Sept. 18, 1951 T. M. MOULDEN 2,568,356

VARIABLE DISPLACEMENT PUMP

Filed March 5, 1948

Fig. 1

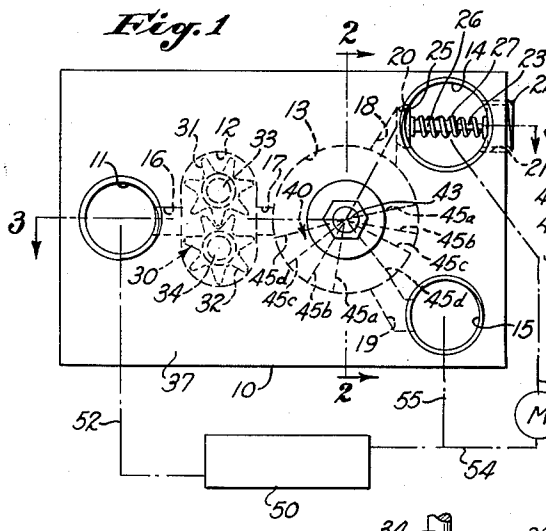


Fig. 2

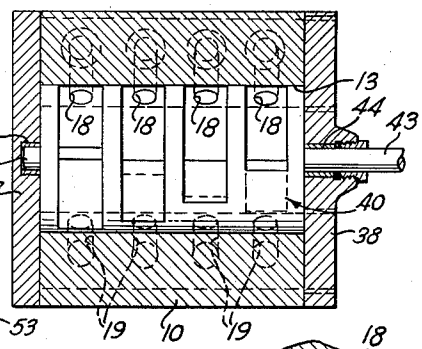


Fig. 4

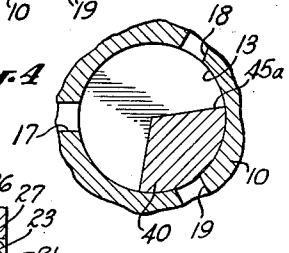


Fig. 3

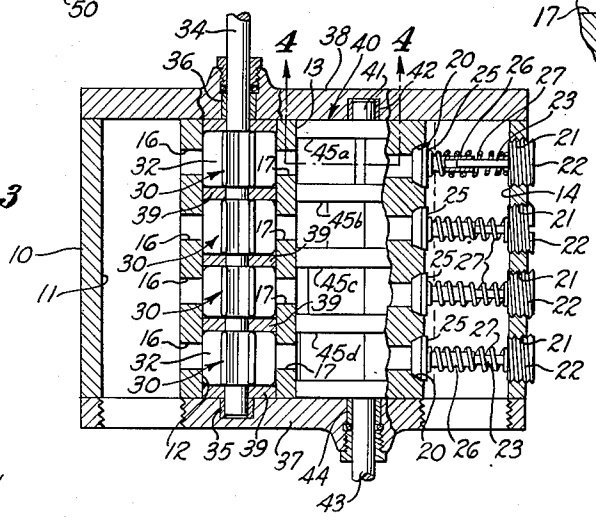
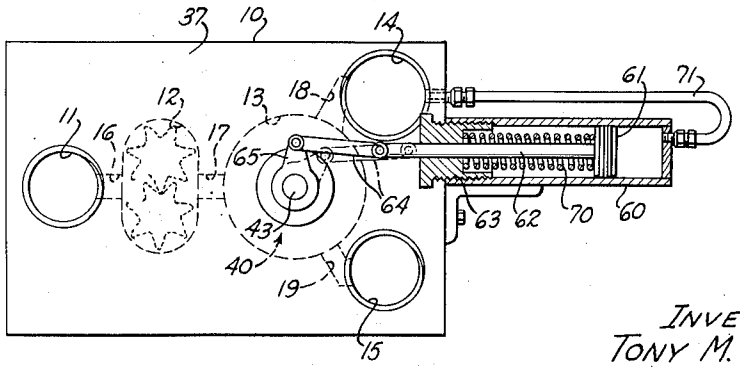


Fig. 5



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VARIABLE DISPLACEMENT PUMP

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9 Claims. (Cl. 103—42)

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My invention relates to the pump art, and particularly to a variable delivery pump capable of delivering fluid at a constant discharge rate but adapted to be adjusted to vary said discharge rate in accordance with requirements.

One object of the invention is to provide a pump, of the class referred to, having rotary pumping means for pumping the fluid, a discharge manifold, a by-pass manifold, and rotary valve means interposed between the pumping means and the discharge manifold and between the pumping means and said by-pass manifold, said valve means having an opening in continuous fluid communication with said pumping means, said valve means being adapted to be rotated to one position to establish fluid communication between said pumping means and the discharge manifold, to a second position to effect fluid communication between said pumping means and said by-pass manifold, or to positions intermediate said first and second positions to effect fluid communication between said pumping means and both said discharge and by-pass manifolds. By this improved valve construction, the pumping means can be operated at a constant speed to deliver a constant volume of fluid to the rotary adjustable valve means which then serves to direct all or a portion of the fluid flow to the discharge manifold to maintain a constant delivery rate of the fluid from the pump device, as established by the setting of the valve means.

It is another object of the invention to provide a pump device of the type indicated in which a plurality of said pumping means is arranged in a pump chamber and connected for unitary rotation, the pumping means being adapted to draw fluid from an intake manifold through a series of independent first ports and deliver the fluid to the rotary adjustable valve means through a series of second ports, there being a first and second port for each pumping means.

In accordance with another object of my invention, the aforementioned rotary valve means has a plurality of the valve openings, these openings being spaced axially of the valve means and arranged at different circumferential angles or, in other words, arranged at progressively greater angles from one end of the valve means toward the other end thereof. By this novel structure, the valve means can be rotated to different positions of angular adjustment to establish flow of the fluid into either or both the discharge manifold or by-pass manifold so that any portion of the combined delivery of the individual pumping

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means may flow to the discharge side of the pump device so that the delivery rate of the multiple pump means can be selectively varied from zero to a maximum value with an infinite number of intermediate delivery rates in accordance with the requirements. The improved pump device thus has particular utility in the fluid circuit of a fluid motor or the like, the speed of operation of the motor being directly proportional to the rate of delivery of the fluid to the motor by the pump device.

Another object is to provide a pump device, of the character referred to, embodying check valve means which function to maintain the fluid in the discharge manifold constant regardless of the number of pumping means delivering fluid to the discharge manifold, said check valve means being adjustable from the exterior of the pump device to set them for a selected fluid pressure. Preferably, the check valve means are arranged in multiple, one for each pump means, and normally adapted to close passages extending between the valve means and the discharge manifold, said check valve means being movable, against spring means, in response to predetermined pressure differentials between the pump chamber and discharge manifold, to permit passage of the pumped fluid into the discharge manifold and the pressure side of the line in which the pump device is incorporated.

Another object of the invention is to provide an automatic control means which is operative to maintain a predetermined substantially constant pressure in the discharge side of the pump device, said control means acting, in response to slight variations in pressure in the discharge manifold, to automatically rotate the valve means and adjust its openings with respect to the ports extending between the valve chamber and the discharge and by-pass manifolds so as to compensate for such variations and thus maintain the discharge pressure and delivery rate of the pump device substantially uniform.

A further object of the invention is to provide a pump device which is especially simple in construction and economical to manufacture and service, one which is positive in maintaining a pre-selected pressure and rate of delivery, and one which is capable of minute adjustment to produce an infinite number of fluid delivery rates.

Further objects of my invention will be apparent from the following detailed description and from the drawing, which is intended for the purpose of illustration only, and in which:

Fig. 1 is a front elevational view of my improved variable delivery pump device;

Fig. 2 is a cross-sectional view through the pump device, taken on line 2—2 of Fig. 1;

Fig. 3 is a sectional plan view, taken on line 3—3 of Fig. 1;

Fig. 4 is a cross-sectional view through the valve member, taken on line 4—4 of Fig. 3; and

Fig. 5 is a view similar to Fig. 1, showing an automatic control means for rotating the valve means.

Referring to the drawing in detail, my improved pump device includes a housing 10 which may be in the form of a rectangular block and suitably bored and machined at spaced intervals to provide an inlet manifold 11, a pump chamber 12, a valve chamber 13, a discharge manifold 14, and a by-pass manifold 15. The housing 10 is also bored transversely to provide a series of first ports 16 communicating between the inlet manifold 11 and the pump chamber 12, and another series of second ports 17 aligned with the first ports and extending between the pump chamber 12 and the valve chamber 13. Extending between the valve chamber 13 and the discharge manifold 14 is a series of inclined third ports 18, and a plurality of similar fourth ports 19 communicates between the valve chamber 13 and the by-pass manifold 15. The several ports 16, 17, 18, and 19 are arranged in transverse alignment, the present drawing showing each series as comprising four of the ports. At the juncture between the third ports 18 and the discharge manifold 14, these ports are provided with valve seats 20. Aligned with the valve seats 20 are tapped holes 21 in the opposite side of the manifold 14, and screwed into each of these holes is an adjusting plug 22 having an inner spindle 23 disposed in the manifold. Check valves 25 of the poppet type have tubular stems 26 slidable on each of the spindles 23, and coil springs 27 surrounding the valve stems between the heads of the valves, and the plugs 22 normally function to yieldingly maintain the heads of the check valves seated against the valve seats 20 as shown in Fig. 3.

Rotatable in the pump chamber 12 is a series of fluid pumping units 30 of the well known gear type, each unit 30 being disposed in alignment with opposite first and second ports 16 and 17 and adapted to draw fluid from the inlet manifold 11 through a first port 16 and force the fluid through a second port 17 into the valve chamber 13. Each pumping unit 30 includes a pair of meshing gears 31 and 32, these gears being respectively keyed to shafts 33 and 34 and thus adapted for unitary rotation. The shafts 33 and 34 are rotatable in bearings 35 and 36 (Fig. 3) provided in end plates 37 and 38 which are suitably secured to the front and rear surfaces of the housing 10. The shaft 33 projects from the end plate 38 and is adapted to be rotated at a substantially constant speed by any suitable prime mover, such as an electric motor (not shown). The gear pump units 30 are held in axially spaced relation on their shafts by means of spacer elements or separators 39 which, in effect, provide a series of four individual pumping chambers each enclosing a pumping unit 30.

Rotatable in the valve chamber 13 is a valve member 40 which has a reduced end 41 journalled in a bearing 42 in the rear end plate 37 and an axial extension or shaft 43 rotatable in a bearing 44 in the other end plate 38, this shaft

projecting from the last named plate to adapt it to be rotated either manually or automatically. As will be observed from the drawing, the rotary valve member 40 is provided with a series of four axially-spaced openings or transverse slots 45*a*, 45*b*, 45*c*, and 45*d*, each slot extending throughout substantially 240° (Fig. 4). The slots are staggered or advanced circumferentially, that is, successive slots are disposed at increasingly greater angles with respect to the endmost slot 45*a* of the series, the angular difference between adjacent slots being herein shown as approximately 15°. The slots 45*a*, 45*b*, 45*c*, and 45*d* are of equal size and each registers continuously with a separate port 17 leading from the pump chamber 12.

In Fig. 1 the opposite ends of the individual slots are identified by the same reference character, i. e., 45*a*, 45*b*, etc., and the valve member 40 is illustrated as having been rotated to its extreme movement in clockwise direction. In this position of adjustment, each of the slots 45*a*–45*d* registers with an aligned pair of second and third ports 17 and 18 so that fluid can flow from the pump chamber 12, through all the ports 17, through all the slots 45*a*–45*d* and enter the discharge manifold 14 by way of the several ports 18. With the valve member 40 adjusted to this position, all of the slots 45*a*–45*d* are out of register with the fourth ports 19 and thus no fluid will flow from the valve chamber 13 into the by-pass manifold and a maximum delivery rate of flow into the discharge manifold 14 is established. On the other hand, if the valve member 40 is rotated to a position wherein all the slots register with the ports 19 but are out of alignment with the ports 18, the entire flow of fluid is from the pump chamber 12 into the by-pass manifold 15 so that the output of the pump device is reduced to zero. When, however, the valve member 40 is adjusted to positions intermediate the two extremes of movement referred to above, certain of the slots 45*a*–45*d* register with both the ports 18 and 19 so that the pump device discharges fluid into the manifold 14 at a rate intermediate its maximum and minimum delivery rates. Consequently, by adjusting the valve member 40 angularly in the valve chamber 13, infinite numbers of intermediate delivery rates can be obtained to meet the requirements.

During the operation of the pump device, the check valves 25 function to control the flow of fluid through the third ports into the discharge manifold 14 so as to maintain the pressure and discharge rate of the fluid substantially constant for any setting of the valve member 40. Assuming that the valve member 40 is adjusted to a position wherein certain of its slots, for example, 45*a* and 45*b*, permit at least partial flow of fluid through the ports 18 and 19, the pumping units 30 function to deliver fluid to the discharge manifold 14, forcing the check valves 25 to open position to permit such flow. At the same time, a portion of the pumped fluid may flow through the ports 19 and discharge into the by-pass manifold 15. This operation may continue as long as the fluid pressure in the discharge manifold 14 remains less than the fluid pressure in the port or ports 18. However, when such pressure differential is reduced to zero or, in other words, when the pressure in the manifold 14 equals the pressure in the ports 18, the check-valves 25 are moved against the seats 20 under the action of their springs 27 so that further flow of fluid through the particular ports 18 is checked. When

this condition prevails, the fluid is diverted through the ports 19 into the by-pass manifold. As the fluid in the discharge manifold is used to perform work in the system in which the pump device is incorporated, the check valve or check valves again open to permit ingress of fluid into the discharge manifold 14. Thus, during operation of the pump device the check valves 25 open and close in response to pressure differentials occurring between the ports 18 and the manifold 14 and, as will be apparent, the check valves may assume a partially open position to admit a limited flow of fluid into the manifold 14, the adjusted position of the valve member 40, that is, the number of slots 45a–45d open to their respective ports 18 and 19, and the rate at which the discharged fluid is used to perform work being important factors which control the function of the check valves.

As shown diagrammatically in Fig. 1, the improved pump device may be incorporated in a fluid system which includes a reservoir 50 and a fluid motor 51. A hydraulic line 52 leads from the reservoir to the inlet manifold 11 and another line 53 is connected between the discharge manifold 14 and the inlet port of the fluid motor 51. A third line 54 extends from the discharge port of the fluid motor 51 to the reservoir 50. By this system, fluid is drawn from the reservoir 50 and pumped into the line 53, this pressurized fluid then being employed for operating the fluid motor 51, the fluid then returning through the line 54 to the reservoir. A further line 55, connected between the by-pass manifold 15 and the line 54, serves to by-pass fluid discharged into the manifold 15 to the reservoir. As previously mentioned, the shaft 43 can be rotated to adjust the valve member 40 angularly in the valve chamber 13 so as to align or disalign any of the slots 45a–45d with their respective ports 18 and 19 and thereby control the delivery rate of the pump device. By so varying the rate of fluid delivery, different rotational speeds of the fluid motor can be readily obtained, so that the pump device, in addition to providing motive power for actuating the fluid motor 51 at various speeds, also serves as a governor to maintain the speed of the motor substantially constant. As will be apparent, when a load is imposed on the motor 51, as is common when the motor must overcome inertia of a mechanism which it actuates, fluid pressure developed in the line 53 will maintain the check valves 25 closed to prevent further discharge of the pumped fluid into the manifold 14 until the pressure within the discharge manifold is reduced to a value less than the pressure within the valve chamber 13, at which time the check valves open to establish flow into the line 53. The shaft 43 may be provided with a handle to facilitate its rotation to different positions of adjustment, and a pointer on the shaft may cooperate with a fixed arcuate dial or similar means to indicate the position of the valve member, these parts not being herein shown as they may be of any type suitable for the purpose.

My invention further contemplates the provision of an automatic control means, shown in Fig. 5, which functions to maintain the selected fluid delivery rate of the pump device constant. This control means consists of a fluid cylinder 60 in which a piston 61 is slidable and which has a piston rod 62 slidable through a head 63 screwed into an end of the cylinder. The rod 62 is operatively connected by means of a link 64 to an arm 65 on the shaft 43 of the valve member 40. A

spring 70 surrounding the rod 62 within the cylinder 60 has its opposite ends bearing against the piston 61 and the head 63 respectively so that the spring normally tends to force the piston toward the right so as to rotate the shaft 43 in clockwise direction and thus adjust the valve member 40 to a position wherein all of the slots 45a–45d of the valve member are in register with the ports 18 but out of register with the ports 19 to produce a maximum rate of delivery of the fluid to the discharge manifold 14. A fluid line 71 is connected between the discharge manifold 14 and the right-hand end of the cylinder 60 so that when fluid pressure of a value which exceeds the force of the spring 70 exists in the manifold 14 and line 71, the piston 61 is forced toward the left to rotate the shaft 43 and valve member 40 in counterclockwise direction. Rotation of the valve member 40 in this direction progressively closes the individual ports 18 and opens the ports 19 so as to reduce the rate of delivery of fluid into the discharge manifold 14. It will be noted that in the embodiment illustrated in Fig. 5, the check valves 25 are dispensed with, the control means 60, 61, etc., being employed in lieu thereof. Since the pressure of the discharged fluid in the manifold is proportional to the rate of fluid delivery, it follows that by automatically adjusting the setting of the valve member 40 in response to variations in this fluid pressure, a substantially constant rate of fluid delivery is maintained. As will be apparent, the control device can be readily adjusted to operate at selected pressures in the manifold 14 by merely screwing the head 63 inwardly and outwardly in the end of the cylinder 60 to vary the strength of the spring 70.

My improved fluid pump has been referred to herein as one of the variable delivery type. The term "variable delivery" is appropriately used only insofar as the pump is capable of delivering fluid at various selected but constant rates. In other words, the present pump is intended for use in maintaining a constant preselected rate of flow. By my improved construction, the pumping elements are operated continuously at a constant speed to continuously deliver a constant volume of the fluid per unit of time the ultimate rate of fluid delivered to the system in which the device is located being automatically controlled in response to variations in pressure in the discharge manifold. It is therefore unnecessary to increase or decrease the operational speed of the pumping elements and the pump device is thus greatly simplified.

While I have herein shown and described the improved variable delivery pump as embodied in two preferred forms of construction and as applied to use in a particular manner, it will be obvious that modifications might be made therein without departing from the spirit of the invention. Consequently I do not wish to be limited in this respect but desire to be afforded the full scope of the appended claims.

I claim as my invention:

1. A variable delivery pump, comprising: a housing having walls defining a fluid inlet manifold, a pump chamber, a valve chamber, a fluid pressure discharge manifold and a by-pass manifold, said housing also having a plurality of first ports in fluid communication between said inlet manifold and said pump chamber, a plurality of second ports in fluid communication between said pump chamber and said valve chamber, a plurality of third ports in fluid com-

munication between said valve chamber and said pressure manifold and a plurality of fourth ports in fluid communication between said valve chamber and said by-pass manifold, said first, second, third and fourth ports being equal in number; a plurality of pumping means, each in alignment with one of said first and second ports, disposed in said pump chamber and adapted for continuous, unitary operation; valve means movable in said valve chamber and provided with a series of axially spaced, transverse openings, each opening being arranged in continuous alignment with one of said second ports and being disposed at progressively greater angles with respect to an endmost opening of said series, each of said openings being adapted to also register with a said third and fourth port, said valve means being adapted to be moved in one direction to successively align certain of its openings with said third ports and successively disalign other of its openings with respect to said fourth ports so as to increase the volumetric flow of fluid from said second ports into said third ports to increase the delivery of fluid to said pressure discharge manifold, said valve means being also adapted to be moved in the opposite direction to successively disalign certain of its openings with respect to said third ports and successively align its other openings with said fourth ports so as to increase the delivery of fluid to said pressure discharge manifold and increase the delivery of fluid to said by-pass manifold; and control means for moving said valve means.

2. A variable delivery pump, comprising: a housing having walls defining a fluid inlet manifold, a pump chamber, a valve chamber, a fluid pressure discharge manifold and a by-pass manifold, said housing also having a plurality of first ports in fluid communication between said inlet manifold and said pump chamber, a plurality of second ports in fluid communication between said pump chamber and said valve chamber, a plurality of third ports in fluid communication between said valve chamber and said pressure manifold and a plurality of fourth ports in fluid communication between said valve chamber and said by-pass manifold, said first, second, third and fourth ports being equal in number; a plurality of pumping means, each in alignment with one of said first and second ports, disposed in said pump chamber and adapted for continuous, unitary rotation; valve means rotatable in said valve chamber and provided with a series of axially spaced transverse openings, each opening being arranged in continuous alignment with one of said second ports and being disposed at progressively greater angles with respect to an endmost opening of said series, each of said openings being adapted to also register with a said third and fourth port, said valve means being adapted to be rotated in one direction to successively align certain of its openings with said third ports and successively disalign other of its openings with respect to said fourth ports so as to increase the volumetric flow of fluid from said second ports into said third ports to increase the delivery of fluid to said pressure discharge manifold, said valve means being also adapted to be rotated in the opposite direction to successively disalign certain of its openings with respect to said third ports and successively align its other openings with said fourth ports so as to increase the delivery of fluid to said pressure discharge manifold and increase the delivery of fluid to said by-pass manifold; and control means for rotating said valve means.

3. A variable delivery pump, comprising: a housing having walls defining a fluid inlet manifold, a pump chamber, a valve chamber, a fluid pressure discharge manifold and a by-pass manifold, said housing also having a plurality of first ports in fluid communication between said inlet manifold and said pump chamber, a plurality of second ports in fluid communication between said pump chamber and said valve chamber, a plurality of third ports in fluid communication between said valve chamber and said pressure manifold and a plurality of fourth ports in fluid communication between said valve chamber and said by-pass manifold, said first, second, third and fourth ports being equal in number; a plurality of pumping means, each in alignment with one of said first and second ports, disposed in said pump chamber and adapted for continuous, unitary operation; valve means movable in said valve chamber and provided with a series of axially spaced openings, each opening being arranged in continuous alignment with one of said second ports and being disposed at progressively greater angles with respect to an endmost opening of said series, each of said openings being adapted to also register with a said third and fourth port, said valve means being adapted to be moved in one direction to successively align certain of its openings with said third ports and successively disalign other of its openings with respect to said fourth ports so as to increase the volumetric flow of fluid from said second ports into said third ports to increase the delivery of fluid to said pressure discharge manifold, said valve means being also adapted to be moved in the opposite direction to successively disalign certain of its openings with respect to said third ports and successively align its other openings with said fourth ports so as to increase the delivery of fluid to said pressure discharge manifold and increase the delivery of fluid to said by-pass manifold; a plurality of check valves in said pressure discharge manifold, each operative to permit fluid flow from a said third port into said pressure discharge manifold when the pressure of the fluid in that port equals a predetermined value but adapted to close in response to a pressure drop of the fluid in said third port below said predetermined value so as to maintain the fluid in said pressure discharge manifold at a substantially constant pressure; and control means for moving said valve means.

4. A variable delivery pump as defined in claim 3 and including: spring means for actuating said check valves; and means for adjusting the tension of each of said spring means.

5. A variable delivery pump as defined in claim 3, in which each of said third ports is provided with a valve seat, each of said check valves being engageable with one of said seats, and including: a spring means normally operative to seat each of said check valves; and adjusting means accessible from the exterior of said housing for adjusting the tension of each spring means.

6. A variable delivery pump, comprising: a housing having walls defining a fluid inlet manifold, a pump chamber, a valve chamber, a fluid pressure discharge manifold and a by-pass manifold, said housing also having a plurality of first ports in fluid communication between said inlet manifold and said pump chamber, a plurality of second ports in fluid communication between

said pump chamber and said valve chamber, a plurality of third ports in fluid communication between said valve chamber and said pressure manifold and a plurality of fourth ports in fluid communication between said valve chamber and said by-pass manifold, said first, second, third and fourth ports being equal in number; a plurality of pumping means, each in alignment with one of said first and second ports, disposed in said pump chamber and adapted for continuous, unitary rotation; valve means rotatable in said valve chamber and provided with a series of axially spaced transverse openings, each opening being arranged in continuous alignment with one of said second ports and being disposed at progressively greater angles with respect to an endmost opening of said series, each of said openings being adapted to also register with a said third and fourth port, said valve means being adapted to be rotated in one direction to successively align certain of its openings with said third ports and successively disalign other of its openings with respect to said fourth ports so as to increase the volumetric flow of fluid from said second ports into said third ports to increase the delivery of fluid to said pressure discharge manifold, said valve means being also adapted to be rotated in the opposite direction to successively disalign certain of its openings with respect to said third ports and successively align its other openings with said fourth ports so as to increase the delivery of fluid to said pressure discharge manifold and increase the delivery of fluid to said by-pass manifold; and means responsive to fluid pressure in said pressure discharge manifold for controlling the flow of fluid through said third ports into said pressure discharge manifold.

7. A variable delivery pump, comprising: a housing having walls defining a fluid inlet manifold, a pump chamber, a valve chamber, a fluid pressure discharge manifold and a by-pass manifold, said housing also having a plurality of first ports in fluid communication between said inlet manifold and said pump chamber, a plurality of second ports in fluid communication between said pump chamber and said valve chamber, a plurality of third ports in fluid communication between said valve chamber and said pressure manifold and a plurality of fourth ports in fluid communication between said valve chamber and said by-pass manifold, said first, second, third and fourth ports being equal in number; a plurality of pumping means, each in alignment with one of said first and second ports, disposed in said pump chamber and adapted for continuous, unitary rotation; valve means rotatable in said valve chamber and provided with a series of axially spaced transverse openings, each opening being arranged in continuous alignment with one of said second ports and being disposed at progressively greater angles with respect to an endmost opening of said series, each of said openings being adapted to also register with a said third and fourth port, said valve means being adapted to be rotated in one direction to successively align certain of its openings with said third ports and successively disalign other of its openings with respect to said fourth ports so as to increase the volumetric flow of fluid from said second ports into said third ports to increase the delivery of fluid to said pressure discharge manifold, said valve means being also adapted to be rotated in the opposite direction to successively disalign certain of its openings with respect to said third ports and successively align its other openings with said fourth ports so as to increase the delivery of fluid to said pressure discharge manifold and increase the delivery of fluid to said by-pass manifold; and means responsive to fluid pressure in said pressure discharge manifold for controlling the total flow of fluid through any or all of said third ports into said pressure discharge manifold.

8. A variable delivery pump, comprising: a housing having walls defining a fluid inlet manifold, a pump chamber, a valve chamber, a fluid pressure discharge manifold and a by-pass manifold, said housing also having a plurality of first ports in fluid communication between said inlet manifold and said pump chamber, a plurality of second ports in fluid communication between said pump chamber and said valve chamber, a plurality of third ports in fluid communication between said valve chamber and said pressure manifold and a plurality of fourth ports in fluid communication between said valve chamber and said by-pass manifold, said first, second, third and fourth ports being equal in number; a plurality of pumping means, each in alignment with one of said first and second ports, disposed in said pump chamber and adapted for continuous, unitary rotation; valve means rotatable in said valve chamber and provided with a series of axially spaced transverse openings, each opening being arranged in continuous alignment with one of said second ports and being disposed at progressively greater angles with respect to an endmost opening of said series, each of said openings being adapted to also register with a said third and fourth port, said valve means being adapted to be rotated in one direction to successively align certain of its openings with said third ports and successively disalign other of its openings with respect to said fourth ports so as to increase the volumetric flow of fluid from said second ports into said third ports to increase the delivery of fluid to said pressure discharge manifold, said valve means being also adapted to be rotated in the opposite direction to successively disalign certain of its openings with respect to said third ports and successively align its other openings with said fourth ports so as to increase the delivery of fluid to said pressure discharge manifold and increase the delivery of fluid to said by-pass manifold; and automatic control means for rotating said valve means.

9. A variable delivery pump, comprising: a housing having walls defining a fluid inlet manifold, a pump chamber, a valve chamber, a fluid pressure discharge manifold and a by-pass manifold, said housing also having a plurality of first ports in fluid communication between said inlet manifold and said pump chamber, a plurality of second ports in fluid communication between said pump chamber and said valve chamber, a plurality of third ports in fluid communication between said valve chamber and said pressure manifold and a plurality of fourth ports in fluid communication between said valve chamber and said by-pass manifold, said first, second, third and fourth ports being equal in number; a plurality of pumping means, each in alignment with one of said first and second ports, disposed in said pump chamber and adapted for continuous, unitary rotation; valve means rotatable in said valve chamber and provided with a series of axially spaced transverse openings, each opening being arranged in continuous alignment with one of said second ports and being disposed at

progressively greater angles with respect to an endmost opening of said series, each of said openings being adapted to also register with a said third and fourth port, said valve means being adapted to be rotated in one direction to successively align certain of its openings with said third ports and successively disalign other of its openings with respect to said fourth ports so as to increase the volumetric flow of fluid from said second ports into said third ports to increase the delivery of fluid to said pressure discharge manifold, said valve means being also adapted to be rotated in the opposite direction to successively disalign certain of its openings with respect to said third ports and successively align its other openings with said fourth ports so as to increase the delivery of fluid to said pressure discharge manifold and increase the delivery of fluid to said by-pass manifold; and automatic control means responsive to variations in pressure in said pressure discharge manifold for rotating said valve means.

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