Feb. 7, 1939. G. A. WAHLMARK 2,146,037

ROTARY PUMP

Filed April 1, 1935 3 Sheets-Sheet 1

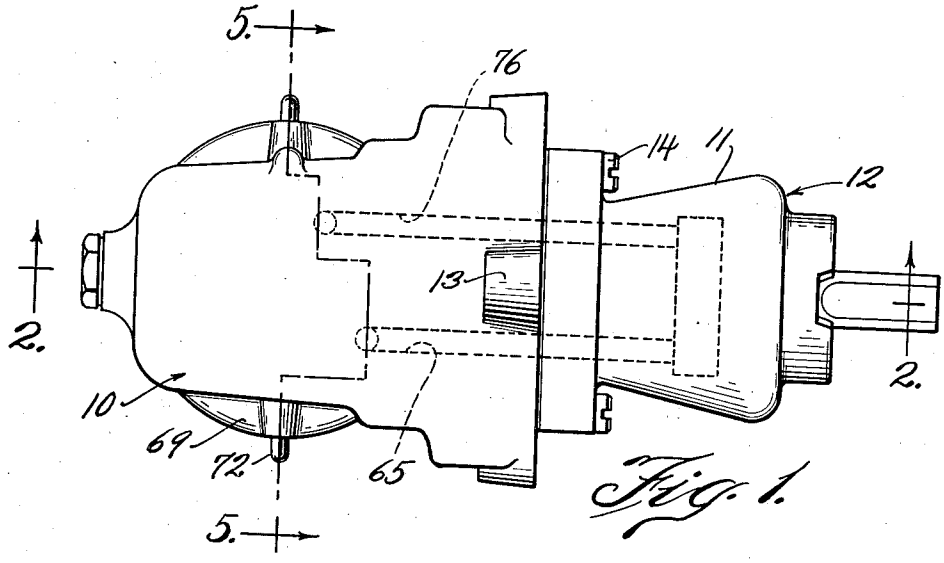


Fig. 1.

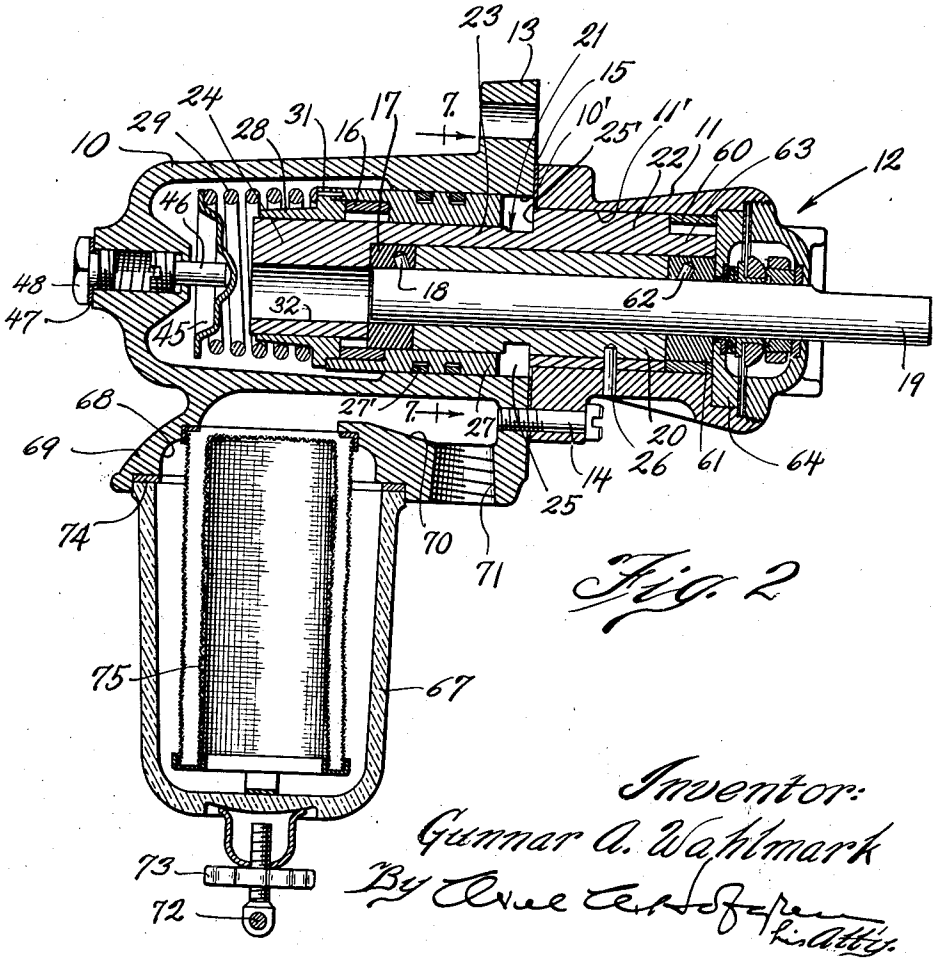


Fig. 2

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ROTARY PUMP

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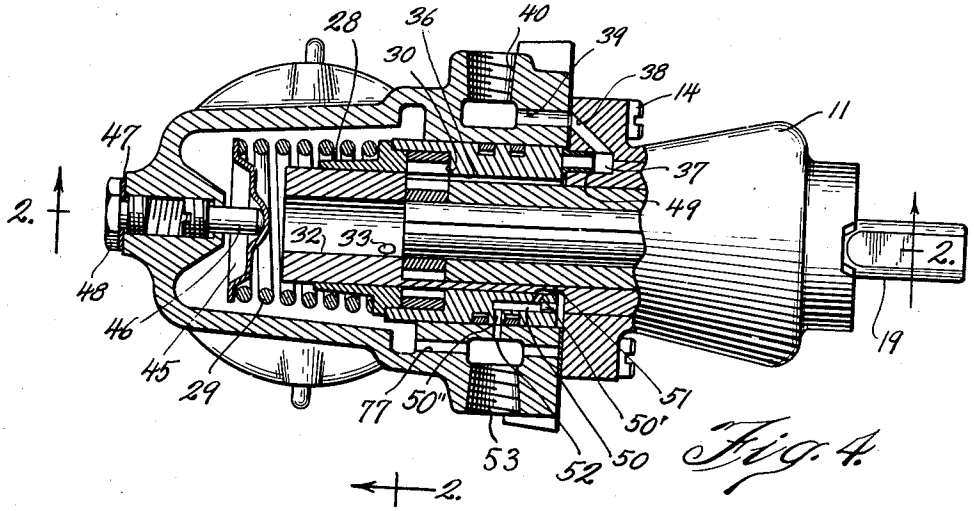


Fig. 4.

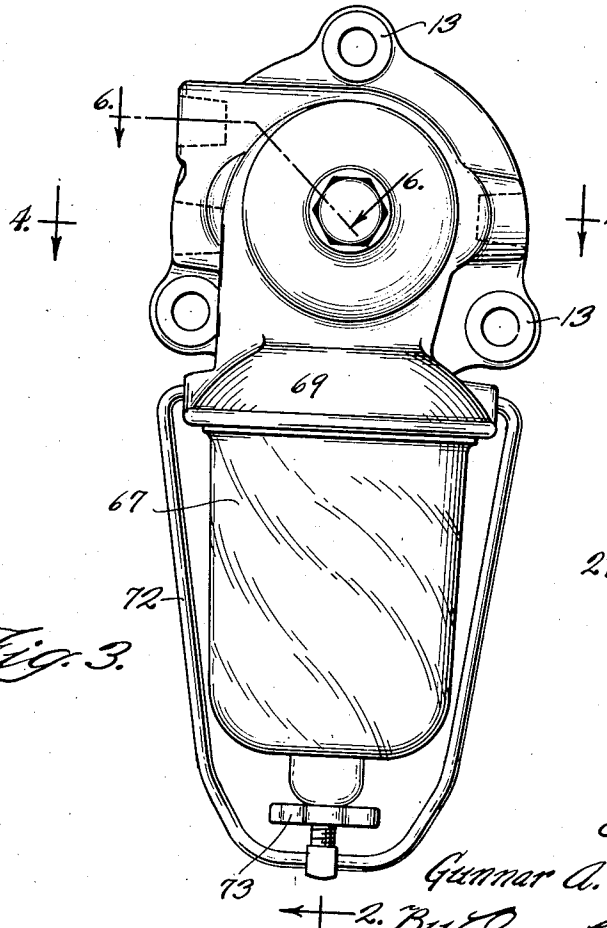


Fig. 3.

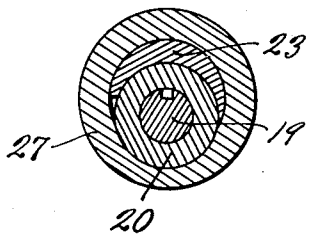


Fig. 7.

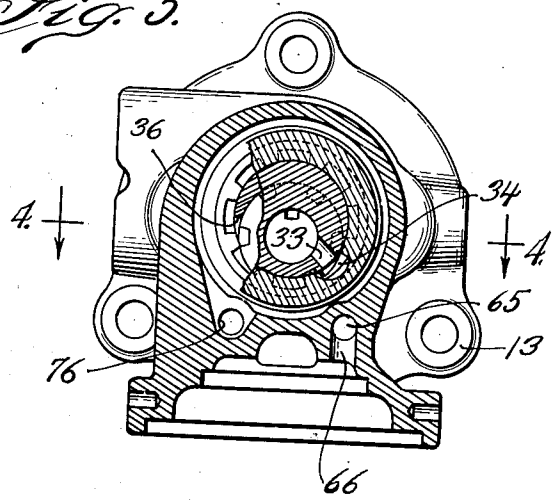
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Feb. 7, 1939. G. A. WAHLMARK 2,146,037

ROTARY PUMP

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Fig. 5.



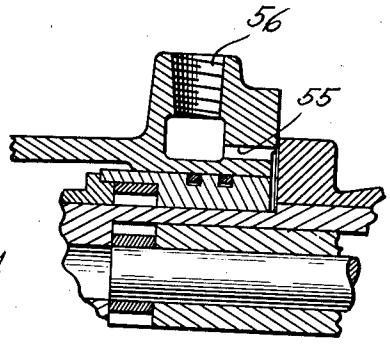


Fig. 6.

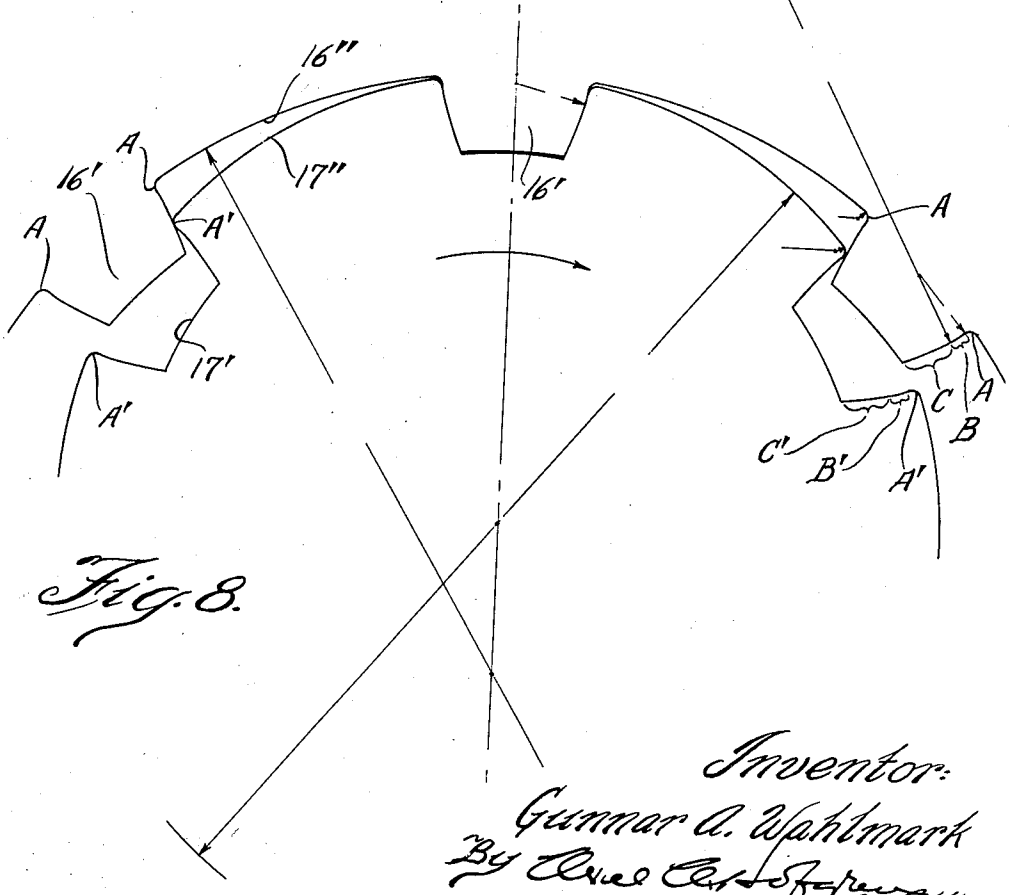


Fig. 8.

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Patented Feb. 7, 1939

2,146,037

UNITED STATES PATENT OFFICE

2,146,037

ROTARY PUMP

Gunnar A. Wahlmark, Rockford, Ill.

Application April 1, 1935, Serial No. 14,017

20 Claims. (Cl. 103—126)

The invention relates to pumps, particularly rotary pumps, and has as its general object to provide a rotary pump of novel and improved construction operable automatically to displace varying amounts of fluid without by-passing any of the fluid or operable to displace a constant amount while driven at varying speeds.

A more particular object of the invention is to provide an improved rotary pump of the character described which is controlled by pressure on the discharge side of the pump acting upon one of the pump elements to vary the displacement of the pump automatically in accordance with the demand on the pump.

Another object of the invention is to provide a rotary pump having an automatic air relief.

Another object is to provide a rotary variable displacement pump in which initial discharge does not take place until a predetermined pressure has been attained, which pressure is immediately increased to full pressure at the commencement of flow from the pump.

A further object of the invention is to perfect a pump having an instantaneous cut-off of fluid discharge when the pump stops.

Yet another object of the invention is to perfect a pump in which the final discharge from the pump is at substantially the same pressure at which the pump has been discharging during the remainder of the operating period.

Yet another object is to provide a rotary, variable displacement pump having a single control means automatically varying the displacement, effecting initial and final discharge at full pressure, and instantaneous cut-off.

Yet a further object is to provide a rotary, variable displacement pump constructed to permit of convenient adjustment of the discharge pressure of the pump.

Yet a further object is to provide a two-stage, rotary pump having but a single shaft carrying two rollers each meshing with and driving the rotor of one of the stages.

Yet a further object of the invention is to provide a rotary pump having a secondary stage operating automatically to displace varying amounts of fluid in accordance with the demand on the pump and a primary stage for charging the secondary stage, the driving elements of the stages being mounted on a common shaft.

Other objects and advantages will become apparent from the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a plan view of a rotary pump embodying the features of the invention.

Fig. 2 is an axial vertical sectional view taken along line 2—2 of Figs. 1 and 4.

Fig. 3 is an end elevational view looking from the left in Fig. 1.

Fig. 4 is a sectional view taken along line 4—4 of Fig. 3.

Fig. 5 is a transverse vertical sectional view taken along line 5—5 of Fig. 1. The figure is broken away in part.

Fig. 6 is a fragmentary sectional view taken along the line 6—6 of Fig. 3.

Fig. 7 is a transverse vertical sectional view taken along line 7—7 of Fig. 2.

Fig. 8 is an enlarged fragmentary view showing the construction of the splines and recesses of the rotor and roller.

While the invention is susceptible of various modifications and alternative constructions, it is shown in the drawings and will be described hereinafter as embodied in a preferred form of pump particularly well adapted for use with an oil burner. However, it is not intended that the invention is to be limited thereby to the specific form disclosed but it is intended to cover all modifications and alternative constructions falling within the spirit and scope of the invention as defined by the appended claims.

As illustrated in the drawings, the pump comprises a secondary stage operating automatically to displace varying amounts of fluid in accordance with the demand on the pump and a primary stage provided for the purpose of charging the secondary stage when the pump is working against an unusually high lift. Both stages are driven from a common shaft and are enclosed in a common casing comprising generally a cup-shaped housing 10, a cylindrical casing portion 11 secured to the open end of the housing 10, and a rotary mechanical seal, generally designated 12, closing the portion 11. The housing 10 is formed with apertured ears 13 for securing the pump to a support and the cylindrical portion 11 is secured to the housing 10 by bolts 14. A gasket 15 is interposed between the abutting faces to make the joint fluid tight. The rotary seal is fully described and claimed in my copending application, Serial No. 704,705, filed December 30, 1933.

Considering now the details of construction of the pump, the variable displacement or secondary stage is housed in the housing 10 which, for that purpose, is formed at its open end with a cylindrical bore 10' slightly larger in diameter than

the bore 11' of the casing portion 11. The remainder of the housing constitutes an auxiliary reservoir as will appear later. One pumping element of the secondary stage is formed by a rotor 16 in the form of a ring having a plurality of circumferentially spaced inwardly projecting splines 16'. The rotor is positioned concentrically within the cylindrical bore 10' but is of a diameter smaller than the bore so as not to be in direct contact therewith. The other pumping element of the secondary stage is formed by a roller 17 positioned eccentrically within the rotor 16 and having a plurality of recesses 17' meshing with the splines of the rotor with a rolling action. The roller meshes with the rotor over a small portion only of the circumference thereof, herein the bottom portion, as best seen in Figs. 2 and 5. Herein the roller 17 constitutes the driving element of the secondary stage and to that end is secured by pin 18 to a driving shaft 19 extending outwardly through the portion 11 and the rotary seal 12. The shaft 19 is journaled in a sleeve 20 one end of which abuts a face of the roller 17 and the outside diameter of which is equal to the outside diameter of the roller to constitute one element of means forming a chamber in which the pumping elements 16 and 17 operate.

Also constituting a part of the means forming a chamber for the pumping elements is an elongated tubular member 21 extending longitudinally within the casing. At one end this member has a cylindrical portion 22 fitting in fluid tight relation within the bore 11' of the cylindrical casing portion 11 and in turn bored eccentrically to receive a portion of the sleeve 20. The intermediate portion 23 is crescent shaped and partially surrounds the remaining portion of the sleeve 20 and fills the space between the eccentrically positioned roller and rotor. At its remaining end, the member terminates in a substantially cylindrical portion 24 disposed opposite the roller 17 in abutting relation to a face thereof. Thus it is seen that the roller 17 is received between the cylindrical portion 24 and the sleeve 20 which, with the crescent shaped portion 23, completely enclose the roller except where it meshes with the rotor 16. The outer circumference of the cylindrical portion 24 is flush with the crescent shaped portion 23 joining therewith in a smooth uninterrupted surface. Both the portion 23 and the portion 24 are reduced from the cylindrical portion 22 to form an annular shoulder at the joint between the housing 10 and the casing portion 11. This shoulder and a shoulder on the casing portion 11 resulting from the difference in diameter of the bores 11' and 10' form the end wall 25' of an annular chamber 25 the side walls of which are formed by the housing 10 and the sleeve 20 and member 21. The sleeve 20 and the member 21 are prevented from rotating with the shaft 19 by a pin 26 anchored in the casing portion 11.

A single movable control means operates to complete the pump chamber, to vary automatically the displacement of the pump, to effect initial and final discharge at full pressure, to effect instantaneous cut-off and to control automatically air relief from the chamber 25. This means comprises a substantially annular piston 27 slidable longitudinally in the bore 10' and encircling the crescent shaped portion 23 and the sleeve 20, a collar 28 slidable on the cylindrical end portion 24 and a compressing spring 29 urging the collar 28 toward the piston and both toward the end wall 25'. At one end the piston 27 is formed with an internal annular groove 30 in which the rotor 16 is positioned, the rotor being retained in the groove and the groove closed by the collar 28 to complete a fluid tight but variable pump chamber for the pump elements 16 and 17. The collar 28 is secured against rotation with the rotor 16 by means of a pin 31 engaging the piston 27. Piston rings 27' may be employed to assure a fluid tight sliding fit between the piston and the bore 10'.

To provide for the intake of fluid into the pump chamber and between the pumping elements, the cylindrical end portion 24 of the member 21 is formed with an eccentric bore 32 communicating with the auxiliary reservoir in the housing 10, and a radial passage 33 communicating with the bore 32. The collar 28 is likewise formed with a passage 34 constituting a radial extension of the passage 33, the combined passages being disposed opposite the faces of the pumping elements at a point rearwardly of the point of engagement thereof, that is, to the right of the point of engagement as shown in Fig. 5. The pumping elements 16 and 17 operate in well known manner to draw fluid through the bore 32 and passages 33 and 34 into the recesses and the spaces between the splines of the roller and rotor, the fluid being retained in the spaces by the crescent shaped portion 23 until the rotor and roller again mesh whereupon the fluid is forced out of the spaces. In addition to the crescent shaped portion, the cylindrical portion 24, the sleeve 20, the piston 27 and the collar 28 all aid in preventing escape of fluid from the spaces between the teeth during rotation of the pumping elements.

As illustrated most clearly in Fig. 8, the rotor 16 and the roller 17 are of special construction designed to obtain unusually high volumetric efficiency and unusually high pressures while having a quiet and efficient operation. These advantages are obtained by designing the rotor and the roller so that the latter engages the former in a rolling contact which is substantially continuous and unbroken. Furthermore the roller engages the rotor in a driving and timing contact thus producing a second seal. To that end the spaces 16'' intermediate the splines 16' of the rotor and the tops of the splines are made concave and truly cylindrical, the center of curvature of both coinciding with the axis of the rotor. The bottoms of the recesses and the portions 17'' of the roller are also truly cylindrical and convex, the center of curvature of both coinciding with the axis of the roller. In addition the recesses in the roller 17 conform closely to the splines on the rotor 16 and are adapted to receive the splines wholly within so that when a spline meshes with a recess the top of the spline and the bottom of the recess are in actual rolling contact. Likewise the portions 17'' between the recesses of the roller contact and roll on the portions 16'' between the splines of the rotor.

To obtain this rolling, substantially continuous contact between the rotor and the roller, the faces of the splines and recesses also are given a particular shape. Thus the splines are slightly undercut at A on a very small radius. Immediately adjacent the undercut A the faces of the splines have a convex portion B with a radius of curvature approximately equal to one-half the width of the spline at the juncture between the convex portion and the undercut. The remainder C of the faces of the splines is also convex but

having a radius of curvature many times that of the portion B. The recesses in the roller are formed so as to be complementary to the splines of the rotor. That is, the outer corners of the recesses are formed with slight projections A' of the same radius as the undercut A of the splines. Adjacent the projection A' the face of the recess is formed with a concave portion B' having the same radius of curvature as the portion B of the spline. The remaining portion C' of the recess is also concave and has the same radius of curvature as the portion C of the spline. Thus it will be seen that the entire spline is received within the recess so that no fluid is trapped between the recess and the spline and so that the top of the spline is in contact with the bottom of the recess.

As shown herein the rotor is provided with eight splines while the roller has six recesses. With the diameter of rotor and roller here employed and with eight splines and six recesses respectively, successive splines and recesses are engaged before the preceding spline and recess are disengaged so as to provide a driving connection obviating the necessity of gearing for maintaining the rotor and roller in timed relationship. As a result the rotor and roller here disclosed may be considered as having two sealing contacts. The one is formed by the rolling action of the roller upon the rotor which contact travels substantially uniformly along the circumference of the rotor as the same is rotated. The second contact may be considered as that formed by the driving engagement of the faces of the recess in the roller within the faces of the splines on the rotor. The contact obtained between the peripheral portions of the roller and rotor is a purely rolling contact and may thus be very fluid tight without causing excessive wear and power consumption. Because of this the pump is capable of producing unusually high pressures or vacuums. With the spacing and shape of splines and recesses here shown the rolling contact travels progressively along the peripheral portions and particularly over the top of a spline to the edge of the driving face thereof before the faces of the spline and recess engage for a driving and sealing contact. Thus there is no trapping of fluid in the bottom of the recess.

Discharge from the pump takes place through a channel **36** (see Figs. 4 and 5) extending longitudinally of the pump and formed by cutting away one tapering edge of the crescent shaped portion **23**. The channel is positioned with one end disposed opposite the faces of the pumping elements just forwardly of the point of engagement thereof, considered in the direction of rotation, that is, to the left of the point of engagement as seen in Fig. 5. At its other end the channel communicates with the annular chamber **25**. To complete the discharge passageway, a channel **37** is formed partly in the cylindrical portion **22** and partly in the casing portion **11** (see Fig. 4). This channel communicates at one end with a channel **38** wholly in the portion **11** and registering with a channel **39** in the bearing **10**. The channel **39** terminates in a recess or port **40** threaded for the reception of a discharge pipe.

Means is provided herein for automatically varying the displacement of the secondary stage of the pump while maintaining a discharge of fluid at the same pressure and without changing the speed of rotation of the pump and without by-passing any of the fluid. Such automatic variation in the displacement of the secondary stage is under control of the pressure in the discharge passageway which operates through one of the pumping elements to increase or decrease the effectiveness of the stage depending upon whether or not the pressure in the discharge passageway falls below or exceeds a predetermined value because the pump is displacing a quantity of fluid respectively less or greater than the demand on the pump. This is accomplished by mounting the rotor **16** for axial shifting movement relative to the roller **17** thereby to vary the area of engagement between the two pumping elements of the secondary stage.

As previously stated the piston **27** and the collar **28**, which form a groove in which the rotor **16** is retained, are axially slidable and with the spring **29** form the means controlling the variation in displacement of the secondary stage of the pump. Normally the spring **29**, acting in compression between the collar **28** and a disk **45** abutting an adjusting screw **46** threaded in and projecting through the closed end of the housing **10**, retains the piston in its extreme forward position, that is, with the rotor and roller fully engaged. The spring **29** is calibrated in accordance with the area of the face of the piston **27** so as to exert a predetermined force which is overcome and permits rearward shifting of the piston and the rotor only after the pressure on the discharge side of the pump and acting upon the piston reaches a predetermined value. Thus the rotor will always engage the roller to an extent such that the quantity of fluid displaced by the pump is equal to the demand on the pump within the capacity thereof. The pressure at which discharge takes place is conveniently varied by adjusting the screw **46**. Preferably the aperture through which the screw **46** projects is closed by a gasket **47** and a screw plug **48** to render the casing fluid tight at that point.

In order that there may always be a space between the face of the piston **27** and the end wall **25'** so that the discharged fluid may at all times exert a pressure on the face of the piston, a bushing **49** is disposed in the channel **37** projecting a slight distance into the annular chamber to form an abutment. When the piston **27** is moved to obtain the maximum engagement between the pumping elements, it abuts the bushing **49** instead of the end wall **25'** and thus there is always an annular chamber between the piston and the end wall into which the secondary stage discharges. Only one such bushing is employed so that the exposed area of the face of the piston when the piston abuts the bushing is reduced only by the area of the bushing which is small compared with the total area of the face, thus assuring that the area of the piston exposed to pressure is substantially constant throughout the entire operating period of the pump.

It will be apparent from the foregoing that the piston **27** in addition to varying the displacement of the pump also controls all discharge therefrom. By abutting against the bushing **49** the piston closes the discharge passageway and retains the same closed until the pressure of the discharged fluid in the annular chamber is sufficient to overcome the force of the spring **29** thereby assuring that discharge will take place only at a desired predetermined pressure.

The axially shiftable mounting of the rotor **16** and piston **27**, under the control of the spring **29** and the pressure in the discharge passage, results in another feature of applicant's con-

struction, that is, a final discharge under full pressure as the pump is stopped. Thus, just as the pressure in the discharge passageway is balanced against the strength of the spring 29 to vary the displacement of the pump in accordance with the demand, so the spring operates to shift the piston forwardly, after the pump is stopped, at a rate sufficient to maintain full pressure in the discharge passageway until substantially all of the fluid has been discharged from the pump chamber 25.

It is also apparent that this axial shifting of the piston 27 by the spring 29 upon cessation of operation of the pump and the abutting of the piston against the bushing 49 operates to effect an instantaneous cut-off of the supply of fluid discharged from the pump. This cut-off is sharp and precise and assures that final discharge will be at substantially full pressure.

The axially shiftable means is employed herein for effecting yet another feature, namely a bleeding or relief of air without the use of the usual relief valve. To that end the piston 27 is formed with a channel 50 (see Fig. 4) terminating at its ends in restricted substantially radial channels 50' and 50''. The channel 50' communicates with the chamber 25 through a groove 51 in the portion 23 while the radial channel 50'' registers with a channel 52 in the housing 10. The channel 52 leads to a port 53 threaded to receive a pipe connected with a supply reservoir not shown. The radial channels 50' and 50'' register with the groove 51 and the channel 52 in the housing only when the pumping elements are in full mesh, that is, when the piston 27 abuts the bushing 49 to close the discharge passageway. This air bleed is provided to permit the pumping elements to exhaust air from the casing and the supply passages. During the period that air only is being pumped the pressure within the annular chamber 25 is not sufficient to move the piston axially and thus the air bleed passageway is maintained open. Immediately when the pump begins to discharge liquid, channels 50' and 50 so restrict the flow of fluid that sufficient pressure is built up within the annular chamber 25 to move the piston axially thereby moving the channels 50'' and 52 and channel 50 and groove 51 out of registry and closing the air bleed passageway.

Communicating with the annular chamber 25 is a channel 55 (see Fig. 6) terminating in a threaded recess 56 for the reception of a pressure gage (not shown) for indicating the pressure at which the pump is operating.

The primary stage operates to displace a constant volume of fluid and is provided for the purpose of lifting the fluid from the supply reservoir to the auxiliary reservoir in the housing 10 to maintain the secondary stage charged with fluid The primary stage comprises only a rotor 60 and a roller 61 meshing with and mounted eccentrically within the rotor. Here again the roller 61 is the driving element and to that end is secured by means of a pin 62 to the shaft 19 which thus forms a common shaft for the driving element of both the primary and the secondary stage. Filling the space between the eccentrically mounted roller and rotor is a crescent shaped projection 63 formed integral with the tubular member 21. The outer faces of the elements 60 and 61 are made fluid tight by an annular washer 64 secured in position by the rotary mechanical seal 12. Preferably the rotor 60 and roller 61 are constructed in the same manner as the rotor and roller of the secondary stage.

Extending horizontally and longitudinally of the lower portion of the casing is a duct 65 terminating at one end opposite the elements 60 and 61 at a point just rearwardly of the point of engagement of the elements to constitute a fluid supply passage for the primary stage. At the other end the duct 65 communicates with a vertical duct 66 extending downwardly into communication with a fuel bowl 67. This bowl is secured over a recess 68 formed in an appendage 69 of the pump casing. Fluid is supplied to the fuel bowl through an intake passage 70 formed in the appendage and terminating in a threaded recess 71 for the reception of a supply pipe (not shown) extending to the main fluid reservoir. The fuel bowl 67 is secured in position over the recess 68 by means of a bale 72 provided with a screw and thumb nut 73 for forcing the fuel bowl tightly against its seat. A gasket 74 is preferably interposed between the fuel bowl and the appendage to assure a fluid tight connection. Disposed within the bowl intermediate the supply passage 70 and the vertical duct 66 is a double screen 75 to prevent foreign matter from reaching the pumping elements.

A second horizontally and longitudinally disposed duct 76 constitutes the discharge passage for the primary stage and extends from a point opposite the elements 60 and 61 and just in advance of the point of engagement of the elements to the auxiliary reservoir formed by the housing 10.

The primary stage is of the same capacity as the secondary stage when the elements 16 and 17 thereof are in full mesh so that the primary stage will supply a greater amount of fluid to the auxiliary reservoir than will be drawn therefrom by the secondary stage when the same is displacing less than its maximum capacity. To take care of the excess amount of fluid supplied under those conditions the housing 10 is provided with a passage 77 communicating at one end with the auxiliary reservoir and at the other end with the air bleed outlet. Thus any excess fluid supplied by the primary stage is returned to the main reservoir through the air bleed outlet. It will be seen from the foregoing that the primary stage serves merely to supply the auxiliary reservoir with fluid and does not constitute a booster for the secondary stage. It is also believed apparent that the secondary stage functions entirely independently of the primary stage and where the lift from the reservoir to the pump is not excessive the secondary stage may be connected directly to the reservoir and the primary stage omitted. The primary stage pumps against no pressure except that offered by the restricted passage 77.

Briefly the operation of the pump is as follows: Assume that the main supply reservoir has been freshly filled with liquid and that the pump is stopped. With the pump at rest the parts will be in the position shown in Fig. 4, that is, the elements 16 and 17 of the secondary stage are in full mesh and the piston 27 is in its forward position abutting the sleeve 49 to close the discharge passage and to complete or open the air bleed passage. Now when the pump is started the primary stage will first draw air from the pipe leading to the main supply reservoir and from the fuel bowl 67 and the passage leading therefrom to the primary stage. This air will be discharged to the auxiliary reservoir of the housing 10 and from there it will be pumped by the secondary

stage. Such pumping of air by the secondary stage, however, does not build up a pressure in the annular chamber 25 and thus the piston 27 remains in its forward position closing the discharge passageway and retaining the air bleed passageway open to permit the exhausting of air. When the air has been exhausted from the fuel bowl 67 and the passage 65 the primary stage begins to pump liquid which likewise is discharged to the auxiliary reservoir. The displacement of the primary stage is constant and any excess liquid supplied to the auxiliary chamber is discharged through the channel 77. Such discharge of excess liquid also serves to carry with it air or vapor bubbles which may have formed in the auxiliary chamber and thus assures a supply of liquid only for the secondary stage.

Immediately upon commencement of a pumping of liquid by the secondary stage a pressure is built up in the annular chamber 25 sufficient to move the piston 27 rearwardly against the action of the spring 29. In such movement the piston opens the discharge passageway and moves the channels 50' and 50'' out of register with the groove 51 and channel 52 to prevent further discharge through the air bleed. The elements of the secondary stage are so proportioned that the maximum rated capacity of the pump is delivered when the piston is moved rearwardly a distance just sufficient to open the discharge passageway and close the air bleed passageway. The extent to which the piston moves axially is such that the secondary stage displaces a quantity of liquid equal to the demand on the pump. Regardless of whether the demand varies or whether the demand remains constant and the speed of the pump varies, the piston 27 functions to maintain the rotor 16 in such engagement with the roller 17 that the displacement of the pump is equal to the demand thereon within the capacity of the pump. Thus the pump may function as a variable displacement pump at either constant or variable speed or as a constant displacement pump at variable speed.

When the pump is stopped the piston 27 under the action of the spring 29 moves forwardly at such rate that the predetermined pressure is maintained until the piston strikes and closes the bushing 49 in the discharge passageway. Thus the final discharge is at the desired pressure and the cut-off is instantaneous.

I claim as my invention:

1. In a rotary pump a casing having an inlet and an outlet passageway, a rotor and a roller within said casing operable to discharge fluid forcibly therefrom, and an element within said casing responsive to the pressure on the discharge side of the pump controlling the outlet passageway from said pump casing and operating to vary the displacement of the rotor and roller.

2. In a rotary pump a casing having an inlet and an outlet passageway, a relatively shiftable rotor and roller within said casing cooperating to draw fluid into said casing and discharge the same therefrom, a shiftable control member carrying one of said pump elements and disposed to govern the outlet passageway, said control member being responsive to the pressure on the discharge side of the pump and shifted thereby to open the outlet passageway and determine the relative position of said rotor and roller, and a spring urging said member to close the outlet passageway to retain the same closed until the pressure reaches a predetermined value.

3. A rotary pump comprising a casing having a bore, an outlet passage communicating with the bore and an inlet passage, means in part forming a pump chamber within the bore, rotary pump elements positioned within the chamber operable to draw fluid into the chamber from the inlet passage and discharge the same into the bore, one of said elements being axially shiftable relative to the other, and an axially shiftable element completing the pump chamber and carrying the shiftable one of said pump elements and governing by its axial shifting the outlet passage and the displacement of the pump in response to the pressure of the fluid within the bore.

4. A rotary pump comprising, a casing having a cylindrical bore, an outlet passage at one end communicating with the bore and an inlet passage, means in part forming a pump chamber within the casing, piston means slidable in the bore completing the pump chamber, a rotor operating within the chamber supported by said piston means, for axial movement, a roller eccentrically mounted within said rotor and cooperating therewith to draw fluid through the pump chamber, the pump chamber communicating with the inlet passage and discharging into the bore in the casing, said piston means when in one extreme position closing off the outlet passage and positioning the rotor in full engagement with the roller, said piston means having an end face exposed to the fluid discharged from said chamber into the bore and urged thereby toward the other extreme position to open the outlet and shift the rotor away from full engagement with said roller, and a spring opposing the action of the fluid on said piston and coacting therewith to govern the opening of the outlet and the displacement of the pump.

5. A rotary pump comprising, in combination, a casing having an inlet and an outlet passage, means forming in part a pump chamber within said casing, rotary pump elements within the chamber operable to draw fluid therethrough, the pump chamber communicating with the inlet passage in the casing and discharging into the interior of the casing, and movable means maintained in contact with at least one of said pump elements forming another part of the pump chamber and operating when the pump stops to change the size of the chamber and thereby force out the fluid in the casing under full pressure.

6. A rotary pump comprising, in combination, a casing having an inlet passage, a first outlet passage, a second outlet passage and conduit means communicating therewith, the first outlet passage being for the discharge of liquid, the second outlet constituting an air relief, rotary pump elements within said casing operable to draw fluid into the casing and discharge it therefrom, one of said pump elements being relatively shiftable axially to vary the displacement of the pump by modifying the effectiveness thereof, and an axially shiftable element co-operating automatically with said elements to vary the displacement of the pump, govern the discharge passages, and effect initial and final discharge at full pressure.

7. A rotary pump comprising, in combination, a casing having a bore therein, means including an annular piston slidable in the bore in said casing forming a pump chamber, a rotor and a roller eccentrically mounted within the rotor and housed in said pump chamber, said rotor being carried by said piston and said piston being urged by the fluid pumped in a direction to unmesh said rotor and roller, a shaft for driving said roller extending outwardly through one end of said

casing, a mechanical rotary seal closing the end of the casing through which the shaft projects, a spring within the casing urging said piston in a direction to effect a full meshing of said rotor and roller and adjusting means for said spring accessible from the exterior of the casing at the end opposite the mechanical seal.

8. A rotary pump comprising, in combination, a casing having a bore therein, an annular piston slidable in said bore, means including said piston forming a pump chamber, means including the end of said piston forming with the bore in the casing an annular chamber, a rotor and a roller housed in said pump chamber with the roller eccentrically mounted within the rotor, operating to draw fluid into the pump chamber and forcibly discharge the same into said annular chamber, and the rotor mounted in said piston for axial movement relative to said roller, said casing having a discharge passage leading from said annular chamber, a shaft for driving said roller extending past the annular chamber and outwardly through one end of said casing, a mechanical rotary seal closing the end of the casing through which the shaft projects, a compression spring within the casing urging said piston in the direction of the projecting end of the shaft to effect a full meshing of said rotor and roller and to reduce the size of said annular chamber, and adjusting means for said spring accessible from the exterior of the casing at the end opposite the mechanical seal.

9. A rotary pump comprising, in combination, a cup-shaped housing having a cylindrical bore at its open end, a cylindrical casing portion secured to the open end of said housing and having a bore therein, a tubular member extending longitudinally of said casing having a first cylindrical end fitting within the bore of said casing portion, a crescent shaped intermediate portion reduced from said end and a second substantially cylindrical end joining with said crescent shaped portion in a smooth uninterrupted outer surface, said first cylindrical end having an eccentric bore therein, a sleeve extending through said bore, a drive shaft journaled in said sleeve, a roller fast on said drive shaft and interposed between the opposed end faces of said sleeve and the second cylindrical end, an annular piston slidable in the bore of said housing and surrounding said crescent shaped portion and said sleeve to form therewith an annular chamber, said piston having an annular internal groove, a rotor mounted in said groove and meshing with said roller over a portion of the circumference thereof, a collar slidable on the second cylindrical end and closing the groove in said piston to complete the pump chamber for said rotor and roller, a passage extending from the interior of said housing to a point rearwardly of the point of engagement of said rotor and roller to provide an intake passageway therefor, a channel extending from a point in advance of the point of engagement of said rotor and roller to said annular chamber to provide an outlet passage, a liquid discharge passage opening into said annular chamber through the end wall thereof and having a bushing projecting inwardly to form an abutment against which said piston strikes, an air bleed passage formed in part in said piston and in part in said housing, the parts of said air bleed passage registering when the piston abuts the bushing of the liquid discharge passageway and being out of register immediately upon movement of said piston away from said abutment, and a spring urging said collar and annular piston toward engagement with the bushing in the discharge passageway.

10. A rotary pump comprising, in combination, a casing having a longitudinal bore therein closed at one end, a tubular member extending longitudinally of the bore and having a crescent shaped portion at one end and a crescent shaped portion intermediate its ends, means including a rotary mechanical seal forming with the tubular member and the crescent shaped end portion thereof a fixed pump chamber, a rotor and a roller housed in said fixed pump chamber with the roller mounted eccentrically within the rotor and constituting a primary stage lifting fluid from a source and discharging the same within the casing at the closed end thereof, means forming with said intermediate crescent shaped portion a variable pump chamber, a rotor and a roller housed in said variable pump chamber with the roller mounted eccentrically within the rotor to constitute a secondary stage for discharging variable quantities of fluid from said casing, and a common shaft extending outwardly through said mechanical rotary seal for driving the rollers of said primary and secondary stages.

11. A rotary pump comprising, in combination, a casing having a bore, a tubular member having a first cylindrical portion fitting tightly within the bore, an intermediate crescent shaped portion, a second cylindrical portion at one end and a second crescent shaped portion at the other end, said intermediate crescent shaped portion and said second cylindrical portion being reduced from said first cylindrical portion to form an annular chamber with the bore, the first cylindrical portion constituting the end wall of said chamber, said first cylindrical portion having an eccentric bore therein, a sleeve extending through said bore, a drive shaft journaled in said sleeve, a first roller fast on said shaft and disposed between the second cylindrical portion and the opposed end of said sleeve, a second roller fast on said shaft disposed opposite the remaining end of said sleeve, a washer and a rotary mechanical seal closing the end of the casing through which said drive shaft projects and forming with the tubular member and the sleeve a pump chamber, a rotor mounted within the chamber encircling the roller and the crescent shaped portion to form a primary stage of the pump, an intake passage for said primary stage, a discharge passage leading to the opposite end of said casing, means including an axially shiftable member cooperating with said tubular member and said sleeve to complete a second pump chamber, a rotor mounted for axial movement with said axially shiftable member to form a secondary stage of the pump, an intake passage for said secondary stage and an outlet passage leading to said annular chamber, a discharge passage leading from said annular chamber having a bushing projecting into the chamber providing an abutment against which said axially shiftable member strikes, and a spring urging said axially shiftable member toward engagement with said abutment to counteract the pressure in said annular chamber and resist axial shifting of the rotor until a predetermined pressure is established.

12. In a rotary pump, a roller and a rotor adapted to cooperate with the roller having a plurality of inwardly projecting circumferentially spaced splines, the inner circumference of said rotor intermediate the splines and the ends of the splines being cylindrical with the center of

the radii of curvature coinciding with the axis of the rotor, said splines having slightly convex faces with a concave undercut at the base of the splines forming thereby a reverse curve near the base, said roller having complementarily shaped splines and recesses adapted to engage the rotor during rotation in constantly progressive contact.

13. In a rotary pump, fluid pumping means comprising a roller and a rotor meshing with the roller, said rotor having a plurality of inwardly projecting circumferentially spaced splines, the inner circumference of said rotor intermediate the splines and the ends of the splines being cylindrical with the center of the radii of curvature coinciding with the axis of the rotor, each face of said splines being undercut on a small radius at the base of the splines, the portion immediately adjacent the undercut portion being convex with a radius of curvature approximately equal to one-half the width of the spline, and the remaining portion of the face being convex and with a substantially larger radius of curvature.

14. In a rotary pump, a rotor and a roller adapted to be mounted eccentrically within and mesh with the rotor, said roller having a plurality of circumferentially spaced recesses, the bottoms of said recesses and the portions of the roller intermediate the recesses being cylindrical with the radii of curvature coinciding with the axis of the roller, each face of said recesses terminating at its outer end in a convex projection of a very small radius of curvature, the portion immediately adjacent said projection being concave with a radius of curvature approximately equal to one-half of the width of said recess, and the remaining portion of each face being concave with a radius of curvature substantially larger than the adjacent portion.

15. In a rotary pump, a rotor having a plurality of inwardly projecting circumferentially spaced splines, the inner circumference of said rotor intermediate the splines and the ends of the splines being cylindrical with the center of the radii of curvature coinciding with the axis of the rotor and a roller adapted to be mounted eccentrically within said rotor having a plurality of circumferentially spaced recesses adapted to mesh with the splines of said rotor, the bottoms of said recesses and the portions of said roller intermediate said recesses being cylindrical with the radii of curvature coinciding with the axis of the roller to enable the roller to engage the rotor in a rolling contact, said splines having convex faces with a convex undercut at the base of the splines and said recesses having concave faces and a convex projection at the outer ends thereof, the concavity and convexity of the faces of the recesses being the same respectively as the convexity and concavity of the faces of the splines so that a spline may be received wholly within a recess without trapping fluid in the recess.

16. A rotary variable displacement pump comprising, a casing having a cylindrical bore, an inlet passage and an outlet passage communicating with the bore, a rotor, a roller mounted eccentrically within said rotor and meshing therewith over a portion of its circumference, a shaft for driving said roller, stationary means including a portion of crescent shape interposed in the space between the rotor and roller, extending longitudinally of the casing in spaced relation thereto providing a journal for said shaft and forming the part of a pump chamber in which said roller operates, an annular piston having a sliding fit with said stationary means and the bore and having an annular groove for supporting therein said rotor for axial movement relative to said roller, the pump chamber so formed having an intake passage and a passage discharging into the bore, said annular piston when in one extreme position positioning the rotor in full engagement with the roller and having an end face exposed to the fluid discharged from said chamber into the bore and urged thereby toward the other extreme position to shift the rotor axially away from full engagement with said roller, and a spring opposing the action of the fluid on said piston means and coacting therewith to govern the displacement of the pump.

17. In a rotary pump, a casing having a cylindrical bore forming in part a chamber, an inlet passage to the casing, and an outlet passage from the chamber, means extending longitudinally of the casing in spaced relation to the walls thereof forming a pump chamber, an intake passage for the pump chamber communicating with the casing and a discharge passage leading to said chamber in the bore, rotary pump elements within the pump chamber operable to discharge fluid to the chamber in the bore, an annular piston slidable in the bore and on the pump chamber forming means and constituting one end wall of the first mentioned chamber to be acted upon by the fluid in the chamber, said piston in one extreme position closing off the outlet passage, but urged by the fluid in the chamber in a direction to open the outlet passage, and a spring opposing the action of the fluid on said piston and coacting therewith to govern the opening of the outlet.

18. In a rotary pump a casing having a cylindrical bore, an inlet passage to the casing and an outlet passage leading from the bore, means extending longitudinally of the casing in spaced relation thereto forming a pump chamber and partially defining a second chamber in the bore communicating with the outlet passage, said pump chamber communicating with the inlet passage to the casing and discharging to the second chamber, cooperating rotary pump elements within the pump chamber, an annular piston axially slidable in said bore along said pump chamber forming means and completing the second chamber, the fluid in said second chamber urging said piston in a direction increasing the size of the chamber, and a spring opposing the action of the fluid and operating when the pump stops to shift the piston and force out the fluid in the chamber under full pressure.

19. A rotary variable displacement pump comprising, in combination, a casing having a cylindrical bore, an inlet passage, a first outlet passage and a second outlet passage, the first outlet passage being for the discharge of liquid, the second outlet passage constituting an air relief and both outlet passages communicating with the bore in said casing, means extending longitudinally within the casing in spaced relation thereto forming part of a pump chamber, a roller in that part of the pump chamber, an annular piston means axially slidable in the bore and along said means completing the pump chamber, said pump chamber communicating with the inlet passage and discharging into the bore, a rotor supported by said piston means in cooperating eccentric relation with and for axial movement relative to said roller, said piston means when in one ex-

treme position closing off the first outlet passage, opening the air relief and positioning the rotor in full engagement with the roller, said piston means having an end face exposed to the fluid discharged from the pump chamber into the bore and urged upon the discharge of liquid toward the other extreme position to open the first outlet passage, close the air relief and shift the rotor away from full engagement with said roller, and a spring opposing the action of the fluid on said piston means and coacting therewith to govern the outlets and the displacement of the pump.

20. In a pump, a casing having a bore therein, an inlet passageway, a first outlet passage and a second outlet passage, means forming a pump chamber within the casing having an intake passage and a discharge passage adapted to communicate respectively with the inlet passage and the outlet passages, pumping elements disposed in said pump chamber operable to draw fluid into the chamber and forcibly discharge the same therefrom, a piston slidable in the bore having an end face exposed to the fluid discharged from said pump chamber and tended to be shifted axially thereby, a spring resisting such movement of the piston by the pressure of the fluid discharged, and a duct in said piston having one end in constant communication with the discharge passage from the said pump chamber, and the other end adapted to register with said second discharge passage when the pump is discharging air only, and to be moved out of register with said second discharge passage when said pump is discharging liquid.

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