force of the spring 45 is transmitted to the end of the valve piston 40 by means of an intermediate end piece 46 of greater diameter than the counter-bore 36, so that the adjacent end of the valve housing 31 acts as a stop for the end piece 46 and limits the distance which said valve piston 40 can be moved toward the right by said spring 45. The drawing shows the position of the parts when the end piece 46 is against the end of the valve housing 31, with the valve piston 40 in the maximum position toward the right to which it can be moved by the spring 45. The arrangement is such that when the valve piston 40 is in this position, the head 41 is to the right of the cylinder port 39 so that said cylinder port 39 is connected with the exhaust end of the valve bore 32, a short over-run beyond the point at which this connection is established also being preferably provided in this direction of movement of the valve piston 40. As the valve piston 40 is not attached to the end piece 46 it is capable of movement still farther toward the right than the position in which it is shown in the drawing; such movement is unlikely to occur but the maximum travel in this direction is limited by the plug 34 which closes the high pressure end 33 of the valve bore 32, this stop being provided to assure that the head 41 will at all times be in the valve bore 32.

The spring 45 is enclosed by a housing 47, one end of which is suitably connected to the valve housing 31, as by the screw threaded connection shown, and the other end of which is closed by a plug 48. A screw 49 extends through the plug 48 and provides means for adjusting the compression of the spring 45, the screw 49 abutting against an abutment member 50 in engagement with the spring 45.

In operation, the pump 10 is continuously driven and provides continuous delivery of pressure fluid which passes into the discharge conduit 13, through the directional valve 15 and to the power cylinder 16 which is actuated thereby.

Pressure fluid from the discharge conduit 13 also passes through the pipe 35 into the high pressure end 33 of the valve bore 32 where it acts upon the exposed end of the valve piston 40, as already explained. During rapid traverse the pressure of this fluid, as previously stated,

is relatively low so that the force which it exerts on the exposed end of the valve piston 40 is insufficient to overcome the opposing force of the spring 45 and the parts assume the position shown. The valve piston 40 is then in its extreme working position toward the right and its head 41 is to the right of the cylinder port 39. The cylinder port 39 is thus connected with the exhaust end of the valve bore 32, so that fluid may be exhausted from the right hand end of the adjusting cylinder 22 through the pipe connection 24, the bore 32, the counterbore 36, the passage 37 and the pipe 38 to the tank 12. The adjusting piston 21 and adjusting rod 20, under action of the spring 25, are moved to their extreme outward or delivery increasing position as determined by the stop 27 and are held in this position as long as the fluid in the discharge conduit 13 and high pressure end 33 of the valve bore 32 remains under low pressure, as is the case during rapid traverse. The pump 10 is thus caused to deliver its maximum volume, as determined by the stop 27, under relatively low pressure for rapid traverse.

The resistance presented by the power cylinder 16 will immediately increase to a relatively high amount upon completion of rapid traverse and the beginning of feed or slow traverse, causing a corresponding immediate increase in the pressure of the fluid in the discharge conduit 13 and the high pressure end of the valve bore 32. The force exerted by this relatively high pressure fluid on the end of the valve piston 40 overcomes the resistance presented by the spring 45 and moves the valve piston 40 to its working position toward the left, in which position the valve head 41 is to the left of the cylinder port 39. The high pressure end of the valve bore 32 is thus connected with the cylinder port 39 so that pressure fluid is admitted to the right hand end of the adjusting cylinder 22. The adjusting piston 21 is immediately moved inward or in a delivery decreasing direction as far as permitted by the stop 28. This movement of the adjusting piston 21 causes similar movement, of course, of the adjusting rod 20 so that the volume of fluid delivered by the pump 10 is reduced to the minimum determined by the stop 28 and is held in this minimum delivery position as long as the pressure of the fluid acting on the end of the valve piston 40 in the high pressure end of the valve bore 32 remains relatively high, as will be the case throughout feed or slow traverse.

The pressure of the fluid in the discharge conduit 13 and hence in the high pressure end of the valve bore 32 will again drop to a relatively low amount upon completion of feed or slow traverse and the beginning of rapid traverse. Immediately upon this pressure drop, the valve piston 40, the adjusting piston 21 and adjusting rod 20 will be returned to their positions as shown and the fluid volume delivered by the pump 10 will thus immediately be increased to the maximum determined by the stop 27.

The control valve and power adjusting mechanism of the present invention therefore act cooperatively to effect delivery of the maximum volume of fluid at low pressure for rapid traverse and to effect delivery of minimum fluid volume at relatively high pressure for feed or slow traverse. The change from maximum to minimum volumes, or vice versa, is made responsive to change in the pressure of the working fluid in the discharge conduit 13 and, while described

somewhat progressively, takes place substantially instantaneously and without interruption. The fluid volume delivered by the pump 10 is thus at all times kept at either maximum or minimum except, of course, for the constantly changing volume incident to the almost instantaneous variation from one to the other of these extreme amounts, which is practically negligible. By adjustment of the stops 27 and 28, the maximum and minimum fluid volumes may be made such as to produce the desired rates of movement of the power cylinder 16 for rapid traverse and for feed or slow traverse respectively. Likewise, by adjustment of the compression of the spring 45 the pressure of the fluid in the discharge conduit 13 required to effect the shift from maximum to minimum volume, or vice versa, may be varied and controlled.

The feed and rapid traverse system of the present invention has numerous advantages. It makes possible, for example, the use of one variable delivery pump instead of two constant delivery pumps, such as are frequently employed for this purpose. It reduces the necessity for by-passing fluid during feed or slow traverse and can be so adjusted that by-passing is entirely eliminated; this saves power and avoids heating and churning of the fluid, which is usually oil. It is efficient, reduces to a minimum the power required to supply the needed actuating fluid and permits the use of a small and inexpensive electric motor to drive the pump; for example, losses neglected, an electric motor delivering two and one-half H. P. will drive the pump to deliver approximately four and one-fourth gallons per minute of fluid at 1,000 lbs. per sq. in. pressure for feed or slow traverse and approximately 17 gals. per minute at 250 lbs. per sq. in. pressure for rapid traverse.

Another important advantage of the system of the present invention is that the volume delivered both for rapid traverse and for feed or slow traverse are held steady without surging or pulsation due to change in the pump's delivery. There is no "hunting" and the delivered volume is not affected by minor variations in operating pressure of the fluid in the discharge conduit 13. This is due to the fact that the pump's delivered volume is maintained at maximum whenever the pressure in the discharge conduit 13 is below the amount necessary to move the valve piston 40 against the spring 45 a distance sufficient to connect the cylinder port 39 with the high pressure end 33 of the valve bore 32. The valve piston 40 is free, of course, to move toward the left to some extent under lower pressures, but the connection between the cylinder port 39 and the valve bore's high pressure end 33 cannot be established until the piston head 41 has been moved to the left of said cylinder port 39, and this cannot occur until the pressure of the fluid reaches an amount determined by the setting of the spring 45. Minor variations in the pressure below this amount do not, therefore, have any effect on the pump's delivery. Similarly, the delivery of the pump will be held steadily and continuously at minimum as long as the pressure of the fluid in the discharge conduit 13 is equal to or greater than the amount, as determined by the spring 45, necessary to connect the cylinder port 39 with the valve bore's high pressure end 33, regardless of variations in the pressure above this amount. The extra width of the valve piston head 41, as compared to the width of the cylinder port

39, thus prevents change of the existing connection between the end of the adjusting cylinder 22 and the cylinder port 39, from the fluid pressure admission connection to the exhaust connection, or vice versa, upon small fluctuations of the pressure in the discharge conduit 13 and thereby assists in eliminating any "hunting" tendency. The pressure employed for feed or slow traverse is usually substantially higher than that used for rapid traverse so that there is no difficulty in setting the spring 45 to bring about the shift from maximum volume to minimum volume, or vice versa, at a satisfactory intermediate pressure and, if desired, the difference in pressures necessary to effect this shift may be held within a relatively narrow range, as by making the spring 45 with a low rate (i. e., such that a relatively small added increment of load is required to produce a given amount of total deflection of the spring).

In addition to the operating advantages which it makes possible, the novel construction of the control valve mechanism also results in easy and relatively inexpensive manufacture. Only one close fit is required in its entire structure and that is the relatively simple one of fitting the valve piston 40 into the valve bore 32. The valve head 41 and guiding surfaces 42 are of the same diameter so that the valve piston 40 may be readily ground from end to end to the proper size.

No other precise sizes are required anywhere in the structure and ordinary machining tolerances, such as $\pm .010''$ or $\pm \frac{1}{64}''$, may be otherwise used throughout. For example, it is not necessary to hold the length of the valve bore 32 or of the valve piston 40 to a precise dimension. Likewise, there is no exact requirement either as to the width (i. e. axial length) of the cylinder port 39 and valve head 41 or as to their relative positions in the valve bore 32 and on the valve piston 40 respectively. Minor variations in size or relative position of these parts merely affects the amount of over-run of the valve head 41. The width of the valve head 41 must, of course, be at least equal to the width of the cylinder port 39 and in many instances its width may be considerably greater than that of the cylinder port 39, which is the arrangement illustrated in the drawing; such excess width of the valve head 41 has no effect on the operation except to increase the pressure range during which said valve head 41 completely covers the cylinder port 39 and thus cuts off communication between the cylinder port 39 and both ends of the valve bore 32, thereby assisting in elimination of "hunting," as already explained.

Another feature of this control valve mechanism is that the high pressure fluid is confined to the bore of the short and relatively easily made valve housing 31, in which all fluid connections to and from the valve mechanism are also made. This permits the use of inexpensive material such as thin steel tubing for the spring housing 47, as its bore is connected with the exhaust, and also makes it possible to use simple threaded joints at both ends of the spring housing.

It will be understood that the foregoing is merely exemplifying disclosure and that changes may be made in the apparatus without departing from the applicant's invention as defined in the appended claims.

I claim:

1. In a fluid circulating system comprising a fluid operated member having a rapid traverse low pressure stroke and a slow traverse high pressure stroke, and a variable delivery pump having a fluid discharge conduit connected with said fluid operated member and delivering the whole fluid pressure supply volumes for both rapid and slow traverse strokes, in combination, a delivery control and determining device for said pump operable to one predetermined position to effect the delivery needed for the rapid traverse and to another predetermined position to effect the delivery for the slow traverse stroke, fluid pressure operated means for effecting an instantaneous shift of said device from one of said positions to the other upon transition of the fluid operated member from one stroke to the other, stops limiting the movement of the fluid pressure operated means in both directions for determining the deliveries during the rapid traverse and the slow traverse strokes respectively, said fluid pressure operated means comprising a fluid pressure piston operated in one direction by fluid pressure and in the other direction by a spring, and means responsive to the change in pressure in the discharge conduit upon transition of the fluid operated member from one stroke to the other for controlling said fluid pressure operated means and causing said instantaneous shifts and for holding said fluid pressure operated means against movement upon changes in pressure in said discharge conduit other than changes incident to transition of the fluid operated member from one stroke to another.

2. In a fluid circulating system comprising a fluid operated member having a rapid traverse low pressure stroke and a slow traverse high pressure stroke, and a variable delivery pump having a fluid discharge conduit connected with said fluid operated member and delivering the whole fluid pressure supply volumes for both rapid and slow traverse strokes, in combination a delivery control and determining device for said pump operable to one predetermined position to effect the delivery needed for the rapid traverse and to another predetermined position to effect the delivery for the slow traverse stroke, fluid pressure operated means for effecting an instantaneous shift of said device from one of said positions to the other upon transition of the fluid operated member from one stroke to the other, stops limiting the movement of the fluid pressure operated means in both directions for determining the deliveries during the rapid traverse and the slow traverse strokes respectively, and a fluid pressure operated valve responsive to the change in pressure in the discharge conduit for controlling said fluid pressure operated means comprising a cylinder one end of which is always in connection with the discharge conduit, said cylinder including an annular port connected with said fluid pressure operated means, a piston therein provided with a head wider than said annular port, said piston at low pressures connecting the fluid pressure operated means with the exhaust, at high pressure connecting said fluid pressure operated means with the discharge conduit and at intermediate pressures disconnecting said fluid pressure operated means from both said discharge conduit and said exhaust, and a spring actuating said piston valve in one direction.

3. In a fluid circulating system comprising a

fluid operated member having a rapid traverse low pressure stroke and a slow traverse high pressure stroke, and a variable delivery pump having a fluid discharge conduit connected with said fluid operated member and delivering the whole fluid pressure supply volumes for both rapid and slow traverse strokes, in combination, a delivery control and determining device for said pump operable to one predetermined position to effect the delivery needed for the rapid traverse and to another predetermined position to effect the delivery for the slow traverse stroke, power actuated means for effecting an instantaneous shift of said device from one of said positions to the other upon transition of the fluid operated member from one stroke to the other, and means responsive only to the large changes in pressure in the discharge conduit incident to transition of the fluid operated member from one stroke to the other for controlling said power actuated means and causing said instantaneous shifts.

4. In a fluid circulating system comprising a fluid operated member having a rapid traverse low pressure stroke and a slow traverse high pressure stroke, and a variable delivery pump having a fluid discharge conduit connected with said fluid operated member and delivering the whole fluid pressure supply volumes for both rapid and slow traverse strokes, in combination, a delivery control and determining device for said pump operable to a predetermined minimum delivery position above zero and to a predetermined maximum delivery position, power actuated means for said delivery determining device holding the latter in one or the other of said predetermined positions, and means responsive to the changes in pressure in the discharge conduit due to transition of the member from one stroke to the other for controlling the shifting of the device from one position to the other, said last named means having a range of movement responsive to intermediate pressures in said discharge conduit in which said device is maintained in the position occupied prior to the occurrence of said intermediate pressures.

5. In a fluid circulating system comprising a fluid operated member and a variable delivery pump having a discharge conduit connected with said fluid operated member, in combination, a delivery determining device for said pump operable to a predetermined minimum delivery position above zero delivery and to a predetermined maximum delivery position, a fluid-pressure piston reciprocable in a cylinder and active to hold said device in said minimum delivery position upon admission of pressure fluid to said cylinder and also active to hold said device in said maximum delivery position upon exhaust of fluid from said cylinder, and valve means responsive to the pressure of the fluid in said discharge conduit for regulating the admission of

pressure fluid to said cylinder and the exhaust of fluid therefrom, said valve means including a valve bore having a fluid pressure supply port, a fluid exhaust port and a cylinder port connected with said cylinder, said valve means also including a valve piston movable in said bore responsive to fluid pressure in said discharge conduit and active to control the admission of pressure fluid to said cylinder port and the exhaust of fluid therefrom, said valve piston having one range of movement responsive to relatively high pressures in said discharge conduit in which range said cylinder port is connected with said fluid pressure supply port, said valve piston having another range of movement responsive to relatively low pressures in said discharge conduit in which range said cylinder port is connected with said exhaust port, and said valve piston also having an intermediate range of movement responsive to pressures in said discharge conduit intermediate said relatively low and relatively high pressures in which range said cylinder port is disconnected from both said fluid pressure supply port and said exhaust port, whereby said delivery determining device is held in the predetermined delivery position occupied prior to the occurrence of said intermediate pressures in said discharge conduit.

6. In a fluid circulating system comprising a fluid operated member having a rapid traverse low pressure stroke and a slow traverse high pressure stroke, and a variable delivery pump having a fluid discharge conduit connected with said fluid operated member and delivering the whole fluid pressure supply volumes for both rapid and slow traverse strokes, in combination, a delivery control and determining device for said pump operable to one predetermined position to effect the delivery needed for the rapid traverse and to another predetermined position to effect the delivery for the slow traverse stroke, a cylinder and piston operated to one position by a spring and to the other position by fluid pressure for effecting an instantaneous shift of said device from one of said traverse positions to the other incident to transition of the fluid operated member from one stroke to the other and a second cylinder having a port at one end connected with the fluid discharge conduit of the pump and another port axially removed from the first named port and in communication with said first named cylinder and a piston in said last named cylinder responsive only to the large changes in pressure in the discharge conduit incident to transition of the fluid operated member from one stroke to the other for connecting and disconnecting the ports of said second named cylinder, including means for exhausting fluid pressure from said first named cylinder at pressures in the discharge conduit below a predetermined value.

CHARLES M. KENDRICK.