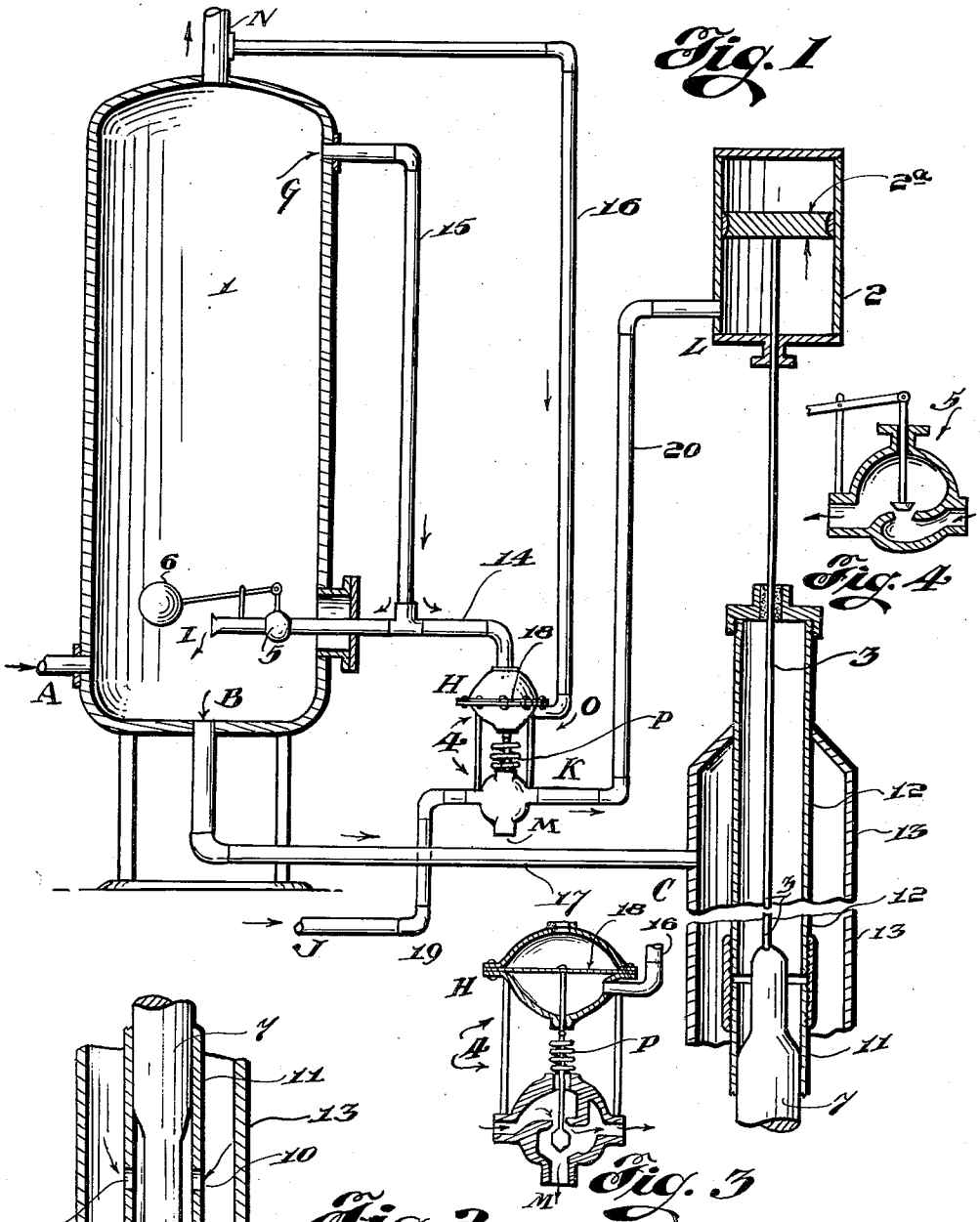
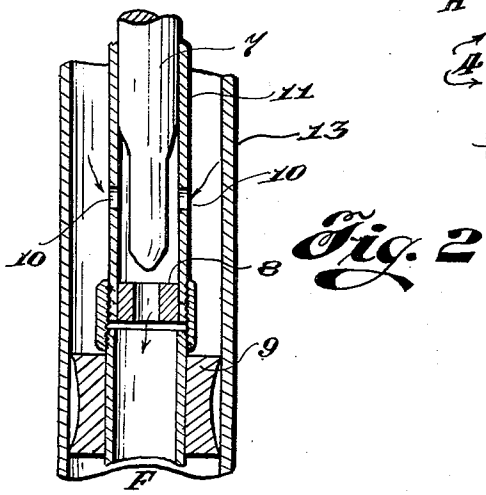
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FLOW REGULATION APPARATUS FOR BRINE INJECTION WELLS

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Ransome W. Erwin
INVENTOR.

BY John M. Spellman
ATTORNEY

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FLOW REGULATION APPARATUS FOR BRINE INJECTION WELLS

Ransome W. Erwin, Tyler, Tex., assignor to Salt Water Control, Inc., Fort Worth, Tex.

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The invention relates to improvements in method and apparatus employed in the regulation of the flow of water or brine to a disposal well in a system of the general type disclosed in my prior Patents Nos. 2,261,057 and 2,261,100, dated October 28, 1941. It will be understood that preferably liquid to be introduced into the disposal well will have been previously treated for the removal of oil and insoluble mineral foreign matter, such as calcium, magnesium and iron compounds, by any suitable means such as disclosed, for example, in my Patents Nos. 2,261,057 and 2,261,101.

In common with the disclosure of my Patents Nos. 2,261,057 and 2,261,100 the present system of brine disposal preferably includes the steps of introducing the liquid into the upper portion of a disposal well having a porous formation at the bottom thereof, preferably from an external source whose level is maintained above the level of the well, and controlling the flow of liquid through the well to said porous formation from a point in the well located substantially below the point of introduction of the liquid, in accordance with variations in the liquid level of said source, in order to maintain a substantially continuous column of liquid from said formation to said source so as to avoid cascading and vacuum formation. Control of the liquid is preferably effected by means of a weighted reciprocable valve automatically actuated in accordance with predetermined variations in the liquid level within a surge tank located outside of the well, so as to periodically cover or uncover an opening in a valve seat located within the well, preferably at a point below the normal static water level, the covering or uncovering of the said opening serving to alternately cut off or permit the flow of liquid from said source into the well, according to the position of the valve.

The primary object of the present invention is accordingly to provide a smooth and workable means and method for keeping brine injection wells full of water at all times, thereby avoiding cascading, vacuum formation and gas lock in casing or sand.

A specific object of the invention is to provide an apparatus with an improved valve arrangement in which the valve is open when the level of a receiving surge tank approaches the top of the tank and to insure closing of the valve when the level falls to a predetermined point, preferably by means of a float valve control located near the bottom of the surge tank.

The apparatus employed in the present system is simple and comparatively inexpensive, many of the parts being preferably of standard equipment useful for other purposes. This apparatus preferably includes a combination weight-bar-cylinder-plunger having reduced end portions and an enlarged polished intermediate portion which works with small tolerance in a polished section of the well tubing. This construction of the plunger has the effect of substantially reducing the undesirable tendency for the valve to jump up as it unseats, thereby kinking the wire line employed in the apparatus and causing such line to break after a few operations. This undesirable feature is entirely eliminated by the use of the improved form of plunger in conjunction with a gas lift piston which serves to cushion the upward movement of the plunger, and to prevent shock or jar at the end of such movement. Another important feature of the invention is the use of a single seat for the valve instead of the double seated arrangement sometimes employed. The single seated arrangement insures a complete fluid tight connection at all times when the valve is in closed position.

Other objects and advantages of the invention will be apparent from a consideration of the following detailed description taken in conjunction with the accompanying drawing, which is intended as illustrative only.

In the drawing:

Fig. 1 is a vertical sectional view partly broken away of an apparatus embodying the invention comprising a surge tank, well casing, tubing and coacting parts,

Figure 2 is a continuation of Figure 1 in reference to the well casing, tubing and related parts; and

Figures 3 and 4 are sectional detail views, respectively, of two valves used in the operation of the apparatus.

Referring to the drawing in detail reference numeral 1 denotes a surge tank or receiving chamber into which water or brine for injection into a well is introduced at A from any suitable source, the water having preferably been previously treated for the removal of oil and other impurities.

The water or brine accumulates in the surge tank until the tank is nearly full, or until it reaches the point G, at which level it overflows through a pipe 15 and provides an hydraulic head at the point H upon a diaphragm 18 which actuates a normally closed spring-pressed control valve 4. This hydraulic head is sufficient to open

the valve against the pressure of its spring P, thereby allowing pressure fluid from a source J to flow through the valve from a pipe 19 to the outlet K and thence through an upright pipe 20 to the lower portion of a cylinder 2, which it enters at point L and exerts pressure on the underside of a piston 2—*a*, working in the cylinder 2. The pressure thus applied lifts the piston in the cylinder 2.

The piston 2—*a* is connected through a wire line 3 with a combination weight-bar-cylinder-valve plunger 7 located a substantial distance below the top of the well. As shown in Figures 1 and 2, the plunger 7 is provided with reduced end portions and with an enlarged intermediate portion. This intermediate portion is preferably highly polished and works with a small tolerance in a correspondingly polished cylindrical section 11 of the well tubing 12, just above the ports 10. This close fitting plunger 7 provides a resisting piston effect as it is pulled up and unseats the orifice seat 8, thereby slowing down or braking the upward travel of the weight-bar-cylinder-valve plunger 7, thus preventing kinking and breaking of wire line 3. The lower end of the plunger is reduced in size and tapers to a point so as to tightly fit an opening in the valve seat 8 which is located within the lower portion of the section 11, preferably at a point of juncture between the said polished section and a lower section which extends downwardly as at F toward the porous formation at the bottom of the well. The plunger 7 is of substantial weight, so that when the pressure fluid is released from below the piston 2—*a* the lower end of the plunger will tightly fit the opening in the valve seat. If desired additional weighting may be secured by attaching another weighted member to the wire line 3, although ordinarily this is not necessary as the weight of the plunger itself is sufficient. The top of the cylinder 11 is preferably closed fluid tight. The improved construction of the plunger as herein described insures the smooth operation of the plunger as it is raised to uncover the opening in the valve 8 on the application of pressure fluid beneath the piston 2—*a*. The usual "jumping" reaction due to unseating a single seated valve is entirely avoided by this arrangement. It will thus be appreciated that when the piston 2—*a* is forced upwardly by pressure fluid entering at L the plunger 7 will be raised with a smooth and even movement and the opening in the valve seat 8 will be uncovered.

As shown the valve seat 8 is located in the injection well just above the packer element 9 interposed between the inner tubing 11 and the outer casing 13. The packer 9 and valve seat 8 are preferably located at a point in the well approximately at or below the normal static water level. The raising of the plunger 7 permits any liquid which has accumulated in the space between the tubing and casing above the packer 9 to flow through the valve seat to the porous formation at the bottom of the well, the liquid entering the tubing 11 through the ports 10 just above the valve seat 8. The water is forced into the porous sand by reason of the hydrostatic pressure of the water in the casing 13 and in the pipe line 17 above.

As shown, the annular space between the casing 13 and the tubing 11 and 12 is connected to the bottom of the surge tank 1 by means of the pipe 17 leading from an inlet point B at the bottom of the surge tank 1 to a discharge point C at the well casing. The pipe 17 is unobstructed and a continuous column of liquid is insured from the packing 9 back to the surge tank 1, so long as the opening in the valve seat 8 remains closed by the tip of the plunger 7, and since the packing is located at or below the static water level, the column of liquid is continuous from the porous formation at the bottom of the well to the surge tank.

When the orifice in the valve seat 8 is uncovered water from the surge tank 1 flows out from the point B and travels through pipe 17, entering the injection well casing 13 at the point C. Water moves down the annular space between the outer casing 13 and the well tubing 12 and enters the ports 10 (Fig. 2), and thence flows past the reduced lower portion of the plunger 7 through the opening in the valve seat 8 and into the bore of the injection well at the point F.

Assuming that the well is taking water faster than it is being introduced into the surge tank 1, the liquid level in the tank immediately begins to fall away from the point G and continues to lower until it reaches a predetermined level I, at which time the valve 4 will be automatically closed by the spring P, thus cutting off the supply of pressure fluid from source J to the under side of the piston 2*a*, while at the same time the exhaust port M of control valve 4 is opened, allowing the pressure fluid from beneath the piston 2*a* to escape through the port M, whereupon the weight of the plunger 7 causes it to fall, thereby closing the opening in the valve seat 8 and preventing any further liquid from draining out from the tank B. Thus a column of liquid is maintained at all times from the porous formation at the bottom of the well to the source of liquid in the tank 1, it being understood that the packer 9 and valve seat 8 are located at or above the normal static water level of the well.

During the period when the liquid level in the tank 1 is declining from the point G to the point I the hydraulic head bearing upon the upper portion of the diaphragm 18 is maintained constant by means of suitable float control mechanism located within the surge tank 1. However, as soon as the liquid level reaches the point I the hydraulic head in the pipe 15 immediately begins to fall until it fails to balance the spring P, whereupon the spring immediately closes the valve 4 as previously described.

As shown, a pipe 14 extends laterally from the point I within the surge tank 1, and communicates with the upper portion of the diaphragm 18. Pipe 15 connects with the pipe 14 intermediate its ends. The inlet to the pipe 14 from the tank 1 is controlled by means of a valve 5 actuated by a float 6, the valve being closed when the float is raised, and opened when the float falls. Thus as soon as the liquid level within the tank 1 rises above the point I the float is raised and the valve 5 is thereby closed, and remains closed during the succeeding rise in the liquid level and until the level again falls to the point I. As the liquid level reaches the point G liquid overflows through the pipe 15 as previously described, thus providing an hydraulic head which unbalances the spring P, thereby opening the valve 4, raising the piston 2*a* and uncovering the opening in the valve seat 8, whereupon the liquid from the tank 1 is discharged into the well through said opening. The liquid level in the tank begins to fall, assuming that the drainage exceeds the in flow, and the level continues to fall until it reaches the point I in the tank during which period the float valve 5 continues closed.

When the level I is reached the float 6 drops, opening the valve 5 and allowing water to drain back into the tank from the pipe 15, thereby reducing the hydraulic head upon the diaphragm 18, allowing the valve 4 to close, cutting off pressure fluid from source J to the piston 2a and allowing the accumulated fluid in the pipe 20 to drain through the outlet M, whereupon the control valve within the well is again closed and the liquid level within the tank B again begins to rise. This cycle of operations is repeated as long as liquid flows into the surge tank from pipe A.

In order to insure hydraulic control only of the motor valve 4, unaffected by gas pressure, it is necessary to equalize all gas pressures, and this is accomplished according to the present invention by applying gas pressure to the under side of the diaphragm 18 equal to the gas pressure above the column of liquid in the surge tank 1. This is accomplished by means of a branch pipe 16 leading from a point N in a gas pressure pipe communicating with the top of the tank 1, the other end of the pipe 16 communicating with the lower portion of the diaphragm 18. Thus the same gas pressure is applied above and below the diaphragm 18, these pressures balancing each other and leaving only the hydraulic pressure applied through the column 15 as the effective force applied to the upper portion of the diaphragm 18.

By the above arrangement there is provided a comparatively simple construction for accomplishing the desired results. The three-port diaphragm motor valve 4 is economical in construction and eliminates the necessity for a plurality of motor valves normally employed, thus reducing the cost of the parts by one-half. Another desirable feature is the overflow float valve assembly to provide an hydraulic head to the diaphragm 18, thereby eliminating the necessity of an additional float and valve. Also, and very important, is the fact that prompt action or application of pressure and a prompt release of pressure are obtained by this arrangement, both of which features are vitally necessary for the proper functioning of the three-port motor valve. It has been demonstrated by experiment that if pressure is allowed to build up gradually on the diaphragm 18 as the level rises in the surge tank the valve 4 only partly opens and tends to stick in the neutral zone, leaving both the gas inlet J and exhaust opening M both partially functioning, which renders the operation of the system unsatisfactory.

While the disclosure presents a practical working embodiment of an apparatus designed to carry out the advantages and features herein shown and described, it is evident that the invention may be modified to some extent, such as would be within the scope and meaning of the claims appended hereto.

What is claimed is:

1. In a liquid disposal system for oil fields, including a disposal well, a well casing and well tubing within the casing, a valve seat within said tubing and having a valve opening therethrough, and a reciprocable valve for coacting with the opening in said valve seat, comprising a weighted plunger having an enlarged portion snugly fitting the tubing and a reduced end portion adapted to close the opening in said valve seat when the plunger is lowered, and means including a flexible cable for raising the plunger.

2. A liquid disposal system as set forth in claim 1 wherein the enlarged portion of the plunger is smoothly polished and co-acts with a similarly polished section of the well tubing, thereby producing a braking effect on the upward travel of the plunger as the valve orifice is uncovered by same.

3. Apparatus for use in a brine disposal well comprising a well tubing having a valve seat therein and provided with a central valve opening, said tubing including an interiorly polished portion extending a substantial distance above said seat, and a weighted valve reciprocable within said polished section comprising a plunger having an enlarged polished portion snugly fitting the cylinder, and having a reduced end portion adapted to close said opening when the plunger is in lowered position, and means including a flexible cable attached to the upper portion of said plunger for raising said valve.

4. Apparatus for use in a brine disposal well comprising a well tubing having a valve seat therein below the normal static water level and provided with a central valve opening, said tubing including an interiorly polished portion extending a substantial distance above said seat, and a weighted valve reciprocable within said polished section comprising a plunger having an enlarged polished portion snugly fitting the cylinder, and having a reduced end portion adapted to close said opening when the plunger is in lowered position, a gas actuated piston located directly above the plunger, and a flexible cable connecting the plunger to the piston.

5. In a device of the character described, vertically disposed tubing, a valve seat within said tubing having a central opening therethrough, a weighted valve coacting with said seat comprising an elongated plunger having a reduced end portion adapted to close said opening, and an enlarged elongated portion above the reduced portion snugly fitting said tubing, and means for raising the valve to uncover said opening comprising a closed cylinder located above said tubing in axial alignment therewith, a piston slidable in said cylinder, a flexible cable connecting said piston and said plunger, and means for supplying fluid pressure beneath said piston to raise the same, thereby lifting the plunger and uncovering the valve seat, said plunger and said tubing having coacting polished surfaces whereby friction is reduced.

6. In an apparatus of the class described the combination with a well casing and tubing; of a cylinder connected to the tubing and having a polished plunger reciprocally mounted to slide in the cylinder, a valve seat below the plunger having an opening providing a passageway to a well bore, a cylinder having a piston mounted therein, a wire line connecting the piston to the plunger, said cylinder in which the plunger moves being interiorly polished, the plunger and piston being movable under pressure to open and close said valve seat opening.

7. In an oil well, in combination with vertical tubing having a portion of uniform bore, a valve seat within said portion having a central valve opening, valve means for controlling the flow of fluid through said opening comprising a weighted plunger having an enlarged portion snugly fitting the tubing, and having a reduced end portion adapted to close the opening when the plunger is lowered, and means including a flexible cable attached to the upper portion of the plunger for raising the plunger to open the valve, the enlarged portion of the plunger engaging the wall of the tubing with an amount of friction sufficient to exert a braking action as the plunger is

raised, but not sufficient to prevent the plunger from falling by its own weight when lifting pressure is released.

8. In an oil well, in combination with vertical tubing having a portion of uniform bore, a valve seat within said portion having a central valve opening, and valve means for opening or closing said opening to control the flow of fluid therethrough, comprising an elongated weighted plunger having a reduced end portion adapted to close the opening when the plunger is lowered and having a body portion fitting said tubing with sufficient friction to exert a braking action as the plunger is raised but not sufficient to prevent the plunger from descending by gravity when no outside force is being exerted thereon, and means including a flexible cable attached to the upper portion of the plunger for raising the same to open the valve.

9. In an oil well, in combination with vertical tubing having a portion of uniform bore, a valve seat within said portion having a central valve opening, and valve means for opening or closing said opening to control the flow of fluid therethrough, comprising an elongated weighted plunger having a reduced end portion adapted to close the opening when the plunger is lowered and having a body portion fitting said tubing with sufficient friction to exert a braking action as the plunger is raised but not sufficient to prevent the plunger from descending by gravity when no outside force is being exerted thereon, and lifting means for said plunger including a flexible cable secured to the upper end thereof.

10. A device of the character described comprising an upright tubing having a valve seat therein, a weighted plunger adapted to reciprocate in said tubing, including a reduced end portion adapted to fit said valve seat to close the same, and having an enlarged body portion frictionally engaging the wall of the tubing to thereby exert a braking effect on the travel of the plunger, and means including a flexible cable attached to the upper portion of the plunger for raising the plunger.

11. A device as set forth in claim 10, wherein the enlarged portion of the plunger is smoothly polished and coacts with a similarly polished portion of the tubing.

12. Apparatus for use in a brine disposal well comprising a well tubing having a valve seat therein and provided with a central valve opening, said tubing including an interiorly polished portion extending a substantial distance above said seat, and a weighted valve reciprocable within said polished section comprising a plunger having an enlarged polished portion snugly fitting the cylinder, and having an end portion adapted to close said opening when the plunger is in lowered position, a fluid actuated piston located above the plunger, and a flexible cable connecting the plunger to the piston.

13. In an apparatus of the character described, a vertically disposed tubing having a valve seat therein and provided with a central valve opening, said tubing including an interiorly polished portion extending a substantial distance above said seat, and a weighted valve reciprocable within said polished section comprising a plunger having an enlarged polished portion snugly fitting the cylinder, and having a reduced end portion adapted to close said opening when the plunger is in lowered position, a fluid actuated piston located directly above the plunger, and a flexible cable connecting the plunger to the piston.

RANSOME W. ERWIN.