Feb. 4, 1958 W. E. MILLER ET AL 2,821,926

VARIABLE VOLUME RECIPROCATING PUMP

Filed June 28, 1954 3 Sheets-Sheet 1

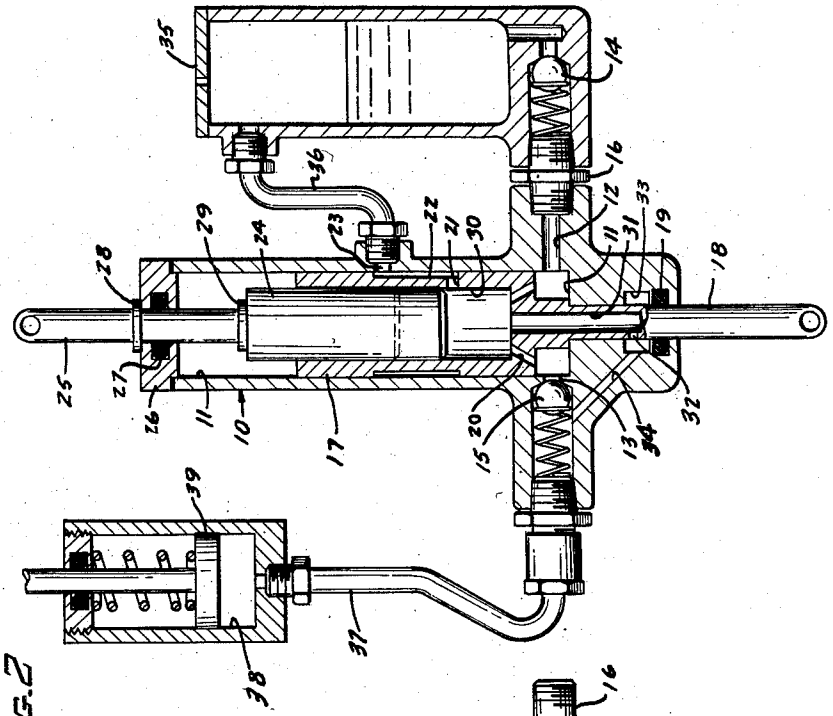


FIG. 2

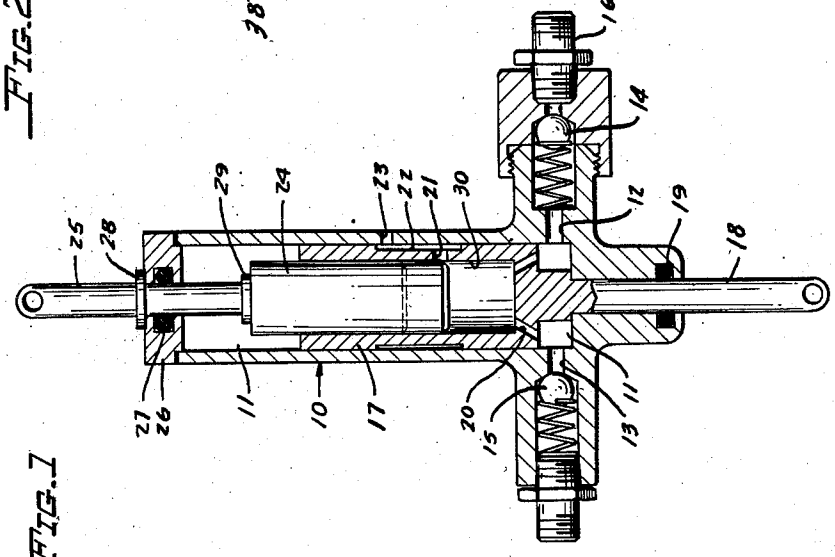


FIG. 1

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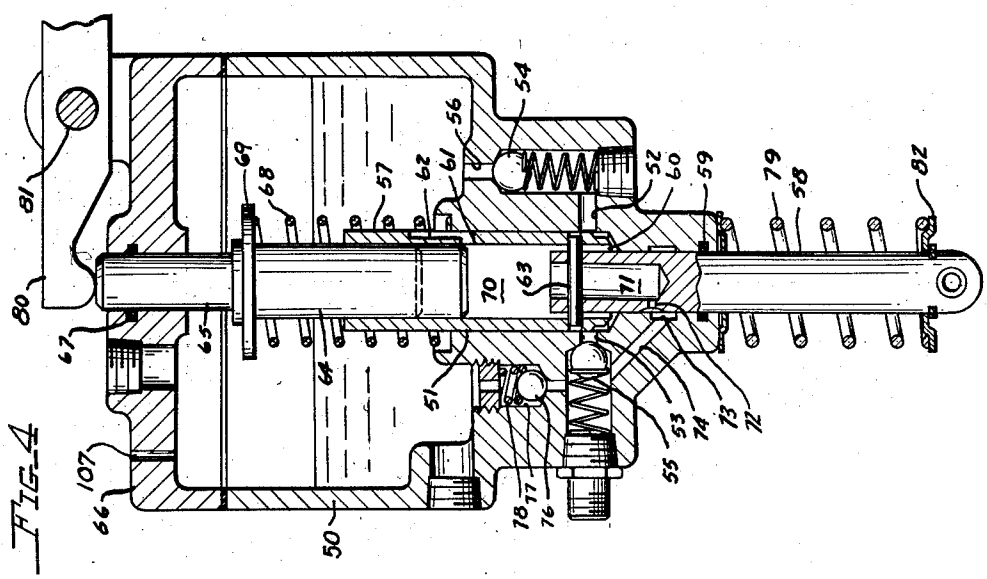


FIG. 4

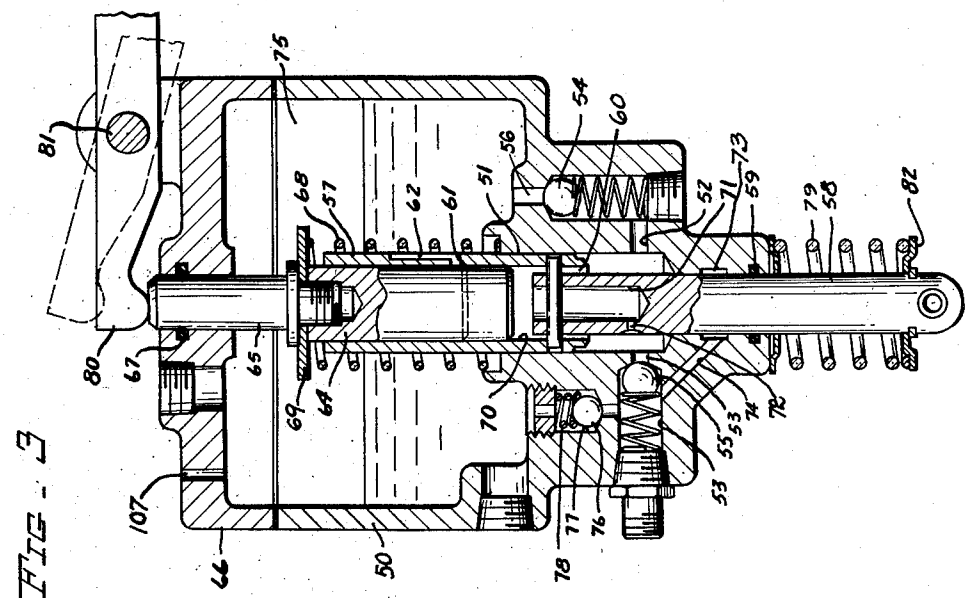


FIG. 3

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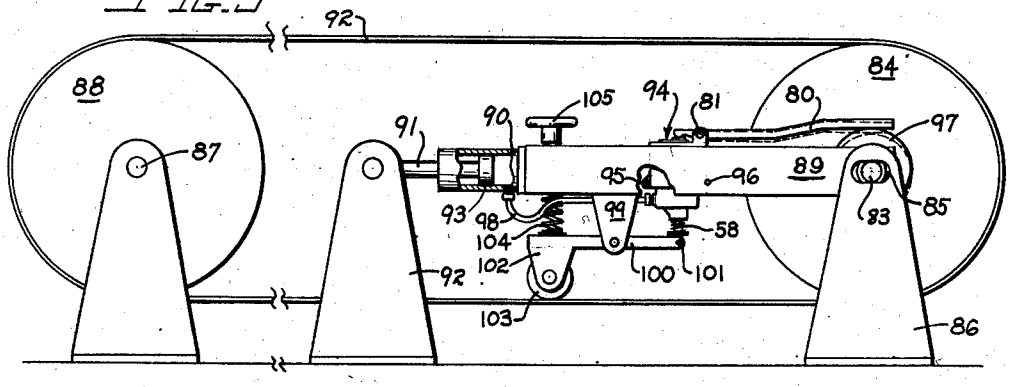
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VARIABLE VOLUME RECIPROCATING PUMP

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FIG. 5



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2,821,926

VARIABLE VOLUME RECIPROCATING PUMP

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Application June 28, 1954, Serial No. 439,574

4 Claims. (Cl. 103—37)

This invention relates to reciprocating plunger type pumps, and more particularly to a pump of that type which is so constructed that its volume delivery during piston reciprocation may be varied selectively.

It is a primary object of the invention to provide a reciprocating pump in which the piston may travel a fixed distance in each direction during its reciprocation, yet which is so constructed that the liquid discharge during each piston stroke may be varied selectively between maximum capacity and zero.

In one of its embodiments the invention provides a pump which not only includes the variable volume discharge feature just mentioned, but which also includes a construction which permits liquid to bleed back under reverse pressure through the discharge line through the pump to a reservoir, together with a means of selectively controlling both the volume discharge and the volume bleed back, all during continuous piston reciprocation.

It is an additional primary object of the invention, then, to provide a pump which may be used to operate a single acting working cylinder the plunger rod of which may be under a continuous but variable one way load, the variable volume and bleed back features of the pump being utilized to control the movement of the working cylinder plunger in both directions, or to maintain the plunger rod of the working cylinder in various desired positions, all at the will of the pump operator, or automatically in response to the movement of the working cylinder plunger in either direction.

Another object is to provide a pump of the type mentioned which may be connected to an outside reservoir or other source of supply to provide continuous discharge under pressure, or which may include its own liquid reservoir from which liquid may be drawn during discharge delivery, and to which liquid may be delivered during bleed back or reverse flow operation.

In the latter form it may be used for operating any small capacity, single acting hoist or ram of the spring or load returned variety when connected to the ram or working cylinder by means of a single pipe or conduit.

Another object is to provide a pump of the class described in which the maximum pressure delivered from the discharge may be predetermined.

The pump of this invention is particularly adapted for the accurate control of such tools as hydraulic vises, arbor presses and the like. Another important use is to automatically control the bale density of material being baled by a mechanical baler. Such control is accomplished through minute and accurate movement of the plunger of a working cylinder connected to the pump discharge, the working cylinder plunger being in turn operably connected to vary the cross sectional area of the bale chamber as the material being baled progresses through the chamber, the automatic control being accomplished through a density feeler or detector in continuous contact with the material in the baler chamber.

An additional use for the pump of this invention is

to automatically maintain the desired tension on a conveyor belt, as will be explained herein.

The invention, together with other objects, will be more clearly understood when the following description is read in connection with the accompanying drawings, in which:

Fig. 1 a vertical sectional view of a plunger type pump constructed in accordance with this invention;

Fig. 2 is a similar view of another embodiment of the invention;

Figs. 3 and 4 are similar sectional views illustrating a third embodiment of the invention; and

Fig. 5 is a schematic side view of a conveyor belt unit illustrating one way in which a pump embodying this invention may be installed to automatically maintain a desired tension on the belt.

Fig. 1 embodiment

Referring to that embodiment of the invention shown in Fig. 1, the numeral **10** indicates a casing defining a cylinder **11**, provided with check valve controlled intake and discharge passages, designated respectively by the numerals **12** and **13**. The check valves may be of any type, but are illustrated as the conventional spring pressed ball type, and are respectively designated as a whole by the numerals **14** and **15**. Intake passage fitting **16** will, of course, be connected to a desired source of liquid supply.

Cylinder **11** houses a generally cylindrical sleeve or liner **17** which is machined to fit snugly but slidably within the cylinder. The lower end of this liner is connected to an adjusting rod **18** which projects through the lower end of the casing **10** through a suitable packing gland or O-ring seal unit **19**. The lower end of liner **17** and the closed end of cylinder **11** cooperate to provide a fluid pressure working chamber **30**. The two communicate by means of a plurality of ports **20**.

A working chamber bleed passage includes a through port **21** in the wall of liner **17** which communicates wtih an axially elongated circumferential groove **22** in the exterior surface of the liner. A port **23** through the wall of casing **10** is positioned to register with groove **22** in all permitted positions of adjustment of liner **17**. Alternatively the groove **22** may extend to the extreme upper end of the liner, and port **23** may be located in the head **26**. In either case the ports **21** and **23**, and the groove **22** cooperate to afford open communication between the interior of the working chamber **30** and the atmosphere save when the inner end of port **21** is closed by a piston **24**.

As will be seen, the interior of liner **17** serves as the piston cylinder proper. Piston **24** is connected to an operating rod **25** which passes through the head **26** of casing **10**, through a suitable packing gland, such as an O-ring seal **27**. Stops **28** and **29** limit piston travel in both directions.

Operation of Fig. 1 embodiment

The pump should first be primed by filling the working chamber **30** and the openly communicating portions of cylinder **11** and passages **12** and **13** with the liquid to be pumped. After the pump is installed and initially primed no additional priming is ever necessary. This priming can be accomplished through the bleed passage (port **23**, groove **22**, and port **21**) with the liner at the bottom of the cylinder, and the piston at the upper end of its stroke.

As the piston moves downward excess liquid will be forced from chamber **30** through the bleed passage until port **21** is closed by the piston. Further downward piston movement forces liquid through discharge passage **13** past valve **15**. During the upstroke or intake stroke

liquid is drawn into working chamber 30 through intake valve 14 until port 21 is uncovered. As the piston upstroke continues, air is drawn into the space above the liquid in the working chamber through the bleed passage, and is again expelled during the early part of the next piston downstroke. After the first complete cycle of piston travel there is no more bleeding of liquid through the bleed passage.

Figure 1 shows the liner at its lowermost position of adjustment, and also shows the piston 24 at the lowermost end of its stroke. Considering these relative positions of the liner and piston, it will be seen that port 21 is at least partially open even at the end of the piston downstroke. Hence only air can be drawn into the working chamber by the piston, and there is zero delivery of liquid through the discharge passage 13 during the piston downstroke.

From the above it will be understood that liquid discharge from the pump cannot begin until port 21 of the bleed passage is closed by the pistion during its downstroke. This bleed passage, and particularly the location of port 21 with relation to the path of travel of the piston (depending on liner positioning) constitutes a means for determining the point in piston travel at which pump delivery starts, as well as a means for determining the amount of liquid which can be forced from the working chamber during each piston downstroke. Liner adjustment thus varies pump delivery from maximum delivery, with port 21 closed by the piston throughout its stroke, to zero delivery, with port 21 open continuously.

Fig. 2 embodiment

The pump of Fig. 2 closely resembles the pump previously described. Like reference numerals indicate corresponding components in both these embodiments of the invention, the corresponding parts being shown in identical positions.

In addition, however, the liner adjusting rod 18 of the Fig. 2 pump is provided with a drilled by-pass duct 31, and a connecting port 32, the latter being adapted to register at times with a rod encircling annular groove 33 formed in the lower end of casing 10. A second by-pass duct 34 connects groove 33 with the outer end of discharge passage 13, outside check valve 15.

The Fig. 2 pump is shown with intake duct 12 connected to the lower end of a liquid supply reservoir 35, check valve 14 being installed in the bottom of the reservoir instead of in the pump casing proper. The upper end of reservoir 35 is connected by a conduit 36 to port 23. The pump discharge passage 13 is shown connected by a conduit 37 to a single acting working cylinder 38, the plunger 39 of which is spring loaded downward.

Operation of Fig. 2 embodiment

The operation of this pump differs from the Fig. 1 embodiment in that the liquid by-pass arrangement (ducts 31 and 34, groove 33, and port 32) permits a reverse flow of liquid from working cylinder 38 through pump working chamber 30, through port 21, groove 22, port 23, and conduit 36 to reservoir 35 during continuous reciprocation of pump piston 24. This is true only when rod 18 is adjusted so that port 32 fully or partially registers with groove 33.

By moving rod 18 and liner 17 upward slightly port 32 is closed off yet port 21 still partially communicates with chamber 30 throughout piston travel. Thus zero delivery can be obtained. As liner 17 is moved upward into the pump cylinder pump delivery increases to a maximum, as previously described with relation to the Fig. 1 embodiment.

Figs. 3 and 4 embodiment

In that embodiment of the invention illustrated in Figs. 3 and 4, numeral 50 indicates a modified pump casing which defines not only a cylinder 51 (in its lower portion), but also defines an adjacent self-contained liquid supply reservoir 75.

The lower end of cylinder 51 communicates with an intake passage 52, and a discharge passage 53. Passage 52 communicates with reservoir 75 through a passage 56, which is provided with an intake check valve 54. A similar check valve 55 controls flow through the discharge passage.

Sleeve or liner 57 has a close tolerance sliding fit in cylinder 51, and is connected to an adjusting rod 58 which projects through the lower end of the casing through a suitable seal unit 59. Rod 58 is smaller in diameter than the inside diameter of liner 57 and the adjacent ends of the two are connected by a pin 63. The two thus define an annular space 60 which affords open communication between the interior of the piston working chamber 70 and the bottom of cylinder 51 below the liner, and hence with the intake and discharge passages.

The bleed passage in this pump includes a liner wall port 61 and a longitudinally disposed groove 62 in the outer wall surface of liner 57. The lower end of groove 62 communicates with port 61, and the upper end of the groove communicates with reservoir 75 in all positions of liner adjustment, and is continuously covered by liquid in the reservoir. Vent 107 in head 66 affords communication between the interior of the reservoir and atmosphere, and hence between working chamber 70 and atmosphere.

Piston 64 is actuated by a rod 65 which passes through head 66 through a suitable seal 67. The piston in this embodiment is spring pressed upward by a spring 68 bearing against a piston carried washer or flange 69, as shown. A power actuated lever 80 pivoted at 81 on head 66 serves to forcibly move rod 65 and consequently the piston downward against spring action.

As in the Fig. 2 embodiment the Fig. 3 embodiment includes a by-pass duct 71 (in rod 58) communicating with a wall port 72, which is adapted to register with a rod encircling annular groove 73. Groove 73 communicates with discharge passage 53 outside of valve 55 by means of a by-pass duct 74 in the pump casing.

In addition this pump is provided with a spring pressed check type relief valve 76 which is mounted in a duct 77 in the casing, which affords communication between the discharge passage 53, outside valve 55, and the reservoir 75. Valve spring 78 has greater compressive resistance than the spring of valve 55, and at a working pressure predetermined by the compressive resistance of spring 78, valve 76 will allow liquid to flow from delivery duct 53 back into the pump reservoir. The maximum pressure delivered by the pump can thus be predetermined.

Liner 57 is biased toward its lowermost position by means of a compressed coil spring 79 which bears against the lower end of casing 50 and against an annular seat 82, carried by rod 58.

An important feature of all embodiments of this invention is the advance establishment of a desired relationship between the cross sectional area of the liner and that of the liner adjusting rod. Since the liquid in the pump cylinder is under pressure during pump delivery, the movement of a portion of the adjusting rod into or out of the liquid in the cylinder would ordinarily increase or decrease the pressure due to liquid displacement. However, the lower end of the liner moves with the inner end of the adjusting rod and has an opposite displacement effect. Thus, if the cross sectional area of the inner end of the adjusting rod is made the same as the cross sectional area of the liner, the displacement effect of one will exactly balance or offset the displacement effect of the other as the two move in unison in either direction. Consequently there would be no resistance to such movement other than friction. If it is desired to bias the liner against upward movement in the cylinder (in a direction increasing pump delivery), then the cross sectional area of the chamber penetrating end of the adjusting rod is made larger than

the cross sectional area of the connected end of the liner. Rod penetrating movement thus increases liquid pressure in the chamber, and the increased pressure resists rod penetrating pressure. Liner movement may be biased in the opposite direction by making the cross sectional area of the liner greater than the cross sectional area of the chamber penetrating end of the adjusting rod.

Operation of Fig. 3 pump

The operation of the Fig. 3 embodiment is almost identical to the operation of the Fig. 2 pump. However, since the open end of bleed passage **62** is continuously submerged in liquid, this liquid instead of air is drawn into the working chamber after the piston opens port **61** during its upward travel. As the piston begins its downstroke, this liquid is expelled through the bleed passage back into the reservoir until the piston closes port **61**. Delivery through discharge passage **53** then begins. During piston upstroke liquid is drawn into the working chamber **70** through intake valve **54** until the piston uncovers port **61**.

Operation of Fig. 5 installation

Fig. 5 illustrates the pump of Figs. 3 and 4 installed to automatically regulate belt tension of a conveyor belt system.

The shaft **83** of conveyor belt pulley or sheave **84** has its opposite ends mounted in elongated slots **85** in a pair of upright standards **86**. The pulley axis is thus capable of horizontal movement toward or away from the fixed axis **87** of similarly supported pulley **88**.

A pair of laterally spaced axis adjusting plates **89** each has one end connected to a respective end of shaft **83**, and its opposite end rigidly secured to the casing **90** of a single acting working cylinder. The piston rod **91** of this cylinder is connected to the upper end of a rigid fixed standard **92**. It will thus be seen that the tension of belt **92** will normally urge the cylinder casing **90** in a direction toward working cylinder plunger **93**, tending to force liquid out of the right hand or working end of the cylinder **90**.

The pump **94** of Figs. 3 and 4 is rigidly supported by bolts **95** and **96** between the plates **89**. Pump piston actuating lever **80** is oscillated by a cam **97** fixed on shaft **83**, thus reciprocating the pump piston continuously as the pulley **84** is rotated.

The discharge passage **53** of the pump is connected by conduit **98** to the working cylinder **90**.

A bracket **99**, connected to the plates **89**, pivotally supports a lever **100** intermediate its ends. One end of lever **100** is pivotally connected at **101** to pump liner adjusting rod **58**, while the other end of lever **100** is connected to a trunnion **102** which journals a belt contacting roller **103**. The trunnion **102**, and consequently the roller **103**, is urged toward belt contact by a coil spring **104**, the compression of which may be manually adjusted by crank **105**.

When the tension of belt **92** lessens roller **103** moves downward and lever **100** moves liner adjusting rod inward, consequently moving liner **57** in a direction to increase pump delivery. Additional liquid is thus forced into working cylinder **90** which actuates plates **89** to move the shaft **83** of pulley **84** to the right in Fig. 5, thus tightening the belt. The tightening of the belt moves roller **103** upward to its pre-set position, lever **100** moves adjusting rod **58** downward until liner **57** moves to a zero delivery position in the pump cylinder.

Should extreme tension be placed on the belt roller **103** is moved upward from its normal position. Lever **100** moves adjusting rod **58** downward and port **72** moves into registry with annular groove **73**, establishing a free flow passage around discharge valve **55**, and allowing liquid to flow from working cylinder **90** thru chamber **70**, port **61** and groove **62** into reservoir **75**, while piston **64** continues reciprocating. A slight adjustment of the compression of spring **104** will accurately determine the belt tension at which this bleed-back of liquid occurs, as well as the belt tension at which the pump begins to deliver liquid to the working cylinder **90**. In the application described liner **57** will normally occupy a position in the pump cylinder at which no fluid delivery and no bleed-back of fluid occurs, or one in which slight delivery alternates with slight bleed back depending on the relative location of ports **61** and **72**.

From the above explanation it will be seen that the Fig. 3 pump operates in a manner almost identical to the Fig. 2 pump, and that the invention provides a reciprocating plunger type pump the delivery of which can be selectively varied from full capacity to zero in one embodiment, and from full capacity thru zero to reverse flow in another embodiment, all during continuous reciprocation of the pump piston.

Having described the invention with sufficient clarity to enable those familiar with this art to construct and use it, we claim:

1. A reciprocating piston type pump comprising: a casing defining a cylinder; a liner having one of its ends in open communication with said cylinder and movable longitudinally therein; means for selectively positioning said liner longitudinally in said cylinder; a liquid reservoir; a liquid escape port in said liner, said port being in open communication with said reservoir regardless of the position of the liner in the cylinder; a piston having a fixed stroke length reciprocable in said liner and adapted to close said escape port when the liner is in certain positions of longitudinal adjustment within the cylinder, said piston, cylinder and the cylinder communicating end of the liner together defining a liquid handling chamber; an intake duct having a valve therein affording passage of liquid from the reservoir into said chamber; a discharge duct having a valve therein affording passage of liquid out of said chamber; a by pass duct affording communication between the chamber and the discharge duct around the valve in the latter; and means movable with the liner as its position is changed to maintain said by pass duct closed save when the liner is positioned to place said escape port at least partially out of reach of closure by said piston during its reciprocation, whereby liquid may flow from a point outside the valve in the discharge duct to the liquid handling chamber and through the escape port to the reservoir during continuous piston reciprocation.

2. A liquid pump comprising: a casing defining a cylinder; a liner movable longitudinally within the cylinder and having one end in open communication therewith; means for selectively positioning the liner longitudinally within said cylinder; a liquid reservoir; a through port in the wall of said liner; an elongated superficial longitudinally extending duct in the outer wall surface of said liner communicating at one of its ends with said port and at its other end with said reservoir, said duct being of such length that it openly communicates with said reservoir in all positions of liner adjustment within the cylinder; a piston having a fixed stroke length reciprocable in said liner and adapted during its reciprocation to close said through port only when the liner is in certain positions of longitudinal adjustment in said cylinder, said piston, liner and one end of said cylinder together defining a liquid handling chamber; a valve controlled intake passage affording communication between said reservoir and said chamber; and a valve controlled discharge passage communicating with said chamber, whereby during only that portion of the suction stroke of said piston during which the through port in the liner is closed by the piston liquid is drawn from the reservoir through the intake passage into said chamber, and during only that portion of the delivery stroke of said piston during which the through port is closed by the piston liquid is forced from the chamber through the discharge passage, and the quantity of liquid delivered through the discharge passage during each complete piston move-

ment cycle is controlled by the selective positioning of the liner and its through port with respect to the fixed stroke length of said piston; a by-pass duct openly connecting said liquid handling chamber with the discharge passage independent of the valve in said discharge passage; and means movable with the liner to maintain said by-pass duct closed save when the liner is positioned to place the through port therein at least partially out of reach of closure by said piston.

3. In a variable volume delivery pump of the reciprocating piston type in which the piston reciprocates in a cylinder liner, the liner is movable longitudinally in the cylinder, and in which the liner is provided with a liquid escape port which is closed by the piston when the liner is in certain positions in the cylinder and the volume of liquid delivered by the piston during its pressure stroke is determined by the position of the escape port and hence of the liner with relation to the permitted travel of the piston, the combination with said liner of a liner positioning rod projecting through the otherwise closed end of the cylinder and the liner and movable longitudinally with respect to the cylinder; and means connecting the adjacent ends of the liner and rod in a manner to maintain open communication between the cylinder and the pumping chamber in the liner, around the periphery of the rod, the volume displacement of the liner and of the cylinder penetrating portion of the rod being substantially equal to eliminate the creation of liquid pressure changes within the cylinder as the rod and liner assembly moves in either permitted longitudinal direction.

4. In a variable volume delivery pump of the reciprocating piston type in which the piston reciprocates in a cylinder liner, the liner is movable longitudinally in the cylinder, and in which the liner is provided with a liquid escape port which is closed by the piston when the liner is

in certain positions in the cylinder, and the volume of liquid delivered by the piston during its pressure stroke is determined by the position of the escape port and hence of the liner with relation to the permitted travel of the piston, the combination with said liner of a liner positioning rod projecting through the otherwise closed end of the cylinder and the liner and movable longitudinally with respect to the cylinder; and means connecting the adjacent ends of the liner and rod in a manner to maintain open communication between the cylinder and the pumping chamber in the liner, and around the periphery of the rod, the volume displacement of the liner and of the cylinder penetrating portion of the rod being unequal to a predetermined degree so that longitudinal movement of the rod and liner assembly in one direction in the cylinder creates an increased pressure therein, and such increased pressure resists movement of the assembly in said one direction.

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