F. C. WEBER.

SUBTERRANEAN PUMPING SYSTEM.

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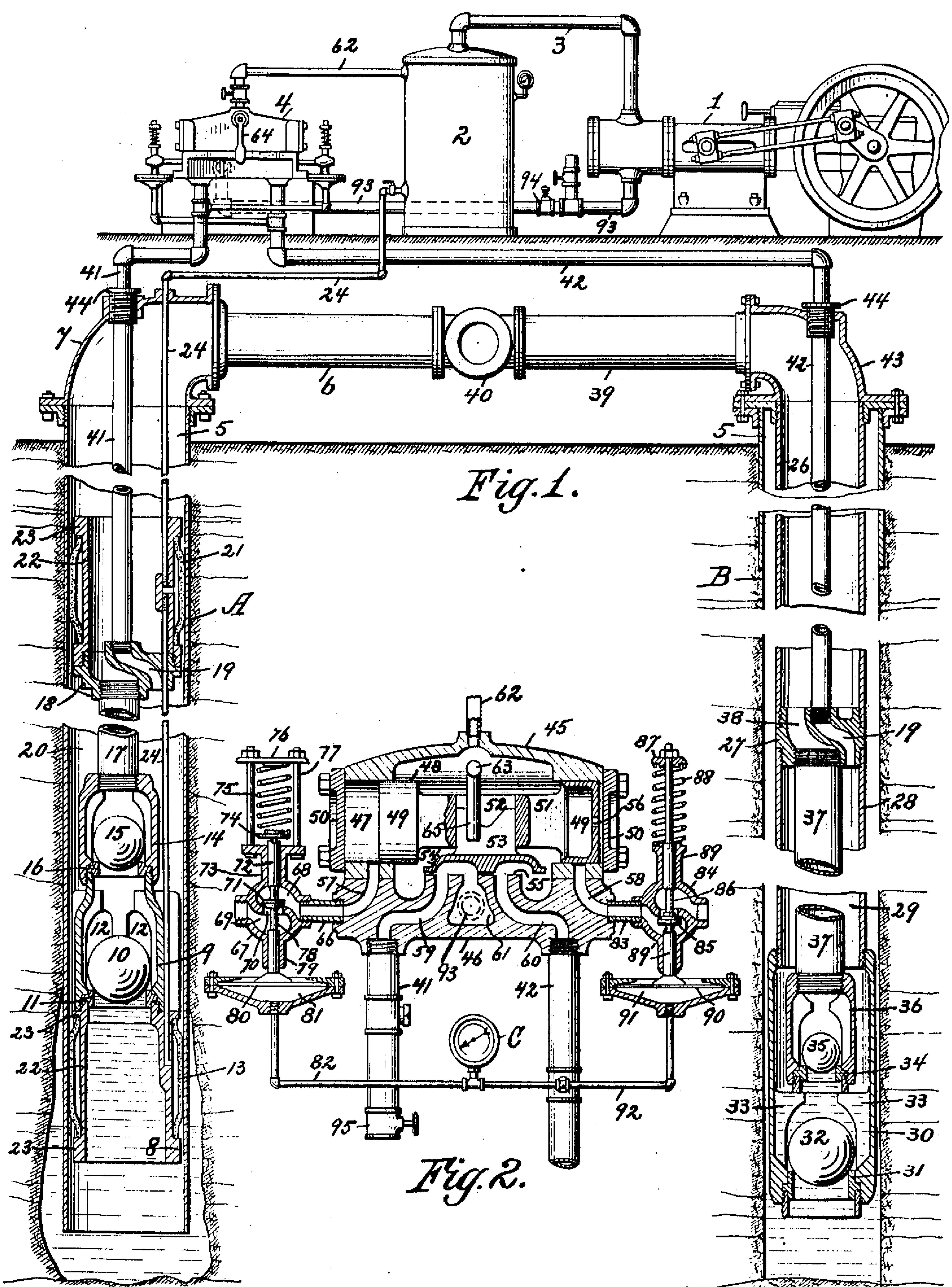

Fig.1.

Fig.2.

WITNESSES

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SUBTERRANEAN PUMPING SYSTEM.

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To all whom it may concern:

Be it known that I, FREDERICK C. WEBER, a citizen of the United States, residing in the city of New York, county and State of New York, have invented certain new and useful Improvements in Subterranean Pumping Systems; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make, construct, and use the same, reference being had to the accompanying drawings, and to letters of reference marked thereon, forming a part of this specification.

My invention relates to that class of pumping systems wherein compressed air is utilized as the motive power for elevating the water from a deep subterranean water level to the surface of the ground, and operates upon the general plan of the well known force-pump. I dispense however, with the usual plunger piston of the force-pump, and utilize the pressure of air in an inclosed chamber for elevating the water through the system.

The essential parts of a complete plant consist of an air compressor, an air receiver, an automatic reversing valve together with the air and water pipes, and the necessary pump valves, and my invention relates particularly to improvements in the reversing valve and in the means for forming the liquid chamber and the valves connected therewith.

The accompanying drawings illustrate an embodiment of my invention, wherein—

Figure 1 illustrates a complete plant showing two wells connected to a single delivery pipe; and Fig. 2 illustrates in vertical section, the details of the reversing valve.

Similar letters of reference refer to like parts throughout the specification and drawings.

In Fig. 1, the reference numeral 1 is the air compressor which may be of any usual or desired type; 2 is the compressed air receiver located in proximity to the air compressor 1 and connected with the compression side of the compressor by the pipe connection 3. 4 is the reversing valve, the details of which will be hereinafter explained. The two wells A and B may be water, oil, salt, or other wells, or the drainage outlets for mines. In Fig. 1 of the drawings, I have shown the two wells A and B as provided with different structures to meet different conditions, and while such structures embody the same generic principles, yet they differ in details. In the well A, I provide a tubular well casing 5 extending from the surface to a point below the level of the liquid to be pumped, and this casing is utilized in the formation of the liquid chamber hereinafter to be described. The upper end of the casing 5 is provided with the liquid discharge 6 to which it is connected by means of the elbow 7. Located at the lower end of the casing 5, is the intake 8, to the upper end of which is secured the valve cage 9, within which cage is located the ball check valve 10, said valve resting upon a valve seat 11, as clearly shown in the drawings. This valve cage 9 is provided with the openings 12 forming a passageway between the lower intake 8 and the chamber above the valve 10, said chamber being formed by means of the liquid seals 13 and 21, the details of which will be fully described farther on.

To the upper end of the valve cage 9 is secured a second valve casing 14, within which is located a ball check valve 15 resting upon a valve seat 16. The upper end of the valve casing 14 is connected by means of a pipe 17, with a ported casting 18, said casting being provided with a central and laterally deflected port 19, which connects directly with the liquid chamber 20. Secured to the upper side of the casting 18, is an upper liquid seal 21. These liquid seals 13 and 21 are substantially alike in structure and operated in the same manner from the same source of fluid pressure. They consist of the tubular castings 22, provided with upper and lower flanges 23, and between these flanges, and directly secured to the tubular portions of the castings, are located the flexible seals proper, said seals consisting of tubes of rubber or other suitable fabric, which are made both water and air tight by securely connecting the upper and lower ends of said seals to the tubular portions of the parts 22, just inside of the flanges 23, as clearly illustrated in the drawings. The methods of securing may be accomplished by means of wrapping wire around the extremities of the flexible tubing, so as to secure the same in air tight connection with the tubular portions of the castings 22, so as to form a liquid chamber between the tubular portions 22.

Compressed air is admitted to the space between the flexible tubing and the tubular portions of the castings by means of the pipe 24, leading from the compressed air reservoir 2, suitable passages being provided in the castings 22 and 22 for that purpose, so that when air pressure is admitted to the space between the flexible tubings and the castings 22 and 22, the flexible tubing will expand outwardly into contact with the tubular casing 5, and thereby form an air and liquid tight chamber between the upper and lower seals 21 and 13. In this manner, I am enabled to utilize that portion of the casing 5 between the upper seal 21 and the lower seal 13, as a liquid chamber, the purpose of which will be hereinafter set forth.

In the well B, which is intended to illustrate a well in which the use of the casing 5 extending to and below the liquid level in the well, would be impractical, I have shown such casing 5 as extending down only a short distance, and from the upper end of such casing, is supported the interior tubing 26, such tubing extending down to a suitable distance and carrying at its lower extremity, the casting 27, similar in all respects to the casting 18, having the passage 19 located therein, in the same manner as the passage 19 in the casting 18.

Secured to the casting 27 and extending downwardly therefrom into the interior of the well, is the tube 28, forming the chamber 29. At the lower extremity of the tubing 28, I have provided a valve casting 30, the lower end of which is provided with a valve seat 31, upon which rests the ball valve 32.

Within the casting 30 and contiguous to the ball-valve 32, are the webs 33, which form guides for the ball valve 32 in its rise and fall during the operation of the valve. Located above the webs 33, is the second valve seat 34, upon which is seated the ball-valve 35, said ball valve being inclosed in a valve casing 36. The upper end of this valve casing 36 is connected to the casting 27 by means of the interior tube 37, said tube 37 forming a passageway between the interior of the valve casing 36 and the tube 26, through the passage 38 in the casting 27. The upper end of the tube 26 connects with the discharge 39, which leads to the common discharge 40 from the other well.

Leading from the ports of the reversing valve 4, are the tubes 41 and 42, said tubes passing through the elbows 7 and 43, located upon the upper ends of the casings 5, and connected therewith by the glands 44, to render them air and water tight. These tubes 41 and 42 lead downwardly into the interior of the casings, and to the ports 19 in the castings 18 and 27.

I will now proceed to describe the details of the reversing valve 4. This reversing valve consists of the valve casing 45 and the port casting 46. The valve casing 45 is provided with a tubular chamber 47, within which is located the valve casting 48, having upon each end the two pistons 49. The chamber 47 is closed at either end by means of the heads 50. The two pistons 49 are connected together by means of the integral web 51, in the center of which is located a vertical aperture 52, in which is guided the stem 53 of the double-D valve 54, said valve resting upon the valve seat 55, which is a part of the port casting 46. The two pistons are identically the same in structure, that upon the right-hand being shown in section as hollow, and provided with a small by-pass 56, it being understood that each piston 49 is provided with such a by-pass.

Ports 57 and 58 are shown leading from the chamber 47 through the port casting 46 to the release valves hereinafter to be described. Through the valve seat 55 of the port casting 46, are also the ports 59 and 60, leading to the pipes 41 and 42, and the central or exhaust port 61. Pressure is admitted into the interior of the valve chamber 47 between the pistons 49, through the pipe 62 from the air reservoir 2. Located in the upper part of the chamber 47, is a horizontal shaft 63, said shaft projecting laterally outside of the valve casing 45, and provided upon its outer extremity with the handle 64. Upon that portion of the shaft 63 which is inside of the valve casing 45, is the downwardly extending arm 65, which projects into the vertical aperture 52 of the piston web 51. By operating this handle 64 from the exterior of the valve casing, it will be readily understood that the pistons 49 and valve 54 may be operated from the exterior by hand, to set the same in either of their extreme positions. From the port 57 leads the short pipe 66, said pipe connecting with the globe check valve 67. This check valve is provided with the chambers 68 and 69, connected by the passage 70, which forms a seat for the upwardly opening valve 71. The stem 72 of the valve 71 extends upwardly through the gland 73, and carries upon its upper end a spring seat 74. The compression spring 75 rests upon the spring seat 74, the upper end bearing upon the spring cap 76, said spring cap being connected to the flanges of the gland 73 by means of the adjusting rods 77. The tendency of the spring 75 in this structure is to maintain the valve 71 upon its seat, so as to retain the pressure within the left-hand end of the chamber 47 of the valve casing 45.

To the lower side of the valve 71 is secured a downwardly projecting stem 78, through a gland 79, to bear upon the upper side of a diaphragm 80, this diaphragm being secured in the manner shown to form the diaphragm chamber 81. This chamber 81 is connected by tubing 82 to the tube 42 as clearly shown. From the port 58 leads the short tube 83 to the globe valve 84, similar in all respects to the globe valve 67, with the exception that the valve 85 opens downwardly instead of upwardly as in valve 67. The upper side of this valve 85 is provided with the valve stem 86, connected at its upper end to a spring cap 87, with the compression spring 88 located between said spring cap and the upper end of the gland 89. The tendency of the spring 88 is to maintain the valve 85 upon its seat to retain the pressure within the valve casing 45.

Extending from the lower side of the valve 85, is a stem 89′ connected to the center of the diaphragm 90, said diaphragm forming a diaphragm chamber 91, similar in all respects to the diaphragm chamber 81. This diaphragm chamber is connected by means of the pipe 92 to the tube 42. In connection with the diaphragm chamber 81, it will be understood that if pressure is admitted to said diaphragm chamber, sufficient to overcome the tension of the spring 75, it will result in unseating the valve 71, and thereby open the port 57 to the atmosphere, whereas, if a vacuum is established in the diaphragm chamber 91 sufficient to overcome the tension of the spring 88, the valve 85 would be unseated, and thereby the chamber 47 would be open to the atmosphere. From the exhaust port 61, leads the suction pipe 93 to the suction side of the air compressor.

I will now proceed to describe the operation of the pump.

It will be understood that the compressor 1 has been in operation a sufficient length of time to store the reservoir 2 with air to a sufficient pressure, and such compressor being constantly in operation, results in maintaining such pressure to a predetermined point. The pressure from the reservoir 2 is led to the valve casing 45 through the pipe 62, passing from the same through the small ports 56 in the ends of the pistons 49, completely filling the chamber 47, the port 57 and the chamber 68 above the valve 71. The pressure also passes around the double-D valve 54 through the ports 60 into the pipe 42, from which it is carried into the liquid chamber 29. This pressure exerted upon the surface of the water which is contained in this liquid chamber, will result in unseating the valve 35, thereby forcing the liquid up through the tube 37 to the discharge tube 39, and out through the final discharge 40. At the same time that this operation is going on, the suction side of the compressor is in connection with the corresponding liquid chamber 20 of well A, thereby creating a vacuum in said liquid chamber 20 through the exhaust port 61, port 59, and tube 41 and port 19, resulting in causing a rise of the water from the well past the valve 10 to fill said liquid chamber 20.

It will be understood that when the air is being forced through the pipe 42, to force the water in liquid chamber 29 into the pipe 37 and to the discharge 39, that this pressure is constantly rising and being free to pass through the pipe 82 to the diaphragm chamber 81, it is clear that when said pressure has arrived at a point sufficient to overcome the spring 75, the valve 71 will rise and thus open the port 57 to the atmosphere. This sudden exhausting of the port 57 and that portion of the chamber 47 at the left-hand end thereof, permits the stored-up pressure at the other end to suddenly drive the two pistons 49 to the left-hand end of the chamber, thus shifting the valve 54 to the opposite end of its throw, and uncovering the port 59 to the interior of the valve casing and the port 60 to the exhaust port 61. This shifting is due to the relative sizes of pass 56 and port 57, pass 56 being about 1/50 of the cross-section of port 57.

It is understood now that the liquid chamber 20 is full of water, while the liquid chamber 29 is nearly exhausted of water. Now the conditions being reversed, the continued operation of the compressor will result in withdrawing the previously compressed air and forming a vacuum in chamber 29, and permitting pressure to pass from the reservoir 2, to the surface of the water in chamber 20. This vacuum in chamber 29 will continue to build up until the degree of exhaustion therein, and also in the pipe 42, which it is understood is in connection with the pipe 92, will result in eventually unseating the valve 85, this occurring when the degree of vacuum shall be sufficient to overcome the tension of the spring 88. The unseating of the valve 85 results in opening the port 58 to the atmosphere, when the pressure which has been passing through the port 56 in the left-hand piston 49, will drive the pistons 49 to the right-hand end of the chamber 47, thereby reversing the valve 54. Thus, it will be seen that by creating an alternate condition of vacuum and pressure in the liquid chamber 29, the valve 54 is alternately reversed, to permit the alternate filling and exhausting of the water in the chamber 29, and while this is going on, the alternate exhausting and filling of the chamber 20.

In Fig. 2, I have shown the entire operation of the reversing valve 4 as depending upon the alternate pressure and vacuum conditions in the chamber 29. Under these conditions, it will be noted that the liquid chamber 20 is at no time depended upon to operate the reversing valve, so that the well A and the parts connected therewith may, if conditions so require, be entirely dispensed with. If however, it is desired to operate two wells it is only necessary to connect the pipe 41 with the second well A, and its parts as shown. Where two wells are to be operated, I may utilize two of the vacuum chambers 91, instead of the pressure diaphragm chamber 81. When this form is used, I substitute for the globe valve 67, with its upwardly opening valve 71, a valve identical in all parts with the valve 84, with its downwardly opening valve 85, and instead of connecting the valve across to the pipe 42, I connect the corresponding pipe for operating such diaphragm to the left-hand tube 41. Under these conditions, it will be noted that the operation of the reversing valve will depend solely upon the height to which the water is drawn into the liquid chambers of the two wells due to the degree of the vacuum in said liquid chambers. On the other hand, I may use two of the upwardly opening globe valves 67 for operating the reversing valve, instead of the construction just described, substituting a small globe valve 67 for the globe valve 84. Under these conditions, the right-hand valve 67 will be cross-connected to the pipe 41, and the left-hand valve with the pipe 42, as clearly illustrated in connection with said valves in Fig. 1. Under these conditions, the two operating valves 71 will be operated to reverse the reversing valve through the pressure which may be exerted in the corresponding pipe 41 or 42, and this pressure will be due to the height to which the water has been forced in the discharge pipes 6 and 39, it being understood that the governing springs 75 have been so adjusted, that the valve 71 will trip, when a predetermined height of water shall have been attained.

From the above description, it will be observed that after a predetermined pressure has been attained in the reservoir 2, and the compressor is operated to maintain such pressure, the air in the system is made to circulate from the reservoir through the reversing valve to the liquid chambers 20 and 29, until the predetermined heights of water have been attained, and then back from said liquid chamber through the valves to the compressor, whence it is again sent to the reservoir 2, and the only loss of air which the system sustains during this operation is that which escapes through the globe valves 67 and 84, due to the unseating of said valves and the shifting of the reversing valve. This loss slight though it may be would in time amount to enough to seriously affect the system, and in order that the system may be replenished with air, I have provided in the suction pipe 93, an intake check valve 94, so that when the vacuum in the pipe 93 and the ports with which it is connected comes to a predetermined point of exhaustion, said check valve will open and admit atmospheric air into the system, and thereby replenish it.

It will be understood that conditions may arise, where the installation of the well system as illustrated at B, will be advisable, and other conditions where the well system A can best be installed, and still other conditions where but a single well exists. Under all of these conditions, it will be seen that my system is applicable, and that the well end A operates upon identically the same principle as the well end B.

In order that proper adjustment of the springs 75 and 88 may be provided for, I have shown a pressure gage C, located in the pipe 82, so that the pressure gage will indicate the degree of pressure in the system, at which point, it is desired that the reversing valve shall operate.

It will be understood that with either of the forms of operating valves 67 or 84, a pressure gage may be located in the corresponding pipe 82 or 92, and this, for the purpose only of determining the degree of pressure or vacuum at which the corresponding valves are to operate to change the position of the reversing valve.

As above indicated, either the structures shown in well A or in the well B may be used either independently or together as conditions may require. Where but a single well is intended to be in operation, the conditions will dictate which form is to be installed.

When but a single well is in operation, it is understood that the reversing valve 4 will be coupled up as indicated in Fig. 2. Under these conditions, the port 59 should remain closed, or some provision made for closing the same. This I have shown in Fig. 2 by providing the pipe 41 with a shut-off valve 95, it being understood that only a sufficient amount of pipe is necessary to provide such a shut-off valve, or if desired, the port 59 can be closed with a solid plug in place of the short length of tubing. These of course are features which will occur to any one skilled in the art to which my invention pertains. I may also accomplish the same purpose by inserting a check valve 95′, in the pipe as shown.

I claim:

1. In a pumping system, the combination of a source of fluid pressure supply, with a liquid chamber, a pipe connection between said supply and said chamber, a reversing valve in said pipe connection for alternately admitting pressure to and exhausting the same from said chamber, means for shifting said valve comprising a duplex piston, a casing therefor, a bypass in each head of said piston to permit the slow accumulation of pressure on each side thereof and thereby balance said piston, means controlled by the

degree of pressure or vacuum in said chamber and pipe connection for releasing said accumulated pressure alternately from opposite ends of said duplex piston.

2. In a pumping system, the combination of means for creating a fluid pressure and a vacuum, a liquid chamber provided with inlet and outlet valves normally submerged in liquid to be pumped, a pipe connection between said means and said chamber, an automatic reversing valve located in said pipe connection, a balanced duplex piston for operating said valve, a by-pass in each head of said piston to permit the equalization of pressure on all sides thereof, supplemental release valves for permitting a predetermined maximum pressure in said liquid chamber to release the pressure on one side of, and thus disturb the balanced pressure on said piston and permit the direct pressure to shift said piston and reversing valve to permit the creating of a vacuum in said chamber and thereby cause the rise of liquid therein through said inlet valve.

3. In a pumping system, the combination of a liquid chamber having valved inlet and discharge passages at its lower end, said inlet passage designed to be normally submerged in liquid to be pumped, means for causing alternate conditions of pressure and vacuum in said chamber, said means including a reversing valve, a duplex pressure balanced piston for operating said valve and release valves for disturbing the pressure balance upon said piston, said release valves being respectively actuated by the alternate conditions of pressure and vacuum in said chamber, whereby liquid is caused to be drawn into said chamber and thereafter forced out from said chamber through said discharge passage.

4. In a pumping system, the combination of a liquid chamber having valved inlet and discharge passages at its lower end, said inlet passage being normally submerged in the liquid to be pumped, means for causing alternate conditions of pressure and vacuum in said chamber, whereby liquid is caused to be drawn into said chamber through said valved inlet passage and thereafter forced out from said chamber through said valved discharge passage, said means including a reversing valve operated by direct pressure and auxiliary valves operated by the predetermined conditions of pressure and vacuum to cause automatically a reversal of said conditions.

5. In a pumping system, the combination of a liquid chamber, with means for creating alternate and predetermined conditions of fluid pressure and vacuum in said chamber, valved inlet and discharge passages in the lower end of said chamber, automatic means for reversing the conditions of pressure and vacuum in said chamber, said means including a reversing valve operated by the direct fluid pressure and auxiliary valves depending for its operation upon the predetermined degree of pressure and vacuum within said chamber.

6. In a pumping system, the combination of means for producing a fluid pressure and a vacuum, a liquid chamber provided with inlet and discharge valves normally submerged in liquid to be pumped, a pipe connection between said means and said chamber, a reversing valve and casing located in said pipe connection and, a duplex piston in said casing and connected to said reversing valve for operating the same, auxiliary release valves connected to said casing, means for permitting a predetermined pressure or vacuum in said pipe connection to alternately actuate said release valves thereby permitting direct fluid pressure to actuate said piston and reversing valve to alternately connect said liquid chamber with said pressure and vacuum producing means.

7. In a pumping system, the combination with pressure and vacuum producing means, a reversing valve and casing therefor, and a liquid chamber, pressure and vacuum pipes connecting said valve casing with said pressure producing means and said vacuum producing means respectively, a pipe connecting said casing with said liquid chamber, release valves connected to said casing, and to said liquid chamber pipe, one of said release valves actuated by a predetermined maximum pressure and the other release valve actuated by a predetermined maximum vacuum in said liquid chamber pipe to operate said reversing valve to alternate the conditions of pressure and vacuum in said liquid chamber.

8. In a pumping system, the combination of a liquid chamber having valved inlet and discharge orifices at its lower end, a discharge pipe connected with said discharge orifice, means connected with said liquid chamber for producing alternate conditions of pressure and vacuum in said chamber, and a reversing valve in said connection operated by direct pressure, means for operating said reversing valve including an auxiliary valve actuated by the pressure in said chamber to reverse the condition in said chamber from pressure to vacuum, and means including an auxiliary valve actuated by the vacuum in said chamber for operating said reversing valve to reverse the condition in said chamber from vacuum to pressure.

9. In a pumping system, the combination with means for producing air pressure and vacuum, of a reversing valve comprising a valve casing, pressure and vacuum ports and pipes connecting said casing with said means, a service port and pipe leading from said

casing, a valve member within said casing operated by the direct pressure and means actuated by the alternate and predetermined conditions of pressure and vacuum in said service pipe whereby the direct pressure is utilized for shifting said valve member to alternately connect said service pipe with said pressure and vacuum pipes respectively.

10. A reversing valve for pumping systems, comprising a valve casing, pressure and vacuum pipes leading to said casing, a service pipe leading from said casing to a liquid chamber, a valve within said casing in direct communication with said pressure pipe, means actuated by the alternate and predetermined condition of pressure and vacuum in said service pipe whereby the pressure in the lead-in pressure pipe is utilized for shifting said valve to alternately connect said service pipe with said vacuum and pressure pipes respectively.

11. In a pumping system, the combination of a liquid chamber having a valved inlet at its lower extremity, a valved discharge pipe extending into said chamber, a combined vacuum and compressor pump for producing alternate conditions of vacuum and pressure within said chamber to cause liquid to rise into said chamber and force the same out through said valved discharge pipe, and an automatic reversing valve actuated by direct pressure and auxiliary valve actuated by the predetermined conditions of vacuum or of pressure in said chamber to automatically reverse said conditions.

12. In a pumping system the combination of a source of fluid pressure supply with a pair of liquid chambers and a reversing valve, a pipe leading from said pressure supply to said valve, and pipes leading from said valve to said chambers, a pressure balanced piston for reversing said valve to alternately connect said pressure supply with said chambers and to exhaust the same respectively, and supplemental release valves actuated by the predetermined maximum and minimum pressures in said chambers to release the balanced pressure on one side of said piston to cause a reversal of said valve and a consequent reversal of the condition of pressure and exhaust in said chambers respectively.

13. In a pumping system, the combination of means for creating a fluid pressure and a vacuum, a pair of liquid chambers each having inlet and outlet valves normally submerged in liquid to be pumped, a pipe connection between said means and said chambers, an automatic reversing valve located in said pipe connection, a duplex direct-pressure-actuated balanced piston for operating said valve, a by-pass in each part of said piston to permit the accumulation of pressure on both sides thereof, an auxiliary valve for releasing said accumulated pressure from one side of said piston, means for permitting a predetermined maximum of pressure in one of said chambers to actuate said auxiliary valve, whereby the exhaust of the direct pressure upon one side of said piston will shift said reversing valve to permit the creation of a vacuum in one of said chambers and a simultaneous pressure in the other chamber.

14. In a pumping system, the combination of a pair of liquid chambers each having valved inlet and discharge passages at its lower end, said inlet passages being normally submerged in liquid to be pumped, means for causing a condition of predetermined pressure in one chamber and a condition of predetermined vacuum in the other chamber, together with means including a reversing valve operated by direct pressure and auxiliary valves actuated by pressure and vacuum in said liquid chambers for simultaneously alternating said conditions in said chambers, whereby liquid is simultaneously drawn into one of said chambers and discharged from the other chamber through the corresponding inlet and discharge passages, and thereafter forced out from said first-named chamber and drawn into said second-named chamber through the corresponding inlet and discharge passages.

15. In a pumping system, the combination of a pair of liquid chambers each having inlet and discharge passages at its lower end, said inlet passages being normally submerged in liquid to be pumped, means for causing alternate and predetermined conditions of pressure and vacuum and vacuum and pressure in said respective chambers, whereby liquid is caused to be drawn into one of said chambers, and simultaneously discharged from the other chamber and thereafter discharged from the first-named chamber and simultaneously drawn into said second-named chamber, said means including a reversing valve operated by direct pressure and auxiliary valves operated by alternate and predetermined conditions of pressure and vacuum to cause automatically a reversal of said conditions.

16. In a pumping system, the combination of a pair of liquid chambers with means for creating a condition of fluid pressure in one of said chambers, and a simultaneous condition of vacuum in the other of said chambers, valved inlet and discharge passages at the lower ends of each of said chambers, automatic means for reversing the conditions of pressure and vacuum in each of said chambers, said means comprising a balanced piston, a reversing valve connected thereto, and an auxiliary valve for releasing pressure from one side of said piston, said auxiliary valve depending for its operation upon the degree of pressure within one of said chambers.

17. In a pumping system, the combina-

tion of a pair of liquid chambers, each having valved inlet and discharge orifices at its lower end, a discharge pipe connected with each of said discharge orifices, means for producing alternate conditions of pressure and vacuum in each of said chambers, comprising a duplex piston, a casing therefor, a bypass in each head of said piston to permit the accumulation of pressure on both sides thereof, a reversing valve connected to said piston, and an auxiliary valve actuated by pressure in one of said chambers to release the balanced pressure upon one side of said piston and thereby permit direct pressure to operate said reversing valve to reverse the condition in said chamber from pressure to vacuum and simultaneously change the condition in the other chamber from vacuum to pressure.

18. In a pumping system, the combination of a pair of liquid chambers each having inlet and discharge orifices at its lower end, a discharge pipe connected with each of said discharge orifices, means connected with each of said liquid chambers for producing alternate conditions of pressure and vacuum in one of said chambers and simultaneous alternate conditions of vacuum and pressure in the other chamber, a duplex pressure balanced piston, a reversing valve connected thereto an auxiliary valve actuated by pressure in one of said chambers to disturb the pressure balance upon one end of said piston a second auxiliary valve actuated by the vacuum in said chamber for disturbing the pressure balance upon the other end of said piston, to alternately reverse the conditions in each of said chambers respectively.

19. In a pumping system, the combination with means for producing air pressure and vacuum, a reversing valve comprising a valve casing, pressure and vacuum ports and pipes connecting said casing with said means, a pair of service ports and pipes leading from said casing, a reversing valve member within said casing operated by the direct air pressure and means including auxiliary valves actuated by the alternate and predetermined conditions of pressure and vacuum in said service pipes for shifting the reversing valve member to alternately connect said service pipes with said pressure and vacuum pipes respectively.

20. A reversing valve for pumping systems, comprising a valve casing, pressure and vacuum pipes leading to said casing, a pair of service pipes leading from said casing to a pair of liquid chambers respectively, a valve within said casing operated directly by the pressure in said pressure pipe, means actuated by the alternate and predetermined condition of pressure and vacuum in one of said service pipes for permitting the pressure to alternately connect said service pipes with said vacuum and pressure pipes respectively.

21. In a pumping system, the combination of means for creating a fluid pressure and a vacuum, a liquid chamber provided with inlet and outlet valves normally submerged in liquid to be pumped, a pipe connected to said liquid chamber for introducing the fluid pressure or vacuum, a reversing valve connected to said pipe, pressure and vacuum pipes connected to said valve, a reciprocating piston for operating said reversing valve, said piston being operated by the direct fluid pressure, auxiliary valves for permitting the direct fluid pressure to operate said reversing valves and means for operating said auxiliary valves by the predetermined conditions of pressure or vacuum in said liquid chamber, whereby said conditions in said liquid chamber are reversed.

22. In a pumping system, the combination of means for creating a fluid pressure and a vacuum, a liquid chamber provided with inlet and outlet valves normally submerged in liquid to be pumped, a pipe connected to said liquid chamber for introducing the fluid pressure or vacuum, a valve chamber connected to said pipe, inlet and exhaust ports for said valve chamber, a fluid pressure pipe connected to said inlet port and a vacuum pipe connected to said exhaust port, a reversing valve for alternately connecting said inlet and exhaust ports with said liquid chamber pipe, whereby said liquid chamber may be subjected to alternate conditions of pressure and vacuum, a reciprocating piston in the path of said inlet port for operating said reversing valve, said piston being reciprocated by direct pressure of the fluid in said inlet pipe, auxiliary valves for permitting the operation of said reciprocating piston, said auxiliary valves being operated by predetermined conditions of pressure or vacuum in said liquid chamber, whereby said reversing valve is operated to reverse said pressure or vacuum conditions in said liquid chamber.

23. In a pumping system, the combination of means for creating a fluid pressure and a vacuum, a liquid chamber provided with inlet and outlet valves normally submerged in liquid to be pumped, a pipe connected to said liquid chamber for introducing the fluid pressure or vacuum, a valve chamber connected to said pipe, inlet and exhaust ports for said valve chamber, a fluid pressure pipe connected to said inlet port and a vacuum pipe connected to said exhaust port, a reversing valve for alternately connecting said inlet and exhaust ports with said liquid chamber pipe, whereby said liquid chamber may be subjected to alternate conditions of pressure and vacuum, a double headed reciprocating piston in the path of said inlet

of said piston heads being provided with by-passes whereby the pressure on the piston is balanced, auxiliary valves operated by a predetermined condition of pressure or vacuum in said liquid chamber, the opening of either of said auxiliary valves disturbing the balance of said piston, thereby permitting the direct pressure in said inlet chamber to operate said piston and the reversing valve, whereby the previous condition of pressure or vacuum in said liquid chamber is reversed.

This specification signed and witnessed this 9th day of December 1908.

FREDERICK C. WEBER.

Witnesses:

H. La Croix,

William Hargraves.