

June 12, 1945.

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2,377,981

WELL FLOWING MEANS

Filed Dec. 6, 1941

2 Sheets-Sheet 1

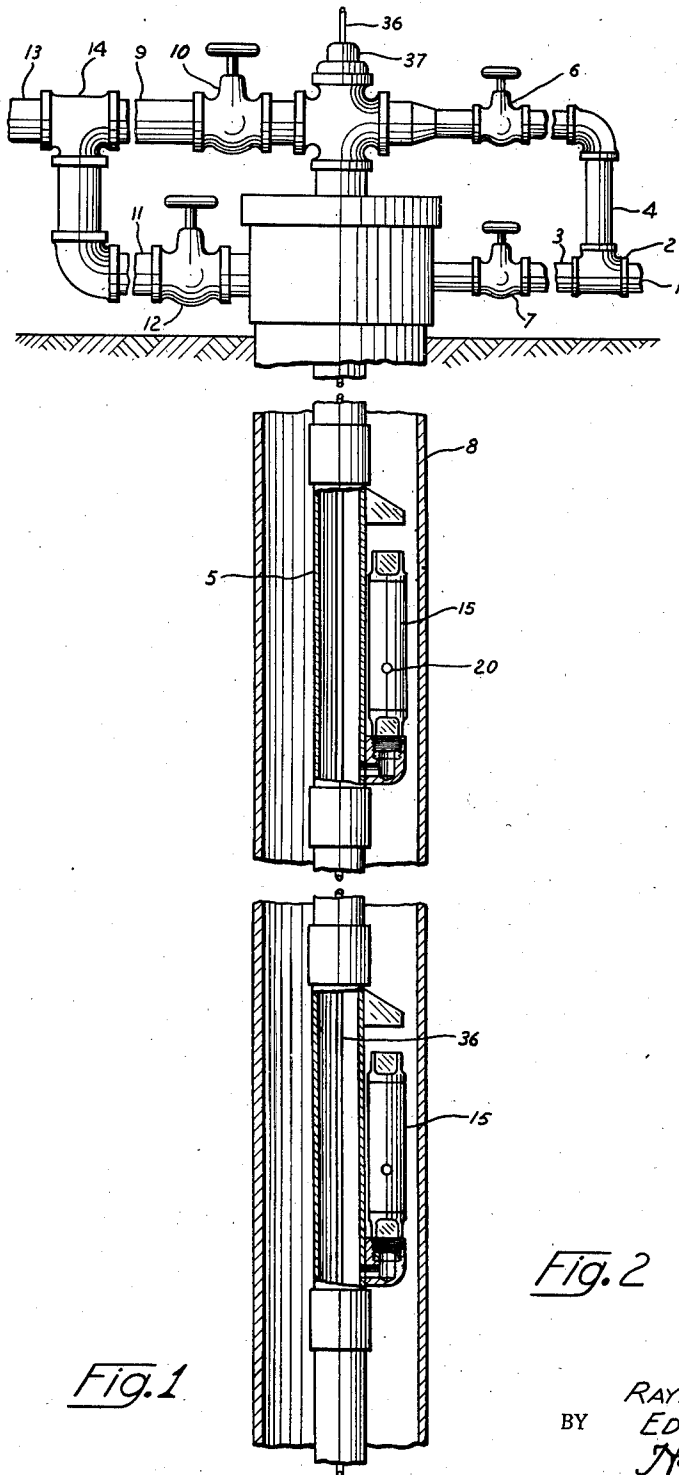


Fig. 1

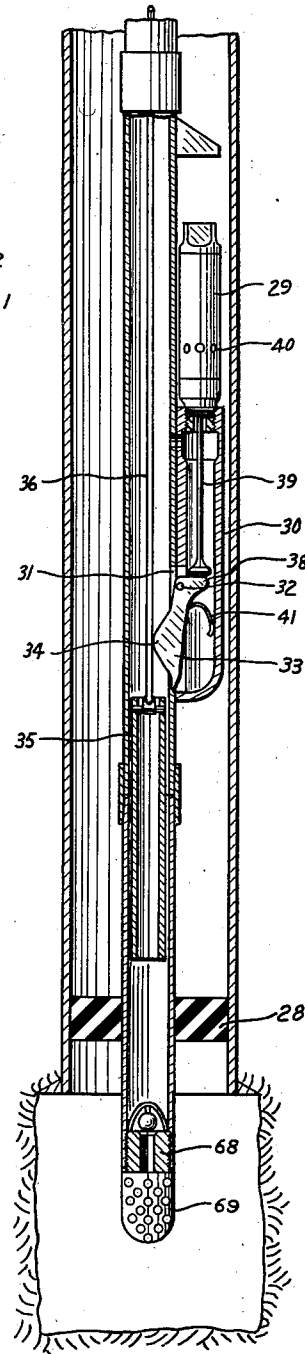


Fig. 2

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2 Sheets-Sheet 2

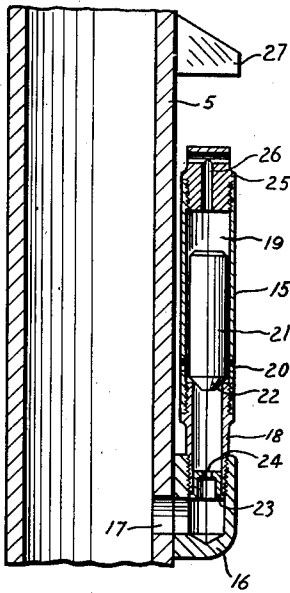


Fig. 4

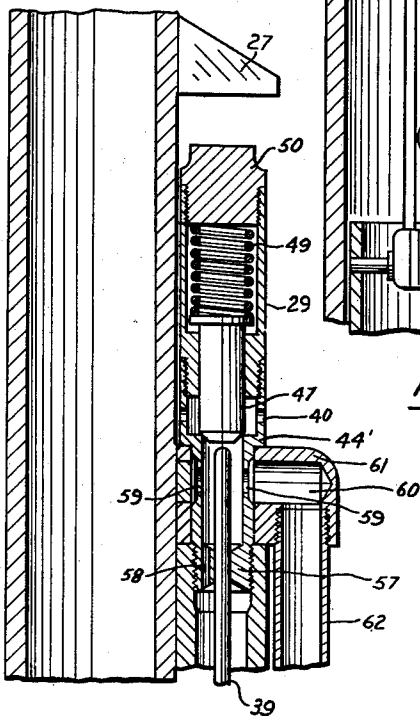


Fig. 6

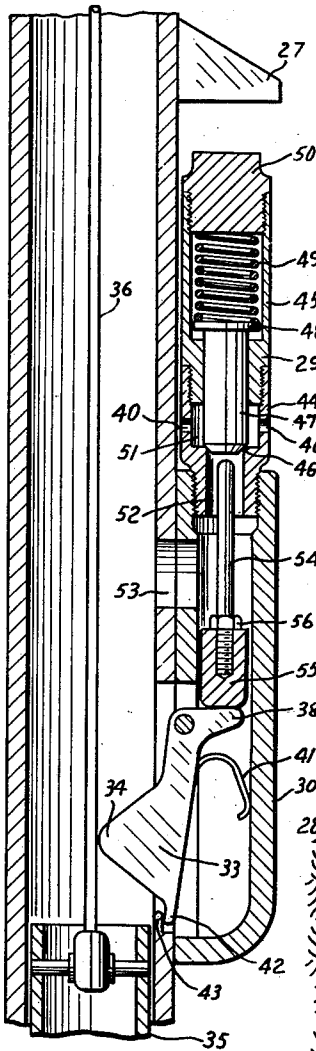


Fig. 5

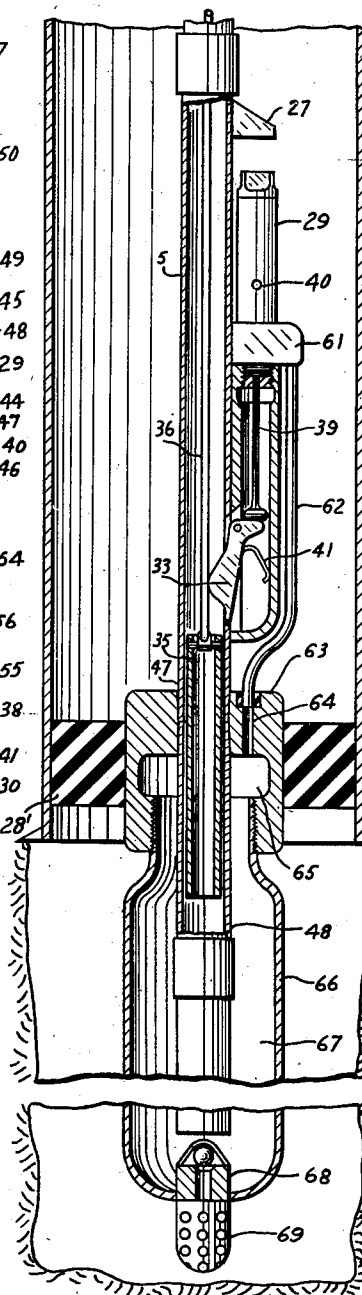


Fig. 3

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WELL FLOWING MEANS

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8 Claims. (Cl. 103—231)

This invention relates to improvements in apparatus for and method of flowing wells.

Various gas lift methods have heretofore been proposed to cause the oil to flow from a well. Various methods and apparatus adapted to perform the methods have been proposed to unload the well. This invention relates to a very simple means of accomplishing both of the above results.

It is well known that initially the oil will flow from a well but as the pressure in the producing sands decreases, the well will cease to flow and it is then necessary to resort to some means to recover the oil which will rise to a certain height in the well. Many methods for pumping this oil or aerating it have heretofore been suggested but difficulty has generally been encountered in unloading the well when aeration apparatus is employed. One of the objects of this invention is to overcome the said difficulties.

In the preferred embodiment of our structure the tubing carrying the aeration apparatus is lowered in the well. The oil is standing in the well at a height possibly 900 ft. from the surface and yet the well may be several thousand feet deep. We propose to force compressed air or gas through the tubing and to provide at given points in the tubing aeration valves so that the compressed air can flow from the tubing into the liquid in the casing and eject the same and after the oil has been ejected from the casing through the successive aeration valves the pressure fluid may be cut off from the tubing and introduced into the casing. We propose to employ a valve near the bottom of the tubing, which valve can be operated by a wire line and which valve when open will afford the sole means for the introduction of the compressed air from the casing into the tubing, the first-mentioned aeration valves performing no function in this latter operation. When the compressed air is introduced into the tubing it raises the oil therein to the surface. This wire line valve may be operated at intervals found to be most suitable to each well's characteristics to lift fluid in the tubing to the surface. The means for operating the wire line may be any suitable means, such as pressure fluid, electrical or mechanical means or even manual control, or it may be arranged to be operated intermittently by clock mechanism or any suitable timing apparatus.

One of the advantages of this invention over other surface control gas lift systems lies in the facility with which a well may be unloaded. In one type of apparatus heretofore suggested a series of wire line valves have been operated so

that it was necessary to lower a weight bar to the first valve and unload progressively down from the top to the bottom. This would take much time which might run into hours and it further requires much manipulation by the operator to definitely locate precisely where each valve is located. In our invention the weight bar to operate the wire line valves operates only the lowest valve and the well is unloaded automatically from the static fluid level down to the wire line valve, through the stage valves located above it and which stage valves are not wire line operated. The circulation of pressure fluid is then reversed so that the pressure fluid would pass downwardly through the casing and upwardly through the tubing when the weight bar opens the wire line valve near the bottom of the well. This is the procedure which would be followed when we desire to intermit through the tubing and in this case the well is unloaded through the casing. Of course, if we desire to intermit through the casing the well would be unloaded through the tubing. We prefer to intermit through the tubing and believe that this practice will generally be followed, but in case an operator desired to intermit through the casing, it is quite obvious that the reverse procedure would be used from that employed when intermitting through the tubing but both ideas are comprehended within this invention. In either case, we have provided a very simplified and quick method of putting a well on production.

Another object of this invention is to provide structure and a method of using the same whereby excessively high pressures will not be required. Compressed air pressure of 300 pounds per square inch is readily available and with such pressure we find that we can quickly unload a well even though the well may extend for thousands of feet below the static fluid level.

We propose a means for unloading the well by forcing the oil from the tubing into the casing in stages and then removing the oil in the casing to the surface in stages, or if we intermit through the casing, this process is reversed. In this we use a more or less automatic system of using one or a series of kick-off valves for unloading purposes and one wire line operated valve for intermitting purposes, the wire line valve being placed below the kick-off valves and near the bottom of the well.

At the extreme bottom of the well we propose to use a check valve to prevent the oil from flowing downwardly from the tubing into the producing formation. Sometimes such a valve becomes

clogged with sand or other deposits. In our improved structure we provide a means whereby this check valve may be cleaned and kept free from sand and other deposits.

These and other objects will appear in the detailed description and specification which follow.

In the drawings, in which we have shown the preferred form of our invention by way of illustration only and not by way of limitation,

Fig. 1 is a view, partly in elevation and partly in cross-section, showing the upper portion of a well with the surface connections and a portion of the equipment forming the subject-matter of this invention;

Fig. 2 is a view similar to Fig. 1 of the parts below Fig. 1, Fig. 2 being considered as a continuation of the lower portion of Fig. 1;

Fig. 3 is a transverse view, partly in cross-section and partly in elevation, of an equipment somewhat similar to what is shown in Fig. 2 but constituting a modification, in part, of the equipment shown in Fig. 2;

Fig. 4 is an enlarged cross-sectional view of a check valve of a kind shown in Fig. 1, the movable part of the valve being shown in elevation;

Fig. 5 is an enlarged cross-sectional view of a modification of the wire line valve shown in Fig. 2, certain of the parts being shown in side elevation;

Fig. 6 is an enlarged sectional view of a portion of the equipment shown in Fig. 3, certain of the parts being shown in side elevation.

In the drawings in which similar reference characters are used throughout to designate similar parts, a pipe 1 is connected to a suitable pump or compressed air chamber and serves as a means to introduce the compressed air into the tubing or the casing as the case may be. A T-coupling 2 is connected to the pipe 1 and connected to this T-coupling are short pipes 3 and 4. The pipe 4 is connected to the tubing 5 and is provided with a valve 6. Pipe 3 is connected to the casing 8 and is provided with a valve 7. An exit pipe 9 is connected to the tubing 5 and is provided with a valve 10. An exit pipe 11 is connected to the casing 8 and is provided with a valve 12. Both of the pipes 9 and 11 are connected to an exit pipe 13 by means of a T-coupling 14. It is obvious that pressure fluid may be introduced into the casing through the pipes 1 and 3 if the valve 7 is opened and the valve 6 is closed and the compressed air may be introduced into the tubing if the valve 6 is opened and the valve 7 is closed. It is likewise obvious that if the valve 10 is opened the contents of the tubing may be evacuated through the pipe 9 and likewise if the valve 12 is opened the contents of the casing may be evacuated through the pipe 11.

The tubing 5 is provided with a series of check valves 15. These check valves are placed suitable distances apart as will be hereinafter more fully described. While these check valves may be of different constructions, a preferred form thereof is shown in detail in Fig. 4. It consists of a coupling 16 secured to the outside of the tubing 5 and this coupling is provided with a passageway 17 in communication with a passageway extending into the tubing. The coupling 16 is screw threaded at its upper end and receives a tubular connection 18 which is screw threaded to a valve chamber 19 which is provided with holes 20 near its lower end. The valve 21 is provided at its lower end with a conical valve portion 22 which seats on the valve seat formed at the upper end of the tubular connection 18. In the lower por-

tion of the tubular connection 18 is a plug 23 which is provided with an orifice 24. This orifice plug 23 is to limit the amount of pressure fluid that can pass out to the holes 20. The size of the orifice is determined so as to be of such size to sufficiently aerate and lift the fluid in the casing without unduly wasting the gas. Where a series of these valves are employed, the size of the orifice may vary, the smallest orifice being at the top and progressively increasing in size in the valves below the same. The top of the valve chamber 19 is closed with a top cap 25 which is provided with a T-shaped vent hole 26 so as to prevent the trapping of the gases above the valve 21.

While we have suggested the use of a series of such check valves for wells in which it would be desirable to unload for a great distance, it is obvious that in shallow wells only one such check valve may be required and in very shallow wells it is possible that no check valves at all would be required. A lug 27 is provided above each of the valves to protect it to prevent the valve from being knocked off when the tubing is pulled from the well.

Near the bottom of the well we provide a packer 28 to seal the space between the tubing and the casing. A short distance above this packer we provide a wire line operated valve 29. As shown in Fig. 2, a connection 30 is secured to the outside of the tubing and has secured thereto the valve 29. A slot 31 is provided extending through the lower portion of the connection 30 and the tubing and a fulcrum pin 32 is carried by the connection 30 and extends laterally across the said slot. On this fulcrum pin is mounted a bell crank lever 33 having a cam portion 34 projecting into the tubing where it may be engaged by a weight 35 supported on a wire line 36 which extends to the top of the well through a stuffing box 37. This weight 35 may be of any suitable construction but we suggest that a preferred construction would be a hollow bar so that the oil can pass upwardly through the same. The wire line may be operated by any suitable mechanical or electrical means or may be operated by hand or a clock mechanism. The bell crank lever 33 is provided with an arm 38 in the connection 30 which underlies a push rod 39 which raises the valve member in the valve 29 so that compressed air can pass from the casing through the holes 40 and downwardly into the tubing, as will be more fully described in connection with the modification shown in Fig. 5. The bell crank lever 33 is urged into the position shown in Fig. 2 by means of a spring 41 but the bell crank lever will be retracted into the connection 30 and against the spring tension 41 when the weight 35 is raised so as to be in contact with the nose of the cam 34.

In Fig. 5 substantially the same arrangement is shown as described in connection with Fig. 2. The bell crank lever 33 is provided at its lower end with a nose 42 which engages a stop 43 on the tubing, thereby limiting the inward movement of the bell crank lever as it is urged into the tubing by the spring 41. The connection 30 is screw threaded at its upper end and receives a connection 44 which is screw threaded to the valve housing 45. As a matter of fact, the connection 44 and the valve housing 45 are made in two parts simply for simplification of construction and they in fact form a valve housing. The member 44 is provided with a valve seat 46 which is engaged by a valve 47. The upper end of the

valve 47 is provided with an enlargement 48 and a spring 49 is interposed between the cap 50 and the enlargement 48, the spring serving as a means to urge the valve against its valve seat. The connection 44 is provided with the holes 40 which lead into a chamber 51 within the connection 44. This chamber is in communication with a passageway 52 when the valve is raised from its valve seat and the passageway communicates with a passageway 53 leading into the tubing and extending through the connection 30. The valve is raised off its valve seat by means of a push rod 54 connected to a screw threaded tappet 55 and a lock nut 56 may be used to adjust the push rod 54 for height. It is, therefore, obvious that when the weight 35 is lifted so as to engage the nose of the cam portion 34 of the lever, the valve 47 will be raised off of the valve seat 46 and compressed gas could pass from the casing into the tubing or vice-versa depending upon the differential of the pressures in the tubing and in the casing.

In Figs. 3 and 6 we have shown a modification of the structure used in connection with the wire line operated valve. In these views the wire line valve is operated precisely as heretofore described. The connection 44', instead of having a passageway leading downwardly and communicating with the interior of the tubing, is provided with a closure 57 through which extends a bleeder hole 58. It is also provided with holes 59 which communicate with a passageway 60 in a sleeve 61 and which passageway communicates with a passageway in a tube 62 which extends into a packer head 63 which extends through and forms an air tight engagement with a packer 28'. This packer performs the same function as the packer 28. The packer head 63 has a bore 64 extending downwardly therethrough and communicating with the tube 62 and with a chamber 65 in the packer head. This packer head has secured thereto an enlarged case 66 enclosing a chamber 67. The lower end of the tubing extends into the chamber 67. The lower end of the chamber 67 is provided with the usual standing valve 68 and fluid inlet 69. In this construction when the weight 35 is raised so as to push the lever 33 against the tension of the spring 41 so as to elevate the push rod 39, the valve 47 is raised and compressed air can pass through the holes 40, downwardly through the connection 44', through the holes 59 into the passageway 60 and thence downwardly through the tube 62 into the chamber 67, and upwardly through the bottom of the tubing 5. It will be noted that the compressed air is, therefore, forced almost to the extreme bottom of the well and that the rush of fluid and gas by the standing valve 68 effectively cleans the same of sand or scale particles and removes any accumulated debris that might tend to cause the standing valve to become stuck in either its open or closed position.

In order to make the operation clear, we will assume for the purpose of illustration that the well is 4,500 feet deep but that the static fluid level in the well is 1,000 feet below the surface of the ground or 3,500 feet above the bottom of the well. We will assume that we run in the tubing carrying its valves so that the fluid inlet 69 is therefore 3,500 feet below the static fluid level. We will further assume for purposes of illustration that the ratio of the cross-sectional area of the tubing and of the casing is 1 to 8 and the gas pressure available is 300 pounds. It is well known that a 300 pound pressure will raise

a column of oil approximately 900 feet or approximately 3 feet for each pound of pressure. If we closed the valve 7 and opened the valve 6 and also opened the valve 12 and closed the valve 10, this 300 pound pressure would pass into the tubing and would force the oil downwardly in the tubing through the passageway 17 of the upper valve 15, raising the valve 21 and this oil would pass out through the holes 20 into the casing, thereby raising the level of the oil in the casing and depressing the level of the oil in the tubing. This differential in these levels could not exceed 900 feet with a 300 pound pressure. As a matter of fact, if we depressed the oil in the tubing for 805 feet, we would raise the oil in the casing 95 feet which would give us the maximum possible differential in levels. If, therefore, we placed the upper valve 15 at 1,600 feet below the surface of the ground or 600 feet below the static fluid level, this valve would not only cause all the oil above it to be passed from the tubing into the casing, but after it had done this the compressed air would exert a pressure of about 66 pounds per square inch at the passageway 17 and therefore the compressed air in the tubing would pass into the casing, elevating all of the oil above the topmost valve to the surface where it would pass out through the valve 12 and pipe 11 into the outlet pipe 13. If we placed the next valve 700 feet below the topmost valve the compressed air in the tubing would then repeat the above-mentioned operation and expel all of the oil between the topmost valve and the valve 700 feet below it out through the second valve and would then blow out the oil thus ejected into the casing so that it likewise would pass out through the exit pipe 13. We would suggest that in the above cited illustration that the valves should be placed approximately 700 feet apart so as to give ample pressure to elevate the oil in the casing. The 700 feet suggested is purely an arbitrary figure. It would not be well to place the valves the entire 900 feet apart for while the compressed air at 300 pounds pressure would expel the oil in the tubing into the casing, there would be no pressure remaining to aerate the oil, that is, the air passing through the passageway 17 after the oil was thus forced into the casing would not have any pressure behind it and we would not, therefore, wish to place the valves a full 900 feet apart. Of course, in the above remark in regard to placing them 900 feet apart, the oil in the casing would be more than 900 feet above the oil in the tubing when the oil between two successive valves had been completely displaced from the tubing into the casing were it not for the fact that all oil above the next highest valve would be expelled by the higher valve. We think that a differential pressure of about 66 pounds per square inch between the tubing and the casing exerted through the passageway 17 would be a safe figure to use to cause initial movement of the oil in the casing. If desirable, however, the valves may be placed closer together than 700 feet so as to have a greater pressure for lifting purposes. Under any condition, however, we would use the requisite number of valves such as the valves 15 and space them a suitable distance apart to force the oil in the tubing from the tubing into the casing and then to lift the oil in the casing to the surface. The number of valves that might be used will depend upon the depth of the well, what was its static fluid level and how far apart we spaced the valves. In the

illustration used above, when we considered that the well was 4500 feet deep and where the static fluid level was at 1,000 feet from the surface, and if the valves are placed 700 feet apart, we would place the topmost valve at 1,600 feet, the next valve at 2,300 feet, the third valve at 3,000 feet and the fourth valve at 3,700 feet. The fifth valve would be placed at about 4,300 feet below the surface and this fifth valve would be the wire line operated valve. The weight 35 would be raised and the oil would move through the passageway 53 upwardly by the valve 47 and out through the holes 40 so that this valve in this case would serve the same function as the valve 15. The spacing of the valves as given in the foregoing explanation is based on a compressed air pressure of 300 lb./sq. inch. It is obvious that other pressures may be used and the spacing of the valves as heretofore described will vary directly as the pressure. The higher the pressure, the wider will be the spacing that may be used, and vice versa. It is not intended to imply that the pressures and spacing of the valves as given herein must necessarily be followed in all cases, but are merely given as an example. By the above described method and with the use of the above described apparatus we are, therefore, able to quickly and virtually automatically unload the well. In other words, with the weight bar set so as to open the wire line valve and by operating the above-mentioned connections above the surface of the ground, the well is unloaded automatically from the static fluid level to the lowermost valve.

After unloading the well, the valves 6 and 12 would be closed and the valves 7 and 10 would be opened so that the compressed air from the inlet pipe 1 would pass into the casing where it would be trapped until such time as the weight 35 was raised so as to open the wire line valve 29. The compressed air would not pass through the valves 15 into the tubing for the valve member 21 would prevent this. The oil would build up in the tubing until the wire line was raised so as to open the wire line valve 29 and then the compressed air would pass into the tubing from the casing through the hole 53 and would lift the oil in the tubing to the surface. As above mentioned, the wire line may be operated by a timing mechanism so as to remove the oil in the tubing after a given interval of time, or it may be manually operated. Whenever the weight is lifted, however, the compressed air in the casing passes through the wire line valve into the tubing and lifts the oil in the tubing to the surface where it passes out through the pipe 9 and the exit pipe 13.

The structure shown in Figs. 3 and 6 might advantageously be used where it is desired to remove all the oil in the tubing from the extreme bottom of the tubing and where it is desired to clean the standing valve 88. In this case the compressed air in the casing would pass through the holes 40 when the weight 35 had caused the rod 39 to be lifted so as to move the valve 47 from its seat and will then pass downwardly through the tube 62 into the chamber 67 where it would pass into the extreme bottom of the tubing, cleaning the standing valve and lifting all of the oil in the tubing to the surface. This, of course, would occur only when the weight 35 was lifted for otherwise no compressed air would pass from the casing into the tubing. Any gas that might become trapped in the chamber 67 could, after the valve is closed, escape up

through the tube 62 and sleeve 61 and could escape through the bleeder hole 58.

While in Figs. 5 and 6 we have shown springs above the valves and have not shown a spring above the valve in Fig. 4, we desire it to be understood that a spring can be used to depress any of these valves, or they can be permitted to fall by gravity as the particular manufacturer or operator may desire.

While we have described our invention by way of illustration, we realize that many changes might be made in the specific form of the invention as shown in the drawings and herein described and without departing from the spirit of the invention. We, therefore, desire to claim the same broadly, except as we may expressly limit ourselves in the appended claims.

Having now described our invention, we claim:

1. In combination with a flow line and a casing, a series of normally closed check valves on the flow line at successive elevations to prevent passage of compressed gas or oil from the casing into the flow line while allowing compressed air or oil to flow therethrough from the flow line to the casing and a wire line valve on the flow line below the check valves and serving as a means to intermit through the flow line.

2. In a well having a flow line and a casing, a valve which when open forms a passageway between the flow line and casing and when closed prevents the passage of oil or compressed gas from the casing into the flow line, a lever to operate said valve, a portion of said lever projecting into the flow line, a wire line, a weight on the wire line and within the flow line to contact the part of the lever projecting into the flow line when the weight is moved by the wire line so as to operate said lever and open said valve and yieldable means to allow said valve to open when pressures in said flow line exceed the pressures in said casing by an amount sufficient to overcome the resistance of said yieldable means.

3. In a well having a flow line, a valve mounted on the flow line to provide a passageway to and from the flow line, a valve actuator projecting into the flow line, a rod operatively connecting said valve and actuator and movable into or out of engagement with said valve and a weight in the flow line which may be operated to actuate said actuator and rod and thereby open said valve.

4. In a well having a flow line, a valve mounted on the flow line to provide a passageway to and from the flow line, a lever projecting into the flow line, means operatively connecting said valve and lever and adapted to be moved into or out of engagement with said valve, a weight in the flow line which may be operated to actuate said lever and thereby open said valve, a wire line to raise or lower said weight, and means to cause said lever to be partly projected into the path of movement of the weight when the weight is removed from adjacent said lever.

5. In an oil well having a flow line, a valve on said flow line, a passageway extending into said flow line and adapted to be opened or closed by said valve, a lever partly projecting into the flow line, means operatively connecting said valve and lever and movable into or out of engagement with said valve, a wire line, a weight on said wire line and adapted to actuate said lever to open said valve when the wire line is operated to move the weight into operative contact with the lever and means to cause said lever to be

partly projected into the path of movement of the weight when the weight is removed from adjacent said lever.

6. In an oil well having a flow line and a casing, a plurality of normally closed check valves at successive elevations on said flow line, each of said check valves being closed at all times except when the pressure in the flow line exceeds the pressure in the casing at the point where any flow valve is positioned, said check valves being used for unloading through the casing and a wire line operated valve below the check valves, said wire line operated valve being used for intermitting through the flow line.

7. In an oil well having a flow line and a casing, a conduit for compressed gas, a pipe extending from the conduit to the casing and another pipe extending from the conduit to the flow line, a valve in each pipe so that by closing one

valve and opening the other the compressed gas may be introduced into the casing or vice-versa, means whereby when the compressed gas is introduced into the flow line the well is automatically unloaded in stages and means whereby when the compressed gas is introduced into the casing after unloading, the oil in the flow line is intermittently evacuated.

8. In an oil well having a tubing and a casing, means to introduce compressed gas into the tubing, means to automatically unload in steps the oil in the casing by the compressed gas from the tubing, means to introduce compressed gas in the casing after the well has been unloaded, and means to intermittently evacuate the oil which may accumulate in the tubing by the use of the compressed gas from the casing.

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