March 22, 1949. W. C. CARLISLE ET AL 2,465,060

WELL FLOWING

Filed Oct. 6, 1945 2 Sheets-Sheet 1

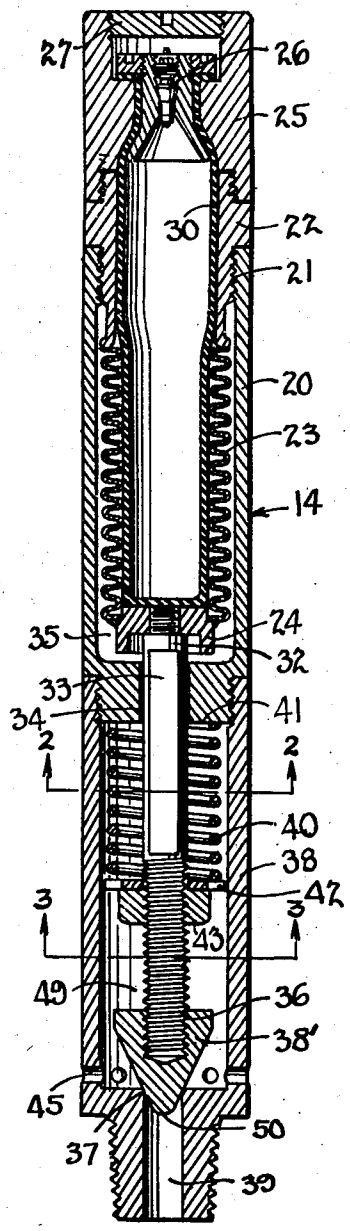


Fig. 1.

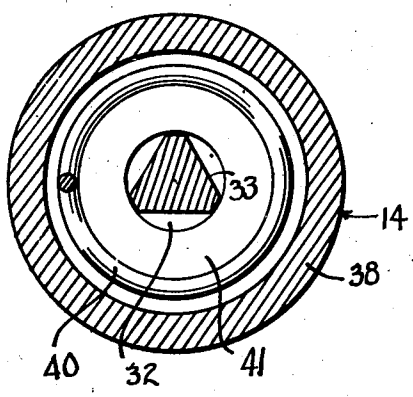


Fig. 2.

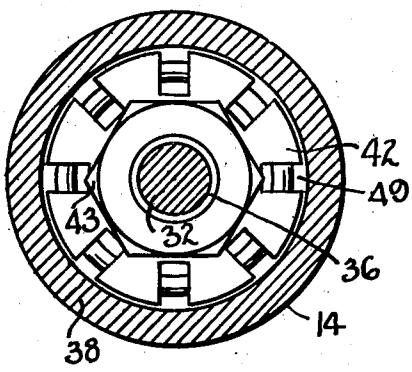


Fig. 3.

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WELL FLOWING

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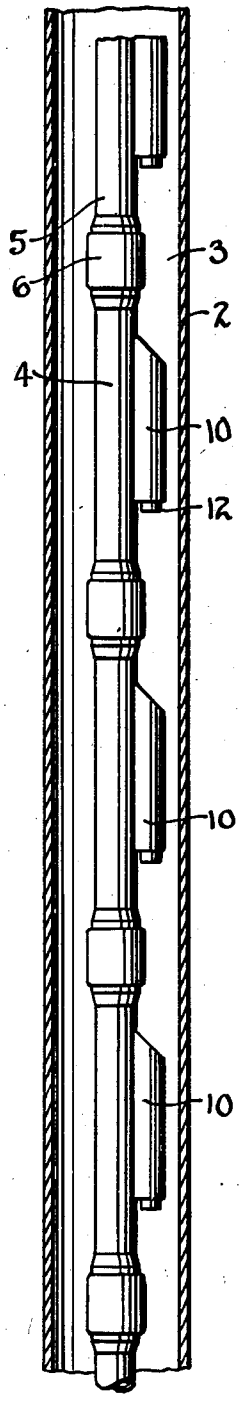


Fig. 4.

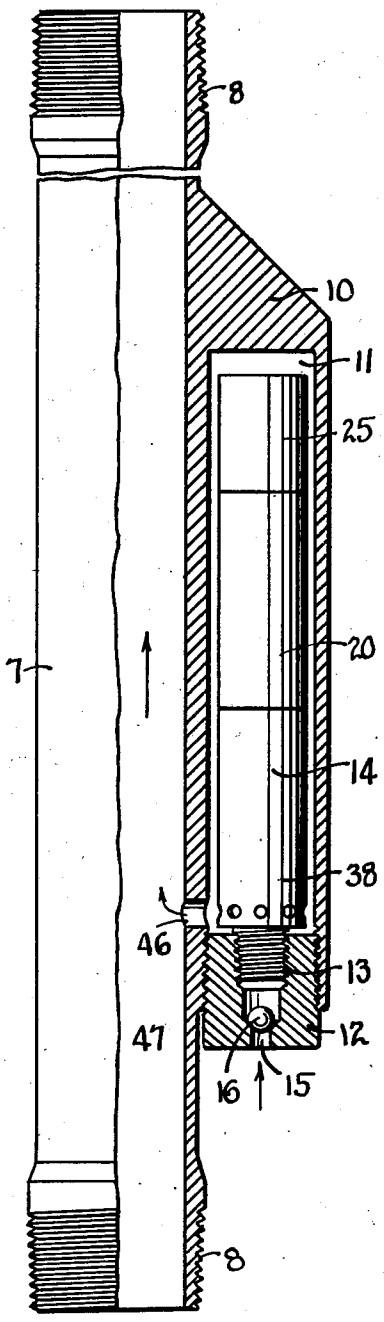


Fig. 5.

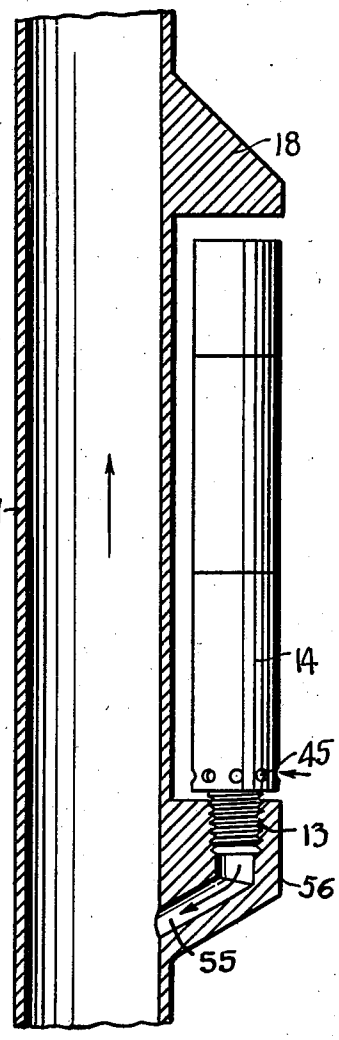


Fig. 6.

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WELL FLOWING

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Application October 6, 1945, Serial No. 620,690

6 Claims. (Cl. 103—233)

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The invention relates to a gas lift valve and the flowing of wells by the application of fluid under pressure.

Considerable difficulty has been encountered in providing valves for gas lift because of the varying conditions and pressures encountered in the different wells and at different elevations in the same well. For instance, a majority of the wells heretofore provided have been arranged to open when a predetermined pressure of the lifting fluid was applied thereto and control of the input pressure fluid thus utilized in controlling the operation of flowing the wells. As distinguished from this the present invention contemplates a valve so constructed that it will be opened due to the load of oil accumulating in the tubing and awaiting to be lifted. With such an arrangement the valve will open automatically when the column of oil in the tubing rises to a predetermined elevation or the weight thereof accumulates to such an extent that it will open the valve for the pressure at which it is set to open.

Optionally, another problem can be solved with this invention since the valve described hereinabove may be employed to react to pressures of gas or fluids extraneous of the pumping or lifting tubing through which the fluid flows since such fluids may be forced into the well area surrounding such tubing and at pressures above the valve opening pressures at which the valves may be set.

It is, therefore, an object of this invention to provide gas lift valves which will be actuated to open responsive to the pressure of gas or fluids in the well externally of the tubing to admit such fluids into the tubing to lift the column of oil or fluid therein.

It is another object of the present invention to provide gas lift valves which will be actuated to open by the load of oil to be lifted and which will close when the load of oil has been removed, so that the valves operate substantially independent of the pressure of the lifting of the fluid.

Another object of the invention is to provide a gas lift valve wherein a very small portion of the valve is exposed to the reservoir of lifting fluid.

Still another object of the invention is to provide a gas lift valve which can be set to open at a predetermined pressure caused by the dead fluid weight of liquid in the tubing.

Still another object of the invention is to provide a pressure loaded bellows type of valve

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which is supplemented by an adjustable strength spring to control the pressure at which the valve will open and close.

Still another object of the invention is to provide a pressure loaded bellows type valve wherein the pressure is confined in the valve by a resilient liner.

Still another object of the invention is to provide a gas lift valve which will open due to the load of oil in the tubing which is to be lifted but which will close when the load is removed therefrom, so that the valve will remain closed while other valves which are loaded with oil will subsequently open.

Other and further objects of the invention will be readily apparent when the following description is considered in connection with the accompanying drawings, wherein:

Fig. 1 is a vertical sectional view through the valve housing and illustrates the internal construction and arrangement thereof.

Figs. 2 and 3 are sections taken on the lines 2—2 and 3—3 respectively of Fig. 1.

Fig. 4 is a side elevation of the well equipped with the tubing and valves of the invention.

Fig. 5 is a view of the sub or section of tubing to which the invention has been applied and illustrates the manner of supporting the valve on the tubing.

Fig. 6 shows a modified arangement for supporting the valve on the tubing so that the gas pressure outside of the tubing will open and close the valve.

In Fig. 4 the well casing 2 is positioned in the well and forms a reservoir 3 when the casing is closed in the usual manner at the surface.

The flow tubing 5 is utilized for removing the oil and is made up of a plurality of sections of pipe joined by the couplings 6.

Fig. 5 shows a tubing section 7 threaded at its end 8 for connection into the string of pipe 4. This section of tubing is arranged with a lateral extension 10 which is received at 11 and arranged to be closed by the plug 12. This plug 12 is threaded at 13 to receive the gas lift valve housing 14. An inlet passage 15 in the plug may have a back pressure valve 16 therein so as to prevent any flow of fluid from the tubing 4 out into the annular reservoir 3 in the casing.

The details of the valve are best seen in Fig. 1 where the housing 14 is made up of a cylinder 20 threaded at 21 to receive the bushing 22 which is arranged to carry the bellows portion 23 of the valve. This bellows portion is closed by a cap 24 at its lower end and with a cap 25 at

the upper end, this upper cap being threaded on the bushing 22.

The cap 25 carries a pressure inlet 26 by which the bellows may be charged with any desired predetermined pressure. A closure disk 27 protects the fitting 26.

It has been the experience with pressure loaded valves of this sort that the applied pressure very often leaks through the metal of the bellows and the connections thereon and to avoid such leakage a liner 30 of any suitable material has been illustrated as having been placed inside of the bellows. This liner actually confines the pressure in much the same manner that an innertube in a tire confines the air. The liner is in the form of a sleeve which may be inserted and clamped in place between the fitting 26 and the cap 25 or it may be in the form of a suitable material sprayed on the inside of the bellows and the various parts thereof.

The lower cap 24 carries the valve stem 32 which is made non-circular at 33 where it extends through the opening 34 in the bottom of the cylinder 20. In this manner the bellows chamber 35 is open to pressure flowing upwardly around the stem. The stem has the valve head 38' threaded at 36 on the lower end so as to engage the seat 37 in the base portion of valve chamber 49 within the valve housing 38. The opening 39 in the base of the housing is of course in alignment with the opening 15 in the plug 12 to form a passageway for fluids, which passageway is opened or closed by the valve head 38' as seen in Fig. 5.

In order that the pressure loaded in the bellows shall not be excessive, a coil spring 40 has been shown as bearing against the base portion 41 of the cylinder 20 and abutting a washer 42 adjustably positioned by a nut 43 threaded on the stem 32. With this construction the bellows can be loaded to any predetermined pressure and then the spring 40 adjusted as desired to supplement the pressure of the bellows. The openings 45 in the base portion of the housing serve to discharge the pressure fluid which is admitted by the valve so that it may pass through the port 46 into the interior 47 of the tubing as shown in Fig. 5.

In actual operation the valve may be assembled and positioned as shown in Fig. 5 and lowered into the well. As the oil accumulates in the space 47 inside of the tubing, the pressure due to the load thereof will of course be exerted in the chamber 49 inside of the base of the housing and such pressure will move through the opening 34 to the bellows chamber 35. This pressure will tend to open the valve and when such pressure exceeds the combined pressure which is charged in the bellows and that exerted by the spring 40 tending to hold the valve closed, then the valve will be caused to open. Of course there is a small area such as 50 on the valve head which is exposed to the gas pressure in the reservoir 3 which tends to open the valve, but it will be noted that this area is small as compared to the entire area exposed to the load of oil in the tubing. This ratio may be as great as ten to one so as to minimize the opening effect of the gas pressure in the casing.

A series of the valves may be applied to the tubing and it is contemplated that all of them may be set to open at the same pressure or they can be set to open at different pressures, depending upon the spacing along the tubing

and other conditions and characteristics of the well.

In actual operation it is intended that the gas pressure in the reservoir may be maintained at a desired pressure sufficient to elevate the column of oil between any two of the gas lift valves and suppose the tubing is substantially filled with oil when the valves are installed, it seems obvious that the load of oil will open all of the valves but the gas pressure will be insufficient to elevate the oil or to enter any of the valves except the uppermost valve. The pressure will thus be exerted to kick off the column of oil above the uppermost valve, the load will be reduced on that valve, and that valve will then close. When this load of oil is thus reduced, the gas pressure remaining in the reservoir will be sufficient to enter the second valve and kick off the load of oil which has opened that valve. This cycle of operations will not be completed until the column of oil has been removed from all of the valves. All of the valves will then be closed. As the oil then begins to accumulate, it will rise sufficiently in the tubing to cause opening of the lowermost valve. The pressure in the casing will then kick off this head of oil which has accumulated and the only time the upper valves will operate is in the unloading of the well initially or in the event it has been shut down for some purpose or other.

The only control required is the control of the discharging oil and gas by a suitable choke because the valves require no control whatsoever once they are installed and ready for operation.

Fig. 6 shows a modified form of the tubing section 7 which permits the installation of the gas lift valve housing 14 by threading it at 13 into lug 56 on the tubing section 7, so that it underlies protective lug 18, with the result that the pressure of the gas outside of the tubing will act upon the bellows 23 to open the valve thus allowing gas to pass into the valve through ports 45 and on into the tubing through passageway 55.

When the gas lift valves are used as shown in Fig. 6 they are spaced in the tubing string in the same manner as shown in Fig. 4, with the valve set to open at the highest pressure usually being located at the top of the string, and valves set at decreasing opening pressures being spaced successively lower on the tubing.

It is therefore seen that the gas lift valve herein disclosed is adaptable to either operation by fluid pressure of the fluid inside the tubing or for operation by the pressure of the gas outside of the tubing, dependent upon the type of tubing connection used.

While the application of gas or air pressure to the well has been described, it seems clear that the well may be such that the natural accumulation of gas from the formation may be used to actuate the valves.

It is an obvious feature of the valve construction, as shown most particularly in Fig. 1, that both the bellows pressure, and the spring pressure, additively react to maintain the valvehead 38' on the seat 37. This construction, combined with the feature by which the valve housing 38 may be removed from the housing 14, permits the bellows to remain at a pre-charged pressure setting while the spring 40 may be adjusted by the nut 43, so that the valve may easily be set in the field to react at any predetermined pressure. It is also a feature of this construction that the washer 42 may act as a guide, as is

shown most clearly in Fig. 3 where the washer is shown notched to permit fluid passage therethrough but is also shown as being of almost the inner diameter of the valve housing 38 so that it may hold the valve stem 32 in alignment and prevent it from wobbling about especially when the valve is unseated.

Another feature of this invention is obvious from the structural features of the valve disclosed, as particularly shown in Fig. 1, since it can be seen that should the bellows 23 and the liner 30 become defective in service so that the fluid within the housing may leak through the bellows and inside of the liner, the pressure of such fluid will add to, rather than subtract from, the pressure which the bellows contributes in keeping the valve 38' seated. Such conditions would also occur in the case of leakage through the wall of the bellows 23 alone, or in cases where the liner may be omitted from the bellows assembly. This obvious feature of construction is of great advantage in oil field operations since with other precharged bellows valve constructions a leaky bellows tends to result in the valve being unseated, with great attendant losses of gas, and also with the resulting expensive operation of withdrawing the tubing from the well to remedy such defect, and with further losses possibly occurring as a result of the necessary reworking of the well.

Broadly the invention contemplates a system of valves wherein the valve will open due to the dead weight of liquid on the valve which liquid is to be elevated from the well.

What is claimed is:

1. In a flow valve, the combination of, a housing assembly comprising a bellows housing and a valve housing, a pressure charged bellows in the bellows housing, a partition in said bellows housing having a port means therein to permit fluid communication between said housings, a passageway in said valve housing from the exterior thereof, a valve to control said passageway, a stem for said valve extending through said partition and connected to said bellows, adjustment means on said stem, spring means in said valve housing and around said stem between said adjustment means and said partition to bear against said partition and to urge said valve to close said passageway, and an opening in said housing assembly from the exterior thereof to admit pressure fluid against said bellows.

2. A flow tubing for wells, an enclosure thereon, an intercommunication duct between said enclosure and said tubing, a plug in said enclosure having an entry passage therethrough, a flow valve unit disposed within said enclosure, said flow valve unit including, a housing assembly comprising a bellows housing and a valve housing, a pressure charged bellows in said bellows housing, a partition in the bellows housing having port means therein to permit fluid communication between said housings, a passageway in said valve housing from the exterior thereof, a valve to control said passageway, a stem for said valve extending through said partition and connected to said bellows, adjustment means on said stem, spring means in said valve housing and around said stem between said adjustment means and said partition to bear against said partition and to urge said valve to close said passageway, an opening in said housing assembly from the exterior thereof to admit pressure fluid against said bellows, and means on said assembly surrounding said passageway and adapted for connection to said plug to place said passageway and said entry passage in communication.

3. A flow tubing for wells, a duct through the wall of said tubing, a flow valve unit including, a housing assembly comprising a bellows housing and a valve housing, a pressure charged bellows in said bellows housing, a partition in said bellows housing having port means therein to permit fluid communication between said housings, a passageway in said valve housing from the exterior thereof, a valve to control said passageway, a stem for said valve extending through said partition and connection to said bellows, adjustment means on said stem, spring means in said valve housing and around said stem between said adjustment means and said partition to bear against said partition and to urge said valve to close said passageway, an opening in said housing assembly from the exterior thereof to admit pressure fluid against said bellows, and means on said assembly surrounding said passageway and adapted for connection to said tubing at the outer end of said duct to place said passageway and said duct in communication.

4. In a flow valve, the combination of, a housing assembly comprising a bellows housing and a valve housing, a pressure charged bellows in the bellows housing, a partition in said bellows housing having port means therein to permit fluid communication between said housings, a passageway in said valve housing from the exterior thereof, a valve to control said passageway, a stem for said valve extending through said partition and connected to said bellows, adjustment means on said stem, spring means in said valve housing and around said stem between said adjustment means and said partition to bear against said partition and to urge said valve to close said passageway, an opening in said housing assembly from the exterior thereof to admit pressure fluid against said bellows, and a guide on said stem to align said valve within the housing.

5. A flow tubing for wells, an enclosure thereon, an intercommunication duct between said enclosure and said tubing, a plug in said enclosure having an entry passage therethrough, a flow valve unit disposed within said enclosure, said flow valve unit including, a housing assembly comprising a bellows housing and a valve housing, a pressure charged bellows in said bellows housing, a partition in the bellows housing having port means therein to permit fluid communication between said housings, a passageway in said valve housing from the exterior thereof, a valve to control said passageway, a stem for said valve extending through said partition and connected to said bellows, adjustment means on said stem, spring means in said valve housing and around said stem between said adjustment means and said partition to bear against said partition and to urge said valve to close said passageway, an opening in said housing assembly from the exterior thereof to admit pressure fluid against said bellows, a guide on said stem to align said valve within the housing, and means on said assembly surrounding said passageway and adapted for connection to said plug to place said passageway and said entry passage in communication.

6. A flow tubing for wells, a duct through the wall of said tubing, a flow valve unit including, a housing assembly comprising a bellows housing and a valve housing, a pressure charged bellows in said bellows housing, a partition in said bellows

housing having port means therein to permit fluid communication between said housings, a passageway in said valve housing from the exterior thereof, a valve to control said passageway, a stem for said valve extending through said partition and connected to said bellows, adjustment means on said stem, spring means in said valve housing and around said stem between said adjustment means and said partition to bear against said partition and to urge said valve to close said passageway, an opening in said housing assembly from the exterior thereof to admit pressure fluid against said bellows, a guide on said stem to align said valve within the housing, and means on said assembly surrounding said passageway and adapted for connection to said tubing at the outer end of said duct to place said passageway and said duct in communication.

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