July 16, 1940. R. R. KYNER 2,208,036

WELL FLOWING APPARATUS AND METHOD

Filed June 1, 1937

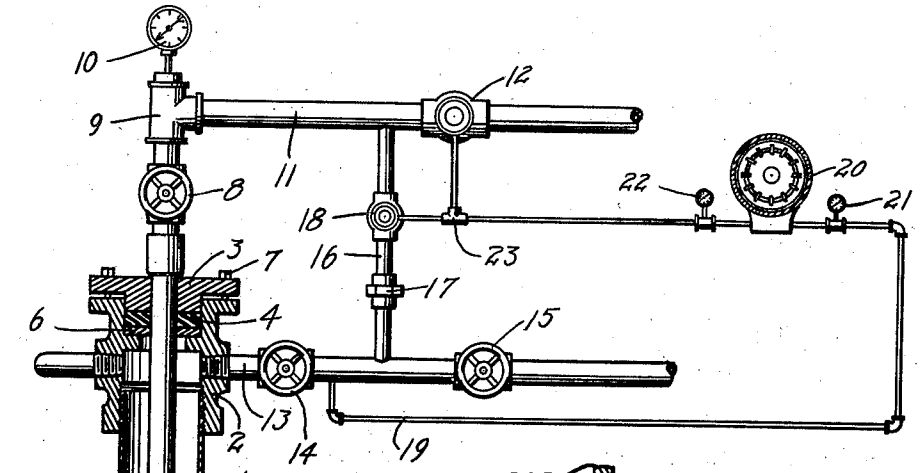


Fig. 1.

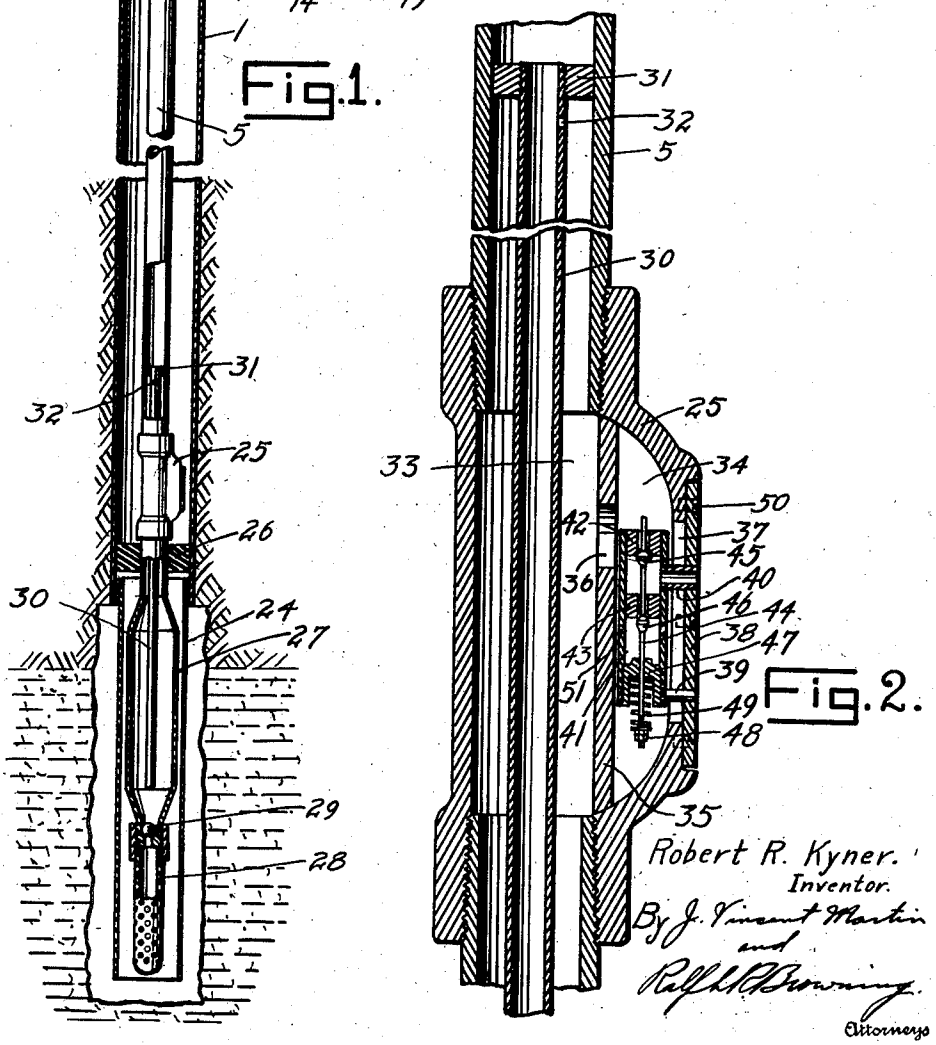


Fig. 2.

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Patented July 16, 1940 2,208,036

UNITED STATES PATENT OFFICE

2,208,036

WELL FLOWING APPARATUS AND METHOD

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Application June 1, 1937, Serial No. 145,748

10 Claims. (Cl. 103—234)

This invention relates to a method of and apparatus for pumping liquids from wells by means or air or gas under pressure.

Many devices have been designed for the purpose of injecting into a column of liquid in a well a quantity of air or gas under pressure so as to lighten said column of liquid and enable the natural pressure within the well to force the said column of liquid from the top of the well when it would not otherwise rise to the level of the top of the well.

Previously also liquid from the bottom of a well has been permitted to rise within a pipe or tubing in the well, which pipe or tubing is provided with a check valve at the lower end thereof, until it reaches or approaches the maximum height to which the natural pressure within the well will force the same, and then the liquid has been forced from the well by means of comparatively large volumes of gas or air under pressure which are admitted to the pipe or tubing adjacent the bottom thereof.

While the foregoing and other arrangements and devices have been successfully employed in the pumping of a fluid from wells where the natural pressure within the well is sufficient to raise the fluid in the eduction pipe to a considerable height, these means and methods have been found to be impractical in pumping a well in which the pressure is extremely low so that the liquid may be raised into the pipe by the natural pressure only to a relatively small height. In such instances, it has been found either that the gas which is injected into the column of fluid will, due to the small amount of submergence, break through the top of the column of liquid and rise as gas without lifting or causing the upward movement of the liquid, or if this has not occurred, the production due to the relatively small height of the column of liquid removed, has been found to be so small as to not warrant the expense of operation.

It is an object of this invention to provide an apparatus by means of which wells having an extremely low natural pressure may be produced economically by means of air or gas under pressure.

Another object of this invention is to provide such a device which will operate automatically to flow liquid from a well substantially as fast as the well is capable of producing.

Another object of this invention is to produce a relatively large volume of liquid from a well having a relatively low natural pressure.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawing, the same being by way of illustration and example, and not by way of limitation.

In the drawing:

Fig. 1 is a view illustrating a well equipped with apparatus arranged in accordance with this invention, said well and a portion of said apparatus being shown in vertical cross section.

Fig. 2 is an enlarged vertical cross section of a portion of the apparatus illustrated in Fig. 1 located adjacent the bottom of the well.

Referring more specifically to Fig. 1, the numeral 1 indicates the customary casing which is provided with a conventional casing head 2 adjacent its upper end. A combined cover plate and gland 3 is adapted to close the upper end of the casing head and compress the packing 4 into contact with the tubing 5 passing therethrough. The packing 4 rests upon a suitable washer or other support 6, and forms a seal between the upper end of the casing head and the outside of the tubing 5. The plate 3 is held in place by means of bolts 7 or the like.

At its upper end the tubing 5 is provided with a control valve 8 and a T connection 9 which receives a pressure gauge 10 and a flow line 11 for conducting away the liquid as it comes out of the well through the tubing 5. Interposed in the flow line 11 is a pressure operated control valve 12 which opens or closes the connection between the upper end of the tubing and whatever receptacle may be provided for the liquid.

Connected to the casing head 2 is a pressure line 13 adapted to conduct air or gas under pressure into the casing. Control valves 14 and 15 are interposed in this line for controlling the flow of gas or air under pressure into the casing, and as will be presently pointed out, into the tubing as well.

A by-pass line 16 joins the gas conduit 13 between the valves 14 and 15 to the flow line 11 between the T-connection 9 and the pressure operated valve 12. This by-pass is provided with the customary union 17 and with a pressure actuated valve 18. The pressure actuated valve 18 may be of substantially the same construction as the valve 12 with the exception that when pressure is applied to the valve 12 it serves to close the same, and when pressure is applied to the valve 18 it serves to open the same.

Tapped into the air or gas supply line 13 between the valves 14 and 15 is a pilot line 19 leading to an automatic, time-operated valve 20. Pressure gauges 21 and 22 may be employed on

both sides of the time-operated valve 20 and the discharge end of the time-operated valve 20 is connected through a T 23 to both of the valves 12 and 18. It will thus be seen that when the time-operated valve 20 is in position to prevent passage of air or gas under pressure through the line 19 to the valves 12 and 18, the valve 12 will be open and the valve 18 closed. When the valve 20 opens, however, to admit pressure to the valves 12 and 18, the valve 12 will then be closed and the valve 18 opened. The purpose of this operation will be presently set forth.

The casing 1 at its lower end is provided with a liner 24 extending into the producing formation. The tubing 5 is provided adjacent its lower end but above the upper end of the casing with a housing 25 which is illustrated more in detail in Fig. 2, and the tubing extends below the said housing through a packing 26 and is connected with an enlarged chamber 27 of as great an internal diameter as the diameter of the liner 24 will permit. The lower end of this chamber 27 is connected to a screen 28 and between the said screen and the chamber 27 is interposed a check valve 29 adapted to prevent back flow from the chamber 27 into and through the screen 28. The packing 26 which has been referred to serves to form a seal between the inner wall of the casing 1 and the outer surface of the tubing at a point below the housing 25.

Extending through the tubing from a point above the housing 25 to a point adjacent the lower end of the chamber 27 is a short section of tubing 30 of relatively small diameter. This tubing is joined at its upper end to the inner walls of the tubing 5, and is sealed thereto by means of a packing 31. A relatively small opening 32 adapted to serve as a bleeder opening is provided in the small diameter tubing 30 just below the packing 31.

The housing 25 has a main passageway therethrough indicated by the numeral 33, which is of substantially the same inner diameter as the tubing 5, and has an off-set chamber 34 separated from the main passageway by means of a partition 35 having an opening 36 therein. The exterior wall of the chamber 34 is formed with an opening 37 which is normally closed by means of a cover plate 38. Mounted on the cover plate 38 by means of a support 39 and a nipple 40 is a tubular housing 41 having valve seats 42 and 43 therein above and below the nipple 40, respectively. A valve stem 44 extends through the tubular housing 41 and carries valve elements 45 and 46 adapted to cooperate respectively with the valve seats 42 and 43 to control passage through the nipple 40 past the valve seats 42 and 43 and through the opening 36. The lower end of the valve stem 44 passes through an abutment 47, and between said abutment and the nut and washer combination 48 on the lower end of the valve stem is mounted a spring 49 which tends to hold both valve elements 45 and 46 away from their respective seats 42 and 43. The plate 38 is normally held in position on the housing 25 by means of screws 50 or the like. Air or gas flowing downwardly past the valve seat 43 is permitted to escape from the tubular housing 41 through openings 51.

The valve element just set forth is capable of adjustment by means of the nuts 48 on the lower end of the valve stem 44, and when properly adjusted a predetermined excess of pressure within the casing over the pressure existing within the tubing will cause the upper valve element 45, which is larger than the lower valve element 46, to be moved against its seat thus closing the passage from the interior of the casing to the interior of the tubing through this valve. When, however, the pressure within the tubing rises until the differential between the pressure in the casing and the pressure in the tubing is less than a predetermined amount which is smaller than the differential at which the valve will close, the valve will be opened by the spring 49.

The time controlled valve 20 has not been described in detail inasmuch as the valve per se forms no part of this invention, and valves capable of performing the function desired are available on the open market. Likewise, the details of the valves 12 and 18 have not been shown inasmuch as such valves are available on the open market, and as such form a part of the present invention only in that they form a part of the combination to which this invention relates.

Assuming that the well illustrated is one in which the natural formation pressure will lift the liquid only to a relatively small height in the tubing or in the chamber 27, the operation of the apparatus is as follows:

The apparatus is first placed in the well as illustrated, whereupon the liquid will rise in the chamber 27 and the tubing 5 to the maximum height to which the natural pressure in the formation will lift it. Due to the fact that there will be at this time little or no differential in pressure between the casing and tubing at the location of the valve housing 25, or if any substantial differential exists, the excess of pressure will be on the inside of the tubing, the valve elements 45 and 46 will be held away from their seats by the spring 49. Air or gas under pressure is then introduced into the casing through the supply line 13 and the pressure within the casing rises until it exceeds the pressure existing within the tubing, whereupon gas will begin to flow through the nipple 40 past the valve seats 42 and 43, through the opening 36, and into the tubing 5 below the packing 31. Inasmuch as the opening 32 is very small, a relatively small amount of gas will pass through this opening, and as the volume of gas within the tubing 5 below the packing 31 increases, it will force the liquid in the annulus between the tubing 5 and the tubing 30, or between the chamber 27 and the tubing 30, downwardly. The check valve 29 will prevent the passage of this liquid downwardly into the formation and the same will be forced upwardly through the tubing 30 and into the upper portion of the tubing 5. Inasmuch as the chamber 27 is of considerably larger diameter than the tubing 5, the liquid which is thus forced into the tubing 5 will form a column of much greater length than the height at which the liquid stood in the chamber 27. This will serve to give the air or gas under pressure, when the level of liquid has been forced to the lower end of the tubing 30 and the air or gas begins to enter the tubing 30, a sufficient submergence so that it will not burst through the liquid, but will instead force the entire column of liquid upwardly through the tubing 5 and out of the well through the flow line 11 and the valve 12. The air or gas passing through the bleeder opening 32 also serves to aid in raising the liquid in the tubing. It is assumed that during this operation the valve 20 will be in closed position so that the valve 12 will be open and the valve 18 closed.

When a predetermined amount of the liquid thus raised is forced out through the flow line 11, the pressure within the tubing due to the weight of said liquid will be reduced, and the pressure of air or gas within the casing will exceed the pressure within the tubing by such an amount that the valve elements 45 and 46 will be forced by this great differential of pressure and the excessive flow caused thereby to seat against their respective seats despite the action of the spring 49. It is noted in this connection that while the pressure differential and flow caused thereby act on the valve elements 45 and 46 in opposite directions, the element 45 is larger and the net result of said differential pressure and flow will be a tendency to move the elements 45 and 46 toward their seats. When this tendency becomes great enough to overcome the tension of the spring 49, the valve will close.

With the valve elements 45 and 46 thus seated, and the pressure within the tubing relatively low compared to the pressure in the casing, the liquid will again be produced by the formation, and will be forced by the formation pressure past the check valve 29 and into the chamber 27. As the liquid rises in the chamber 27, the air above the level of the liquid and outside of the tubing 30 will be permitted to escape through the opening 32. The liquid will thus rise substantially to the height to which the formation pressure will efficiently raise it. It is contemplated that this height will be insufficient to raise the pressure within the tubing at the level of the housing 25 by a sufficient amount to cause the movement of the valve elements 45 and 46 away from their seats and thus open this valve. The valve 20, however, is so regulated depending upon the capacity of the formation in a particular well to produce liquid, that it will open after a sufficient period of time has passed for the liquid in the chamber 27 and the tubing 5 to rise to an efficient height. When the valve 20 opens this admits pressure to the valves 12 and 18 and causes the closing of the valve 12 and the opening of the valve 18. This valve action permits gas or air under pressure from the supply line 13 to be by-passed through the by-pass 16 into the flow line 11 from whence it is forced into the tubing 5. This raises the pressure within the tubing 5 until it approaches the pressure within the casing by an amount sufficient to cause the opening of the valve elements 45 and 46. The time controlled valve 20 will be so regulated that as soon as the valve elements 45 and 46 move away from their seats it will close again so as to permit the opening of the valve 12 and the closing of the valve 18. With the valve elements 45 and 46 now open, flow of air or gas will take place from the casing into the tubing in the manner hereinbefore described, and the oil which has risen into the chamber 27 and the tubing 5 will be forced from the well. This process will be repeated automatically as the time controlled valve 20 operates, said valve being adjusted in each instance to the particular conditions prevailing in the well on which it is installed.

From the foregoing, it will be seen that a means has been provided for forcing liquid from a well substantially as fast as the well is capable of producing the liquid, even though said well may have a natural formation pressure which will only raise the level of the liquid in the well by a relatively small amount.

It will likewise be appreciated that the various other objects and advantages sought by this invention will be accomplished by the apparatus and the method set forth.

What I claim is:

1. In an apparatus for pumping liquids, a tubing extending below the static level of the liquid, means for supplying gas under pressure to said tubing at a point adjacent the lower end thereof, a valve controlling the admission of such gas and adapted to open when the pressure within the tubing rises to within a predetermined pressure difference below the pressure of the gas supply and to close when the pressure within the tubing falls to more than a predetermined greater pressure difference less than the pressure of the gas supply, and means for momentarily admitting gas under pressure to said tubing adjacent the upper end thereof to raise the pressure within said tubing and cause said valve to open.

2. In an apparatus for pumping liquids, a tubing extending below the static level of the liquid, means for supplying gas under pressure to said tubing at a point adjacent the lower end thereof, a valve controlling the admission of such gas and adapted to open when the pressure within the tubing rises to within a predetermined pressure difference below the pressure of the gas supply and to close when the pressure within the tubing falls to more than a predetermined greater pressure difference less than the pressure of the gas supply, and time controlled means for momentarily admitting gas under pressure to said tubing adjacent the upper end thereof to raise the pressure within said tubing and cause said valve to open at predetermined intervals.

3. In an apparatus for pumping liquids, a tubing extending below the static level of the liquid, means for supplying gas under pressure to said tubing at a point adjacent the lower end thereof, a valve controlling the admission of such gas and adapted to open when the pressure within the tubing rises to within a predetermined pressure difference below the pressure of the gas supply and to close when the pressure within the tubing falls to more than a predetermined greater pressure difference less than the pressure of the gas supply, and means for momentarily raising the pressure within said tubing to cause said valve to open.

4. In a method of opening a valve for admitting gas under pressure adjacent the lower end of a well tubing, where said valve will only open upon the existence of a predetermined pressure within the tubing at the valve and the natural formation pressure within the well is incapable of producing such pressure, the steps of permitting the natural formation pressure to force the well liquid into the tubing until such flow into the tubing falls below a predetermined rate, and admitting gas under pressure into said tubing adjacent the upper end thereof while preventing backflow from said tubing into said well, to raise the pressure within said tubing at said valve and cause the valve to open.

5. In a method of flowing a well having a chamber therein extending below the static level of the liquid in the well, a tubing of relatively small diameter extending upwardly from said chamber, and a valve for admitting gas under pressure to said chamber, where said valve will only open upon the existence of a predetermined pressure within the chamber at the valve and the natural formation pressure within the well is incapable of producing such pressure, the steps of permitting the natural formation pressure to

force the well liquid into the chamber and tubing until such flow into the chamber falls below a predetermined rate, admitting gas under pressure into said chamber adjacent the upper end thereof while preventing backflow from said chamber into said well, to raise the pressure within said chamber at said valve and cause the valve to open, and repeating the admission of gas under pressure to said tubing for said purpose at intervals depending upon the rate of flow of well liquid into said chamber when the valve is closed.

6. In combination, an apparatus for flowing a well comprising a casing, a tubing within said casing and having an opening therein adjacent the lower end of said casing, a valve controlling flow through said opening and adapted to open when the pressure within said tubing rises to within a predetermined pressure difference less than the pressure within the casing and to close when the pressure within said tubing falls to a greater predetermined pressure difference less than the pressure within the casing, a seal between said casing and tubing below said valve, a chamber of enlarged diameter on said tubing having an opening adjacent its lower end, a check valve for preventing flow from said chamber through said opening, a tubing section of reduced diameter extending from a point within said first mentioned tubing above said valve to a point adjacent the lower end of said chamber, a packing between said tubing section and said tubing above said valve, said tubing section having a relatively small bleeder opening therein adjacent and below said packing, means for introducing gas under pressure into said casing, means for admitting gas under pressure into said tubing adjacent the upper end thereof, and time controlled means for causing the admission of said gas into the tubing at predetermined intervals.

7. In an apparatus for pumping liquids, a conduit extending below the static level of the liquid, means for supplying gas under pressure to said conduit at a point remote from the upper end thereof, a valve for controlling the admission of such gas and adapted to open when the pressure within the tubing rises to within a predetermined pressure difference below the pressure of the gas supply, and to close when the pressure within the tubing falls to more than a predetermined pressure difference less than the pressure of the gas supply, and means for momentarily raising the pressure within said tubing to cause said valve to open.

8. In an apparatus for pumping liquids, a conduit extending below the static level of the liquid, means for supplying gas under pressure to said conduit at a point remote from the upper end thereof, a valve for controlling the admission of such gas and adapted to open when the pressure within the tubing rises to within a predetermined pressure difference below the pressure of the gas supply, and to close when the pressure within the tubing falls to more than a predetermined pressure difference less than the pressure of the gas supply, and means for raising the pressure within said tubing to cause said valve to open.

9. In a method of flowing a well having a tubing therein and a valve for admitting gas under pressure adjacent the lower end of said tubing, where said valve will only open upon the existence of a predetermined pressure in the tubing at the valve and the natural formation pressure within the well is incapable of efficiently producing such pressure, the steps of permitting the natural formation pressure to force the well liquid into the tubing for a predetermined period of time, and admitting gas under pressure into said tubing adjacent the upper end thereof to raise the pressure within said tubing at said valve and cause the valve to open.

10. In a method of flowing a well having a tubing therein and a valve for admitting gas under pressure adjacent the lower end of said tubing, where said valve will only open upon the existence of a predetermined pressure within the tubing at the valve, th steps of admitting the natural formation pressure to said tubing to build up pressure at said valve for a period of time, and then artificially raising the pressure within the tubing at said valve by an additional amount sufficient to cause said valve to open.

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