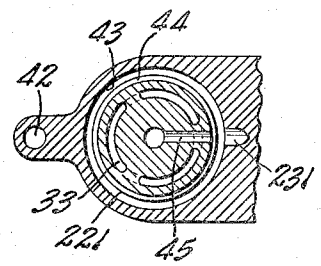
Dec. 14, 1954 F. D. FUNSTON 2,696,788

VARIABLE VOLUME CONSTANT PRESSURE PUMP

Filed Feb. 13, 1951

Fig. 3



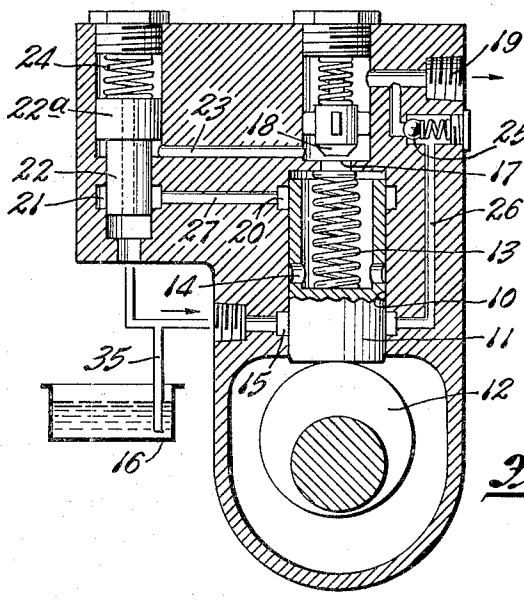


Fig. 1

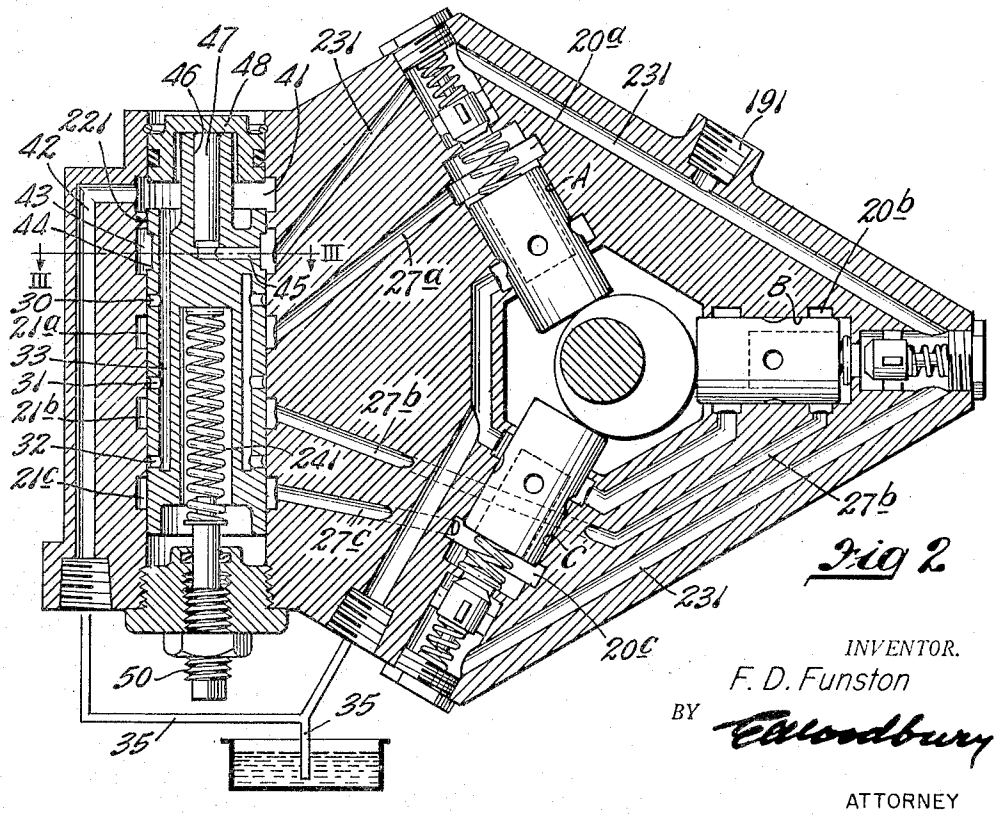


Fig 2

INVENTOR.
F. D. Funston
BY Cadwalader
ATTORNEY

United States Patent Office 2,696,788 Patented Dec. 14, 1954

2,696,788

VARIABLE VOLUME CONSTANT PRESSURE PUMP

Frederick D. Funston, Tujunga, Calif., assignor to Bendix Aviation Corporation, South Bend, Ind., a corporation of Delaware

Application February 13, 1951, Serial No. 210,645

7 Claims. (Cl. 103—42)

This invention relates to pumps for supplying liquid at constant pressure and variable volume dependent upon the demand placed upon it. The invention is particularly applicable to hydraulic power systems for vehicles such as tractors, airplanes, etc. in which the pump is coupled to the vehicle engine and runs constantly whether or not there is a demand upon it.

An object of the invention is to provide a simple inexpensive and reliable pump of the type referred to.

Other more specific objects and features of the invention will appear from the description to follow.

Basically, a pump in accordance with the invention comprises a plunger reciprocating in a cylinder, the cylinder having an inlet port in its side wall which is uncovered by the plunger at the end of its suction stroke, and having in its end an outlet port connected by a check valve with a delivery or pressure passage. To unload the pump when no fluid is being utilized, an exhaust port is provided in the wall of the cylinder in such position as to be covered by the plunger only near the end of its pumping stroke. This exhaust port is connected to a low pressure return line by a valve that is normally closed, but is opened by pressure in the delivery passage when that pressure rises to a predetermined value. When the delivery pressure is up, the plunger discharges fluid at low pressure through the exhaust port with little waste of power and heating of the fluid. Further in accordance with the invention, the exhaust port is so located that the plunger moves slightly past it on each stroke, whereby it pumps a small amount of fluid even when the exhaust valve is open, and a relief valve is provided to prevent the pressure in the delivery (pressure) passage from rising much above the predetermined pressure at which the exhaust valve opens. The slight amount of fluid that is pumped when the pressure is up takes care of leakage losses and prevents the pressure-responsive valve from constantly opening and closing during periods when there is no demand on the pump.

A full understanding of the invention may be had from the following detailed description with reference to the drawing in which:

Fig. 1 is a schematic diagram of a single cylinder pump incorporating the invention;

Fig. 2 is a schematic diagram of a triple cylinder pump incorporating the invention; and

Fig. 3 is a section taken on line III—III of Fig. 2.

Referring first to Fig. 1, the pump proper consists of a cylinder **10** containing a plunger **11** which is repeatedly cycled through a full stroke by a constantly rotating cam **12**. The piston is returned by a spring **13**. In the bottom stroke position of the plunger **11**, a port **14** therein registers with an inlet port **15** in the cylinder to draw in fluid from a reservoir **16** through an intake pipe **35**. During the upstroke of the plunger the fluid is discharged through one or both of two paths.

The main discharge path is through a discharge valve seat **17** in the top of the cylinder, past a spring-closed discharge valve **18**, to a delivery port **19**. When the pressure in the delivery port **19** is below a predetermined value, all of the fluid is displaced past the valve **18** and through the port **19**.

A separate exhaust path for the escape of fluid is provided through a port **20** in the cylinder wall near the upper end thereof, which port is covered by the upper end of the plunger **11** shortly before it reaches its upper limit position. This port **20** is connected by an exhaust passage **27** to a port **21** in a pressure-controlled exhaust

valve, which port is covered by a valve piston **22** whenever the pressure in the delivery port **19** is below a predetermined value. The valve piston **22** has an enlarged head **22***a*, the underside of which is connected by a passage **23** to the delivery port **19**, so that the pressure of the delivered fluid is constantly applied to the underside of the head **22***a*, in opposition to the force of a spring **24** that urges the valve piston **22** downward. It will be observed that as long as the delivery pressure is below a predetermined value, the valve piston **22** covers the port **21**, and all of the fluid displaced by upward movement of the pump plunger **11** is delivered to the delivery port **19**. However when the pressure in the delivery port rises above the predetermined value, the lower end of the valve piston **22** uncovers the port **21**, and thereafter fluid within the cylinder **10** is exhausted through the port **20** and the port **21** and through the intake pipe **35** back to the reservoir **16**, during the major portion of the upward stroke of the piston **11**. Very little work is performed by the plunger **11** during this portion of its stroke, because the fluid is returned to the reservoir at low pressure. During the small movement of the plunger **11** at the upper end of its stroke after it has covered the port **20**, fluid is delivered past the valve **18** to the delivery port **19**, and during this small portion of its stroke the plunger is doing work.

If no fluid is being withdrawn, the slight amount of fluid supplied by the plunger **11** at the upper end of its stroke is vented past a conventional relief valve **25** through a passage **26** and through the port **15** back to the reservoir **16**.

When the port **21** is closed by the valve **22**, the plunger **11** draws a vacuum in the cylinder **10** during its down stroke until the intake port **15** is uncovered, whereupon the fluid rushes in. When the valve **22** is open, fluid can enter the cylinder through port **20** while the plunger is moving through the major portion of its suction stroke.

It is old to run a pump continuously and vent all of the fluid through a relief valve back to the reservoir when no fluid is being used. However, such systems are objectionable because they waste power and overheat the fluid. The present invention pumps so little fluid against high pressure, when no fluid is being drawn from the port **19**, that it can be readily vented through the relief valve **25** without an appreciable waste of energy and without appreciable overheating. The bulk of the pumped fluid is returned to the reservoir at low pressure.

Fig. 2 shows the adaptation of the invention to a multi-cylinder pump. In this figure three cylinders, A, B and C correspond in structure to the cylinder **10** of Fig. 1, each having a similar piston, ports, etc. The only essential difference is in the construction of the pressure control valve. Thus, in Fig. 2, the exhaust passages **27***a*, **27***b* and **27***c*, each corresponding to the exhaust passages **27** of Fig. 1, connect to three different ports **21***a*, **21***b* and **21***c* associated with the pressure controlled exhaust piston valve **221**, which corresponds to the exhaust valve **22** of Fig. 1, except that it has three separate ports **30**, **31** and **32** adapted to individually communicate the ports **21***a*, **21***b* and **21***c* with an annular exhaust passage **33** in the piston valve which passage communicates with the reservoir through a port **41** in the body, and a passage **42** that connects to the return pipe **35**.

A delivery passage **231** connects the delivery passages of all three cylinders A, B and C to each other, to a common delivery port **191**, and to a port **43** in the valve cylinder that communicates with a port **44** in the valve piston **221** in all positions of the latter.

The port **44** is connected by a passage **45** with a cylindrical counterbore **46** in the upper end of the valve piston, to develop pressure between the lower end of the counterbore and the lower end of a plug **47** which is slidably fitted in the counterbore. A cap **48** closes and seals the upper end of the valve cylinder and supports the plug **47** against upward movement.

The pressure fluid in the counterbore opposes the spring **241**, and when the delivery pressure rises to a predetermined value it moves the valve piston down to register the ports **30**, **31** and **32** respectively with the ports **21***a*, **21***b* and **21***c*, and unload the pump by permitting

fluid to leave the cylinder ports **20***a*, **20***b* and **20***c* at low pressure.

When the delivery pressure rises slightly above that at which the pump unloads, the valve piston **221** is further depressed to communicate the pressure port **43** with the return port **41** and relieve the pressure .

The piston valve **221** therefore performs both the function of unloading the pump and the function of relieving excess pressure, thereby eliminating the need of a separate relief valve as in Fig. 1. The arrangement of Fig. 2 has the advantage over that of Fig. 1 in that it is impossible for the relief valve to function before the unloading valve functions, and both can be adjusted to vary the delivery pressure by changing the loading of the single spring **241**. A screw **50** is provided for this purpose.

Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

1. A pump comprising: a cylinder having a plunger reciprocable therein and means for reciprocating said plunger; means defining a pressure fluid delivery passage, and a check valve connecting one end of said cylinder to said delivery passage in response to pressure in said cylinder exceeding the pressure in said delivery passage; means defining an inlet passage adapted to be connected to a source of fluid to be pumped, and means for admitting fluid from said inlet passage into said cylinder in response to suction in said cylinder; means defining an exhaust passage connected to said cylinder adjacent said one end thereof through a port in the side of the cylinder so longitudinally positioned as to be covered by said plunger prior to completion of its working stroke for exhausting fluid therefrom at low pressure; exhaust valve means normally closing said exhaust passage; and means responsive to pressure in said delivery passage for opening said exhaust valve in response to increase in the pressure in said delivery passage above a predetermined value.

2. A pump according to claim 1 having a relief valve connected to said delivery passage, said relief valve opening only in response to pressure higher than the pressure required to open said exhaust valve.

3. A pump comprising: a plurality of cylinders each having a plunger therein, and means for reciprocating said plungers through fixed strokes in out of phase relation to each other; means defining a pressure fluid delivery passage; individual check valves for said cylinders, each connecting one end of its associated cylinder to said delivery passage in response to pressure in said cylinder exceeding the pressure in said delivery passage; means defining an inlet passage adapted to be connected to a source of fluid to be pumped, and means for admitting fluid from said inlet passage into said cylinders in response to suction in said cylinders; means defining individual exhaust passages for said cylinders, each connected to its associated cylinder adjacent said one end thereof for exhausting fluid therefrom at low pressure; exhaust valve means normally closing all said exhaust passages; and means responsive to pressure in said delivery passage for opening said exhaust valve means in response to increase in the pressure in said outlet passage above a predetermined value.

4. A pump according to claim 3 in which said exhaust valve means comprises a pair of relatively slidable members in fluid sealing relation with each other, one of said members having a set of separate ports respectively connected to said individual exhaust passages, the other said member having a set of ports connected together and to exhaust, and movable simultaneously into and out of registration with said ports in said one member; spring means urging said members toward position in which said sets of ports are out of registration with each other; and means for applying the pressure in said delivery port between said two members in opposition to said spring means.

5. A pump according to claim 3 in which said exhaust passage connects to said cylinder through a port in the side of the cylinder so longitudinally positioned as to be covered by said plunger prior to completion of the working stroke thereof.

6. A pump according to claim 5 having a relief valve connected to said delivery passage, said relief valve opening only in response to pressure higher than the pressure required to open said exhaust valve.

7. A pump comprising: a cylinder having a plunger reciprocable therein and means for reciprocating said plunger; means defining a pressure fluid delivery passage, and a check valve connecting one end of said cylinder to said delivery passage in response to pressure in said cylinder exceeding the pressure in said delivery passage; means defining an inlet passage adapted to be connected to a source of fluid to be pumped, and means for admitting fluid from said inlet passage into said cylinder in response to suction in said cylinder; means defining an exhaust passage connected to said cylinder adjacent said one end thereof for exhausting fluid therefrom at low pressure; exhaust valve means normally closing said exhaust passage; and means responsive to pressure in said delivery passage for opening said exhaust valve in response to increase in the pressure in said delivery passage above a predetermined value; said exhaust valve means comprising a pair of relatively sliding members in fluid sealing relation, said members having a first pair of cooperating ports connected in said exhaust passage for closing said passage in one relative position of said members and opening said passage in response to predetermined relative movement from said one position; said members having a second pair of cooperating ports, one connected to said delivery passage and the other connected to a relief passage; spring means urging said members toward said one relative position; and means for applying the pressure in said delivery port between said two members in opposition to said spring means; the ports of said second pair being so positioned in their respective valve members that they are out of registration in said one relative position of said members and move into registration in response to relative movement of said members away from said one position in excess of said predetermined movement.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,451,481	Vincent	Apr. 10, 1923
1,801,414	Davis	Apr. 21, 1931
2,313,351	Magnuson	Mar. 9, 1943
2,510,150	Stephens	June 6, 1950