F. C. WEBER.
PUMPING SYSTEM.
APPLICATION FILED FEB. 29, 1912.

1,136,070.

Patented Apr. 20, 1915.
7 SHEETS—SHEET 1.

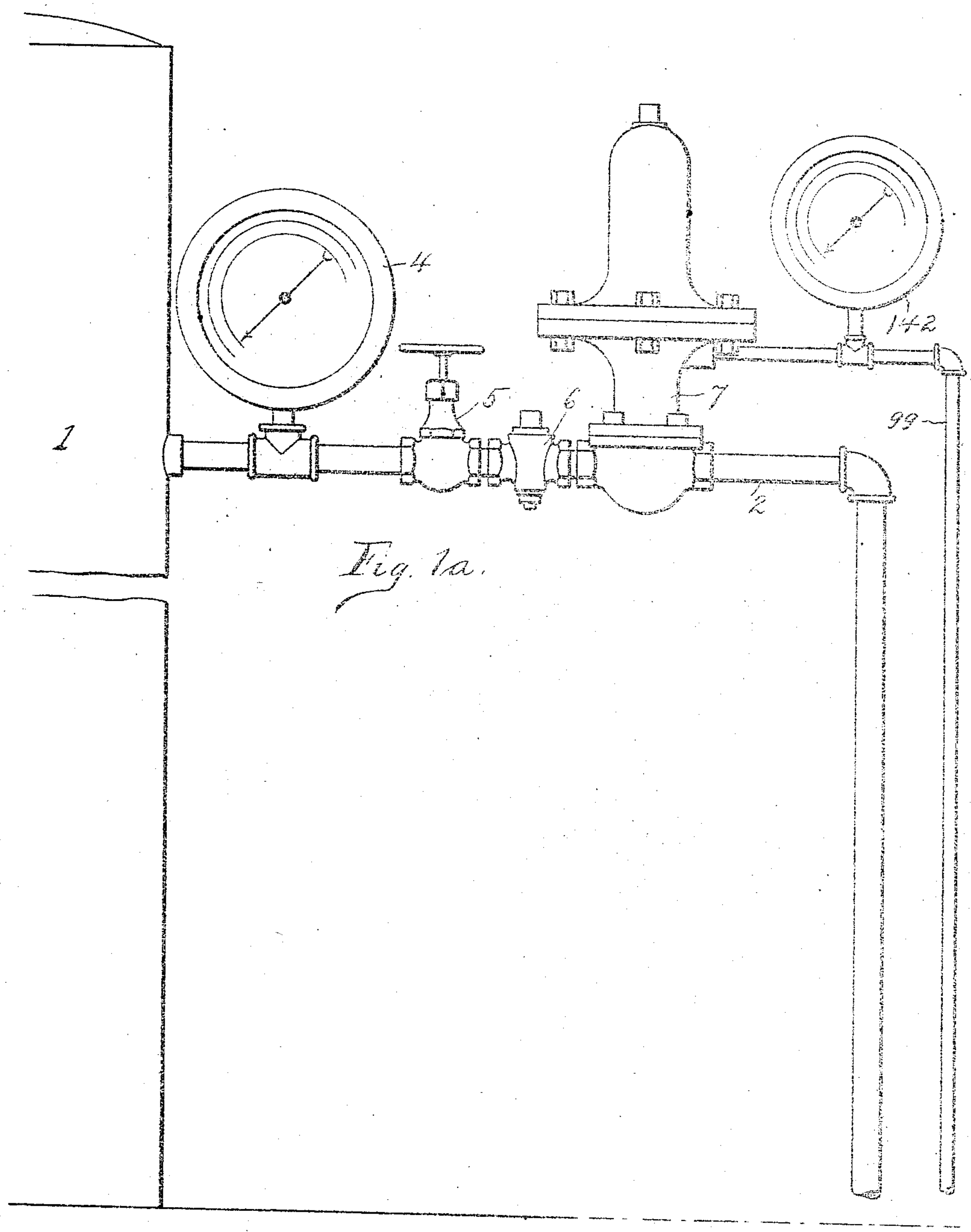

Fig. 1a.

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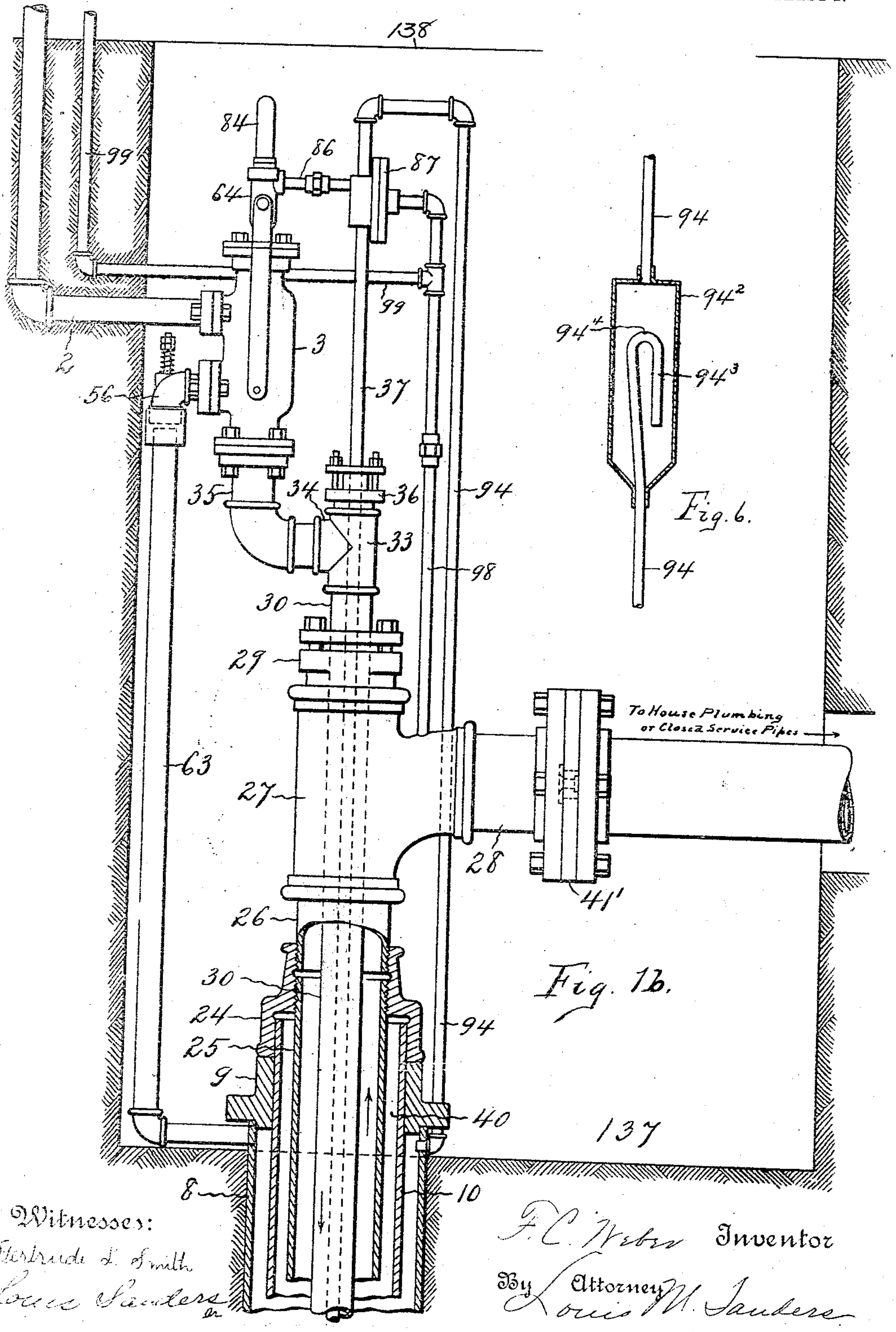
7 SHEETS—SHEET 2.



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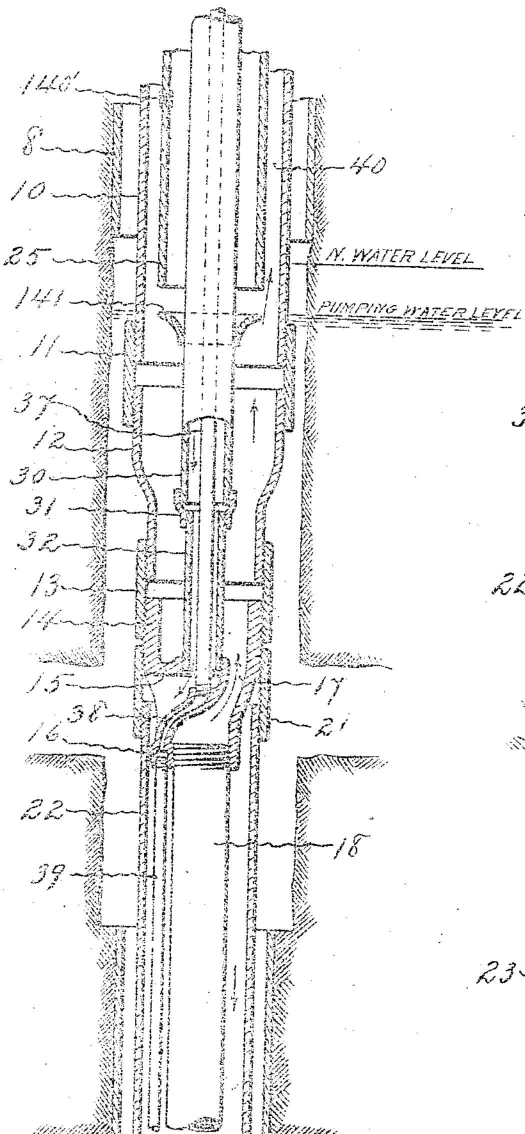

Fig. 1c.

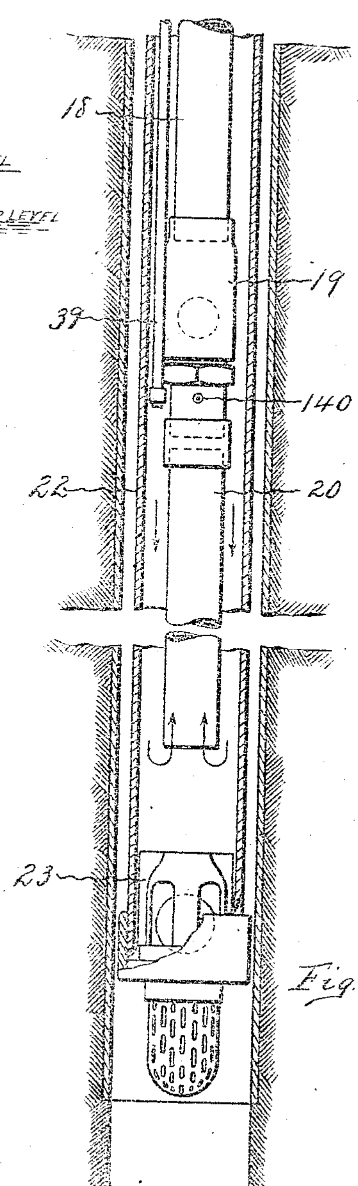

Fig. 1d.

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7 SHEETS—SHEET 4.

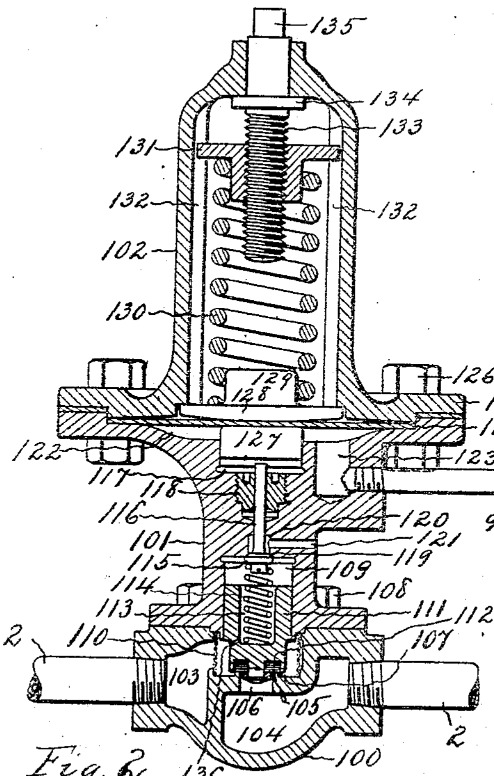

Fig. 2.

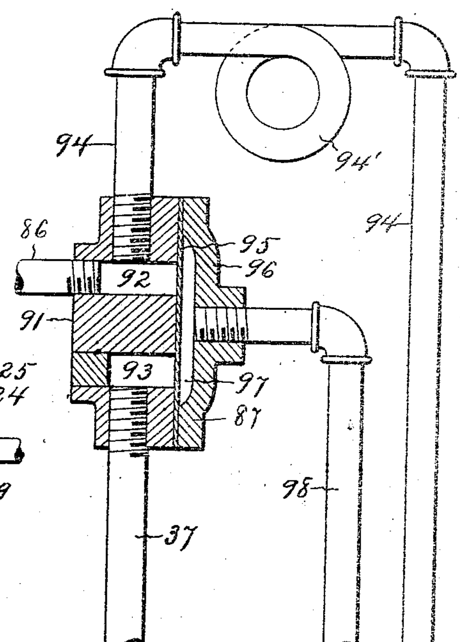

Fig. 5.

Witnesses:

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7 SHEETS—SHEET 5.

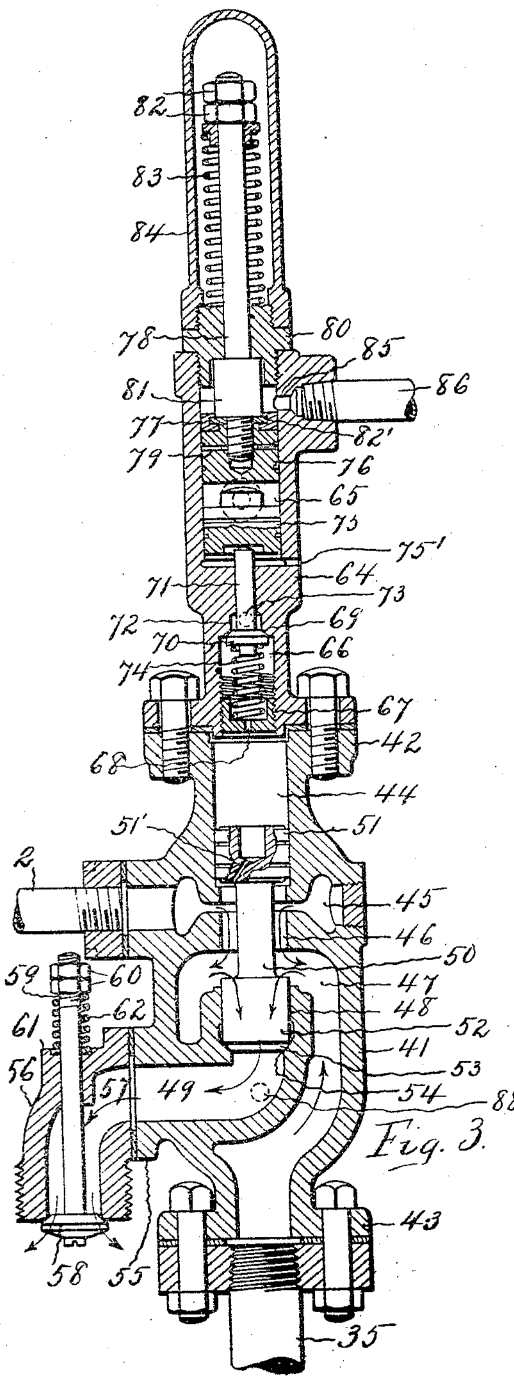

Fig. 3.

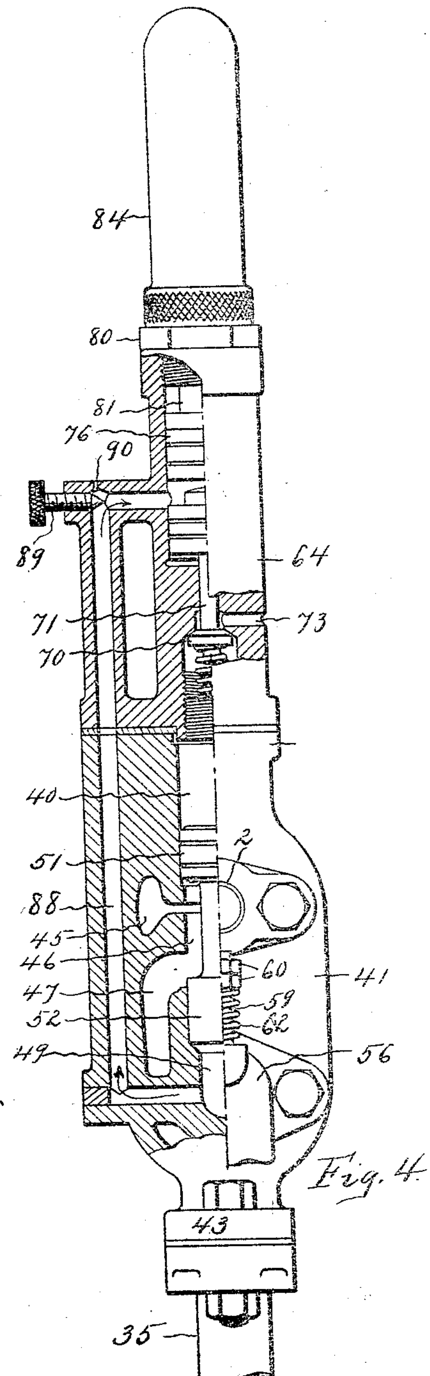

Fig. 4.

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7 SHEETS—SHEET 6.

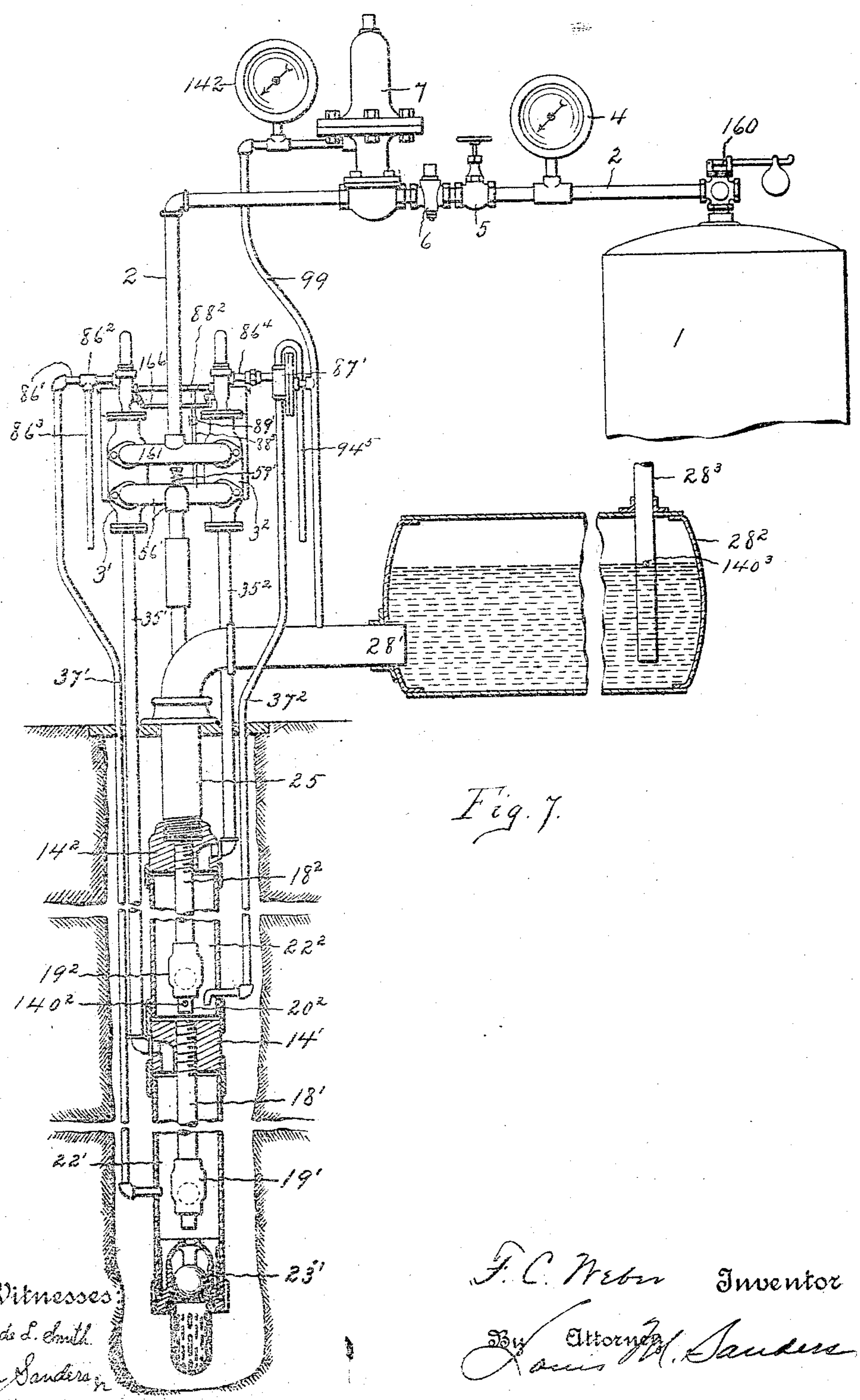

Fig. 7.

Witnesses:
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F. C. WEBER.
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APPLICATION FILED FEB. 29, 1912.

1,136,070 Patented Apr. 20, 1915.

7 SHEETS—SHEET 7.

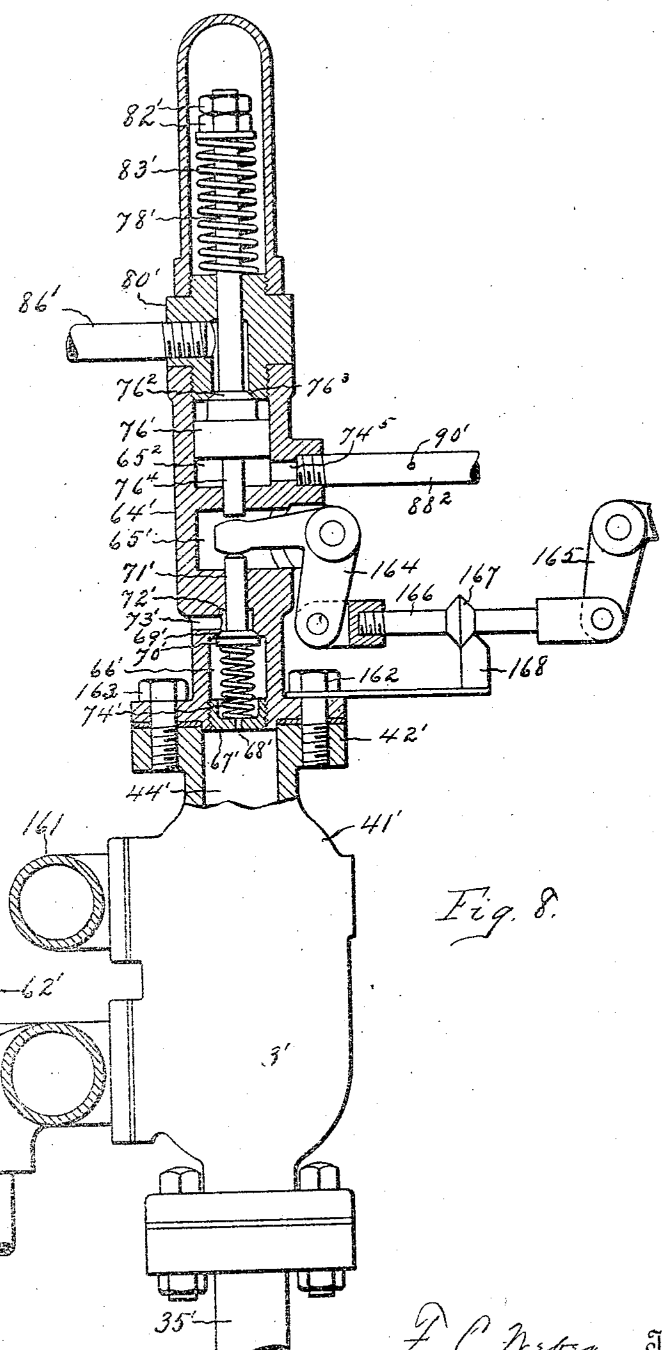

Fig. 8.

Witnesses:
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Louis Sanders Jr

F. C. Weber Inventor

By Louis M. Sanders Attorney

UNITED STATES PATENT OFFICE.

FREDERICK C. WEBER, OF NEW YORK, N. Y.

PUMPING SYSTEM.

1,136,070. Specification of Letters Patent. Patented Apr. 20, 1915.

Application filed February 29, 1912. Serial No. 680,684.

To all whom it may concern:

Be it known that I, FREDERICK C. WEBER, a citizen of the United States, and a resident of the city, county, and State of New York, have invented certain new and useful Improvements in Pumping Systems, of which the following is a specification.

In my prior Letters Patent No. 990,085, dated April 18, 1911, I have illustrated and described a pumping system wherein I have utilized compressed air and vacuum as a means for elevating water or other liquid from great depths. This system is particularly adapted for use in mines or deep oil or Artesian wells. In a later Patent No. 998,059, dated July 18, 1911, I have shown the basic principle adapted for use in connection with what I have called a suburban type or isolated pumping plant. This latter type is also adapted for deep well pumping, but is of a type requiring more or less attention. The principles involved, however, are substantially the same as those set forth in the first patent above named, although many improvements are set forth in the later patent. In my present form, I have introduced many improvements designed to render the system entirely automatic and self replenishing whenever any draft is made upon the system, and so long as pressure is maintained in the air receiver. The details of my present invention, I will now proceed to set forth. They are fully disclosed in the accompanying drawings wherein,

Figure 1[a] illustrates the air reservoir, gages, and regulating valve, together with the pipes leading therefrom to the pump proper. Fig. 1[b] illustrates the reversing valve and mechanism located at the top of the well tube. Fig. 1[c] illustrates an intermediate section of the well tube and its parts. Fig. 1[d] illustrates the bottom section of the well tube with the valves and the piping system. Figs. 1[a], 1[b], 1[c], and 1[d] are to be considered together as a single figure illustrating the complete system. Fig. 2 illustrates a vertical section of the regulating valve and its details. Fig. 3 illustrates a vertical sectional view of the reversing valve. Fig. 4 illustrates another view of the reversing valve partly in section at right angles to the view shown in Fig. 3. Fig. 5 illustrates a sectional view of the diaphragm valve and its piping system, hereinafter more particularly referred to. Fig. 6 illustrates a trap which may be used on one of the pipes, as hereinafter referred to. Fig. 7 represents the surface, intermediate, and bottom sections of a duplex system. Fig. 8 is a side plan view partly in section of one of the reversing valves used in the duplex system.

In carrying out my invention, I make use of any desired or preferred air pumping system (not shown), for the purpose of maintaining air pressure in the air receiver 1. Leading from this air receiver is the air pipe 2, running to the reversing valve 3. In the pipe 2, I first interpose the pressure gage 4 by means of which the air pressure in the receiver 1 may be at any time determined. The ordinary globe valve 5 is also interposed in the pipe 2, for the purpose of shutting the air off from the system whenever desired. I also interpose in the pipe 2, a valve 6, said valve being what is known as the straightway type, for the purpose of regulating the size of the opening in the pipe 2. There is also interposed adjacent to the valve 6, what I term the regulating valve 7, the details of which will be hereinafter more fully explained.

The well tube consists substantially of a curb tube 8 extending down into the well any desired distance, but usually down to some impervious stratum as rock or hardpan. At the top of the curb tube 8 is mounted a cap 9 as clearly shown in Fig. 1[b]. Within this cap and projecting above it is a second well tube 10, the latter extending down into the well for a considerable distance, and being provided at its lower end with a coupling nipple 11, and from said nipple extends a comparatively short reducing nipple 12. Next follows the coupling nipple 13 secured to the reducing nipple 12, and into the lower end of nipple 13 is screwed the by pass casting 14, said casting being provided with a separating diaphragm 15, and a reduced internally threaded lower end 16. This casting as clearly illustrated in Fig. 1[c] is provided with the passage 17 surrounding a portion of the diaphragm 15, said passage communicating with the upper well chamber formed by the tubes 10 and parts 11, 12, and 13, all of which are in open communication with the lower pipe 18, which latter carries at its lower end the usual ball valve and casting 19. I also extend below the valve 19, a pipe 20, said pipe extending nearly to the bottom of the well chamber as clearly shown in Fig. 1[d]. Extending downwardly from the casting 14 is the coupling nipple 21, the latter supporting at its lower end the tube 22, which latter carries the usual intake ball valve 23. The ball valves 19 and 23 are substantially the same as the valves illustrated in my prior patent above referred to, and need no specific description at this point.

Screwed upon the upper end of the pipe 10 and resting upon the cap 9 is a second coupling 24, and from said coupling cap the air chamber pipe 25 extends downwardly, nearly to the lower end of the tube 10, and into the vicinity of the pumping water level as indicated in Fig. 1ᶜ. From the upper end of the coupling cap 24, I extend the short nipple 26, leading to the standard T 27, and from the latter, I lead the discharge pipe 28. Upon the upper opening of the T 27 is the gland 29, and through the interior of this gland 29, I extend the air pipe 30, continuing the same down through the interior of the well tubes 8, 10 and 25 to the vicinity of the reducing nipple 12, and at its lower end, I provide the reducing nipple 31 from which extends a short section of pipe 32, the lower end of which latter pipe is screwed into the diaphragm 15, as clearly shown. In this manner it will be seen that the upper pipe 10 and the lower pipe 22 form chambers separated from each other by the diaphragm 15, and that said chambers have no communication with each other, except through the valve 19 at the lowermost end of the pipe 18. Upon the upper end of the pipe 30 I secure the T 33, and from its lateral opening 34, I extend a pipe 35 to the lower end of the reversing valve 3, as clearly shown in Fig. 1ᵇ. The upper opening of the T 33 is provided with a gland 36 through which extends the pipe 37 down through the interior of the pipe 30 to its lowermost extremity through the pipe 32, where it is screwed into a by pass 38 in the by pass casting 14 from which by pass leads a pipe 39 down to a point somewhat below the upper discharge valve 19.

From the above described piping system it will be noted that the pipes 10 and 25 form an annular chamber 40, closed at the top and open at the bottom. This chamber forms the air chamber, the purpose of which will be more fully hereinafter explained. In the discharge pipe 28, I may, if desired, insert at the coupling 41′ what I term a capacity disk, that is to say, a disk or diaphragm located in the discharge opening of the pipe 28, having a central aperture therethrough, which aperture has a diameter less than the internal diameter of the pipe 28, so that the capacity of the pumping system may be reduced below the normal capacity of the discharge pipe 28. The discharge pipe 28 leads to the closed house plumbing system, and it is to be understood that such system is normally closed and opened only when water is to be drawn from some one of the faucets connected up with said discharge pipe 28. As above indicated the pipe 2 from the reservoir leads to the reversing valve 3 which is also connected by means of the pipe 35, with the air line pipe 30.

I will now proceed to describe the details of the reversing valve. This valve consists of the case 41 provided with the upper and lower coupling flanges 42 and 43, the latter affording means for connection with the air pipe 35. The interior of the case is divided into several chambers, first, the upper piston valve chamber 44 leading to the annular chamber 45, which latter chamber communicates directly with the pipe 2 leading from the air receiver 1. This annular chamber communicates with a cylindrical passage 46 to a lower air chamber 47 in the center of which is located an exhaust passage 48, the latter leading out through the orifice 49 to the exterior of the case. The passage 48 is of the same diameter as the passage 46 and their diameters are slightly less than the diameter of the upper chamber 44. The annular chamber 47 is in direct communication with the air pipe 35. Located in the chamber 44 and lower passage 48 is the spool piston valve 50. This piston valve consists of an upper head 51 neatly fitting the upper chamber 44, and a lower valve head 52, the latter fitted to the passages 46 and 48. The lower end of the head 52 is slightly conical as at 53, so as to fit the valve seat 54. Communicating with the exhaust passage 49 and coupled to the flange 55 of the casting 41, is what I term a throttle valve elbow 56 having the passage 57 registering and communicating with the exhaust passage 49. The lower opening of the passage 57 forms a valve seat for the puppet valve 58, the stem 59 of which extends up through the body of the elbow, as shown and has at its upper extremity the pair of set nuts 60. Beneath said nuts and bearing upon the cup 61 is the tension spring 62. The tendency of this tension spring 62 is to hold the puppet valve 58 upon its seat and thus throttle the exhaust. If desired, the throttle elbow 56 may be connected by the pipe 63 with the well curb pipe 8, as illustrated in Fig. 1ᵇ, so that in case there should be any excessive noise it may be muffled or any water drip will be discharged directly back into the well.

Coupled to the upper end of the case 41 through the flange 42 is the supplemental piston valve case 64. This latter case is provided with the upper piston and valve chamber 65 and the lower valve chamber 66. The lower chamber 66 is formed by counterboring the lower end of 64, screwthreading the same for a considerable distance and then inserting the screw-threaded thimble 67 therein. This thimble 67 is provided with a central aperture 68, so as to form a communication between the chamber 66 and the chamber 44. In the upper end of the chamber 66 is formed a valve seat 69 for the puppet valve 70, the stem 71 of which extends upwardly into the chamber 65. Just above the valve seat 69 is a small exhaust chamber 72 from which leads the exhaust port 73 to the open atmosphere. Between the head of the puppet valve 70 and the screw threaded thimble 67, I locate the compression spring 74, the tendency of which is to hold the puppet valve 70 upon its seat 69. In the upper chamber 65 are located the two disconnected pistons 75 and 76, the lower one 75 normally resting upon the upper end of the valve stem 71. In order to prevent any cushioning action of the piston 75 in the lower end of the chamber 65, I provide the lateral vent 75′ leading to the open atmosphere. The upper piston 76 is provided with the leather packing ring 77 so as to make the same air tight within the chamber 65. Screwed into the upper side of the piston 76 is the stem 78, said stem being further secured to the piston 76 by means of a cross pin 79, passing through an aperture in both the piston and stem. The upper end of the chamber 65 is closed by means of the apertured and screw-threaded plug 80 through which the stem 78 passes as clearly shown in Fig. 3. The stem 78 is provided with an enlargement 81 for the double purpose of forming a backing for the clamping ring 82′ which holds the leather cup ring 77 in position as clearly shown. This enlargement 81 also forms a stop to limit the upward movement of the piston 76; as shown in Fig. 3, the enlargement 81 is bearing against the lower side of the aperture cap 80. The stem 78 extends upwardly for a considerable distance and has at its upper end a pair of set nuts 82 beneath which is the compression spring 83, which latter bears at its lower end upon the face of the cap 80. The tendency of this spring 83 is to hold the piston 76 in its uppermost position with the enlargement 81 bearing upon the under side of the cap 80. The tension of this spring 83 may be accurately adjusted by means of the set nuts 82. In order to form a protection for the spring 83 and the set nuts 82, I provide a cap 84 screwing the same upon the upper end of the cap 80, as clearly shown in Fig. 3. From the chamber 65 and above the piston 76 I lead a passage 85 by way of the pipe 86 to a supplemental regulating diaphragm valve 87 shown in Fig. 5, which latter I will hereafter proceed to describe in detail. In the two casings 41 and 64 I have provided a passage 88, said passage leading from the exhaust passage 49 up to the chamber 65. In said passage anywhere to be convenient I have located a needle valve 89 which latter may be regulated by screwing the same in or out to increase or decrease the size of said passage. I also provide said passage 88 with a very small vent opening 90 so that whenever there is pressure within said passage 88, such pressure will be equalized in the exhaust passage 49 at the lower end of the exhaust valve and also in the chamber 65 between the pistons 75 and 76, and at the same time such pressure will be gradually dissipated through the small vent 90.

The diaphragm valve 87 consists of the main casting 91 provided with the apertures 92 and 93, the former being connected with the pipe 86 to the upper end of the chamber 65 of the reverse valve heretofore referred to. This passage 92 also communicates by means of the drip pipe 94 with the curbing tube 8 so that any overflow of water may pass through the valve 87 and find its way back into the well. In the pipe 94 I locate the loop 94′ so as to form a trap or water seal, the purpose of which will be hereinafter explained. The lower passage 93 is connected directly with the central tube 37 leading down into the interior of the air pipe 30 as heretofore described. Covering the passages 92 and 93 is the flexible diaphragm 95 held in position by the chambered casting 96, the chamber 97 of which permits the diaphragm 95 to have a considerable movement therein. Leading from the chamber 97 is the pipe 98 connected to some part of the discharge pipe 28, as for example, to the horizontal branch of the T 27, and branch 99 where this pipe 98 leads back to the regulating valve 7.

The regulating valve 7, shown in vertical cross section in Fig. 2 is as heretofore stated, located in the air pipe 2 leading from the air receiver to the reversing valve. This valve consists essentially of the lower casting 100, the intermediate casting 101 and the upper casting 102. The lower casting 100 is provided with the two chambers 103 and 104, separated by the diaphragm 105, having therein the passage 106. The upper side of the diaphragm 105 is formed into a valve seat 107. Upon the upper side of the casting 100 is secured by means of the flange bolts 108, the casting 101, said casting being provided with the valve chamber 109 opening into the chamber 103 and separated therefrom by means of a gauze screen 110. Within the chamber 109 is located the hollow valve plug 111, the lower end of which is provided with the leather packing 112, to bear upon the seat 107. The upper side of the valve plug 111 is recessed as at 113, to receive the compression spring 114, the upper end of which bears upon the under side of the puppet valve 115. The puppet valve stem 116 extends upwardly through the casting 101, and projects into an upper chamber 117 in said casting, through a packing gland 118, the latter being interposed to make the stem air tight. Just above the valve 115 is formed a valve seat 119. At the lower end of the small chamber 120, an exhaust port 121 leads from the chamber 120 to the open atmosphere. The upper part of the casting 101 is hollowed out as at 122 to form a shallow chamber. From this chamber the passage 123 opens communicating with the pipe 99 leading from the pipe 98 heretofore referred to. The chamber 122 is formed by means of a flexible diaphragm 124 made of rubber, specially treated leather or other material impervious to water. This diaphragm 124 is held in position by the flange 125 of the upper casting 102, by means of the bolts 126. Secured to the central portion of the diaphragm 124 is a downwardly extending boss 127 which extends into the chamber 117. Upon the upper side of the diaphragm is secured the flat spring seat 128 with its upwardly projecting boss 129, for supporting the lower end of the compression spring 130. Upon the upper end of the spring 130 is located the cap 131 which has marginal slots taking over the internal guide ribs 132, so as to prevent the rotation of said cap 131. The compression of the spring 130 is effected by means of a screw 133, which is screwed into the central aperture of said cap, said screw being provided with a collar 134 which bears upon the under side of the domelike top of the casting 102. The upper end of the bolt 133 projects outside of the dome and is squared as at 135, so that the bolt may be turned by means of a wrench when it is desired to adjust the compression of the spring 130. The plug valve 111 is made to move easily within the chamber 109 with a very slight clearance, so that air pressure coming through the pipe 2 into the chamber 103 may gradually find its way from said chamber 103 into the chamber 109, so as to equalize both above and below the valve 111, or if desired, the valve 111 may be made to fit the chamber 109 quite closely and the leakage from the chamber 103 into chamber 109 be provided for by a small by pass, at 136.

Having now fully described the structure of the various parts of my improved pumping system, I will now proceed to describe its operation. It will be understood at the beginning that the well is comparatively deep and its upper end is sufficiently enlarged as at 137 to receive the parts of the structure illustrated in Fig. 1[b], and that said enlarged upper end of the well is covered with the cover 138, while the pipes 2 and 99 lead laterally to the air reservoir and parts contiguous thereto above the ground level, such air receiver being usually located in the residence or other building. It is also to be understood that pressure in the reservoir 1, is to be maintained at a comparatively high point and that the degree of such pressure will be registered upon the gage 4. With the valve 5 open, air pressure will be admitted into the chamber 103, where it will pass beneath the valve 111, and if there is normal air pressure in the chamber 109, said valve will be raised from its seat 107, and such pressure will pass from the chamber 103 into the chamber 104 and thence along the pipe 2 to the annular chamber 45 of the reverse valve, thence it will pass down through the passage 47 through pipe 35, thence through the by pass casting 14 to the liquid chamber formed by the pipe 22. Normally the lower end of the pump tube should be immersed to a depth substantially as indicated in Fig. 1[c]. Under such conditions the water will find its level in the interior of the lower liquid chamber 22, through the valve 23. The air pressure coming down through the pipe 30 and through the by pass casting 14, exerts itself upon the surface of the liquid in the liquid chamber 22, with the result that the liquid or water is forced up through the interior pipe 20 past the valve 19 into the pipe 18, thence through the by pass casting 14, and to the upper pump section 10, and within the chamber 40. As above described, this inner tube 25 is in direct communication with the discharge pipe 28 through the T 27. As the water or liquid is forced up through the upper pump section, the air in the annular chamber 40 formed by the pipe 25 and the pipe 10 is trapped in such a manner as to form a compression chamber. At the beginning, the discharge pipe 28 leading to the house plumbing system is left open until a solid column of water fills the discharge pipe 28, and all of the various pipes in the house plumbing system. When the level of the water within the lower liquid chamber 22 drops below the lower extremity of the pipe 39, which of course takes place only when some one or more of the faucets connected with the house plumbing system is open and the pressure in the discharge pipe 28 correspondingly lowered, the excess of pressure in the liquid chamber 22 will force the water upwardly through the pipe 39, the by pass 38 and the pipe 37 to the diaphragm valve 87 through the passage 93.

The upward air pressure in the pipe 39, the by pass 38, and the pipe 37, is partially balanced by the weight or head of the liquid in this column. It must be understood that this column has a comparatively small cross section. As the liquid level in the chamber 22 lowers, air of course will have access to the lower end of the pipe 39 and bubbles of air will shoot up through this water column and as they approach the top, will drive the superposed water ahead and not only produce a "water hammer" effect but also diminish the head and overbalance the pressure on the opposite side of the diaphragm

95 resulting, of course, in unseating the diaphragm and permitting this excess of pressure to escape into the passage 92 thence through the pipe 86 to the chamber 65 at the upper end of the reversing valve 3. This action it must be understood is very quick, in fact too quick for the excess of pressure to escape around through the pipe 94 to the upper end of the well curbing tube 8. The loop 94′ in the pipe 94 forming as it does, a water seal, also adds to the retardation of the flow of the excess of water through the pipe 94. This retardation permits the quick action of the pressure through the passage 92, and pipe 86 to the chamber 65. The action is somewhat similar to the principle of the "water hammer," which is produced in a pipe through which water is flowing and suddenly stopped by the turning of a valve in such pipe. The frictional resistance in passing the water seal 94′ adds materially to the effect of this "water hammer" action. Inasmuch as the chamber 65 contains only atmospheric pressure below the piston 76, the quick "water hammer" pressure coming through the pipe 86 will suddenly depress the piston 76 against the force of the compression spring 83 and the lower end of said piston 76 will contact with the upper end of the plug piston 75, with the result of depressing the valve 70, from its seat 69 and thus venting the chamber 66. The sudden venting of the chamber 66 will gradually vent the chamber 44 in the reversing valve case and permit the differential pressure upon the spool valve 51 and 52, to raise said valve off the lower seat 54. The raising of this valve from the seat 54 will first cut off the passage 47 down through the pipe 35 and finally, when said spool valve with the piston 51 has risen to the upper end of the chamber 44, the pipe 35 will be open to the exhaust passage 49 through the passage 47. The spring 62 controlling the puppet valve 58 is ordinarily comparatively weak and sufficient only to hold the puppet valve 58 in its seat, when the pressure in the passage is about 2 pounds above atmospheric pressure. This results in the great bulk of the pressure in the pipe 35 throughout this system, being exhausted with only the retention of about 2 pounds in the system. This 2 pounds excess of pressure now finds its way from the passage 49 through the by pass 88 back to the chamber 65, with the result that such pressure is exerted upon the under side of the piston 76, and being added to the upward tension by the spring 83 will result in lifting the piston 76 from the upper end of the piston 75 and thereby relieve the upper end of the valve stem 71 from the pressure due to piston 76. The air pressure however, in the chamber 65 can only escape slowly through the vent 90, so that it will be exerted upon the upper side of the plug piston 75, and as such pressure is dissipated, the spring 74 beneath the puppet valve 70 will slowly restore said puppet valve to its seat. This retardation of the valve 70, I find of considerable advantage, because otherwise, if the puppet valve were suddenly restored to its seat, it would result in the accumulation of the differential pressure in the chamber 44 above the valve head 51 and consequently restore said valve to the position illustrated in Fig. 3, before the other parts of the structure had performed their necessary and proper functions. The spring 74 within the chamber 66 will now restore the puppet valve 70 to its seat and permit the air pressure which has been trapped above the head 51 and from the pipe 2 to gradually leak by the piston 51 through the capillary by-pass 51′ (the latter being considerably smaller in cross-section than 68) and restore the pressure in the chamber 44. This will result in the gradual lowering of the piston 51 and a consequent seating of the cone valve upon its seat 54 thereby reopening communication between the pipe 2 and the pipe 35. In the mean time, during the period of exhaustion of pipe 35, the pressure having been removed from the surface of the liquid in the lower liquid chamber 22, the water in the well will rise therein, through the valve 23 and seek its level within said chamber 22. With the pump tubes and the discharge itself filled with water and the house plumbing system closed off, the entire system is ready for operation at a moment's notice, simply by opening any one or more of the faucets connected with the house plumbing system by way of the discharge 28. Ordinarily slight drafts of water from the discharge pipe 28 will be taken care of by the air expansion in the chamber 40 and the automatic valves will operate only when the level of the liquid in the liquid chamber 22 has dropped to a point below the lower end of the pipe 39.

I have described the initial operation of the system whereby the pipes are filled for the first time, thereafter with the pipes leading from the discharge pipe 28 ordinarily closed with only an occasional draft of water therefrom, the air pressure coming through the regulating valve and the reverse valve 3 and the pipe 35, will gradually drive the level of the water in the liquid chamber 22 downwardly and force the water up through the interior pipe 20 past the valve 19 and up into the discharge 28. When, however, this level has been forced down below the bottom end of the pipe 39, the automatic operation will take place as above indicated, but the initial charging of the system with water, as above described, will compress the air trapped in the annular chamber 40 formed by the exterior tube 10 and the interior tube 25, and thus form a compression chamber in the upper end of the system, whereby the normal water pressure in the house plumbing system will be maintained substantially uniform and produce a continuous flow which would otherwise be intermittent. In practice, air chamber 40 may be slowly exhausted of its air by leakage through imperfect joints of the structure, so that it becomes quite important that means be provided whereby the air in this chamber should be replenished. In order to meet such a condition, I provide a small aperture 140 in the water line pipe 20 below the valve 19 and at a point on a level with the lower end of the pipe 30, so that whenever the air pressure in the liquid chamber 22 forces the water level down to or below such aperture 140, the air will have access to the interior of the pipe 20. This air, under the heavy pressure to which it is subjected, will pass through the aperture 140 and trickle up past the valve 19 through the water column to the upper water chamber formed by the pipe 10. In order to prevent the air bubbles from rising into the water discharge pipe 28 through the pipe 25, I provide a deflector 141 mounting the same upon the pipe 30 just beneath the lower extremity of the pipe 25. In this manner, the rising bubbles will be directed into the annular chamber 40, between the pipes 10 and 25. In this manner I am able to maintain the normal supply of air in the chamber 20 against any leakage through imperfect joints.

It is possible for this means of replenishing the air in the chamber 40 to supply more air than is necessary for actual practical use, and in order to dispose of any surplus air, that is, more than is required for maintaining the uniform pressure in the chamber 40, I provide a small aperture 140′ in the side of the pipe 25 at a predetermined height above its lower end, so that when the water level within the chamber 40 is forced below the aperture 140′ the surplus air will escape into the discharge pipe 28 and the pressure within the chamber 40 will be correspondingly reduced. Immediately upon venting the chamber 40 through the aperture 140′ the level of the water in said chamber will rise until equilibrium is again restored. When water is drawn from the discharge pipe 28, it might be thought that the air pressure in the chamber 40 would not operate to continue the discharge of water after the level in the chamber 40, has passed below the aperture 140′. This is not the case, for the reason, that when water is drawn from the discharge pipe 28, it is under what may be considered two heads of pressure, namely, that in the chamber 40 and that which comes through the pipe 35 into the liquid chamber 22. Considerable drafts of water may be taken from the discharge pipe 22 and the expansion of the air in the chamber 40 will follow the liquid level therein, below the aperture 140′ to a considerable distance before any considerable amount of air in the chamber 40 will have had time to escape through the aperture 140′, so that, practically the entire length of the pipe 25 may be utilized as a compression air chamber.

In order to insure sufficient water friction in the pipe 94, I have, as above indicated, interposed the water seal or loop 94′ in the pipe 94. Under ordinary circumstances, where the water lift is not too high, I find that this means affords sufficient water friction in the pipe 94. It may be desirable however, under certain circumstances to provide additional means of producing friction in the pipe 94 and to this end, I may interpose a trap substantially as illustrated in Fig. 6. In this case the pipe 94 enters the upper end of cylindrical chamber 94^2. The lower end of this chamber receives the lower section of the pipe 94 and such pipe extends up into the chamber 94^2 for a considerable distance, and then is turned back upon itself to form the goose neck 94^3. At the very uppermost part of the turn in the goose neck 94^3, I locate a minute vent as 94^4. This trap serves the same purpose as the loop 94′ and its action is substantially as follows:

The surplus or overflow of water from the valve 87, it will be remembered must be disposed of, and yet it must be retarded in its discharge. In Fig. 1^b the structure is shown as depending solely upon the friction of the water in the pipe 94. In Fig. 5, to add to this friction and form a water seal, the loop 94′, is inserted, but where increased friction is desired, the structure in Fig. 6 is used. Water from the pipe 94 is discharged into the chamber 94^2. This chamber being hermetically sealed otherwise than by way of the inlet pipe 94 and the discharge goose neck 94^3, the air which the chamber contains must, upon the accumulation of water therein, find an outlet through a small vent 94^4. No siphoning action of the goose neck however, takes place until water has accumulated in the chamber to a height above the upper turn of the goose neck 94^3, at which point the accumulation of the water in the chamber 94^2 above the vent 94^4 will discharge, and thus leave the trap ready for immediate action at any time. The vent 94^4 prevents siphoning after the level of the water goes below said vent.

It may be and frequently is advisable for the water pressure in the house plumbing system to be registered, and in order to provide such means in a convenient location, I place the registering gage 142 in the pipe 99. This gage, it will be noted, will register all of the fluctuations of the pressure in the discharge pipe 28, which of course means the water pressure in the house plumbing system above ground.

The interposition of the regulating valve 7 is for the purpose of shutting off the air pressure from the air receiver 1, from the pumping system at times when excessive drafts are not made upon the discharge pipe 28, as for example, at night. It is a fact that in all isolated pumping systems, it is almost impossible to make all pipe joints perfectly air and water tight. Leakages in out of the way places frequently occur and it is in order to retain the air in the reservoir and prevent its slow leakage, by way of the pipe 2, beyond the regulating valve 7 and the discharge passage 49 to the exhaust vent 90, through imperfectly operating valves or the like. At such times the pressure in the house plumbing or closed service pipes will be maintained by the accumulated pressure in the air chamber 40, and inasmuch as the water in the house plumbing system is trapped above the valve 19, such pressure will meet slight or even ordinary drafts upon the same. When however, such drafts are sufficient to reduce the level of the water in the lower liquid chamber 22 below the lower end of the pipe 39, then the automatic action, as heretofore described will take place, and the supply of air under pressure will again be admitted to the system. The purpose of the regulating valve 7 is to stop off the air from the pumping system after the same has been supplied with an initial charge and then permit that charge to be exhausted to a certain point, then a new charge of air is admitted to the system from the receiver 1. In this manner, the air receiver, into which goes the principal cost of maintenance, is isolated from the pumping system except at times when the air in said system needs replenishing.

As hitherto described, by pumping system is applicable to wells of ordinary or medium depth; but in order to adapt it to wells of greater depth, I find it advisable to elevate the water from the well by stages and for that reason the duplex form, as illustrated in Fig. 7 is used. In this case it is necessary also to slightly modify the reversing valve 3, so that for the duplex system the valves 3^1 and 3^2 are so interconnected as to operate alternately. In Fig. 7 the air receiver 1, the gage 4, globe valve 5, cut off valve 6, regulating valve 7, and the pipe 99 with its gage 142, are the same in purpose and arrangement as shown in Fig. 1^a. In practice I find it advisable to provide a safety valve 160 at the receiver 1 to prevent overcharging the receiver. The pipe 2 is led from the above described parts to a T 161, said T being connected as shown in Fig. 7 to the pair of regulating valves 3^1 and 3^2. These regulating valves are in the main the same as the regulating valve 3 shown in detail in Fig. 3. The changes or modifications will be subsequently described in detail.

The valve 3^1 is connected by the pipe 35′ to the lower stage liquid chamber 22′ by way of a by-pass casting 14′. The other reversing valve 3^2 is connected to the upper stage liquid chamber 22^2 by way of the pipe 35^2 through the by-pass casting 14^2. The pipe 37′ leads from a point in the liquid chamber 22′ adjacent to the intake of the valve 19′ to the upper end of the reversing valve 3^1 and it operates substantially in the same manner as the pipe 37 heretofore described in connection with the single stage system. The pipe 37^2 leads from a point in the lower end of the liquid chamber 22^2 adjacent to the discharge valve 19^2 to the upper end of the reversing valve 3^2 by way of the diaphragm valve 87′ and pipe 86^4. The lower intake valve 23′ is in all respects the same as the valve 23 illustrated in Fig. 1^b. From the by-pass casting 14^2 leads the discharge pipe 28′ to the receiving tank 28^2. This tank is water and air tight so that I may utilize the same as a compressed air tank for substantially the same purpose as described in connection with the air chamber 40. From the lower end of the tank 28^2 I lead the pipe 28^3 outside for connection with the house plumbing or closed service system. The exhaust from each of the valves 3^1 and 3^2 leads into a T 56′ and is provided with the same character of throttle valve and connection as shown in Fig. 3 with a puppet valve, valve stem 59′ and spring 62′. It will be noted hereafter that inasmuch as the valves 3^1 and 3^2 operate alternately a single exhaust will answer for both of the reversing valves.

Referring now to Fig. 8 for the details of the reversing valves 3^1 and 3^2, these valves are identical in every respect with the exception that for convenience in assembling and operation, one is "right" and the other is "left." In order also for convenience in understanding the operation I have shown the upper part of the valve as turned upon its axis through an angle of 90 degrees as it sets upon the lower valve casting 41′. In practice however, the parts are assembled as shown in Fig. 7. The interior structure of the lower casting 41′, together with the spool valve, ports and passages therein, is identical in all respects with that shown in connection with Fig. 3, so that further detailed description of said parts is deemed unnecessary.

Secured to the upper end of the casting 41′ is the valve casting 64′. This method of securing may be by any convenient means, as for example, by means of the bolts 162 and 163 passing through the flange of the upper casting 64′ into the flange 42′ of the casting 41′. The lower end of the casting 64′ is counterbored to form the chamber 66′ into the lower end of which is screwed the cap 67′ centrally apertured as at 68′ to form a communication between the chamber 66′ and the chamber 44′. The valve seat 69′ is provided in the upper end of the chamber 66′ for the reception of the puppet valve 70′, said valve being guided by means of the stem 71′ in the casting 64′ as shown. Directly above the puppet valve 70′ is located the small chamber 72′ and leading from it is an exhaust passage 73′ to the open atmosphere. The stem 71′ projects into an opening 65′ which opens laterally outside of the casting. The spring 74′, located within this chamber 66′ serves to hold the puppet valve 70′ upon its seat.

Adjacent to the opening 65′ I locate the bell crank 164 with one arm thereof projecting into the chamber 65′ for contact with the upper end of the valve stem 71′. A corresponding bell crank 165 is connected to the twin reversing valve in identically the same manner and for the same purpose. These bell cranks 164 and 165 are connected together by the rod 166 so that they operate in unison but in opposite phases; that is to say, when the inwardly projecting arm of the lever 164 swings down to depress the valve 70′, the corresponding inwardly projecting arm of the bell crank 165 is raised to permit the seating of the corresponding puppet valve in the other reversing valve mechanism, and vice versa. In order to prevent accidental displacement of this toggle link and lever arrangement, I provide a collar 167 upon the middle portion of the link 166, said collar being V shaped in cross section, for coöperation with the V shaped spring snap 168, which is secured in place by means of the bolt 162. From this construction it will be seen that the toggle lever and link mechanism will shift so that the collar 167 will first be upon one side of the spring snap 168 and then upon the other, the spring serving as a yielding means for preventing accidental shifting of the parts.

The casting 64′ is provided with an upper chamber 65^2 for the reception of the piston 76′. This piston is slightly different from the corresponding piston illustrated in Fig. 3, inasmuch as it is provided with a valve 76^2 upon its upper end for coöperation with the valve seat 76^3, the purpose of which will be hereinafter fully described. The piston 76′ is further provided with a depending stem 76^4 which passes through an aperture in the casting and extends into the chamber 65′ in position to engage the inner arm of the toggle lever 164. I provide the chamber 65^2 with a lateral discharge or exhaust opening 74^5 to correspond with the passage 88 of the valve shown in Fig. 4. In Fig. 7 I have shown this opening as connected across to the corresponding opening in the reversing valve 3^2, by means of the pipe 88^2 with a connection 88^5 down from said pipe 88^2 to to the exhaust T 56′. In the pipe 88^2 is a minute vent 90′.

Above the valve 76^2 the valve stem 78′ extends for a considerable distance through the plug 80′ which closes the upper end of chamber 65^2 and is provided at its upper end with a pair of adjusting set nuts 82′ for the purpose of adjusting the tension of the spring 83′ in exactly the same manner as the corresponding parts illustrated in Fig. 3, are operated. The upper end of the chamber 65^2 is closed by the casting 80′ in which the valve seat 76^3 is formed. The valve 76^2 is for the purpose of closing off the chamber 65^2 from the pipe 86′. Reference to Fig. 7 will show that the pipe 37′ is coupled directly with the pipe 86′ and that in the pipe 86′ I have located a T 86^2 with a drip pipe 86^3. The corresponding pipe 86^4 leads into the valve 87′ which as above described is in all respects the same as the diaphragm valve 87 illustrated in Fig. 5.

It is to be understood that each of the valves 3^1 and 3^2 may be provided with a side passage 88 leading from the exhaust passage 49 up to the upper castings 64′ in the same manner as is shown in Fig. 4; but in such case, I would dispense with the pipe 88^2 and its connection with the exhaust T 56′. I prefer however, in the duplex system to omit said side passages 88 from the valves 3^1 and 3^2, and use as a substitute, the pipe 88^2 with a connection 88^5 to the T 56 and locate in said connection a needle valve as 89′ for throttling the retained two pounds of pressure from the exhaust T 56′. The latter construction is solely for the purpose of reducing the number of parts to be looked after and adjusted. This duplex system operates as follows: Air pressure is admitted from the receiver 1 through the regulating valve 7 to the T 161 where it is admitted to the chambers within the valve casting 41′ to operate in substantially the manner described in connection with the reversing valve illustrated in Fig. 3. It must be understood that one or the other of the puppet valves 70′ of the reversing valves 3^1 and 3^2 will be unseated thereby permitting the corresponding upper chamber 44′ to be vented through the orifice 68′ and the exhaust opening 73′. At such time the spool valve corresponding to the valve 50 will be raised so as to exhaust the corresponding liquid chamber 22′ or 22^2. In the position of the part shown in Fig. 7 the lower chamber 22′ is being exhausted of its air through the corresponding pipe 35′ and reversing valve 3^1. This will permit an influx of water from the well past the valve 23′ into the lower chamber 22′. Simultaneously with this operation the corresponding puppet valve 70′ in the reversing valve 3^2 is closed and the accumulated pressure in the corresponding chamber

44′ will seat the spool valve within said reversing valve case which will open the passage from the pipe 2 through the reversing valve 3^2 to the pipe 35^2 and thence to the upper liquid chamber 22^2. The water that had been previously accumulated in this chamber will now be driven out past the valve 19^2 through the pipe 18^2 to the discharge pipe 28′ and thence to the water tank 28^2. The accumulation of water in this tank will result in compressing the air retained therein to a considerable degree and thus the upper portion of the tank 28^2 serves as an air chamber.

When the level of the liquid in the liquid chamber 22^2 falls to the lower end of the pipe 37^2 air pressure will be admitted into said pipe, and will immediately rise therein to the diaphragm valve 87′ unseating the diaphragm therein in the same manner as described in connection with the diaphragm valve 87. The surplus of water along with the air in the pipe 37^2 will escape out through the pipe 94^5 but the friction of the water escaping from said pipe 94^5 will cause a sort of water hammer or impulse of water to pass through the pipe 86^4 to the upper side of the valve 76^2. The accumulation of this pressure will result in forcing the corresponding piston 76′ down thereby unseating the valve 76^2 and permit the pressure from the pipe 86^4 to in a measure spread out and fill the chamber 65^2 above the piston 76′. It must be understood that this pressure coming through the pipe 86^4 comes as a sudden impulse. If it were to come slowly or by a slowly accumulating pressure it would be insufficient to overcome the tension of the spring 83′ to which is added the back pressure within the lower part of the chamber 65^2, but being as it is, a sudden impulse, the piston 76′ is driven downwardly with its stem 76^4 contacting with the inwardly projecting arm of the lever 164 which in turn contacts with the upper end of the stem 71′. This results in simultaneously unseating the valve 70′ in the reversing valve 3^2 and at the same time throws the toggle link system 164, 165, and 166 into the position shown in Fig. 8, thereby permitting the seating of the valve 70′ in the reversing valve 3^1. The condition of affairs now is reversed and the same cycle of operation will now take place in the lower liquid chamber 22′ through the reversing valve 3^1 and its parts so that when the liquid in the chamber 22′ has been driven to the level of the lower end of the pipe 37′ the liquid impelled by the very rapidly rising bubble of the water, will shoot up said pipe to the pipe 86′ and into the small chamber above the valve 76^2 in the reversing valve 3^1. This results in unseating the corresponding spool valve within the casting 41′ whence the same cycle of operations will take place as just described in connection with the chamber 22^2. The surplus of liquid from the pipe 37′ after it has operated the piston 76′ may escape through the drip pipe 86^5. I find that for the lower stage it is unnecessary to provide a diaphragm valve such as the diaphragm valve 87′ although if desired, such a valve may be interposed in the pipe 86′.

The retention of a portion of the exhaust from each of the stages by means of the throttle valve inserted in the T 56′ and its access around through the corresponding passage 88^2 to the chamber 65^2 beneath the piston 76′ serves as a sort of balancing effect upon said piston and by throttling this retained pressure by means of a needle valve 89′ I may regulate the times of reversal of the phases of operation to a great degree of nicety. When the accumulation of water in the tank 28^2 has compressed the retained air therein to the proper degree the pressure will be communicated through the pipe 98′ back to the regulating valve 7, when of course the pressure from the main air receiver 1 will be cut off from the system. Small drafts of water from the house plumbing system will be taken care of by the compressed air in the tank 28^2, and until the level of water therein so reduces the air pressure as to cause the automatic actuation of the regulating valve 7, whereupon pressure from the receiver is again admitted to the system and its operation will follow as above described. Air in the tank 28^2 may be replenished through the small aperture 140^2 in the short section of pipe 20^2 just below the discharge valve 19^2 of the upper stage, and a surplus of air in the tank 28^2 may also be disposed of by locating a small aperture 140^3 in the discharge pipe 28^2 as above described in connection with the air chamber 40 of the single stage system.

While I have described the duplex system in connection with a two stage well, I do not desire to be considered as limiting the duplex valve connection 3^1 and 3^2 to a two stage well. The two stages may be separated and considered as separate and distinct wells, each connected up in substantially the same way as illustrated in Figs. 1^c and 1^d.

It must be understood that Fig. 7 is largely diagrammatic particularly so as to the parts below ground level. In practice the pipes 35′, 35^2, 37′ and 37^2 are arranged concentric to each other, somewhat in the manner as illustrated in Figs. 1^b, 1^c, and 1^d, so that the pipes which form the liquid chambers 22′ and 22^2 are substantially of the same diameter and of a size practically to fit the bore of the well.

It is unnecessary to provide the lower discharge pipe 18′ of the lower stage with means for replenishing the tank 28^2 for the reason that there is no direct access from such lower liquid chamber 22 with said tank, except by way of the upper liquid chamber 22^2 and its discharge pipe 18^2. Moreover, I find that the method above described for replenishing the tank 28^2 with air, by way of the pipe 37^2 and the small aperture 140^2, is adequate. However, in case the two stages are separated, as in the case of their operating in separate wells, I may if desired, provide an aperture in the short section of pipe below the valve 19′ corresponding in all respects to the aperture 140^2 in the pipe 20^2, so that this replenishing of the chamber 28^2, by the means illustrated, would be substantially the same; but such a structure would be substantially the same as that illustrated in connection with Figs. 1^b, 1^c, and 1^d, and the two wells would each have a duplicate of that structure. The duplex reversing valve in such a two well system would be substantially the same as that illustrated in Figs. 7 and 8, except that each of the valves 3^1 and 3^2 could be provided with the diaphragm valve 87′.

I have not shown the two drip pipes 86^3 and 94^5 as connected back to the well, but it should be understood that these pipes may be connected back so as to discharge into the well in the same manner as the pipe 94 shown in Fig. 1^b, if desired. These changes of parts to meet different conditions in practice, I do not regard as modifications in any respect, but consider them as part and parcel of the entire structure and to be used as and where conditions may require.

I claim,

1. In a pumping system, the combination of a source of fluid pressure supply, a liquid chamber having inlet and discharge valves, a reversing valve for admitting fluid pressure from said supply to said chamber, and for exhausting said pressure therefrom, and means for throttling the exhaust from said liquid chamber.

2. In a pumping system, the combination of a source of fluid pressure, a liquid chamber, inlet and discharge valves for said chamber, a reversing valve for admitting pressure from said supply to and exhausting the same from said liquid chamber, and a differential pressure operated means actuated by the lowering of the liquid in said liquid chamber to admit said fluid pressure to and for actuating said reversing valve to exhaust the pressure from said liquid chamber.

3. In a pumping system, the combination of a source of fluid pressure supply and a source of liquid supply, a liquid chamber, a valve inlet connection between said chamber and said liquid supply, a normally closed discharge pipe leading from said chamber, a reversing valve for admitting fluid pressure from said fluid supply to said liquid chamber, said reversing valve having an exhaust passage therein, with a throttling valve in said exhaust passage.

4. In a pumping system, the combination of a source of fluid pressure supply, a source of liquid supply, a liquid chamber, a valved inlet connection from said liquid supply to said chamber, a valved and normally closed discharge pipe leading from said chamber to a level higher than that of said liquid supply, a reversing valve for admitting pressure supply to said liquid chamber, said valve actuated by differential pressure from said fluid pressure supply to exhaust said fluid pressure from said liquid chamber, and means for creating said differential of pressure for actuating said reversing valve.

5. In a pumping system, the combination of a liquid chamber having a valved inlet and a valved discharge pipe, a reversing valve for introducing air pressure to and exhausting the same from said chamber, and means for actuating said valve operated by a differential of pressure between said discharge pipe and said liquid chamber.

6. In a pumping system, the combination of a liquid chamber, a valved inlet and a valved and normally closed discharge pipe for said chamber, a valve for exhausting the pressure from said chamber to cause an influx of liquid thereto, through said valved inlet and for permitting fluid pressure to said chamber to cause a discharge of the liquid therefrom, means actuated by the differential of pressure between said discharge pipe and said liquid chamber for actuating said valve to exhaust said liquid chamber.

7. In a pumping system, the combination of a liquid chamber, a valved liquid inlet and a valved and normally closed discharge pipe having a valved connection with said liquid chamber, a reversing valve for exhausting pressure from said chamber to cause a rise of liquid therein, and for admitting pressure thereto to cause a discharge of liquid therefrom into said discharge pipe, means comprising a diaphragm valve operated by a differential of pressure between said discharge pipe and said liquid chamber to admit accumulated pressure from said liquid chamber to actuate said reversing valve.

8. In a pumping system, a valve, means for permitting fluid pressure to actuate said valve to admit such pressure to the pumping mechanism, and differential pressure actuated mechanism for operating said valve to exhaust said pressure from said pumping system and a valve for throttling the exhaust of said pressure from said system.

9. In a pumping system, a reversing valve comprising a valve case having inlet, discharge, and exhaust passages therein, differential piston and valve chambers connecting said several passages, a differential pis-

ton valve within said chambers, means for permitting fluid pressure to actuate said differential valve to open said inlet to said discharge passage, and simultaneously close said exhaust passage, and means for permitting an external differential of pressure to actuate said valve to close said inlet from said discharge passage and open said discharge passage to said exhaust passage, and means for throttling said exhaust passage.

10. In a pumping system, a reversing valve, gravity means for actuating said valve to admit fluid pressure to the pumping system, a differential pressure piston connected to said valve for releasing accumulated pressure upon the upper side of said piston, to cause the same to actuate said first named valve and thereby exhaust the pressure from said system, and means for retaining a portion of the pressure within said system.

11. In a pumping system, the combination of a source of fluid pressure supply, a liquid chamber having inlet and discharge valves, a reversing valve for admitting pressure from said supply to said chamber and for exhausting said pressure therefrom, means for automatically regulating the admission of fluid pressure from said supply to said reversing valve, and means for throttling the exhaust from said liquid chamber.

12. In a pumping system, the combination of a source of fluid pressure supply, a liquid chamber having inlet and discharge valves, a reversing valve for admitting pressure from said supply to said chamber and for exhausting said pressure therefrom, means for retarding the exhaust from said liquid chamber and means for utilizing the retarded exhaust pressure for retarding the actuation of said reversing valve to readmit pressure to said chamber.

13. In a pumping system, the combination of a source of fluid pressure supply, a liquid chamber having inlet and discharge valves for said chamber, a reversing valve for admitting pressure from said supply to and exhausting the same from said liquid chamber, means for retarding the exhaust from said chamber and means for utilizing said retarded exhaust to retard the readmission of pressure from said supply to said liquid chamber.

14. In a pumping system, the combination of a source of fluid pressure supply, a liquid chamber having inlet and discharge valves, a reversing valve for admitting pressure from said supply to and for exhausting said pressure therefrom, means for arresting the complete exhaust of pressure from said liquid chamber and means for utilizing said arrested exhaust pressure for retarding the actuation of said reversing valve to readmit pressure from said supply to said liquid chamber.

15. In a pumping system, a differential pressure and gravity actuated valve comprising a valve case having a pressure inlet port and an exhaust outlet port, a service pipe and a valve chamber therein, a valve in said chamber in a position to normally close the same from said inlet port, means whereby pressure may gradually fill said chamber above said valve and thereby equalize the pressure therein with that below said valve, a restricted exhaust port from said chamber above said valve, a puppet valve controlling said exhaust port and differential pressure actuated mechanism for operating said puppet valve to open said exhaust port, whereby a gradual operation of said reversing valve will close said inlet port and simultaneously open said service pipe to said exhaust port.

16. In a pumping system, a differential pressure and gravity actuated valve comprising a valve case having a pressure inlet port and an exhaust outlet port, a service pipe and a valve chamber therein, a valve in said chamber in a position to normally close the same from said inlet port, means whereby pressure may gradually fill said chamber above said valve and thereby equalize the pressure therein with that below said valve, a restricted exhaust port for said chamber above said valve, a puppet valve controlling said exhaust port and differential pressure actuated mechanism for operating said puppet valve to open said exhaust port, whereby a gradual operation of said reversing valve will close said inlet port and simultaneously open said service pipe to said exhaust port, and means for retarding the closing of said puppet valve.

17. In a pumping system, a differential pressure and gravity actuated valve comprising a valve case having a pressure inlet port and an exhaust outlet port, a service pipe and a valve chamber therein, a valve in said chamber in a position to normally close the same from said inlet port, means whereby pressure may gradually fill said chamber above said valve and thereby equalize the pressure therein with that below said valve, a restricted exhaust port for said chamber above said valve, a puppet valve controlling said exhaust port and differential pressure actuated mechanism for operating said puppet valve to open said exhaust port whereby a gradual operation of said reversing valve will close said inlet port and simultaneously open said service pipe to said exhaust port, and a throttle valve connected to said exhaust port for retaining a portion of the pressure within said service pipe.

18. In a pumping system, the combination of a source of fluid pressure supply, a liquid chamber having inlet and discharge valves,

means for admitting fluid pressure from said supply to said chamber and for exhausting said pressure therefrom, a discharge pipe connected with said discharge valve, and a compressed air chamber associated with said discharge pipe for maintaining substantially a uniform pressure upon the liquid in said discharge pipe and means for automatically replenishing the air in said chamber from said fluid pressure supply.

19. In a pumping system, the combination of a source of fluid pressure supply, a liquid chamber having inlet and discharge valves, means for admitting fluid pressure from said supply to said chamber and for exhausting said pressure therefrom, a discharge pipe connected with said discharge valve, and a compressed air chamber associated with said discharge pipe for maintaining substantially a uniform pressure upon the liquid in said discharge pipe, and means for replenishing the air in said compressed air chamber from said liquid chamber, for maintaining the pressure in said compressed air chamber against leakage therefrom.

20. In a pumping system, the combination of a liquid chamber, a valved inlet and a valved discharge pipe for said chamber, a valve for exhausting the pressure from said chamber to cause an influx of liquid thereto through said valved inlet, and for admitting fluid pressure to said chamber to cause the discharge of the liquid therefrom, a compressed air chamber connected with said discharge pipe, and means for admitting compressed air from said liquid chamber to said compressed air chamber by way of said valved discharge pipe, for maintaining the pressure in said compressed air chamber against leakage therefrom.

21. In a pumping system, the combination of a source of fluid pressure supply, a plurality of liquid chambers each having inlet and discharge valves, a plurality of reversing valves for admitting fluid pressure from said supply to said chambers, and for exhausting said pressure therefrom alternately, and means for throttling the exhaust from said liquid chambers.

22. In a pumping system, the combination of a source of fluid pressure supply, a plurality of liquid chambers each having inlet and discharge valves, a reversing valve for each of said chambers for admitting pressure from said supply to and exhausting the same from said liquid chambers alternately, and a differential pressure operated means actuated by the lowering of the liquid in said liquid chambers to admit said fluid pressure to and for alternately actuating said reversing valves respectively to exhaust the pressure from said liquid chambers.

23. In a pumping system, the combination of a source of fluid pressure supply, and a source of liquid supply, a plurality of liquid chambers, valved inlet connections between each of said liquid chambers respectively and said liquid supply, a normally closed discharge pipe leading from each of said chambers, a reversing valve for each of said liquid chambers for admitting fluid pressure from said fluid supply to said liquid chambers respectively, said reversing valves each having an exhaust passage therein leading to a common exhaust discharge, and a throttling valve in said exhaust discharge.

24. In a pumping system, the combination of a source of fluid pressure supply, a source of liquid supply, a plurality of liquid chambers, valved inlet connections from said liquid supply to said chambers respectively, a valved and normally closed discharge pipe leading from said chambers to a level higher than that of the liquid supply, reversing valves for admitting pressure from said pressure supply to said liquid chambers respectively and alternately, said valves actuated by differential pressure from said fluid pressure supply to exhaust said pressure from said liquid chambers respectively, and means for creating a differential of pressure for actuaing said reversing valves.

25. In a pumping system, the combination of a plurality of liquid chambers each having a valved inlet and a valved discharge pipe, a reversing valve for each of said liquid chambers for alternately introducing air pressure to and exhausting the same from said chambers respectively, and means for actuating said reversing valves operated by a differential of pressure between said discharge pipe and said liquid chamber.

26. In a pumping system, the combination of a plurality of liquid chambers, a valved inlet and a valved and normally closed discharge pipe for each of said chambers, a valve for exhausting the pressure from said chambers, a valve for each of said chambers for exhausting the pressure therefrom to cause an influx of liquid thereto through said valved liquid inlets and for permitting liquid pressure to said chamber to cause a discharge of liquid therefrom, and means actuated by the differential of pressure between said discharge pipe and said liquid chambers for actuating said valves to exhaust said liquid chambers alterantely.

27. In a pumping system, the combination of a plurality of liquid chambers, a valved inlet and a normally closed discharge pipe having a valved connection with and for each of said liquid chambers, a valve for each of said liquid chambers for exhausting pressure therefrom to cause a rise of liquid therein, and for admitting pressure thereto to cause a discharge of liquid therefrom into said discharge pipes, means for actuating said valve operated by a differential of pres-

sure between said discharge pipes and said liquid chambers respectively and alternately.

28. In a pumping system, a plurality of reversing valves, means for permitting fluid pressure to actuate said valves alternately to admit such pressure to the pumping mechanism, and differential pressure actuated mechanism for operating said valves alternately to exhaust said pressure from said pumping system, and means for throttling the exhaust of said pressure from said system.

29. In a pumping system, a pair of reversing valves each comprising a valve case having inlet, discharge, and exhaust passages therein respectively, differential piston and valve chambers connecting said several chambers respectively, differential piston valves within said chambers, means for permitting fluid pressure to actuate said differential valves alternately to open said inlet and discharge passages and simultaneously close said exhaust passages, and means for permitting an external differential of pressure to actuate said valves alternately to close said inlet and discharge passages and open said discharge passages to said exhaust passages alternately, and means for throttling said exhaust passages.

30. In a pumping system, a pair of reversing valves, spring and gravity actuating means for actuating said valves to admit fluid pressure to the pumping system, a differential pressure piston connected to each of said valves for releasing accumulated pressure upon the upper sides of said piston to cause the same to actuate said first named valves, and thereby exhaust said pressure from said system, interconnecting means between said valves for causing the same to operate alternately, and means for retaining a portion of the exhaust pressure within said system.

31. In a pumping system, the combination of a source of fluid pressure supply, a pair of liquid chambers each having inlet and discharging valves, a reversing valve for each of said liquid chambers for admitting pressure from said supply to the corresponding liquid chamber and for exhausting said pressure therefrom, means connecting said reversing valves for causing the same to operate alternately, and means for regulating the admission of fluid pressure from said supply to said reversing valves, and means for throttling the exhaust from said liquid chambers respectively to assist in alternately actuating said valves.

32. In a pumping system, the combination of a source of fluid pressure supply, a pair of liquid chambers each having inlet and discharge valves, a reversing valve for each of said chambers for admitting pressure from said supply thereto, and for exhausting said pressure therefrom, means for retarding the exhaust from said liquid chambers respectively, and means for utilizing the retarded exhaust pressure for retarding the actuation of said reversing valves to readmit pressure to said liquid chambers respectively, and means for causing said reversing valves to operate alternately.

33. In a pumping system, the combination of a source of fluid pressure supply, a pair of liquid chambers having inlet and discharge valves, a reversing valve for each of said chambers for admitting pressure from said supply to and exhausting the same from said liquid chambers, interconnected means for causing the operation of said valves alternately, means for retarding the exhaust for each of said chambers respectively, and means for utilizing said retarded exhaust to retard the readmission of pressure from said supply to said liquid chambers respectively.

34. In a pumping system, the combination of a source of fluid pressure supply, a pair of liquid chambers each having inlet and discharge valves, a reversing valve for each of said liquid chambers for admitting pressure from said supply to and for exhausting said pressure therefrom alternately, means for arresting the complete exhaust of pressure from said liquid chambers respectively, means for utilizing said arrested exhaust pressure for retarding the actuation of said reversing valve to readmit pressure from said supply to said liquid chamber, and means connecting said reversing valves for causing the same to operate alternately.

35. In a pumping system, a pair of differential pressure and gravity actuated valves each comprising a valve case, having a pressure inlet port and an exhaust outlet port, a service pipe and a valve chamber therein, a valve in each of said chambers in position to normally close the same from said inlet port respectively, means whereby pressure may gradually fill said chamber above said valve, and thereby equalize the pressure therein with that below said valve, a restricted exhaust port from each of said chambers above said valve, a puppet valve controlling each of said exhaust ports, differential actuated pressure for operating said puppet valves to open said exhaust ports, whereby a gradual operation of said reversing valves will close said inlet ports and simultaneously open said service pipe to said exhaust outlet port, and means connecting said valves for causing the same to operate alternately.

36. In a pumping system, the combination of a pair of differential pressure and gravity actuated valves each comprising a valve case having a pressure inlet port, an exhaust outlet port, and a valve chamber therein, a service pipe connected to each of said valve cases, a valve for each of said chambers in a position to normally close the same from

said inlet ports respectively, means whereby pressure may gradually fill said chambers above said valves, and thereby equalize the pressure therein with that below said valves, a restricted exhaust port for each of said chambers above said valve, puppet valves controlling each of said exhaust ports, a differential pressure actuated mechanism for operating said puppet valves to open said exhaust port, a connection between each of said puppet valves to cause the same to operate alternately, whereby a gradual operation of one reversing valve will lose its inlet port, open its service pipe to its exhaust port, and simultaneously operate the other reversing valve to open its inlet port and close its service pipe from its exhaust port, and means for retarding the alternate closing of said puppet valves.

37. In a pumping system, the combination of a pair of differential pressure and gravity actuated valves each comprising a valve case having a pressure inlet port and an exhaust outlet port, a valve chamber therein, and a service pipe connected thereto, a valve in said chamber in position to normally close the same from said inlet port, means whereby pressure may gradually fill said chamber above said valve and thereby equalize the pressure therein with that below said valve, a restricted exhaust port for said chamber above said valve, a puppet valve controlling said exhaust port, and differential pressure actuated mechanism for operating said puppet valve to open said exhaust port whereby a gradual operation of said reversing valve will close said inlet port and simultaneously open said service pipe to said exhaust port, means connecting said reversing valves for causing the same to operate alternately, a common exhaust pipe connected to each of the exhaust ports of said reversing valves, and a throttle valve connected to said exhaust pipe for retaining a portion of the pressure within said service pipe.

38. In a pumping system, the combination of a source of fluid pressure supply, a pair of liquid chambers each having inlet and discharge valves, means for alternately admitting fluid pressure from said supply to each of said chambers and for alternately exhausting said pressure therefrom, a common discharge pipe connected with each of said discharge valves, a compressed air chamber associated with said discharge pipe, means for maintaining substantially a uniform pressure upon the liquid within said discharge pipe, and for automatically replenishing said pressure from said liquid chamber.

39. In a pumping system, the combination of a source of fluid pressure supply, a pair of liquid chambers each having inlet and discharge valves, means for admitting fluid pressure from said supply to each of said chambers alternately, and for exhausting said pressure from said chambers alternately, a common discharge pipe connected to said liquid chambers, a compressed air chamber associated with said discharge pipe for maintaining substantially a uniform pressure upon the liquid in said discharge pipe, and means for automatically replenishing the air in said compressed air chamber from said liquid chamber, for maintaining the pressure in said liquid chamber against leakage.

40. In a pumping system, the combination of a pair of liquid chambers, a valved inlet and valved discharge pipe for each of said chambers, a valve for exhausting the pressure from each of said chambers to cause an influx of liquid thereto from the corresponding valve inlet, and for admitting fluid pressure to each of said chambers to cause the discharge of liquid therefrom, a compressed air chamber connected with one of said discharge pipes, and means for admitting compressed air from one of said liquid chambers to said compressed air chamber by way of the corresponding valved discharge pipe for maintaining the pressure in said compressed air chamber against leakage therefrom.

41. In a pumping system, the combination of an air chamber, a liquid chamber communicating with said air chamber, an air pressure supply, and a liquid discharge pipe leading from said air chamber, means for admitting air pressure from said supply to said liquid chamber to force the liquid therefrom into said air chamber to compress the air therein, and automatic means for replenishing the air in said air chamber from said supply by way of said liquid chamber.

42. In a pumping system, the combination of an air chamber, a liquid chamber communicating with said air chamber, an air pressure supply, and a liquid discharge pipe leading from said air chamber, means for admitting air from said air pressure supply to force liquid therefrom into said air chamber, a by-pass leading from said liquid chamber to said air chamber for replenishing air therein.

43. In a pumping system, the combination of an air pressure supply, a liquid chamber, an air chamber in communication with said liquid chamber, a discharge pipe leading from said air chamber, means for supplying air from said pressure supply to said air chamber, by way of said liquid chamber, and means for discharging a surplus of air therefrom through said discharge pipe.

44. In a pumping system, the combination of an air chamber, a liquid chamber communicating with said air chamber, an air pressure supply, and a liquid\discharge pipe leading from said air chamber to said liquid chamber, to force liquid therefrom into said

air chamber, a by-pass leading from said air chamber into said discharge pipe, said by-pass being located below the normal liquid level in said air chamber, whereby a surplus of air in said air chamber may be discharged from said discharge pipe when the liquid level shall fall below said by-pass.

45. In a pumping system, the combination of an air pressure supply, a liquid chamber, an air chamber in communication with said liquid chamber, a discharge pipe leading from said air chamber, means for supplying air from said pressure supply to said air chamber, by way of said liquid chamber to replenish the air in said air chamber, and a by-pass leading from said air chamber into said discharge pipe below the normal liquid level, whereby a surplus of air pressure in said air chamber may be discharged through said discharge pipe.

46. In a pumping system, the combination of an air pressure supply, a liquid chamber, a pipe leading from said air supply to said liquid chamber, a reversing valve in said pipe for alternately admitting pressure from said air supply to said liquid chamber and for exhausting said pressure therefrom, a supplemental pipe leading from said liquid chamber to said reversing valve, a diaphragm valve in said pipe, an auxiliary pipe leading from said diaphragm valve to the discharge pipe, an overflow pipe leading from said diaphragm valve in communication with said supplemental pipe, and a trap in said overflow pipe for retarding the overflow therethrough.

47. In a pumping system, an overflow trap comprising an overflow pipe leading from said pumping system, a closed chamber communicating with said pipe, and a discharge pipe leading from said chamber, said discharge pipe extending into said chamber to a point near its upper end, and having a reverse or siphon bend therein, said siphon bend having a minute vent at its uppermost point for preventing the siphoning of the liquid accumulated in said chamber below the point of said bend.

48. In a pumping system, the combination of a source of fluid pressure supply, a liquid chamber having inlet and discharge valves, a regulating valve for admitting pressure from said supply to said chamber, said regulating valve being controlled through differential air pressure between water in the discharge line and the fluid pressure supply.

49. In a pumping system, the combination of a source of fluid pressure supply, a liquid chamber having inlet and discharge valves, a regulating valve for admitting pressure from said supply to said chamber and means for exhausting said pressure therefrom; said regulating valve being controlled through differential air pressure between water in the discharge line and the fluid pressure supply.

In testimony whereof I have hereunto set my hand this 26th day of February, 1912.

FREDERICK C. WEBER.

Witnesses:

LOUIS M. SANDERS,

R. K. BLANCHARD.