

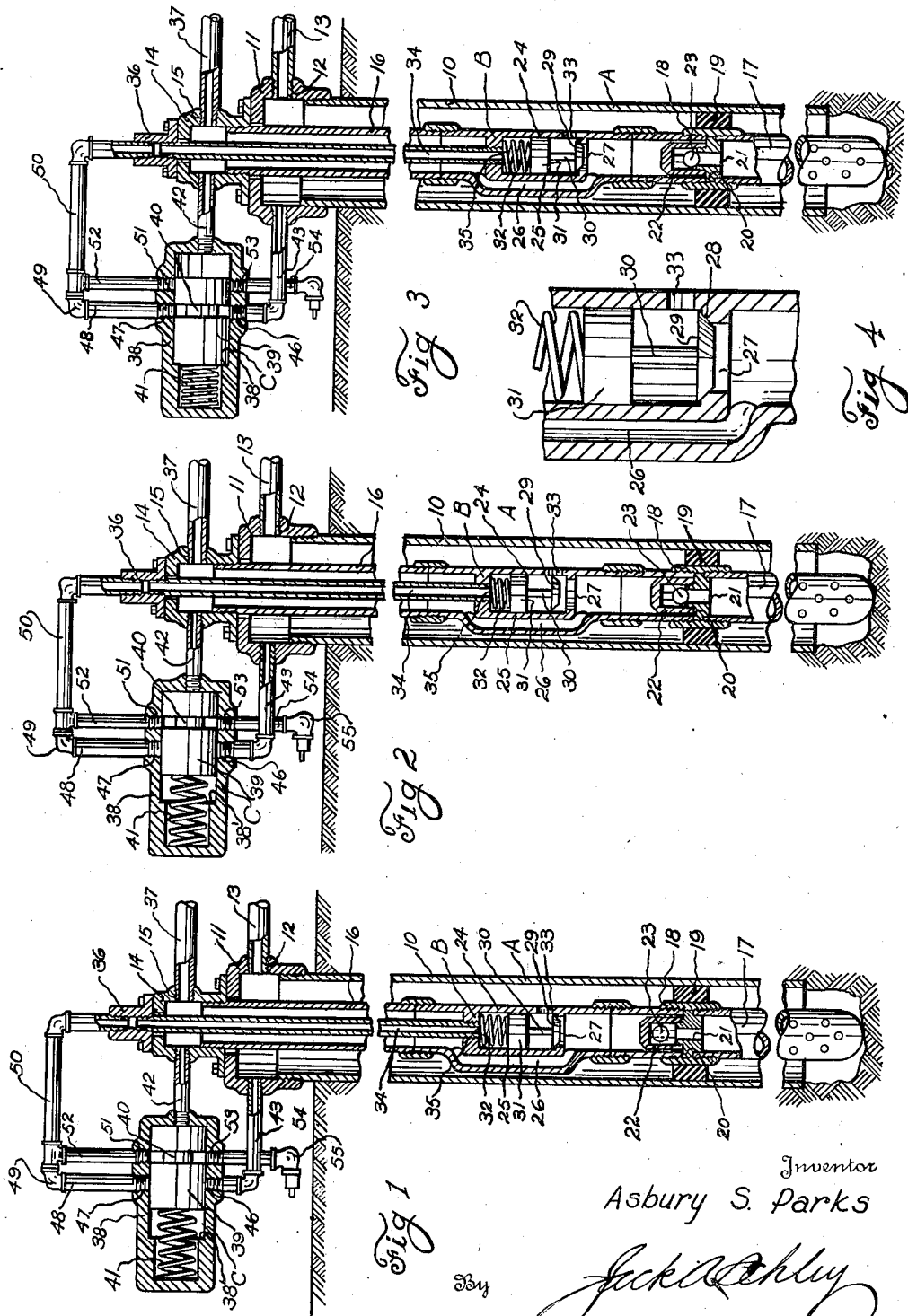
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A. S. PARKS

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FLOW APPARATUS

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Inventor
Asbury S. Parks

Jack A. Ehly
Attorney

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FLOW APPARATUS

Asbury S. Parks, Houston, Tex.

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This invention relates to new and useful improvements in flow apparatus.

One object of the invention is to provide an improved flow apparatus for wells, which will efficiently control the admission of an auxiliary lifting fluid into the well liquid column to lift said liquid to the surface, said apparatus being particularly adapted for use as an "intermitter," whereby the lifting fluid is intermittently admitted as and when needed in accordance with the height of the fluid column.

An important object of the invention is to provide an improved well flow apparatus having a control valve, actuated by the pressure differential thereacross, for admitting a lifting fluid to the lower end of a well liquid column, together with means at the surface for accurately controlling the pressure differential required to open and close said valve, whereby a surface control of the gas-admitting valve is had and said valve can be readily regulated to operate under the various well conditions which may be encountered.

Another object of the invention is to provide an improved flow apparatus, wherein a single valve member, which has one side exposed to the well liquid pressure, is employed for controlling the admission of a lifting fluid into the well liquid column, the opposite side of said piston being exposed to a predetermined fluid pressure which is controllable from the surface, whereby the valve is actuated by the differential in pressure between the well liquid pressure and the controlled fluid pressure, the arrangement permitting the apparatus to be adjusted so that the valve will automatically open when the well liquid column reaches a predetermined height in the well bore.

A particular object of the invention is to provide an improved apparatus, of the character described, having a valve for controlling the admission of gas to the liquid column, which valve has one side exposed to the liquid pressure and its opposite side exposed to a controllable fluid pressure when in a closed position, whereby the valve is opened when a predetermined pressure differential thereacross occurs; the apparatus also including automatically operable means for equalizing the pressures across the valve when the well liquid has been raised to the surface, whereby said valve may automatically close to shut off the admission of lifting fluid after such lifting of the well liquid.

Still another object of the invention is to provide an improved apparatus, of the character de-

scribed, having a gas-admitting valve member arranged to be disposed in the lower end of the well bore for controlling the admittance of the fluid to the liquid column, together with a piston operated valve element at the surface for controlling the actuation of the gas-admitting valve member; the surface valve element being automatically operable, whereby lifting fluid is admitted to the liquid column to raise the same when said column builds up to a predetermined height, and said lifting fluid is shut off after the liquid has been lifted to the surface to permit additional well liquid to enter and rise upwardly in the well bore.

A further object of the invention is to provide an improved apparatus, of the character described, which is simple in construction and which includes a minimum number of working parts, whereby manufacturing and operating costs are minimized; the surface control equipment being small and compact and being readily attached to the "Christmas tree" hook-up, whereby its mounting is facilitated.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, in which an example of the invention is shown, and wherein:

Figure 1 is a transverse, vertical, sectional view of a flow apparatus, constructed in accordance with the invention, and showing the gas-admitting valve in its closed position prior to the admission of the lifting gas.

Figure 2 is a similar view with the valve in an open position.

Figure 3 is a similar view, showing the valve in a balanced condition immediately after the well liquid has been lifted to the surface, and

Figure 4 is an enlarged transverse, sectional view of the gas-admitting valve.

In the drawing, the numeral 10 designates a well casing which extends downwardly through the well bore A in the usual manner. The upper end of the well casing projects above the surface of the ground and is externally screw-threaded whereby a suitable casing head 11 may be mounted thereon. The casing head is provided with an inlet port 12 which extends radially through the side wall thereof and an inlet pipe 13 is connected within this port. A lifting fluid, such as gas or air, may be introduced through the pipe 13 and will enter the upper end of the

well casing so as to flow downwardly there-through. A tubing support or head 14 is provided with an annular flange at its lower end and this flange is bolted, or otherwise secured, to the casing head 11. The tubing support is provided with an axial bore 15 which has its lower end threaded, whereby the upper end of the tubing string 16 may be threaded thereinto. Manifestly, the tubing is suspended from the support 14 and extends axially through the well casing 10.

The lower end of the well tubing 16 has the usual well screen or perforated section of pipe 17 connected thereto by means of a coupling collar 18 and this well screen is located in the lower end of the bore A. For packing off the annular space between the tubing string and the well casing 10, a suitable packer 19, which is shown schematically, is provided. This packer may be of any construction such as the packers which may be purchased on the open market and is preferably set immediately above the well screen 17. When the packer is in its set position, the lifting fluid which is introduced through the pipe 13 may pass downwardly through the casing but cannot pass to the lower end of the well bore A; similarly the well liquid from the lower end of the bore must flow into the tubing through the perforated section of pipe or screen 17.

A standing valve is mounted in the lower end of the tubing string 16 and includes the usual seat 20 having an axial bore 21 extending there-through. A valve cage 22 is secured to the seat 20 and has a ball valve 23 confined therein. When the ball 23 is in its seated position, a flow downwardly from the tubing string is prevented. Since the ball 23 is moved to a seated position by gravity, it is evident that the well liquid which is entering the well screen and flowing upwardly serves to unseat said ball and permit entrance into the lower end of the tubing string.

A control valve assembly B for controlling the admittance of the lifting fluid from the well casing into the well tubing is connected in the tubing string 16 above the standing valve and packer 19. This assembly includes an elongate sleeve 24 which has its extremities externally screw-threaded, whereby it may be readily coupled in the tubing string. The diameter of the sleeve is substantially that of the tubing, as is clearly shown in the drawing. A cylinder 25, which is preferably made integral with the sleeve 24, is disposed intermediate the ends of said sleeve and, for by-passing fluid around the cylinder, a vertical by-pass passage 26 is formed at one side of said sleeve. This passage communicates with the tubing below the cylinder 25 and also with the tubing above said cylinder, whereby an upward flow of the well liquid past the cylinder may occur.

The bottom of the cylinder is provided with an opening 27 and the wall of this opening is bevelled at its upper end, as indicated at 28 in Figure 4, whereby a valve seat is formed. A valve disk 29 is arranged to engage the seat 28 to close the opening 27 and said disk is provided with an axial stem 30 which has its upper end secured to a piston 31 which is movable vertically within the cylinder 25. It is pointed out that the upper surface of the valve disk 29 is substantially the same as the diameter of the piston 31, whereby a balanced valve effect is produced. The valve is normally held on its seat by a coiled spring 32 which is confined between the top of the piston 31 and the underside of the top of the cylinder 25, said

spring exerting its pressure to constantly urge the piston and valve disk to their lowermost positions. The interior of the cylinder 25 communicates with the casing through an inlet port 33 which is formed in the wall of the cylinder.

With the above arrangement, it will be obvious that the pressure of the lifting fluid within the casing 10 may enter the interior of the cylinder 25 between the piston 31 and the valve disk 29. Since the exposed surfaces of the piston and disks are substantially the same, it is manifest that the pressure of the lifting fluid will not affect the position of said disk and piston, such position being shown in Figure 1. At this time, the valve and piston are urged to a lowered position by the spring 32. For aiding the spring 32 in holding the valve disk seated until a predetermined amount of liquid enters the tubing string, as will be hereinafter explained, a pressure fluid is conducted to the upper end of the cylinder 25 through a vertically extending tube or conductor 34. This conductor has its lower end threaded into an opening 35 formed in the top of the cylinder and said conductor extends axially through the well tubing 16. The upper end of the conductor is suspended from a supporting collar or nipple 36, which is bolted or otherwise secured to the tubing support 14. It is preferable to thread the upper end of the tube or conductor 34 into the lower end of the bore of the nipple 36. Obviously, the pressure of the fluid within the conductor 34 will act downwardly on the piston 31 and will aid the spring 32 in holding the valve in its seated position.

The well liquid which flows into the tubing from the lower end of the well bore acts against the underside of the valve disk 29 which is exposed thereto through the opening 27. When the liquid column in the tubing string rises to a point in the tubing which raises the pressure of the well liquid a sufficient amount to overcome the pressure acting downwardly on the piston 31 through the conductor, plus the pressure of the spring 32, then the valve disk 29 is lifted from its seat 28. As soon as this occurs, the lifting fluid within the well casing 10 flows through the opening 27 and into the tubing. This lifting fluid flows upwardly through the by-pass 26 and serves to lift the column of liquid to the surface. The raised liquid escapes from the casing head through an outlet opening 37, provided for the purpose.

When the valve disk and piston move to their raised position, as shown in Figure 2, the pressure of the lifting gas is acting against the underside of the disk, whereby said disk is held in its raised position. Such position of the valve disk remains until the pressure across said valve is equalized, at which time the coiled spring 32 will again seat the valve to cut off the admission of the lifting fluid.

For controlling the pressure of the fluid within the conductor 34 so as to control the point at which the valve disk 29 is unseated, and also for automatically balancing the pressures across the valve and piston when the well liquids have been lifted to the surface, a control valve C is provided at the surface of the well. This valve includes a cylinder 38 having a piston valve 39 slidable therein. The valve is formed with an annular groove 40 and a coiled spring 41 is confined between one end of the valve and the end wall of the cylinder. This spring exerts its pressure to constantly urge the piston to one end of the cylinder, such end being to the right in Fig-

ure 1. The spring 41 is of a predetermined tension, as will be explained, and may be readily changed to take care of different conditions. If desired, an adjusting screw, which could extend through the end wall of the cylinder 33, could be secured to said spring 41, whereby an adjustment for varying the tension of said spring would be had.

The end of the piston 33 opposite that in which the spring 41 is disposed is directly connected to the bore of the tubing support 14 by a pipe 42, whereby this end of the cylinder communicates with the interior of the tubing string 16. An angular pipe 43 has one end secured within a port 44 provided in the casing head 11, while the other end of said pipe is fastened in a radial opening 46 formed in the wall of the cylinder 33 and this pipe is arranged to establish communication between the interior of the casing 10 and the interior of said cylinder. Diametrically opposite the opening 46 in the cylinder 33 is an opening 47 which has the lower end of an upright pipe 48 secured thereto. This pipe is connected by an elbow 49 with an angular pipe 50 which is threaded into the top of the supporting collar or nipple 36, whereby the interior of the cylinder 33 communicates with the interior of the conductor 34. An opening 51 is provided in the wall of the cylinder 33 adjacent the opening 47 and an upright pipe 52 connects the lateral or angular pipe 50 with this opening. Diametrically opposite the opening 51 is another opening or port 53, which opening is formed in the wall of the cylinder 33 adjacent the opening 46. An outlet pipe 54 leads from the opening 53 and has a suitable pop valve 55 connected thereto. This valve may be set for any desired pressure and when the pressure in the line 54 exceeds that amount, such excessive pressure is released. The valve 55 is of standard construction and may be purchased on the open market.

When the piston 33 within the cylinder 33 is in the position shown in Figure 1, it has moved to the right within said cylinder and, at such time, the annular groove 40 in said piston is aligned with the openings 51 and 53, whereby a communication is established between the pipe 54 and pipe 52. Therefore, at this time, the pressure within the conductor 34 flows into the angular pipe 50, then through the pipe 52 and into the pipe 54. Since the pop valve 55 is connected in the line 54, it is manifest that the adjustment of this valve will maintain the pressure within the conductor 34 at a predetermined point, as controlled by the adjustment of said valve.

As will be explained, the piston is arranged to be moved to the left in Figure 1, so as to abut an internal shoulder 38' which is formed in the bore of said cylinder. In this position, as shown in Figure 3, the annular groove 40 in the piston 33 is aligned or registered with the openings 46 and 47 provided in the cylinder wall. In such position, communication is established between the interior of the casing 10 and the interior of the conductor 34, such communication being through the pipes 43, 48 and 50. Manifestly, when the piston is in this position (Figure 3), the pressure within the casing 10 and the pressure within the conductor 34 is equalized, whereby the pressures on opposite sides of the piston 31 and valve disk 29 are also equalized. When this occurs, the coiled spring 32 will move the

piston and disk into engagement with the valve seat 28.

In the operation of the apparatus, a predetermined pressure fluid is introduced into the conductor 34 in any suitable manner. This pressure may be built up by introducing the gas or air which is used for lifting purposes. At this time, the control piston 39 is in the position shown in Figure 1, whereby a communication between the interior of the conductor 34 and the line 54, wherein the valve 55 is connected, is had. The valve 55, as explained, will maintain the pressure within the conductor 34 at a predetermined point. The pressure within the conductor 34 is acting downwardly on the piston 31 within the valve device B, whereby the valve disk 29 is in its seated position. The lifting fluid, which is within the well casing 10, enters the interior of the cylinder 25 through the ports 33 and is acting on the underside of the piston 31 and on the upper side of the valve disk 29. Since the exposed areas of these two elements are the same, it is manifest that a balanced condition is present, whereby the valve disk is held in its seated position by the action of the pressure within the conductor 34, and the pressure of the spring 32.

The well liquids from the bore enter the well screen 17 and flow upwardly into the tubing 16, said liquids unseating the ball check or standing valve 23. As the well liquids rise upwardly in the tubing, they flow through the by-pass passage 26 and into the tubing above the valve assembly B. The pressure of the well liquids is, of course, acting against the underside of the valve disk 27 and tending to urge the same upwardly. When the column of liquid within the tubing rises to a predetermined point to build up the pressure sufficiently to overcome the pressure within the conductor 34, plus the pressure of the spring 32, the valve disk 29 is moved upwardly or unseated. When this occurs, the lifting fluid within the casing flows through the port 33 and then through the opening 27 and into the tubing below the fluid column. At this time, the pressure of the lifting gas is acting against the underside of the valve disk and holds the same in its wide open position, as shown in Figure 2.

As the lifting gas rises upwardly through the by-pass 26, it lifts the liquid thereabove to the surface of the well, where said liquid is forced outwardly through the outlet 37 in the tubing support 14. The admittance of the lifting gas to the tubing will immediately close the ball check 23, whereby said gas cannot escape downwardly to the formation.

After the liquid is lifted to the surface, the pressure within the well tubing 16 and that within the well casing 10 is equalized because the lifting fluid is present in each. As the pressure in the upper end of the tubing 16 is built up by the lifting fluid rising therein, this pressure is exerted through the pipe 42 against the end of the control piston 39. When this pressure builds up to a predetermined point sufficient to overcome the pressure of the spring 41, the piston 39 is moved to the position shown in Figure 3. When this occurs, communication is established between the ports 46 and 47, whereby communication between the interior of the casing 10 and the interior of the conductor 34 is established. This equalizes the pressure in the casing 10 and in the conductor 34, whereby the pressures acting on opposite sides of the piston 31 and valve disk 29 are equal-

ized. Such equalization of pressures across the valve permits the spring 32 to close the valve by moving the disk 29 onto its seat 27, as shown in Figure 3. As the tubing pressure drops by the escape of the lifting fluid through the outlet 37, the spring 41 in the control valve cylinder C returns the piston 39 to its original position, as shown in Figure 1, whereby the interior of the conductor 34 again communicates with the line 54, which line has the pop valve 55 therein. As soon as such communication is established, the pressure which exceeds that for which the valve 55 is adjusted, escapes through the line 54 and this returns the pressure in the conductor 34 to its original or predetermined point. Thus, the parts have returned to their original positions, as shown in Figure 1, and the well liquids may again enter the tubing to rise upwardly therein to a predetermined column. The operation of the valve is then repeated.

From the above, it will be seen that a simple and efficient apparatus for intermittently and automatically introducing a lifting gas to the liquid column is provided. There are only two moving parts to the entire apparatus, whereby wear is reduced to a minimum. The adjustments of the spring 41 in the control valve assembly C control the sliding of the piston to its position shown in Figure 3 and thereby control the point at which the valve disk 29 is closed. Any desired pressure may be maintained within the conductor 34 and, manifestly, this pressure controls the height of the column which may be built up prior to the admission of the lifting gas. The device is particularly adapted for use as an intermitter since it automatically admits the lifting fluid when a predetermined amount of liquid has entered the tubing. When the valve is seated, its upper end is exposed to the fixed or predetermined pressure in the conductor 34, while its lower end is exposed to the pressure of the well liquid, whereby the differential in these two pressures opens said valve. The valve, after being opened, is maintained in such open position, until the control valve piston 39 is moved to equalize the pressures across the valve and piston, at which time the spring 32 returns the same to its seated position. It is pointed out that the size of the tube or conductor 34 is subject to variation and the fixed or predetermined pressure which is maintained therein is varied in accordance with well conditions.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. A flow apparatus including, a well tubing, means connected in the tubing and actuated by a pressure differential thereacross for controlling the admission of a lifting fluid into the well tubing, said means having one side exposed to the pressure of the well liquid in the tubing, and means controllable from the surface and communicating with the other side of said control means for subjecting the latter side of said control means to a predetermined fluid pressure, whereby said control means is actuated to admit lifting fluid to the tubing when the pressure of the well liquid reaches a predetermined point.

2. A flow apparatus including, a well tubing having a well liquid inlet, a valve member mount-

ed in the tubing above the liquid inlet and arranged to be actuated by the pressure differential thereacross, said valve member having one side exposed to the well liquid pressure, means for subjecting the other side of the member to a predetermined pressure, whereby the valve member is moved to an open position to admit lifting fluid to the tubing when the well liquid pressure exceeds such predetermined pressure, means at the surface for controlling the fluid pressure to which the valve member is subjected, and means for closing the valve member after the well liquid has been ejected from the tubing.

3. A flow apparatus including, a well tubing having a well liquid inlet, a valve member mounted in the tubing above the liquid inlet and arranged to be actuated by the pressure differential thereacross, said valve member having one side exposed to the well liquid pressure, means for subjecting the other side of the member to a predetermined pressure, whereby the valve member is moved to an open position to admit lifting fluid to the tubing when the well liquid pressure exceeds such predetermined pressure, means at the surface having communication with said tubing for automatically equalizing the pressures across the valve member after the liquid has been ejected from the tubing, and resilient means for urging the member to its closed position to assure such closure upon the equalization of pressures thereacross.

4. A flow apparatus including, a well tubing having a well liquid inlet, a valve member mounted in the tubing above the liquid inlet and arranged to be actuated by the pressure differential thereacross, said valve member having one side exposed to the well liquid pressure, means for subjecting the other side of the member to a predetermined pressure, whereby the valve member is moved to an open position to admit lifting fluid to the tubing when the well liquid pressure exceeds such predetermined pressure, and control means at the surface having communication with said tubing actuated by a predetermined pressure within the tubing string for equalizing the pressures across the valve member to permit closing thereof after the well liquid has been ejected from the tubing.

5. An intermittent flow apparatus including, a well tubing, a cylinder connected in said tubing, means for by-passing well liquid upwardly past the cylinder, a valve member movable in the cylinder for controlling the admission of lifting gas to the tubing, said valve member having one side exposed to the well liquid, means for subjecting the other side of the member to a predetermined pressure, whereby the well liquid must attain a predetermined pressure before the valve member is actuated to admit the lifting fluid to the tubing to raise the liquid to the surface, and means controllable from the surface for controlling said predetermined pressure acting against the valve.

6. An intermittent flow apparatus including, a well tubing, a cylinder connected in said tubing, means for by-passing well liquids upwardly past the cylinder, a valve member movable in the cylinder for controlling the admission of lifting gas to the tubing, said valve member having one side exposed to the well liquid, means for subjecting the other side of the member to a predetermined pressure, whereby the well liquid must attain a predetermined pressure before the valve member is actuated to admit the lifting fluid to the tubing to raise the liquid to the surface, and means at the surface of the well having com-

munication with said cylinder for equalizing the pressure across the valve member after the liquid is ejected to permit closing of said member.

7. An intermittent flow apparatus including, a well tubing, a cylinder connected in said tubing, means for by-passing well liquids upwardly past the cylinder, a valve member movable in the cylinder for controlling the admission of lifting gas to the tubing, said valve member having one side exposed to the well liquid, means for subjecting the other side of the member to a predetermined pressure, whereby the well liquid must attain a predetermined pressure before the valve member is actuated to admit the lifting fluid to the tubing to raise the liquid to the surface, means controllable from the surface for controlling said predetermined pressure acting against the valve, and valve means at the surface actuated by a predetermined pressure within the tubing string for equalizing the pressures across the valve member to permit closing thereof after the well liquid has been ejected from the tubing.

8. An intermittent flow apparatus including, a well tubing, a cylinder connected in said tubing, means for by-passing well liquids upwardly past the cylinder, a valve member movable in the cylinder for controlling the admission of lifting gas to the tubing, said valve member having one side exposed to the well liquid, a conductor leading upwardly from the cylinder to the surface of the well, means for maintaining a predetermined pressure in said conductor whereby the other side of the valve member is exposed to such predetermined pressure and said member is actuated to admit the lifting gas when the well liquid pressure exceeds such predetermined pressure, a line connecting said conductor with the lifting fluid pressure exteriorly of the tubing, and a control valve at the surface connected in said line and arranged to admit the lifting fluid pressure to the conductor to balance the pressures across the gas-admitting valve member after the well liquid has been lifted, whereby said member may return to its closed position.

9. An intermittent flow apparatus including, a well tubing, a cylinder connected in said tubing, means for by-passing well liquids upwardly past the cylinder, a valve member movable in the cylinder for controlling the admission of lifting gas to the tubing, said valve member having one side exposed to the well liquid, a conductor leading upwardly from the cylinder to the surface of

the well, means for maintaining a predetermined pressure in said conductor whereby the other side of the valve member is exposed to such predetermined pressure and said member is actuated to admit the lifting gas when the well liquid pressure exceeds such predetermined pressure, a line connecting said conductor with the lifting fluid pressure exteriorly of the tubing, and a control valve at the surface connected in said line and arranged to admit the lifting fluid pressure to the conductor to balance the pressures across the gas-admitting valve member after the well liquid has been lifted, whereby said member may return to its closed position, said control valve being actuated by a predetermined pressure in the well tubing.

10. A flow apparatus including, a well tubing having a well liquid inlet, a valve member mounted in the tubing above the liquid inlet and arranged to be actuated by the pressure differential thereacross, said valve member having one side exposed to the well liquid pressure, means for subjecting the other side of the member to a predetermined fluid pressure, whereby the valve member is moved to an open position to admit lifting fluid to the tubing when the well liquid pressure exceeds such predetermined pressure, and means for controlling the fluid pressure to which the valve member is subjected, whereby said fluid pressure may be varied under various operating conditions.

11. A flow apparatus including, a well tubing having a well liquid inlet and a lifting fluid inlet, means connected in the tubing and actuated by a pressure differential thereacross for controlling the admission of a lifting fluid into the tubing, said means being exposed to the lifting fluid, means for balancing the effect of said lifting fluid on the control means so that the pressure of the lifting fluid does not affect the operation thereof, said control means having one side exposed to the pressure of the well liquid in the tubing, and means for subjecting the other side of said control means to a predetermined fluid pressure which is separate from the lifting fluid pressure, whereby said control means is actuated solely by the differential in these pressures and without the aid of the lifting fluid pressure to admit the lifting fluid to the tubing when the pressure of the well liquid reaches a predetermined point.

ASBURY S. PARKS.