Dec. 22, 1959 W. R. EAMES 2,918,013

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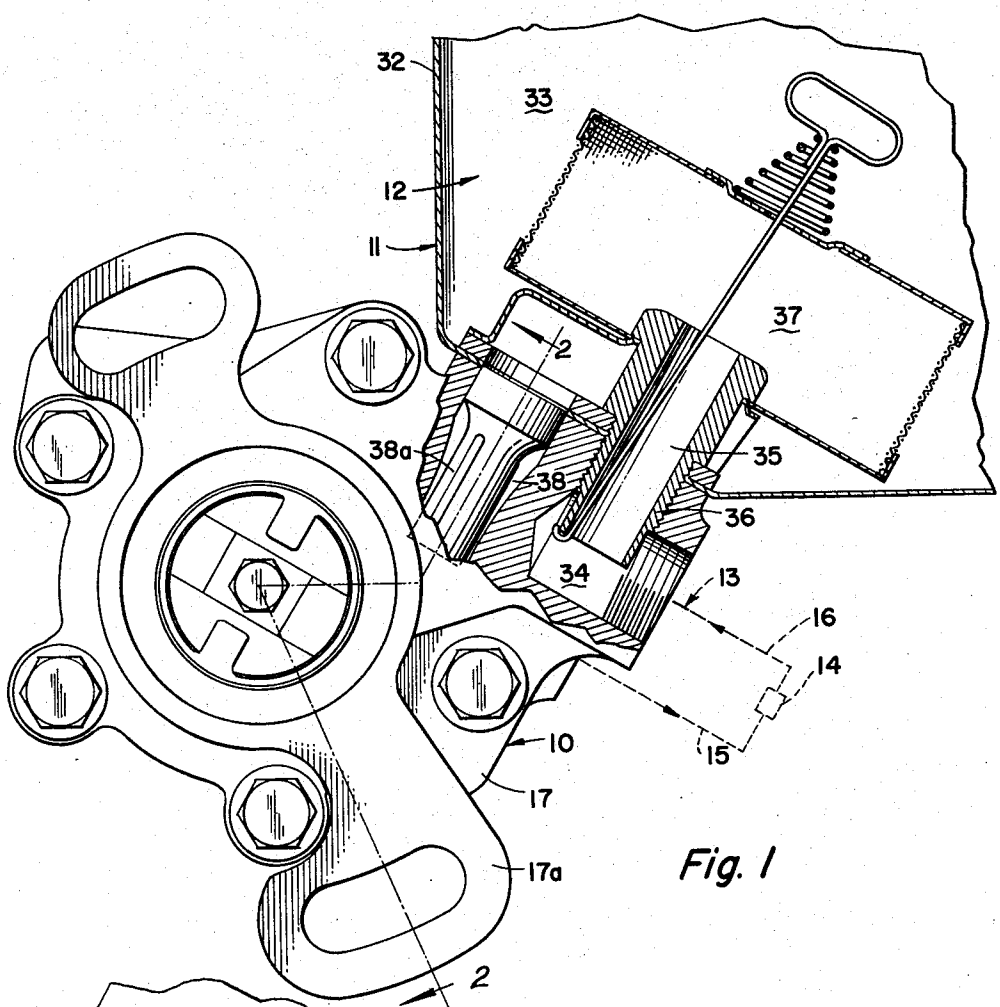



Fig. 1

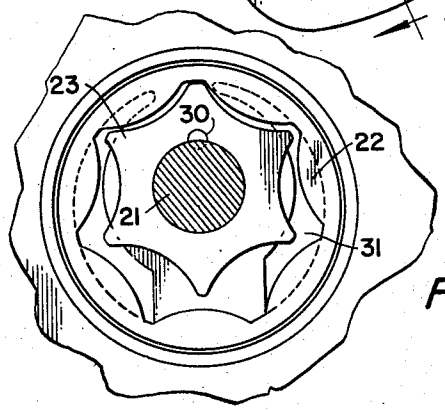



Fig. 3

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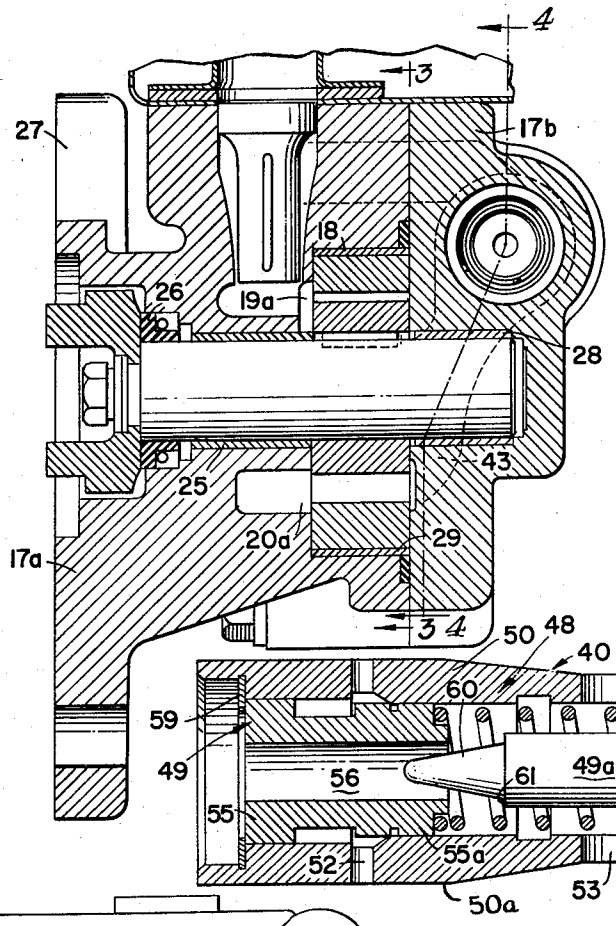



Fig. 2

Fig. 5

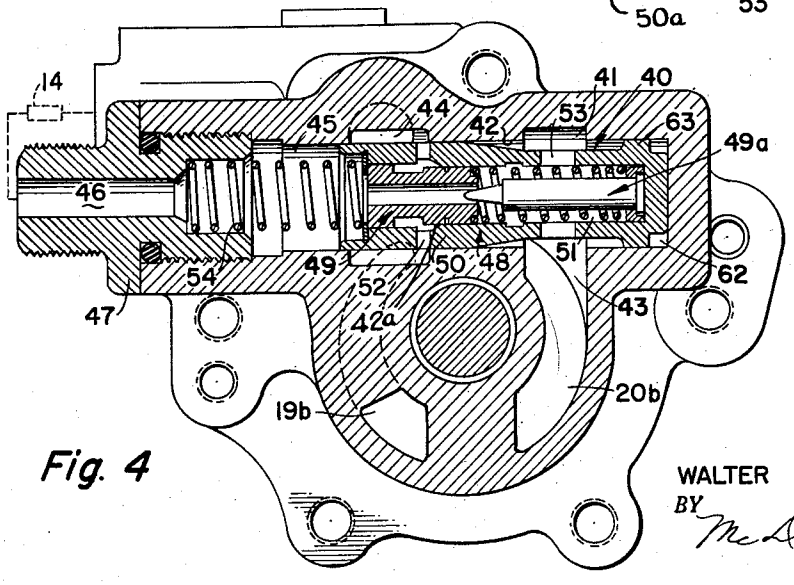



Fig. 4

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2,918,013

# PUMP

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Application May 18, 1955, Serial No. 509,247

4 Claims. (Cl. 103—42)

This invention relates to fluid pumps and, more particularly, to positive displacement pumps embodying novel flow control valve means. The invention is disclosed herein with reference to rotary pumps of the gear type, but is also applicable to other types of pumps.

Rotary pumps of the gear type are being used as a part of the auxiliary equipment of motor vehicles, as for example, for supplying fluid under pressure for actuating a hydraulic power steering device. When so used, the pump is usually driven from the vehicle power plant, and accordingly, is operated at widely varying rates of speed.

The rotary pump intended for this kind of service must be built of a size such that during its low speed operation it will be capable of delivering fluid at volume and pressure values suitable for the actuation of the steering device, or other auxiliary hydraulic device being supplied with the pumped fluid, and hence, when the pump is being driven at a relatively high speed its fluid delivery capacity may have volume and pressure values considerably in excess of the requirements of the auxiliary device being supplied.

The auxiliary device being supplied with fluid is usually contained in a closed-loop external hydraulic circuit through which the fluid is forced by the pump. When the excess fluid is forced through such a circuit at relatively high pressure and velocity values, it produces objectionable noises. The present invention is particularly concerned with the bypassing of such excess fluid from the discharge side to the intake side of the pump and, as its principal object, aims to provide a rotary pump having novel fluid control valve means by which the fluid being delivered will be automatically reduced in volume proportionately to increase in pressure and by which the excess fluid will be by-passed quietly and efficiently within the pump structure.

Another object of this invention is to provide a rotary pump of this character having novel fluid control valve mechanism comprising a volume control valve means.

A further object is to provide a rotary pump in which the fluid control means includes a variable flow control orifice through which the pumped fluid is delivered and valve means which is responsive to the pressure differential across the orifice.

Still another object is to provide a rotary pump of the character mentioned in which the valve mechanism of the control means comprises a volume control valve means and a variable orifice valve means.

Yet another object is to provide a rotary pump in which the control valve mechanism is simple and compact and comprises a volume control valve means and a variable orifice valve means in a coaxially disposed relation, preferably with the variable orifice valve means movable in the hollow volume control valve means.

The invention can be further briefly summarized as consisting in certain novel combinations and arrangements of parts hereinafter described and particularly set out in the claims hereof.



In the accompanying sheets of drawings:

Fig. 1 is an end view showing the rotary pump of this invention embodied in a pumping unit and with the reservoir of the pumping unit shown in vertical section;

Fig. 2 is a partial vertical section taken through the pump on the irregular section line 22 of Fig. 1;

Fig. 3 is a partial vertical section taken through the pump on section line 33 of Fig. 2 and showing the cooperating toothed rotors;

Fig. 4 is a vertical section taken through the valve mechanism of the pump, the view being taken on section line 4—4 of Fig. 2; and

Fig. 5 is a sectional view on an enlarged scale corresponding substantially with a portion of Fig. 4 and further illustrating the valve mechanism thereof.

Before proceeding with the detailed description of the rotary pump 10, it should be explained that this pump is here shown, by way of example, as forming a part of a pumping unit 11 of the kind intended to be used on motor vehicles in conjunction with the actuation of one or more hydraulic auxiliary devices such as a hydraulic power steering device. In addition to the pump 10, the pumping unit 11 comprises a reservoir 12 mounted directly on the pump and adapted to contain a quantity of oil or other suitable hydraulic fluid, and an external closed-loop fluid circuit 13. The external fluid circuit 13 contains the hydraulic device being actuated, such as the power steering deivce 14 which is here shown only diagrammatically, and fluid pressure delivery and return conduits 15 and 16 connecting the steering device 14 with the pump 10.

The pump 10 comprises a housing 17 which is here shown as being formed by a pair of connected housing members consisting of a body member $17^a$ and a cover member $17^b$. The body member $17^a$ has a substantially cylindrical working chamber or rotor chamber 18 therein, and also has a pair of arcuate intake and discharge ports $19^a$ and $20^a$ therein at one end of the rotor chamber. The cover member $17^b$ forms a closure for the rotor chamber and has a pair of arcuate intake and discharge ports $19^b$ and $20^b$ formed therein at the other end of the rotor chamber.

The rotary pump 10 also includes pump means operable in the chamber 18 and which pump means is here shown as comprising a shaft 21 and a pair of cooperating toothed rotors 22 and 23 adapted to be driven by the shaft. The shaft 21 has its inner end rotatably supported in the body member $17^a$ by a bushing 25 mounted in the latter. This end of the shaft projects through a sealing device 26 and is adapted for connection with some available rotatable part of the vehicle power plant from which the pump 10 is to be driven. The body member $17^a$ is provided with a suitable mounting flange 27 by which the pump 10 is adapted to be secured to an available support. The opposite or outer end of the shaft 21 is rotatably supported in the cover member $17^b$ by a bushing 28 mounted in the latter.

The outer rotor member 22 is an internal gear rotatably supported in the rotor chamber 18 by the annular bushing or liner 29. The inner rotor member 23 comprises a gear member mounted on the shaft 21 and connected therewith by means of the key 30. The outer and inner rotor members 22 and 23 have their toothed portions in meshing engagement and define variable pumping chambers 31 which communicate in succession with the intake and discharge ports $19^a$, $19^b$ and $20^a$, $20^b$ to produce the desired pumping action.

The reservoir 12 comprises a substantially cup-shaped structure 32 which is mounted directly on the body member $17^a$ of the rotary pump 10 and defines a reservoir chamber 33. Fluid being returned to the pump 10 from the steering mechanism 14 through the conduit 16 flows

into the reservoir chamber 33 through a passage 34 of the body member 17a and through the passage 35 of a fitting 36 which extends axially of the reservoir chamber. The fitting 36 supports a strainer 37 through which the returning fluid passes for the separation of foreign particles therefrom.

Fluid is supplied to the intake port 19a from the reservoir chamber 33 through a passage 38 formed in the body member 17a in depending relation to the reservoir chamber by way of a flow directing tube 38a inserted therein. The pumped fluid is delivered into the discharge port 20b by the pumping chambers 31 and is supplied to the conduit 15 of the external fluid circuit 13 under pressure through control valve mechanism 40 which will be presently described in detail.

In the operation of the pumping unit 11 above described, it is desirable that the rotary pump 10 supply fluid to the external fluid circuit 13 at a rate not to exceed a predetermined maximum regardless of widely varying rates of speeds at which the pump is driven by the vehicle engine. The capacity of the pump 10 must be such that the volume and pressure values of the fluid which is supplied to the external circuit 13 during a relatively low speed operation of the pump, will be adequate for the requirements of the steering mechanism 14, and accordingly, during a relatively high speed operation of the pump the quantity of pumped fluid will be substantially in excess of that required by the steering mechanism. The control valve mechanism 40 serves to by-pass the excess quantity of the pumped fluid from the discharge side of the pump to the intake side thereof and accomplishes this internally of the pump structure in a quiet and efficient manner.

As shown in the drawings, a portion of the cover member 17b has a substantially cylindrical valve chamber 41 formed therein which extends in spanning relation to the pair of intake and discharge ports 19b and 20b. The valve chamber 41 is provided at an intermediate point thereof with an internal annular valve seat 42. Inwardly of the valve seat 42, the valve chamber 41 is in communication with the discharge port 20b through a connecting passage 43. Outwardly of the valve seat 42, the valve chamber 41 is in communication with the intake port 19b through a connecting passage 44. The outer end portion of the valve chamber 41 forms a delivery passage 45 for the pumped fluid and with which the delivery conduit 16 of the external fluid circuit 13 is connected through the passage 46 of the fitting or plug 47.

The valve means 40 which is operable in the valve chamber 41 is in the form of a valve assembly comprising a volume control valve member 48, a valve member 49 and a metering rod 49a. The volume control valve member 48 comprises a hollow valve member having a valve plunger portion 50 which is slidable in the valve chamber 41 and sealingly cooperates with the valve seat 42. The valve member 48 has an axial passage 51 therein and the valve plunger portion 50 of this valve member has a pair of ports 52 therein which communicates with the connecting passage 44 leading to the intake port 19b.

The wall of the hollow valve member 48 is provided with one or more openings 53 at a point inwardly of the valve plunger portion 50 and which connect the axial passage 51 of this valve member with the connecting passage 43 leading from the discharge port 20b. A compression spring 54 disposed between the fitting 47 and the outer end of the valve member 48 urges the latter toward the right as seen in Fig. 4 and tends to shift the valve member toward a position of closed engagement of the valve plunger portion 50 with the valve seat 42.

The operative member 49 of the valve assembly 40 is located in the outer end of the axial passage 51 of the hollow valve member 40 and is in the form of a plunger slidably cooperable with rod 49a. Valve member 49 is provided with axially opposite, different area, pressure fluid opposed heads 55 and 55a and an axial passage 56 extending therethrough into communication with passage 51 on opposite ends thereof.

Metering or flow modulating rod 49a is arranged in passage 51 adjacent the closed end of member 48 and is supported therein by a collar 57 embracing one flanged end 49b of the rod. Collar 57 is in turn held upon the closed end of member 48 by a compression spring 58 interposed in passage 52 intermediate the collar 57 and the smaller area head 55a of valve member 49. A spring retaining ring 59 retains valve member 49 in the valve member 48 against the force of spring 58.

The axial opposite end of rod 49a from flanged end 49b thereof is in the form of a taper or needle point 60 with the base thereof adjacent a shoulder 61 of the rod. Taper 60 is positioned in head 55a end of passage and is cooperative therewith upon relative axial movement between valve member 49 and rod 49a to provide a variable or metering flow control orifice.

The variable orifice provided cooperatively between valve member 49 and rod 49a is the means through which the delivery passage 45 of the pump 10 is connected with discharge port 20b.

To first explain the volume control function of the valve mechanism 40 in a general way, it is pointed out that under normal operating conditions the delivery passage 45 of the pump 10 is filled with pumped fluid under the pressure of the fluid being supplied to the closed-loop external fluid circuit 13 through the delivery conduit 15. This fluid pressure acts continuously against the outer ends of the volume control valve member 48 and the valve member 49, that is to say, this pressure acts continuously against the outer end of the valve assembly 40. When the pump 10 is being driven at a speed such that the volume of pumped fluid being delivered through the discharge port 20b is in excess of that required in the external fluid circuit, the valve assembly 40 is shifted toward the left in opposition to the spring 54 causing an opening of the valve member 48 to permit such excess fluid to be returned directly to the intake port 19b.

To explain the volume control function in greater detail it is pointed out that the fluid which is in the valve chamber 41 at the right of head 55a of valve member 49 can be referred to as being upstream relative to the orifice provided by passage 56 of valve member 49 and taper 60. The fluid in the portion of the valve chamber constituting the delivery passage 45 can be referred to as being downstream with respect to the orifice. The pressure of the fluid on the upstream side of the orifice is greater than the pressure of the fluid on the downstream side of the orifice and the difference in these pressures is referred to as the differential pressure across the orifice.

In accordance with a known law of physics, this differential pressure varies with the rate of flow through the orifice such that the greater the flow of fluid through the orifice, the greater the differential pressure will be. The construction of the valve assembly 40 is such that the effective area which is subjected to the pressure of the upstream fluid is substantially equal to the effective area which is subjected to the pressure of the downstream fluid. The valve assembly is, therefore, substantially balanced except for the force of the compression spring 54 and the pressure differential across the orifice.

When the speed of the pump 10 increases, as just above mentioned, the pressure of the upstream fluid in the valve chamber 41 will increase and will produce an increased rate of flow through the orifice and the pressure differential across the orifice will likewise increase. The resultant effect of the increased pump speed will be to produce a movement of the valve assembly 40 toward the left against the action of the spring 54, such that the annular edge or shoulder 50a of the valve plunger portion 50 will move past the annular edge or shoulder 42a of the valve seat 42 to establish communication between the discharge port 20b and the intake port 19b. Thereupon, pumped fluid will be bypassed from the discharge

port to the intake port in an amount depending upon the extent of the opening movement of the plunger portion 50 of the valve member 48 and will result in the volume of fluid being supplied to the external fluid circuit 13 being automatically controlled not to exceed a predetermined maximum as regulated by the orifice when no relative axial movement takes place between valve member 49 and rod 49a.

The valve member 49 is constructed so that the right hand end thereof, which is exposed to the pressure of the upstream fluid, that is head 55a, is of a smaller area than the left hand end, head 55, which is exposed to the pressure of the downstream fluid. Whenever operating conditions are such that the pressure of the fluid in the discharge passage 45 and in the closed-loop external fluid circuit 13 increases above a desired value, such pressure increase will move the valve member 49 toward the right against the action of the spring 58. This movement of the valve member 49 acts to meter or vary the orifice provided by passage 56 and taper 60 between the delivery passage 45 and the intake port 19b. This will result in a reduced volume of fluid being delivered through the delivery passage 45 from the intake port 19b in an amount depending upon the extent of closing movement of the passage 56 by the taper 60.

The valve chamber 41 is of such construction that the inner end thereof defines a dashpot chamber or cylinder 62. A plunger 63 formed on or carried by the inner end of the volume control valve member 48, operates in this dashpot cylinder. The dashpot means formed by the cylinder 62 and the plunger 63, provides an additional bearing surface and aligning means for the movable valve member 48, and the dashpot action produced is effective on the valve member 48 to substantially eliminate the tendency for this valve member to oscillate or chatter. The dashpot means, therefore, assures smoother and more efficient operation of the valve assembly 40 throughout a long period of life.

By reason of the variable orifice provided through the axial movement of valve member 49 against spring 58 wherein passage 56 is controlled to size at head 55a end of member 49 by taper 60, it is possible to provide a high or maximum predetermined rate of flow for say high speed, low pressure operation of power steering device 14. This operation is desirable in the case where quick reaction is necessary in the driving of an automotive vehicle down a highway or when making a quick turn at moderate speeds. This high rate of flow, however, would be objectionable in the parking of a vehicle and accordingly, through the operative movement of the valve member to vary the orifice provided between its passage 56 and taper 60, a lower rate of flow for low speed, high pressure steering is accomplished. Taper 60 operates with continued axial movement of valve member 49 against spring 58 to meter the flow at a gradual rate up to a predetermined pressure of the pumped fluid and shoulder 61 acts to increase the rate of drop at a faster rate above said predetermined pressure until a no flow condition is reached when a maximum pressure is attained.

From the foregoing detailed description and the accompanying drawings, it will now be readily understood that this invention provides forms of positive displacement rotary pumps which are well suited for use in supplying fluid under pressure to a closed-loop external fluid circuit and which embody control valve mechanism by which the volume and maximum pressure values of the fluid thus supplied will be automatically maintained at the values desired for the external fluid circuit, regardless of wide variations occurring in the speed at which the pumps are driven. It will now also be understood that the control valve mechanism herein provided includes a volume control valve device and a variable orifice valve device, both of which are responsive to the pressure of the pumped fluid and with the volume control valve operative to bypass fluid from the discharge side of the pump to the intake side thereof and in which such bypassing of pumped fluid takes place efficiently and quietly within the pump structure such that objectionable noises in the external fluid circuit will be substantially prevented. It will likewise be seen that the volume control valve device is responsive to a pressure differential across the orifice and the variable orifice valve device is operable proportionately to the increase in pumped fluid pressure.

Although the improved rotary pumps of this invention have been illustrated and described herein to a somewhat detailed extent, it will be understood of course, that the invention is not to be regarded as being limited correspondingly in scope, but includes all changes and modifications coming within the terms of the claims hereof.

Having thus described my invention, I claim:

1. In a control valve construction having inlet and outlet passages for pressure fluid and an interposed chamber means through which a fluid flow path leads from one passage to the other, a compound valve assembly movable within the chamber means and cooperating therewith to form a controlled passage connected to a bypass outlet spaced apart with respect to the inlet and outlet passages, said compound assembly including a pressure-differential-producing orifice interposed in the fluid flow path within the chamber means and comprising telescopically related hollow valves, the outer valve controllably covering said controlled passage and being pressure movable for progressively opening the same in response to the flow pressure differential produced by said orifice, the inner valve having said orifice and a set of opposite ends thereon which present a difference in areas exposed to fluid pressure for forcing the valve to move under pressure, and metering means movable with said outer valve and disposed adjacent said orifice so that longitudinal movement of said inner valve with respect to said metering means varies the flow area of said orifice.

2. A pressure fluid control valve construction having a central bore, a compound hollow valve assembly therein and providing a variable restriction to fluid flow within the bore, and a lateral outlet adjacent said bore, said valve assembly comprising inner and outer telescopically related valves, said inner valve having dissimilar ends for presenting unequal opposite areas to pressure fluid to move under the differential force of pressure fluid thereagainst, said outer valve being pressure movable under the influence of the pressure difference caused by the pressure drop across the restriction for progressively opening a passage connected to the lateral outlet, and said variable restriction constituting an orifice in said inner valve, a metering rod movable with said outer valve, and said variable restriction being controlled as to size by the relative longitudinal position of said inner valve orifice with respect to said metering rod.

3. In a rotary pump, a housing having a rotor chamber therein, rotor means operable in said rotor chamber and defining variable pumping chambers, said housing also having intake and discharge ports therein adapted respectively to supply intake fluid to and receive pumped fluid from said pumping chambers, portions of said housing defining a valve chamber having an internal annular valve seat therein and having communication with said intake and discharge ports on opposite sides of said valve seat, means defining a delivery passage for the external delivery of pumped fluid from said pump, valve means operable in said valve chamber and comprising a volume control valve member and an orifice control valve member, said volume control valve member comprising a hollow valve plunger cooperating with said first valve seat, said control valve member comprising a second valve plunger movable in said hollow valve plunger, a first spring means effective on said volume control valve member and urging the same toward its closed position,

a second spring means effective on said control valve member and urging the same toward its at rest position, metering means adjacent said control valve member and forming therewith a variable flow control orifice through which said delivery passage is connected with said discharge port, said volume control valve member being responsive to the resultant effect of said first spring means and the fluid pressure differential across said orifice for by-passing fluid from said discharge port to said intake port for maintaining the fluid delivery in said delivery passage at a volume in accordance with the size of said orifice, said control valve member being responsive to the resultant effect of said second spring means and the fluid pressures acting on opposite ends of said control valve member for varying the size of said orifice.

4. In a rotary pump, a housing having a rotor chamber therein and a pair of intake and discharge ports communicating with said rotor chamber at spaced points, rotor means operable in said rotor chamber and defining variable pumping chambers therein for producing a pumping action, portions of said housing defining a substantially cylindrical valve chamber spanning said intake and discharge ports and having an annular valve seat therein at a point intermediate its ends, said discharge port being in communication with said valve chamber at a point between the inner end of the valve chamber and said valve seat and said intake port being in communication with said valve chamber outwardly of said valve seat, the outer end portion of said valve chamber forming a delivery passage for the external delivery of



pumped fluid from the pump, a hollow valve member slidable in said valve chamber and cooperating with said valve seat, spring means effective on said hollow valve member and urging the same toward a closed position relative to said valve seat, a second valve member movable in said hollow valve member and having a size controllable orifice therein, spring means effective on said second valve member and urging the same toward an at rest position, and metering means movable with respect to said second valve member for controlling the size of the orifice in said second valve member, said hollow valve member constituting a by-pass valve means operable to by-pass fluid from said discharge port to said intake port for automatically maintaining the fluid delivery in said delivery passage at a volume in accordance with the size of said orifice.

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