Feb. 7, 1928.

1,658,031

B. S. AIKMAN

PNEUMATIC PUMP

Filed Dec. 31, 1923

4 Sheets-Sheet 1

Fig. 1.

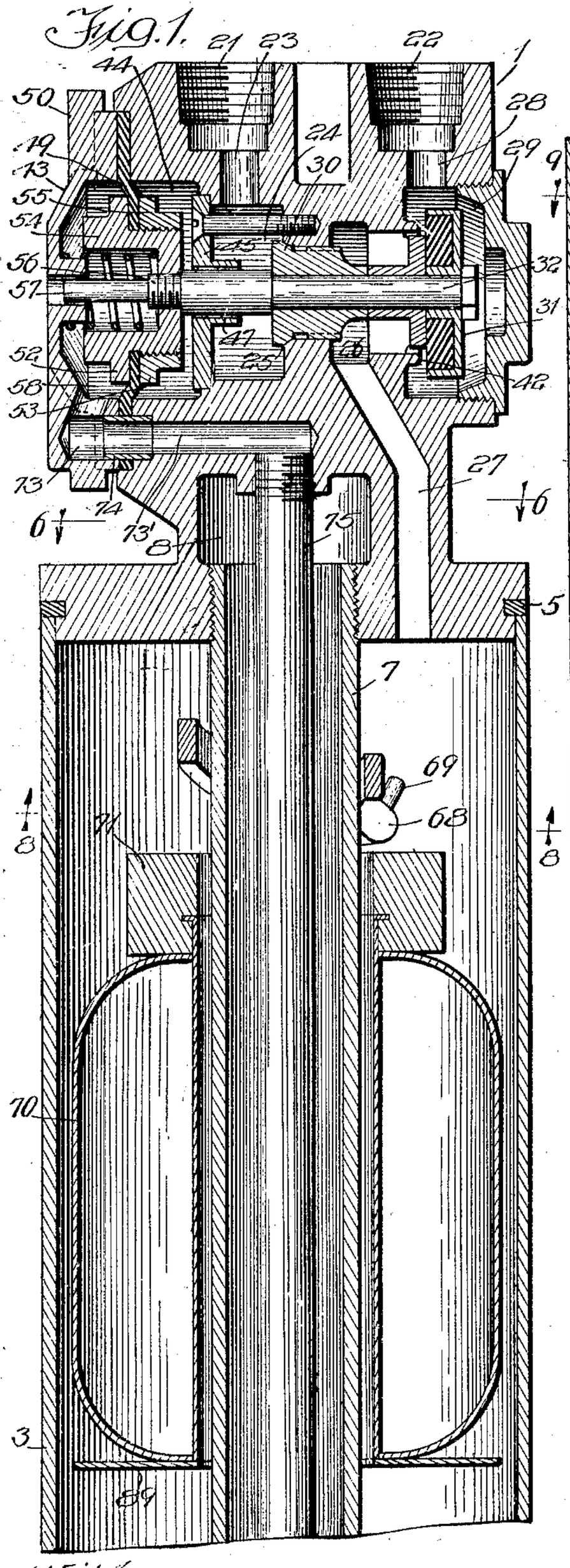
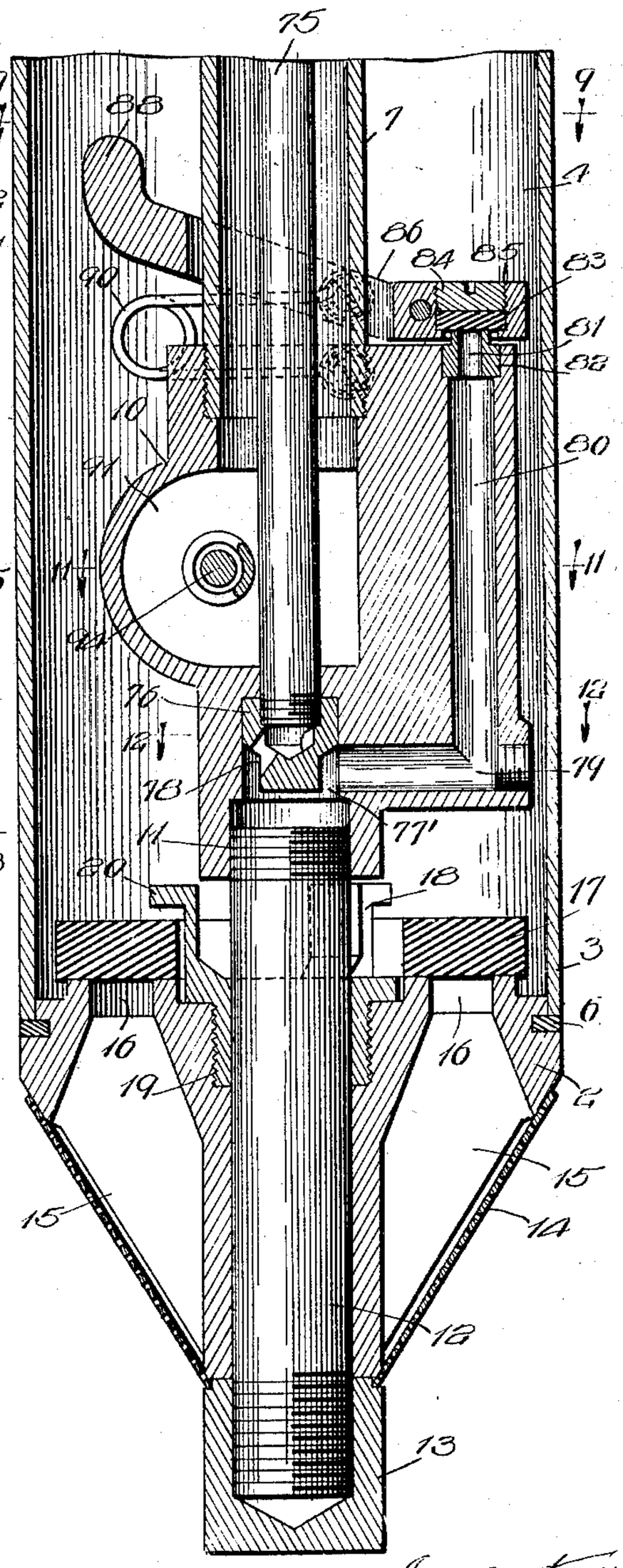


Fig. 2.



Witnesses:
W. P. Kilroy
Harry R. L. White

Inventor:
Burton S. Aikman
Brown Bostteter Dinner
By
Attys.

Feb. 7, 1928.

B. S. AIKMAN

PNEUMATIC PUMP

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1,658,031

4 Sheets-Sheet 2

Fig. 3.

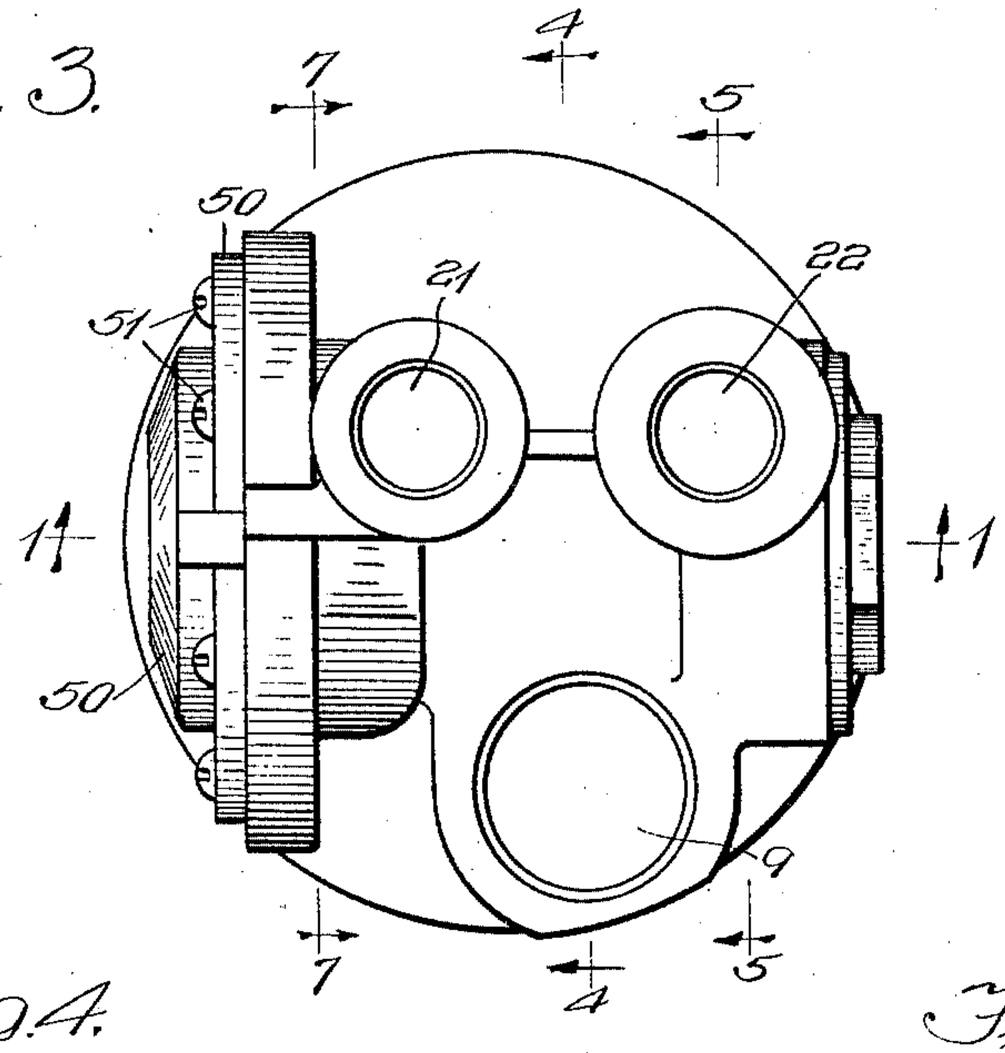


Fig. 4.

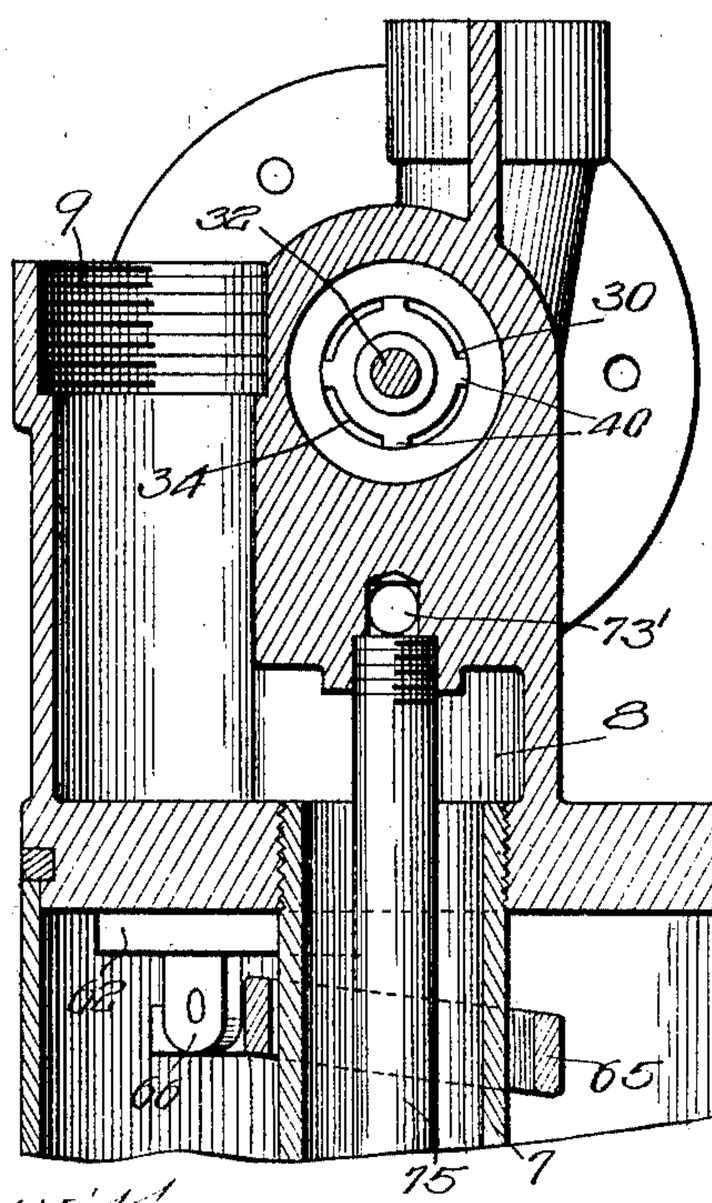
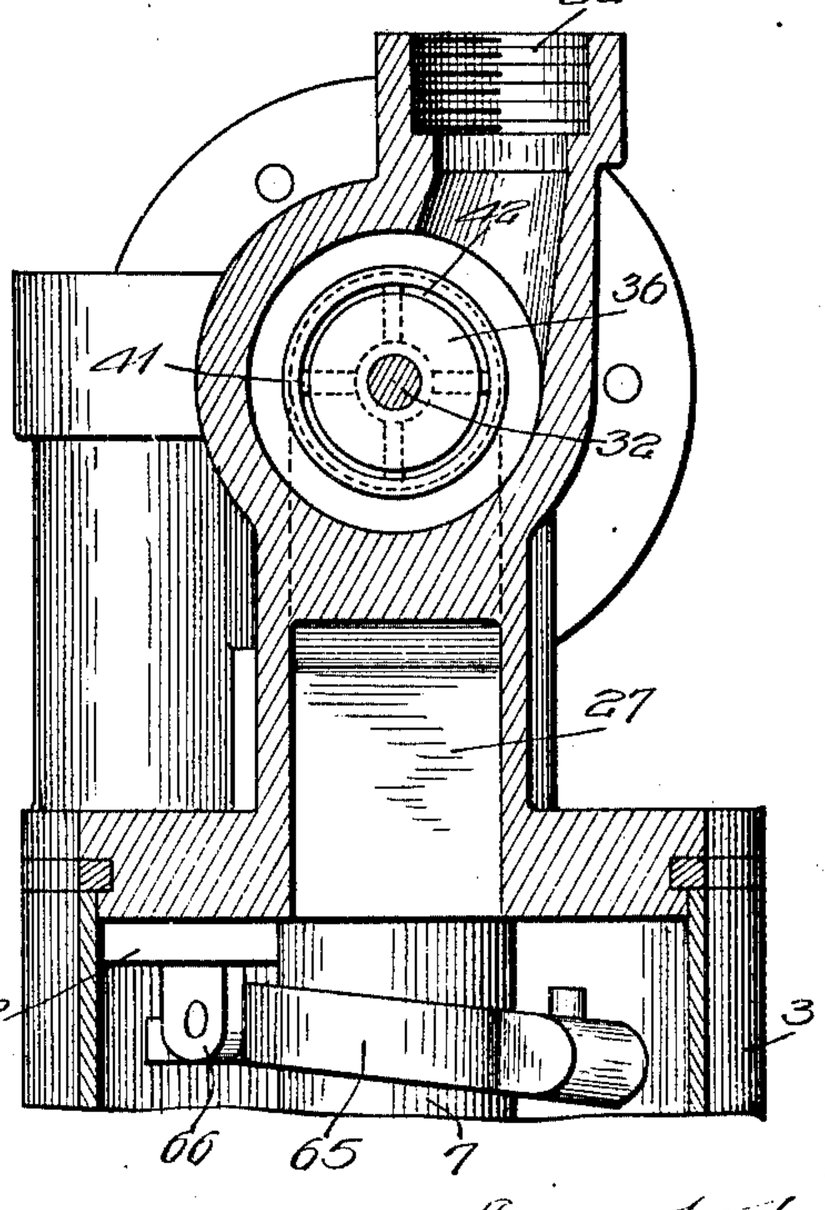


Fig. 5.



Witnesses:
W. P. Kilroy
Harry R. L. White

Inventor:
Burton S. Aikman
By Brown Boettcher Dunn
Attys

Feb. 7, 1928.

1,658,031

B. S. AIKMAN

PNEUMATIC PUMP

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4 Sheets-Sheet 3

Fig. 6.

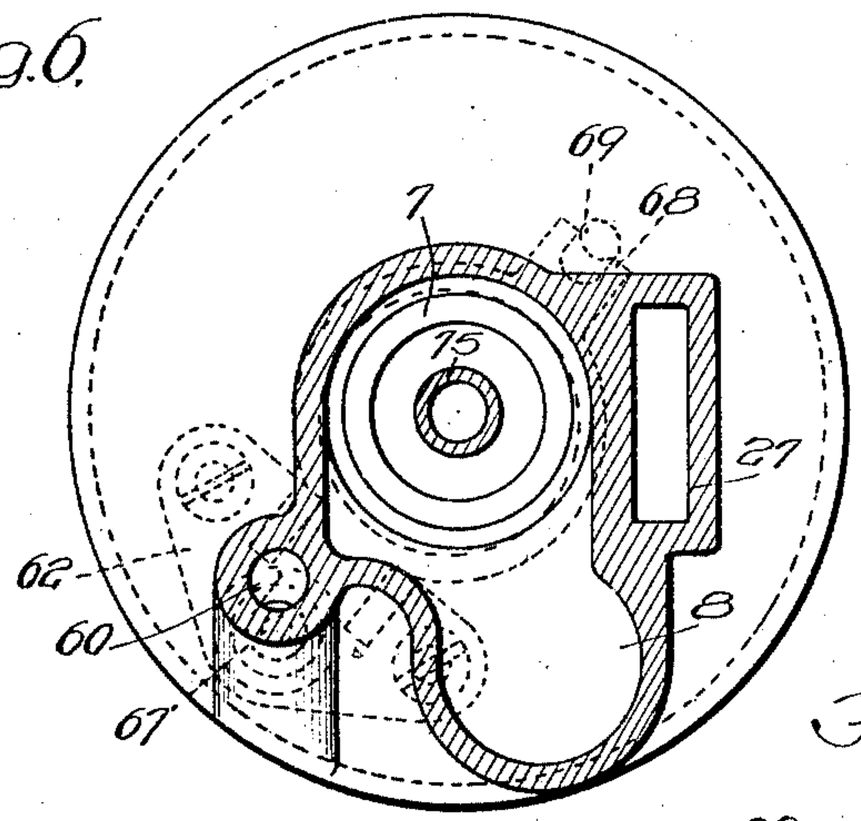


Fig. 13.

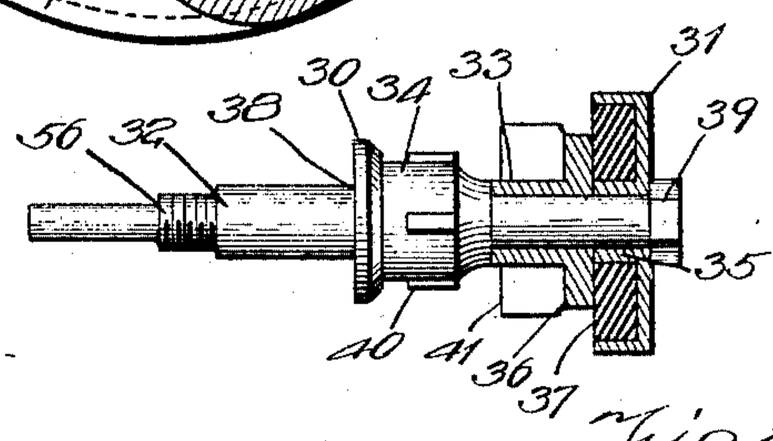


Fig. 7.

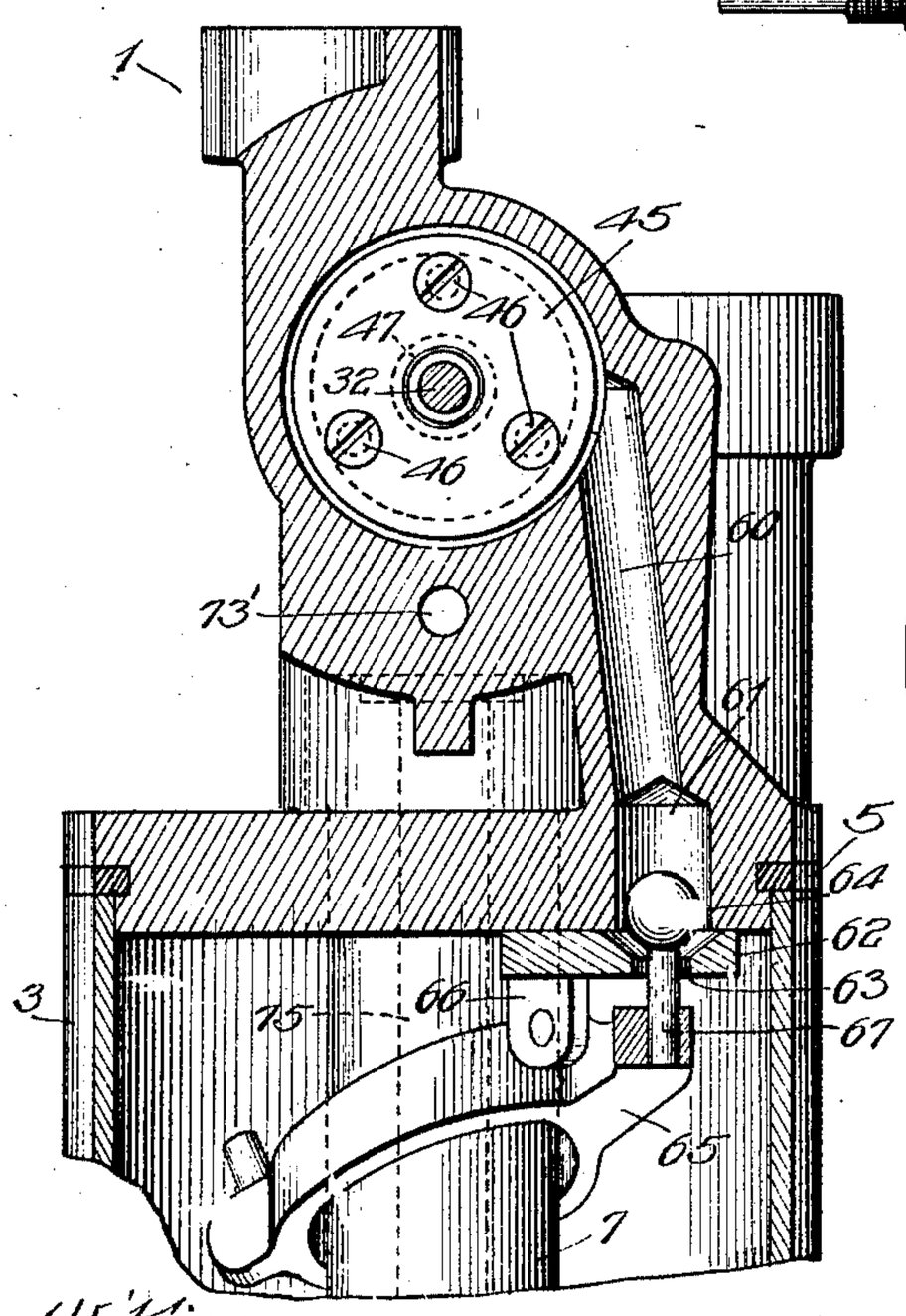
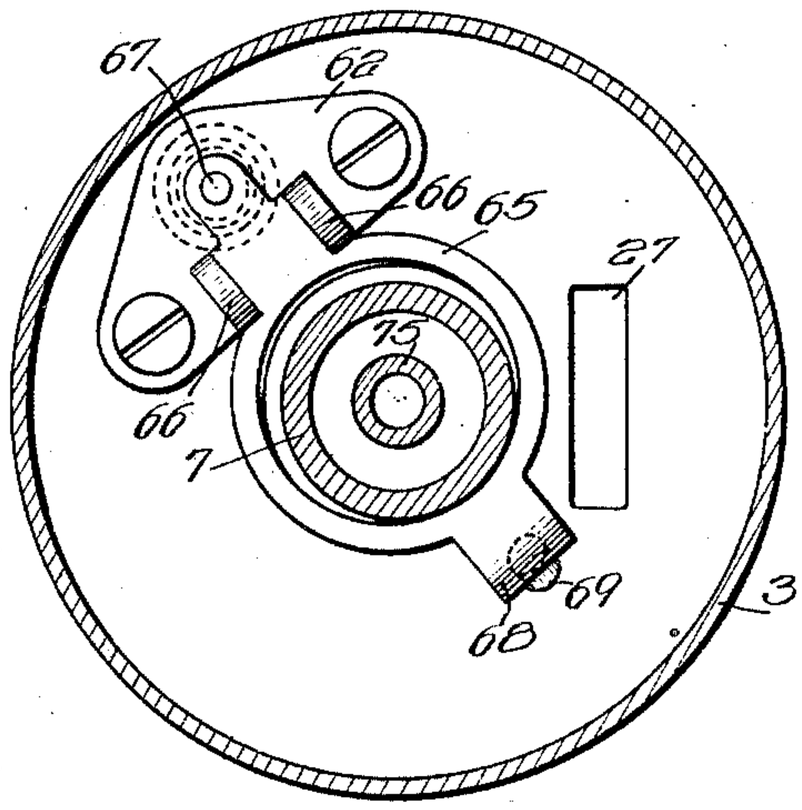


Fig. 8.



Witnesses:
W. P. Kilroy
Harry R. L. Wheeler

Inventor:
Burton S. Aikman
By Brown Boettcher Dimmock
Attys

Feb. 7, 1928.

B. S. AIKMAN

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1,658,031

4 Sheets-Sheet 4

Fig. 9.

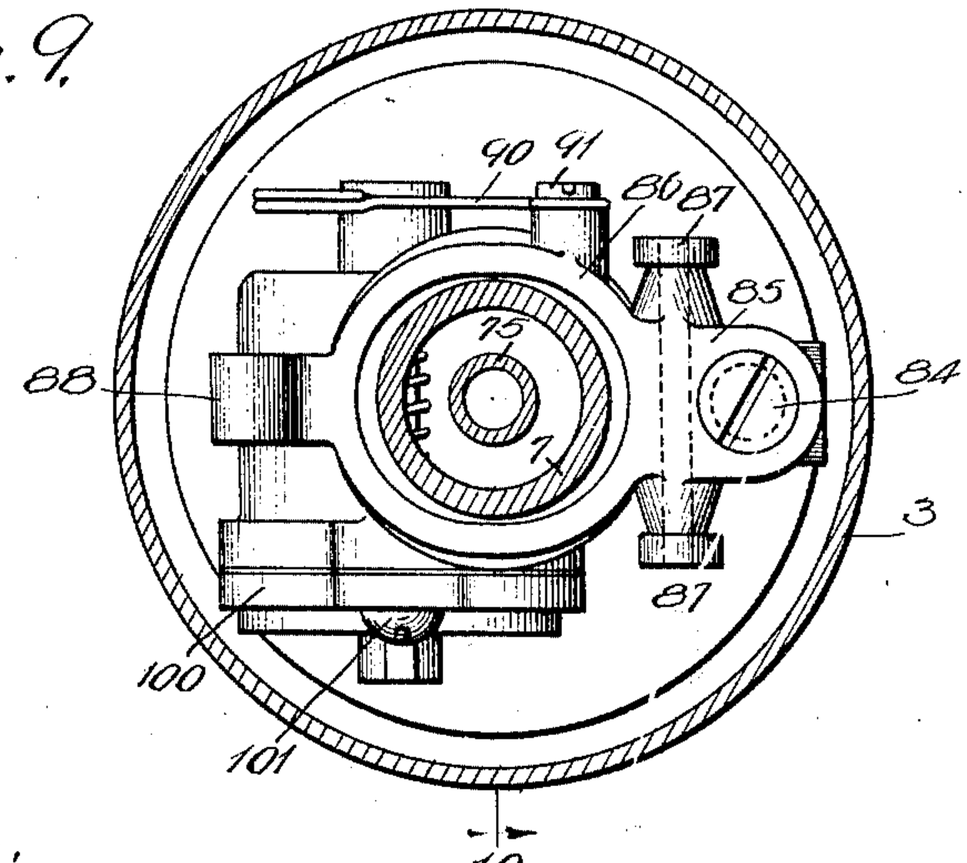


Fig. 10.

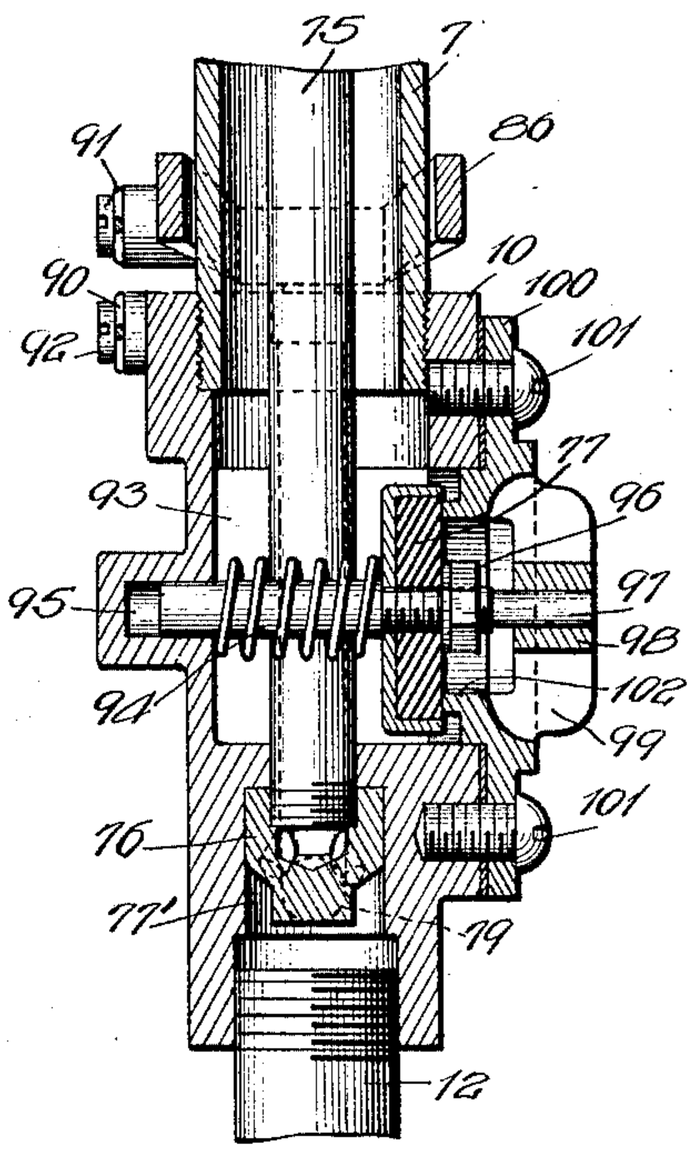


Fig. 11.

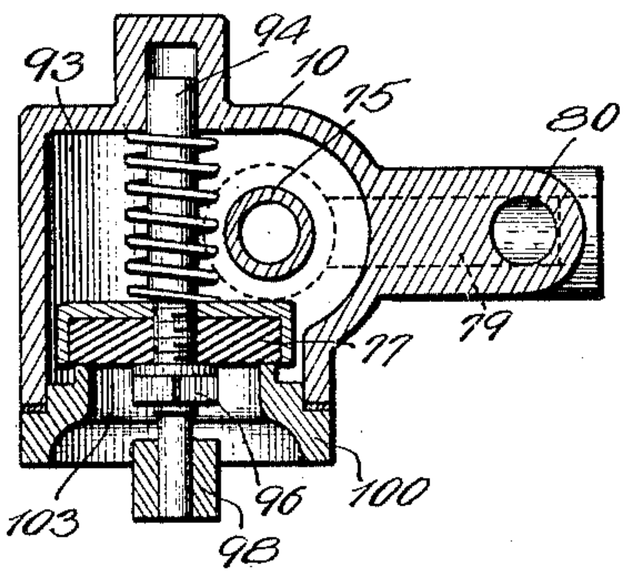
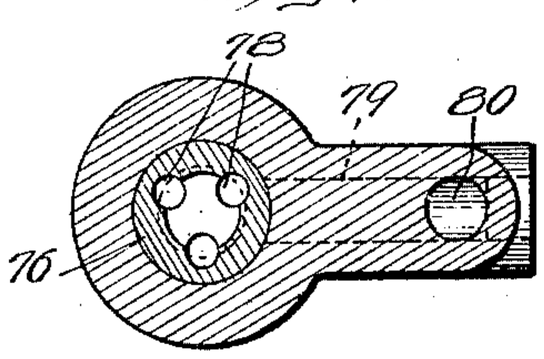


Fig. 12.



Witnesses:
W. P. Kilroy
Harry R. L. White.

Inventor.
Burton S. Aikman
By Brown Bottcher Dennis
Attys.

Patented Feb. 7, 1928. 1,658,031

UNITED STATES PATENT OFFICE.

BURTON S. AIKMAN, OF MILWAUKEE, WISCONSIN, ASSIGNOR TO NATIONAL BRAKE AND ELECTRIC COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF WISCONSIN.

PNEUMATIC PUMP.

Application filed December 31, 1923. Serial No. 683,538.

My invention relates to pneumatic pumps of the class disclosed in my prior Patent No. 1,423,291, granted July 18, 1922. While the invention is particularly suitable for faucet control and is particularly adapted to a single cylinder pump it is to be understood that the invention is not limited to such use or such particular embodiment.

As explained in said prior patent, one of the fundamental requirements of a single cylinder faucet control pump is that the pump be able to fill rapidly so that the intermission between discharge strokes shall be as short as possible in order to avoid storing of any substantial amount of water in the steady flow chamber which is used on the discharge line. In said prior patent a relatively large exhaust port is provided and this exhaust port is obstructed by a poppet valve seating with pressure so as to remain tight. A large valve is essential for rapid evacuation of air pressure but this entails the requirement of relatively great power to open such a poppet valve. While this arrangement is highly advantageous I find that it has one structural difficulty, namely that if a yielding face be employed on the valve for insuring tightness of the valve the pulling of the valve off against internal pressure tends to tear the valve face loose from the exhaust valve. As is well known to those skilled in the art a yielding valve face is essential to maintaining the exhaust valve tight where the same is of considerable size.

One of the novel features of the present invention is a valve employing a yielding face and seating against pressure so that opening of the valve does not tend to displace or stress the yielding face. To hold such valve closed I employ a normally unbalanced differential pressure motor. Even if a yielding face be provided on the valve, and it is to be understood that this is not absolutely essential to the practice of the invention, very small clearance of the exhaust valve is required for suitable operation because the stresses upon the valve face are such as to tend to clear the valve port when the valve starts to open.

It will be understood that in the prior construction where the yielding face of the exhaust valve tended to tear loose as the valve is opened, such valve must be moved a considerable distance away from the port to insure clearance and continued opening of such port. In the valve of my present invention only a small travel of the valve is necessary to secure complete and adequate opening of the same.

This opening of the exhaust valve I secure by a low level control which changes the pressure condition on the differential pressure motor to a sufficient degree to permit the exhaust valve to move to open position.

At the same time I employ the admission valve as a snap actuating device to impart a quick and positive motion to the exhaust valve in both its opening and its closing motion. I believe that I am the first to use a slightly open poppet valve as snap acting means for closing another control valve or for opening the same.

The admission valve is made preferably with a metal face so that its opening as it moves away from its seat against pressure may be relatively small to secure this snap action which I have mentioned. No difficulty is encountered even if the admission valve leaks slightly since such leakage can occur only during the brief periods that the exhaust valve is open. The exhaust valve, however, must be tight because it holds the pneumatic pressure while the pump stands under pressure as is required by faucet control.

Furthermore I wish to point out that according to my present invention the mode of operation of the admission and exhaust valves and their control or operating motor is substantially different from and an improvement upon the device shown in my prior patent.

Incidently there are a number of other features and improvements which will be apparent from the following specification and the claims.

In order to acquaint those skilled in the art with the manner of constructing and operating a device embodying my invention I shall now describe in connection with the accompanying drawings a specific embodiment thereof.

In the drawings:

Figure 1 is a longitudinal vertical section

through the head and upper part of the pump valve of a device embodying my invention;

Fig. 2 is a vertical longitudinal section of the lower and foot portion of the same;

Fig. 3 is a plan view of the pump shown in Figures 1 and 2;

Fig. 4 is a section taken through the head on the line 4—4 of Fig. 3;

Fig. 5 is a similar section through the head taken on the line 5—5 of Fig. 3;

Fig. 6 is a horizontal section through the head taken on the line 6—6 of Fig. 1;

Fig. 7 is a section taken through the head on the line 7—7 of Fig. 3;

Fig. 8 is a horizontal cross section taken on the line 8—8 of Fig. 1 showing the high level control valve;

Fig. 9 is a horizontal cross section taken on the line 9—9 of Fig. 2 showing the low level control valve in plan view;

Fig. 10 is a fragmentary vertical section of the valve box taken on the line 10—10 of Fig. 9;

Fig. 11 is a horizontal transverse section of the valve box taken on the line 11—11 of Fig. 2;

Fig. 12 is a similar view taken on the line 12—12 of Fig. 2 showing the connection for low level control of the valve operating motor; and

Fig. 13 is an elevational view of the main valves and the stem therefor.

The pump which I have illustrated comprises primarily the head member 1 which is preferably made of a brass or bronze casting, the foot member 2 which is preferably of like construction, and the barrel member 3 which is preferably a piece of seamless tubing. The head casting 1 is suitably cored and machined to provide the various sockets, passageways and chambers hereinafter more specifically described. The foot casting 2 is similarly cored and machined to provide an inlet passage and valve seat for the admission of water into the pumping chamber 4 which is the space defined between the head and foot members 1 and 2 and enclosed by the barrel 3. Suitable ring gaskets 5 and 6 are engaged by the upper and lower ends respectively of the tube or sleeve 3 to form a fluid tight joint. The head and foot casting members 1 and 2 are held upon the ends of the tube or sleeve 3 by a central water discharge pipe 7 which at its upper end is threaded into a suitable pipe socket formed in the lower face of the head casting 1. This water discharge pipe 7 communicates at its upper end with a water discharge passageway 8 as will be more clear from Figures 1, 4 and 6 and it terminates in a pipe socket 9 at the top side of the head casting 1 into which pipe socket the water discharge pipe from the pump is threaded.

The lower end of the water discharge pipe 7 is threaded into a pipe socket formed in the upper side of a valve box 10 shown more clearly in Figures 2, 10 and 11. This valve box casting has a threaded socket 11 at its lower end into which there is threaded the stud or pin 12. This stud or pin 12 passes down through a central axial bore in the foot member 2 and extends therethrough to receive the cap nut 13 which draws up the head and foot casting members upon the ends of sleeve or barrel member 3. A suitable screen which may be made of perforated sheet metal or the like is held in place under the edge of the nut 13 and covers the intake passageways 15 which are formed in the foot casting. These inlet passageways 15 terminate in the inlet check valve port 16 which port is annular and has concentric seats covered by the ring check valve 17. This ring check valve 17 may be made of hard rubber or a suitable molded composition such as bakelite. It is guided upon a tubular guiding member 18, the lower end of which is a continuous sleeve threaded into a socket 19 and the upper end of which consists of three arms having suitable lugs 20 for limiting the upward movement or lift of said inlet check valve 17.

The head casting 1 contains two pipe sockets 21 and 22 in addition to the pipe socket 9. The socket 21 communicates with an inlet passageway 23 which leads into a valve pocket 24 and then through a valve port 25 into a pocket 26 which pocket communicates by way of a passageway 27 with the interior of the pumping chamber 4. Thus said pipe socket 21 is adapted to be connected by suitable pipe to a source of pressure fluid such as a tank of compressed air. The socket 22 is adapted to be connected to an exhaust pipe leading to atmosphere. This socket 22 connects by way of a short passageway 28 into a valve pocket 29 and through a valve port to the pocket 26 which communicates also by way of passageway 27 with the interior of the pumping chamber 4. An admission valve 30 and an exhaust valve 31 are mounted upon a common stem 32 with a spacing sleeve 33 between them. This spacing sleeve bears at one end against the guiding portion 34 of the admission valve 30 and at the opposite end it bears against the central hub portion 35 of the exhaust valve 31 and it has an extending flange 36 which partially overhangs the yielding valve face 37. The admission valve 30 fits closely on the reduced portion of the stem and bears against a shoulder 38. Nut 39 is threaded upon the end of the stem 32 so as to draw the exhaust valve against the sleeve 33 and this in turn against the adjacent end of the admission valve 30 and the admission valve 30 against the shoulder 38 to form a rigid unitary struc-

ture. The guide portion 34 of the admission valve 30 has suitable wings or lands 40 which are guided in the cylindrical passageway formed between the valve pocket 24 and the pocket or chamber 26. The sleeve 33 similarly has wings or lands 41 which guide the same in the cylindrical concentric bore of the exhaust port 42. It will be observed that the travel of this compound valve structure is short and in the structure which I have illustrated one thirty second of an inch travel is sufficient to secure complete opening and closing of the valves 30 and 31 alternately. Since compressed air is admitted upon the back of the admission valve 30 it will be appreciated that considerable force is required to pull it from its seat and also that considerable force will be required to hold the exhaust valve 31 closed against its seat. I have provided therefore a differential pressure motor 43 which is adapted to operate the compound valve structure and which motor 43 is controlled by means responsive to high and to low level in the pumping chaber 4 for shifting the valve to admission position when the liquid has substantially filled the pumping chamber and for shifting the valve structure to the exhaust position when the pumping chamber has been substantially emptied. This differential pressure motor 43 comprises a cylinder or chamber 44 formed in the head 1, one side of said chamber being closed by the guide plate 45, this guide plate being held in a suitable seat by means of three conical head screws 46 as will be more apparent from Figures 1 and 7. The guide plate 45 has a central boss 47 which is drilled to provide a loose or so called "sloppy" fit with the stem 32. This loose fit of the stem 32, with the hole through the boss 47 of the guide plate 45, provides a leakage passageway for live air from the live air admission port 23 in advance of the admission valve 30 and its seat 25 to the interior of the pumping chamber. This leakage passageway extends along the stem 32, through the diaphragm chamber or pocket 44, down the passageway 60, pocket 61, past the valve 64, and through the port 63 into the interior of the pumping chamber. Stoppage of the inner end of said leakage passageway results in an accumulation of pressure in said passage or chamber 44, which actuates the motor member 49 to admit live air to the pumping chamber. The other side of the chamber 44 is closed by a flexible diaphragm 49 which diaphragm is clamped about its edges by means of the cap or head 50, this cap or head being clamped on by six machine screws 51 as indicated in Figure 3. The diaphragm 49 is apertured at its center and the inner edges are clamped between flanges 52 and 53 of the diaphragm support or plate 54 and nut 55 respectively. This diaphragm support or plate 54 has a central boss which is threaded to receive said nut 55. This boss is threaded upon a reduced threaded portion 56 of the stem 32. The outer reduced end 57 of the stem 32 passes through a guiding opening in a boss formed in the cap 50, the fit of said reduced end 57 in the guiding opening being loose or what is known as a "sloppy" fit. A biasing spring is mounted in the hollow stud formed on plate member 54 and is supported upon the boss formed on the cap member 50. The function of this biasing spring is to hold the compound valve structure in the position shown in Fig. 1 when there is no pressure upon the pump so that an orderly sequence of operations may be established. Since the biasing spring holds the admission valve 30 normally closed and the exhaust valve 31 normally open when there is no pressure upon the pump, the pump will fill with water as soon as it is submerged and it will at once be ready for operation as soon as the pressure is applied.

The chamber 44 which is formed on the back side of the diaphragm 49 communicates at all times with the admission passageway 23 through the restriction formed by the loose fit of the stem 32 in the guiding plate 45. The connection between the valve pocket 24 and said chamber 44 is restricted but it is sufficient for the purpose of operating the motor as will be apparent later. This chamber 44 has an exhaust opening comprising a passageway 60 (see Figs. 6 and 7) preferably formed by drilling through a casting, which terminates in a valve pocket 61 which pocket is closed by a valve plate and bracket member 62 clamped to the lower surface of the head member 1. A valve port 63 is formed through said plate member 62 and a ball check valve 64 is adapted to obstruct port 63. A swinging lever member 65 is pivoted to the arms or brackets 66 which are formed on said plate member 62 and this lever member 65 has a pin 67 which enters the port 63 and holds the ball check valve 64 off its seat. The lever 65 is made relatively heavy so that its outer free end 68 overbalances the short end which bears the pin 67 to insure automatic opening of said valve 64. The outer free end 68 has a boss or stud 69 which is adapted to engage the under side of the head casting 1 when the lever is raised to its uppermost position. It will be noted that the lever 65 surrounds the water discharge pipe 7 and the outer end 68 is in position to be engaged by the traveling float member 70 which is guided upon said water discharge pipe 7.

The upper end of said float 70 bears a rubber buffer member 71 adapted to engage said outer end 68 of the lever 65 when water rises in the pumping chamber so that the valve 64 may drop to its seat by gravity. The rubber buffer 71 serves the dual purpose of preventing hammering against the lever

68 when water fills the pumping chamber and also it serves as loading for the float 70 to give it sufficient weight to operate the low level control valve as will be described later.

Assuming that the valve structure and diaphragm and other parts are in the position shown in Fig. 1 and compressed air is supplied through the passageway 23 the leakage of compressed air past the bearing 47 on the stem 32 enters the chamber 44 but exhausts therefrom into the top of the pumping chamber 4 because the valve 64 is held away from its seat and pressure cannot accumulate in the chamber 44. Now as soon as the float 70 rises and permits the valve 64 to seat, pressure builds up in said chamber 44 until the total pressure upon the diaphragm is greater than the pressure upon the admission valve 30 whereupon the entire structure is snapped to the left, as viewed in Fig. 1, opening the admission valve and closing the exhaust valve. Live air is thereupon admitted to the pumping chamber 4 and builds up a pressure therein very rapidly, this pressure acting upon the valve 31 tending to open the same but is ineffectual because of the pressure of live air upon the right-hand side of the diaphragm 49. Water is thereupon expelled from the pumping chamber as will be explained later, and the level of water in the pumping chamber 4 drops with the result that the float 70 no longer supports the outer end of the lever 65 and check valve 64 is opened. However, it will be noted that the pressure from the pumping chamber 4 then freely communicates with the diaphragm chamber 44 on the right-hand side of the diaphragm 49 so that the same pressure which tends to push the exhaust valve off the seat also acts on the diaphragm 49 tending to hold the exhaust valve upon its seat. The proportioning of the parts, and particularly of the areas involved, is such that the area of the diaphragm 49 is substantially in excess of the area of the exhaust valve 31 with the result that there is a larger force tending to hold the exhaust valve closed than to open it. The net result is that the exhaust valve remains closed.

The diaphragm chamber 58 formed on the left-hand side of diaphragm 49 as viewed in Figure 1 communicates with the outside pressure, which is usually the pressure of submersion, through the loose fit between the reduced stem portion 57 and the guiding boss in which it lies. Normally, therefore, the pressure prevailing in chamber 58 is a relatively low hydrostatic pressure not much more than a few pounds above atmospheric pressure. This diaphragm chamber communicates by way of a passageway 73 formed in the lower part of the cap member 50 and an extension thereof 73′ formed in the metal of the head member 1. A short nipple 74 telescopes in the parts of the passageways 73 and 73′ to bridge the gap caused by the diaphragm 49. This permits a tight seal to be made around the passageway 73–73′ and also a tight seal about the edge of said diaphragm 49. The passageway 73′ in turn communicates through a central axial pipe 75 which at its upper end is threaded into a socket formed in the metal of the head member 1 and which at its lower end is threaded into a nut 76 in the lower part of the valve box. This pipe 75 which is preferably a length of small diameter copper tubing, extends substantially axially of the water discharge pipe 7 down through said valve box 10 past the water discharge check valve 77 and into the lower part of said boss 10 where a pocket 77′ is formed for receiving the nut 76. The threaded stud 12 threads into the lower end of said pocket 77′ closing off the same. The nut 76 is a cap nut having a series of passageways 78 therethrough, said passageways permitting communication between the pipe 75 and the interior of the pocket 77′. The pocket 77′ in turn communicates through a horizontal passageway 79 and a vertical passageway 80 with a valve port 81 formed in the removable seat 82. This seat 82 is pressed into a counterbore formed in the end of passageway 80. This valve port 81 is controlled by a suitable valve formed of a yielding disc 83 held by a clamping nut 84 in the short end 85 of the valve operating lever 86. This lever is pivoted on lugs 87 forming a part of the structure of the valve 10. The central part of the lever 86 is hollowed out to surround the water discharge pipe 7 and the outer end 88 of this lever is adapted to engage the lower plate member 89 of the float member 70. A suitable wire spring in the shape of a hair pin is shown at 90. This spring is fastened by shouldered screws 91 and 92 to the lever 86 and to the body of the valve box 10 respectively so as to hold the valve 83 over the port 81 except when the weight of the float 70 is brought upon the outer end of the lever 86. The water discharge valve 77 is formed of a metal back and a yielding face portion clamped upon a stem 94, the rear end of which is guided in a hollow lug 95 providing a guiding pocket. A nut 96 threaded upon a reduced portion of said stem 94 clamps the valve 77 against a shoulder on said stem 94. The forward or outer end 97 of said stem 94 is reduced in diameter and is guided in a suitable guide 98 supported by spider arms 99 from a plate 100 which plate is clamped upon the outer surface of said valve box 10 by screws 101. The back side of the plate 100 has a valve seat 102 formed thereupon. This valve seat surrounding the valve port which is closed by said valve 77. This valve 77 is placed

as low as practicable in the pumping chamber 4 and the reversal controlling valve 83 is placed slightly higher than the water discharge valve, so that the valve 77 is always submerged. The valve 83 is placed below the float 70 so that it will be submerged and sealed by the liquid in the pumping chamber. This is an advantage first because it is much easier to retain a liquid under pressure than it is a gas and second the discharge of liquid from the pumping chamber by the opening of said valve 83 accelerates the opening of the valve by further lowering the level of liquid in the pumping chamber. It will be noted that the valve 83 seats with the internal pressure; that is it has the internal pressure upon its back tending to hold it closed. Hence when the water is discharged sufficiently from the pumping chamber as to bring the weight of the float 70 upon the outer end 88 of said lever 86 the point will be reached, no matter how slow the discharge of water, where the weight of the float will exceed the holding power of the pressure upon the back of the valve 83 with the result that the valve will be cracked open. When this occurs then water is forced down through the passageway 81, 80, 79 through the passageways in the nut 78 up through the pipe 75 through the passageways 73′ and 73 into the diaphragm chamber 58, a part of the liquid being discharged out through the loose fit around the stem portion 57 and the remainder acting upon the diaphragm 49 to force the same to the right to close the admission valve and open the exhaust valve. Pressure in the chamber 58 does not need to exceed the pressure in the chamber 44 since the air pressure upon the exhaust valve 31 also assists in opening said exhaust valve and closing the admission valve. As soon as the valve system starts to move to the right, the motion is accelerated by snapping of the admission valve to its seat. Thus it will be seen that the motion of the air valve structure in either direction is accomplished with a snap action, this snap being secured chiefly by the construction and proportions of the admission and exhaust valve structure. The reversal of the valve structure just described is advantageously effected by the construction and mode of operation of the low level control valve 83.

For the sake of clearness I shall recapitulate briefly the operation of the device.

Assuming that the parts are in the condition shown and that water is filling the pumping chamber the float 70 rising, live air is acting upon the back of the admission valve 30 holding it closed. Live air is leaking past the stem 32 along the guide 47 into the diaphragm chamber 44 and is exhausting from same through the open valve port 63. Air is being expelled from the pumping chamber and out the exhaust valve as the liquid level rises. The low level control valve 83 is closed and held in such position by the hair-pin spring 90, the diaphragm chamber 58 is under submergence pressure only and is substantially full of liquid.

The rising of the float 70 lifts the outer end of the lever 65 and permits the check valve 64 to close whereupon pressure builds up in the chamber 44 relatively rapidly and forces the diaphragm and connected parts to the left as viewed in Fig. 1. As soon as the admmission valve 30 is cracked from seat it moves very readily and brings the exhaust valve 31 against its seat. The motion of the valves is small but it is sufficient to secure ample valve opening.

Thereafter as the pressure in the pumping chamber rises and begins to expel the liquid through the discharge check valve 77 the float 70 is lowered permitting the weighted lever to open the ball valve 64. This valve 64 is readily opened at this time since the pressures upon opposite sides of the same are substantially equal. Any slight leakage that there might be past the valve 83 up through the central tube 75 and into the chamber 58 is free to leak out of said chamber past the reduced portion 57 of the stem 32. As the liquid level lowers the float 70 finally rests upon the outer end 88 of the lever 86 and when the weight of the float bears heavily enough upon said lever the control valve 83 is opened against internal pressure and liquid is immediately discharged through the valve port 81 and through the connecting passageways into the diaphragm chamber 58 tending to equalize or substantially equalize the pressures upon opposite sides of the diaphragm 49. As soon as this differential motor is sufficiently nearly balanced, the pressure upon the exhaust valve 31 assisting, said exhaust valve will be opened and the admission valve 30 will be snapped to its seat. Thereupon the compressed air which has filled the pump chamber 7 is permitted to exhaust out of the exhaust passageway and also the air which occupied the diaphragm chamber 44 discharges past the valve 64 into the pumping chamber 4 and from there out the exhaust passageway. At the same time the pressure upon the left-hand side of the diaphragm 49 drops substantially to atmosphere because the pressure of air in the chamber 4 drops substantially to atmosphere. The result is that the pressures upon opposite sides of the diaphragm 49 are substantially equal, but the pressure of live air upon the admission valve 30 holds it firmly to seat and holds the parts in their indicated positions. When the chamber 4 has exhausted, liquid under a suitable hydrostatic pressure, such as that caused by submersion, enters the pumping chamber by

lifting the admission check valve 17 and raises the float closing off the valve 83 and promptly filling the pumping chamber with liquid and repeating the cycle of operation.

The provisions for easy and quick assembly of the pump are noteworthy. There is a straight transverse opening through the head, the central part which forms a guide for the guiding portion 34 of the admission valve 30 is the most restricted part. This bore is finished to provide a suitable guide. The adjacent bore forming the exhaust port 42 is also finished to form a suitable guide for the wings of the guiding sleeve of the exhaust valve. The guiding plate 45 seats in a larger bore closing off the communication between the chamber 44 and the valve pocket 24.

It will be noted that in assembling the valve in the head, the diaphragm and clamping plate may be individually assembled, thereafter the valve stem 32 with the admission valve 30 thereupon is inserted from the left-hand side of the head as viewed in Fig. 1, whereupon the plate 45 is put in place, then the guiding sleeve 33 and exhaust valve 31 are put in place and fastened by the clamping nut 39. The diaphragm plate 54, with diaphragm attached, is then threaded upon the threaded portion 56 and the diaphragm brought properly into register and cap 50 with thimble 74 brought into place and passed over the reduced stem portion 57 with the biasing spring suitably interposed. The cap 50 is then secured in place by the screws 51 and thereafter the screw cap at the right-hand end of the bore is fastened in place over the exhaust valve 31. The control valve 63 and its connected lever may then be assembled upon the base of the head. The valve box 10 with its controlling valve and its discharge valve may next be assembled in connection with the discharge pipe 7 and float 70. The central tube 75 with its nut 76 may then be assembled in place. The sleeve 3 brought into engagement with the head member 1 and the foot member being brought upon the end of the sleeve and assembled upon the stud 12 with the cap 13 securing the parts together.

I do not intend to be limited to the details shown or described except as limited by the claims.

I claim:

1. In a pump the combination of a pumping chamber adapted to be filled by hydrostatic pressure and emptied by pneumatic pressure of inlet and discharge check valves for liquid, a pneumatic pressure connection, said chamber having an exhaust port, an exhaust valve adapted to close said port when water has filled the pumping chamber, a differential pressure motor adapted to be subjected to the internal pressure in the cylinder and being unbalanced in one direction to hold the exhaust valve against its seat and means responsive to emptying of the pumping chamber for changing the pressure condition of the motor to permit opening of the exhaust valve by said internal pressure.

2. In a pump the combination of a pumping chamber adapted to be filled by hydrostatic pressure and emptied by pneumatic pressure suitably provided, said chamber having an exhaust port for pressure fluid, an exhaust valve having a yielding face for closing said port, said valve seating against internal pressure, a piston of greater area than the area of the exhaust valve exposed to the internal pressure of the pressure fluid for holding said exhaust valve to seat against internal pressure, a stem connecting said piston to said valve, and means operating at low level of liquid in the chamber for opposing the pressure upon said piston to a sufficient extent to permit said exhaust valve to open and exhaust the pressure fluid in the pumping chamber.

3. In a pump the combination of a pumping chamber having means for providing pneumatic pressure and having an exhaust port, an exhaust valve seating over said port, said valve face being exposed to internal pressure, a piston of greater effective area than the effective area of the exhaust valve exposed to internal pressure and tending to hold said exhaust valve to seat against internal pressure, a connection between said piston and said valve, means operating at low level of liquid in the chamber for opposing the pressure upon said piston to a sufficient extent to permit said exhaust valve to open and means for holding said exhaust valve open until liquid has substantially filled the pumping chamber.

4. In a pump the combination of a pumping chamber for liquid adapted to be filled by hydrostatic pressure and emptied by pneumatic pressure, a connection providing pneumatic pressure, an exhaust port for the chamber leading to atmosphere, an exhaust lift valve seating over the atmospheric end of said port to retain pneumatic pressure in the pump and opening to exhaust the same, a pressure actuated member of greater effective area than the effective area of said valve exposed on one side to the pneumatic pressure within the chamber and connected to said valve for holding said valve closed.

5. In a pump the combination of a pumping chamber for liquid adapted to be filled by hydrostatic pressure and emptied by pneumatic pressure, a connection providing pneumatic pressure, an exhaust port for the chamber leading to atmosphere, an exhaust lift valve seating over the atmospheric end of said port to retain pneumatic pressure in the pump and opening to exhaust the same, a pressure actuated member of greater effec-

tive area than the effective area of said valve exposed on one side to the pneumatic pressure within the chamber and connected to said valve for holding said valve closed, and means operable on low level of liquid in the chamber for substantially neutralizing the pressure on said pressure actuated member.

6. In a pump, the combination of a pumping chamber for liquid adapted to be filled by hydrostatic pressure and emptied by pneumatic pressure, a connection providing pneumatic pressure, an exhaust port for the chamber leading to atmosphere, an exhaust lift valve seating over the atmospheric end of said port to retain pneumatic pressure in the pump and opening to exhaust the same, a pressure actuated member of greater effective area than the effective area of said valve exposed on one side to the pneumatic pressure within the chamber for holding said valve closed and means for causing the valve to move to open position upon low level of liquid in the chamber.

7. In a pump, the combination of a pumping chamber for liquid adapted to be filled by hydrostatic pressure and emptied by pneumatic pressure, a connection providing pneumatic pressure, an exhaust port for the chamber leading to atmosphere, an exhaust lift valve seating over the atmospheric end of said port to retain pneumatic pressure in the pump and opening to exhaust the same, a pressure actuated member of greater effective area than the effective area of said valve exposed on one side to the pneumatic pressure within the chamber for holding said valve closed and means controlled by low level of liquid in the chamber for applying fluid pressure to the opposite side of said pressure actuated member to permit the internal pressure to open said valve.

8. In a pump having a liquid pumping chamber provided with inlet and discharge valves and adapted to be filled by hydrostatic pressure and emptied by pneumatic pressure suitably provided, an air exhaust port, an air exhaust valve adapted to close the exhaust port when water has filled the pumping chamber, a pressure actuated member subject to pressure in the chamber for holding said valve closed against internal pressure, and means for neutralizing the pressure upon said holding means when water in the pumping chamber has been lowered to a predetermined level.

9. In combination a pumping chamber having inlet and discharge check valves adapted to be filled by hydrostatic pressure and emptied by pneumatic pressure, an exhaust port leading to atmosphere, an exhaust valve seating over the atmospheric end of said port against internal pressure, a pressure fluid inlet passageway, a differential pressure actuated member connected to the exhaust valve, a first chamber for the pressure actuated member having restricted communication with the fluid inlet port and having a valve communicating with the pumping chamber, high level control means for closing said valve, pressure in said first chamber tending to close the exhaust valve, a second chamber on the opposite side of the pressure actuated member having a restricted communication with the outside of the pump and having a valved connection with the interior of the pumping chamber and low level means for opening said last named valve to admit pressure from the pumping chamber to said second chamber pressure in said second chamber tending to open said exhaust valve.

10. In combination a pumping chamber having inlet and discharge check valves adapted to be filled by hydrostatic pressure and emptied by pneumatic pressure, and having an exhaust port leading to atmosphere, an exhaust valve seating over the atmospheric end of said port against internal pressure, said pumping chamber having a pressure fluid inlet passageway, a differential pressure actuated member connected to the exhaust valve, a first chamber for the pressure actuated member having restricted communication with the fluid inlet port and having a valve communicating with the pumping chamber, high level control means for closing said valve, a second chamber on the opposite side of the pressure actuated member having a restricted communication with the outside of the pump and having a valved connection with the interior of the pumping chamber and low level means for opening said connection to admit pressure from the pumping chamber to said second chamber, said pumping chamber having an air admission port and an air admission valve connected to the pressure actuated member and to the exhaust valve and facing said exhaust valve, said admission valve being adapted to be held to its seat by live pneumatic pressure when the exhaust valve is open.

11. In a pump of a class described, a pumping chamber having an exhaust passageway, a fluid pressure actuated piston having a chamber upon each side thereof, a live air admission passageway to the pumping chamber , a restricted communication between said live air admission passageway and one of said chambers, a restricted communication between the other of said chambers and atmosphere, a valved pressure connection from the first chamber to the top of the pumping chamber, a valved connection from the second chamber to the bottom of the pumping chamber, level responsive means for controlling said connections and an air valve governing admission and exhaust of compressed air to and from the

pumping chamber connected to said piston member.

12. In a pump of the class described, the combination of a pumping chamber, an exhaust passageway having an exhaust port leading to atmosphere, an exhaust valve closing the atmospheric end of said exhaust port, a source of compressed air, and admission valve between said source of compressed air and the pumping chamber, said pumping chamber having an admission port adapted to be closed by said admission valve and held upon said port by pressure of the compressed air while the exhaust valve is open, a pressure actuated member and means to apply compressed air thereto when water has filled the pumping chamber for pulling said admission valve off its seat and for bringing the exhaust valve upon its seat to make the discharge stroke of the pumping chamber.

13. In combination, a pumping chamber having a live air admission passageway, and an exhaust passageway, an admission port having a poppet valve adapted to seat with live air pressure over said admission port, said exhaust passageway having an exhaust port leading to atmosphere with an exhaust valve closing the atmospheric end of said port to retain pressure in the pumping chamber, a pressure actuated member connected to said valves, a chamber for said pressure actuated member having restricted communication with the admission passageway and means for relieving the pressure in said last named chamber.

14. In a device of the class described, a pumping chamber having an admission passageway having an admission port, and an exhaust passageway having an exhaust port, an admission valve seating with live air pressure on its port, an exhaust valve seating against internal pressure of the pumping chamber over its port, a diaphragm having a stem connecting said valves, chambers on opposite sides of the diaphragm, a restricted communication between the admission port and one of said chambers, a restricted communication between atmosphere and the other of said chambers and level controlled valve connections between said chambers and the interior of the pumping chamber.

15. In a pump, a pumping chamber, a source of compressed air, a compressed air admission valve, of the lift type seating with the difference in pressure between the live air and the air in the pumping chamber during exhaust, a compressed air exhaust valve of the lift type seating against the difference in pressure between the compressed air in the pumping chamber and outside thereof during admission, and a differential pressure motor connected to said valves and adapted to be unbalanced alternately to overcome the forces acting against said valves.

16. In a pump, a pumping chamber, a live air connection comprising an admission port and an admission valve on said port when the pumping chamber is substantially empty and held on said port by the pressure of the live air, a leakage passageway leading from the live air connection to the interior of the pumping chamber, means for closing the inner end of said leakage passageway when water has substantially filled the pumping chamber, and a motor for opening the admission valve operated by the air accumulated in said leakage passageway when the inner end thereof is closed.

17. In a pump, a pumping chamber, a live air connection comprising an admission port and an admission valve seated on said port when the pumping chamber is substantially empty and held on said port by the pressure of the live air, a leakage passageway leading from the live air connection to the interior of the pumping chamber, means for closing the inner end of said leakage passageway when water has substantially filled the pumping chamber, and a valve operating motor having a diaphragm connected to said admission valve and a diaphragm chamber communicating with said leakage port intermediate its ends, said diaphragm being actuated by the air pressure accumulated in said chamber when the inner end of said leakage passageway is closed.

18. In a pump, a pumping chamber, a live air connection comprising an admission port and an admission valve seated on said port when the pumping chamber is substantially empty and held on said port by the pressure of the live air, a leakage passageway leading from the live air connection to the interior of the pumping chamber, means for closing the inner end of said leakage passageway when water has substantially filled the pumping chamber, a motor for opening the admission valve operated by the air accumulated in said leakage passageway, an exhaust connection for the pumping chamber comprising an exhaust port, an exhaust lift valve seating over the atmospheric end of of said exhaust port against internal pressure, and a connection between said admission valve and said exhaust valve.

19. In a pump, a pumping chamber, a live air connection comprising an admission port and an admission valve seated on said port when the pumping chamber is substantially empty and held on said port by the pressure of the live air, a leakage passageway leading from the live air connection to the interior of the pumping chamber, means controlled by the high level of liquid in the pumping chamber for closing the inner end of said leakage passageway when water has substantially filled the pumping chamber, a valve operating motor having a diaphragm connected to said admission valve and hav-

ing a diaphragm chamber communicating with said leakage port intermediate its ends, said diaphragm being actuated to open the admission valve by the air pressure accumulated in said chamber when the inner end of said leakage passageway is closed, an exhaust connetction for the pumping chamber comprising an exhaust port, an exhaust lift valve seating over the atmospheric end of said exhaust port against internal pressure in the pumping chamber, a connection between said admission valve and said exhaust valve, a fluid pressure chamber for the other side of said motor diaphragm and means controlled by low level of liquid in the pumping chamber for admitting pressure from the interior of the pumping chamber to said latter diaphragm chamber to permit the admission valve to close and the exhaust valve to open.

20. In a pump, a pumping chamber, a live air connection having a port leading to the chamber, an admission poppet valve seating on the live air side of said port, a pressure motor for the admission valve having a motor chamber connected to said live air connection through a restricted inlet connection and having a valved exhaust connection leading to the interior of the pumping chamber, and high level means governing the closing of said exhaust connection when liquid has substantially filled the pumping chamber.

21. In a pump, a pumping chamber, a live air connection having a port leading to the chamber, a poppet admission valve for said port seating over the live air side of the same and being adapted to be held over said port by said live air pressure, spring means tending to hold said valve upon said port, a motor for pulling said valve off said port, said motor having a motor chamber, a constantly open passageway of restricted size leading from the live air connection to said motor chamber, and an unrestricted exhaust passageway from said motor chamber to the interior of the pumping chamber and high level means for closing the said exhaust passageway when water has substantially filled the pumping chamber.

22. In combination, in a pump having a pumping chamber comprising a sleeve member, a head member closing the upper end of the sleeve, a foot member closing the lower end of the sleeve, a discharge pipe extending down from the head member to the lower end of the pumping chamber, a discharge check valve mounted at the lower end of the pipe, a fluid pressure pipe extending up through the discharge pipe, an air valve having an operating motor communicating with the upper end of said fluid pressure pipe, and a low level valve having a passageway communicating with the lower end of the fluid pressure pipe for admitting fluid pressure from the pumping chamber to said valve operating motor when the discharge stroke has been substantially completed.

23. In a pump having a pumping chamber comprising a sleeve, a head member closing the upper end of the sleeve and a foot member closing the lower end of the sleeve, a central discharge pipe extending down from the head member, a valve box at the lower end of the discharge pipe having a discharge check valve opening laterally into the bottom of the pumping chamber, a pocket in the lower end of said valve box, a stud closing the lower end of said pocket and being connected to the foot member, a fluid pressure pipe connected to the bottom of the head member and lying inside of said water discharge pipe, said fluid pressure pipe extending down into said pocket, a nut secured to the lower end of said fluid pressure pipe, said nut lying in the pocket, a low level control valve having a passageway communicating with said pocket, said low level valve being arranged to admit fluid pressure from the pumping chamber to said fluid pressure pipe when the pumping chamber has been substantially emptied, and an air valve controlling the application of pressure to said pumping chamber, said air valve having a fluid pressure operated motor connected to the upper end of said fluid pressure pipe.

24. In a pump, a pumping chamber comprising a sleeve member, a head member closing the upper end of the sleeve member, a foot member closing the lower end of the sleeve, a central water discharge pipe connected to the bottom of the head, the water discharge pipe extending through the head and communicating with the said pipe, a valve box at the lower end of said pipe, a connection between the box and the foot member, a discharge check valve mounted in said valve box, and controlling the communication between the lower end of the water discharge pipe and the interior of the pumping chamber, a central fluid pressure pipe disposed within the water discharge pipe, a valve having a passageway communicating with the lower end of said fluid pressure pipe, said valve having an arm extending into proximity with the water discharge pipe, a traveling float guided on the outside of said water discharge pipe and adapted to engage said arm upon low level conditions in said pumping chamber, a fluid pressure control valve for the pumping chamber and a fluid pressure operated motor for said control valve, said fluid pressure motor being connected to the upper end of said fluid pressure pipe.

25. In a pump, a pumping chamber comprising a sleeve, a head member closing the upper end of the sleeve and a foot member closing the lower end of the sleeve, a water

discharge pipe extending from the lower end of the head member towards the foot member, a water discharge valve box connected to the lower end of the pipe, a connection between the foot member and the lower end of the valve box, a central fluid pressure pipe inside the water discharge pipe, a low level valve having a passageway communicating with the lower end of the fluid pressure pipe, said valve being adapted to control the communication between the interior of the pumping chamber and said fluid pressure pipe, a valve operating lever extending into proximity to said water discharge pipe, a motor chamber communicating with the upper end of said fluid pressure pipe, a second motor chamber having a passageway extending through the head to the interior of the pumping chamber, a valve controlling said communication, a valve operating lever extending into proximity to the water discharge pipe, a diaphragm between said motor chambers, an air valve connected to said diaphragm, and a travelling float guided on the water discharge pipe and adapted to engage alternately said valve operating levers.

26. In a pneumatic pump, the combination with a pump chamber provided with water inlet and outlet valves, an air admission valve, and an air exhaust port, of an air exhaust valve located outside said pump chamber to control said exhaust port, a fluid pressure actuated motor acting during the discharge stroke of the pump to keep said exhaust valve closed against the pressure in said pump chamber, and low level means governing the motor for opening said exhaust valve.

27. In a pneumatic pump, the combination with a pump chamber provided with water inlet and outlet valves, an air admission valve, and an air exhaust port, of an air exhaust valve located outside said pump chamber to control said exhaust port, a reversible motor, said motor acting in one direction by fluid pressure to keep said air exhaust valve closed against the pressure in said pump chamber, and means responsive to low level in said pump chamber to control said motor to permit the internal pressure to open said exhaust valve.

28. In a pneumatic pump, the combination with a pump chamber provided with water inlet and outlet valves, an air admission valve, and an air exhaust port, of an air exhaust valve located outside said pump chamber to control said exhaust port, means operated by fluid pressure and controlled by high level in the pump chamber to apply said exhaust valve to said exhaust port and to hold it thereupon against internal pressure in the pumping chamber, and means controlled by low level in said pump for opposing said first means to cause the exhaust valve to be opened by the internal pressure in the pumping chamber.

29. In a pneumatic pump, the combination with a pump chamber provided with water inlet and discharge valves, and air admission port and an air exhaust port, an air admission valve and an air exhaust valve located outside the pump chamber to control said exhaust port, a fluid pressure operated member acting during the discharge stroke of the pump to keep said exhaust valve closed against the pressure in the pump chamber, and low level means governing the motor to permit the exhaust valve to open, said admission and said exhaust valves having a continuous connection with each other.

30. In a pump, a pump chamber having water inlet and discharge valves, an air admission valve, an air exhaust port and an air exhaust valve seating on said port against the internal pressure of said chamber, a motor element connected to said exhaust valve, a high level controlled pilot valve for controlling the application of pressure to said motor element to close the exhaust valve and open the admission valve, a fluid pressure chamber for applying a balancing pressure to said motor element, and a low level controlled pilot valve controlling the application of fluid pressure to said fluid pressure chamber.

31. In a pneumatic pump, a pump chamber having an air admission valve and an air exhaust valve, a fluid pressure chamber saving a motor element connected to said valves, an air supply line, a constantly open restricted air passage from the line to the fluid pressure chamber, a passage from the pump chamber to the fluid pressure chamber, a pilot valve controlling said latter passage, and level controlled means operating on high level to close said pilot valve.

32. In a pneumatic pump, a pump chamber having an air admission valve and an air exhaust valve, a fluid pressure chamber having a motor element connected to said valves, an air supply line, a constantly open restricted air passage from the line to the fluid pressure chamber, a passage from the pump chamber to the fluid pressure chamber, a pilot valve controlling said latter passage, said pilot valve comprising a check valve opening inwardly towards the fluid pressure chamber, means tending to hold said check valve open, and a float operating on high level of liquid in the chamber to neutralize said holding means to permit the check valve to close.

33. In a pneumatic pump, a pump chamber having an inlet for fluid pressure and an exhaust port therefor, an exhaust valve seating on said port against the internal pressure in the chamber, means to hold said valve on said port by the fluid pressure in

the pumping chamber with a force which increases directly with the internal pressure in said pumping chamber.

34. In a pneumatic pump, a pump chamber having an inlet for fluid pressure and an exhaust port therefor, an exhaust valve seating on said port against the internal pressure in the chamber, means to hold said valve on said port by the fluid pressure in the pumping chamber with a force which increases directly with the internal pressure in said pumping chamber, said means comprising a motor element having a larger effective area than the effective area of the exhaust valve, both said motor element and said exhaust valve being exposed to the same internal pressure in the pump chamber but in opposite directions.

35. In combination, a pumping chamber, an air control valve mechanism therefor having admission and exhaust passageways terminating in seats facing in opposite directions in line with each other and comprising a valve stem having a fluid pressure motor member connected to one end thereof, said stem having a shoulder, a sleeve having an admission valve at one end embracing the stem and engaging the shoulder, an exhaust valve on the stem engaging the other end of the sleeve, a nut for the stem for holding said sleeve and exhaust valve rigidly on said stem, said admission and exhaust valves facing the corresponding seats and cooperating therewith.

36. In a pneumatic pump, the combination of a barrel for providing a pumping chamber, a head member for the barrel containing an air control valve mechanism having movable parts, said head having a transverse bore for housing the movable parts of the mechanism, said transverse bore comprising an admission valve seat and an exhaust valve seat, a plug closing one end of the bore adjacent the exhaust valve seat and defining an exhaust valve chamber communicating with exhaust, an apertured plate secured across the bore adjacent the admission valve seat defining on one side an admission valve chamber, a diaphragm across the outer end of the transverse bore and defining with said plate a diaphragm chamber, a cap clamped on the edge of the diaphragm and defining a second diaphragm chamber, a central stem secured to the diaphragm and passing through said apertured plate, said stem having a reduced portion starting with a shoulder, a sleeve having an admission valve member disposed in the admission valve chamber, said sleeve abutting said shoulder, an exhaust valve member on the stem and disposed in the exhaust valve chamber, said exhaust valve abutting said sleeve, and means on the end of the stem for clamping the exhaust valve against the sleeve, said head having passageways for admission and exhaust connections to the pumping chamber under the control of said valves, and means to control the application of pressure to said diaphragm chambers.

37. In a pump having a pumping chamber, an air control valve for the pumping chamber, a diaphragm having a central opening therethrough, a clamping plate having a hollow stud extending through the opening in the diaphragm, a nut for the stud, said nut clamping the diaphragm against the plate, a valve stem secured to the hollow stud, said stem being connected to the air control valve, means supporting the edges of the diaphragm and forming motor chambers on each side of the valve, said stem extending loosely through an opening in the wall of one of said motor chambers to provide a guide, and also to provide a restricted fluid passageway kept open by movement of the stem in the opening.

38. In a pump having a pumping chamber, an air control valve therefor, a diaphragm having a central opening, a clamping member having a stud extending through the opening, a threaded clamping plate cooperating therewith to clamp the diaphragm between them, means supporting the outer edges of the diaphragm and forming a motor chamber for one side thereof, a stem for the air control valve, said stem being secured to the clamping member on the diaphragm, said motor chamber having an opening through one wall thereof, said stem projecting loosely through said opening to provide a restricted fluid passageway which is kept open by the movement of the stem.

In witness whereof, I hereunto subscribe my name this 26th day of December 1923.

BURTON S. AIKMAN.