April 15, 1930. R. M. HASKELL 1,754,945

METHOD AND APPARATUS FOR FLOWING OR PUMPING WELLS

Filed Aug. 5, 1927 4 Sheets-Sheet 1

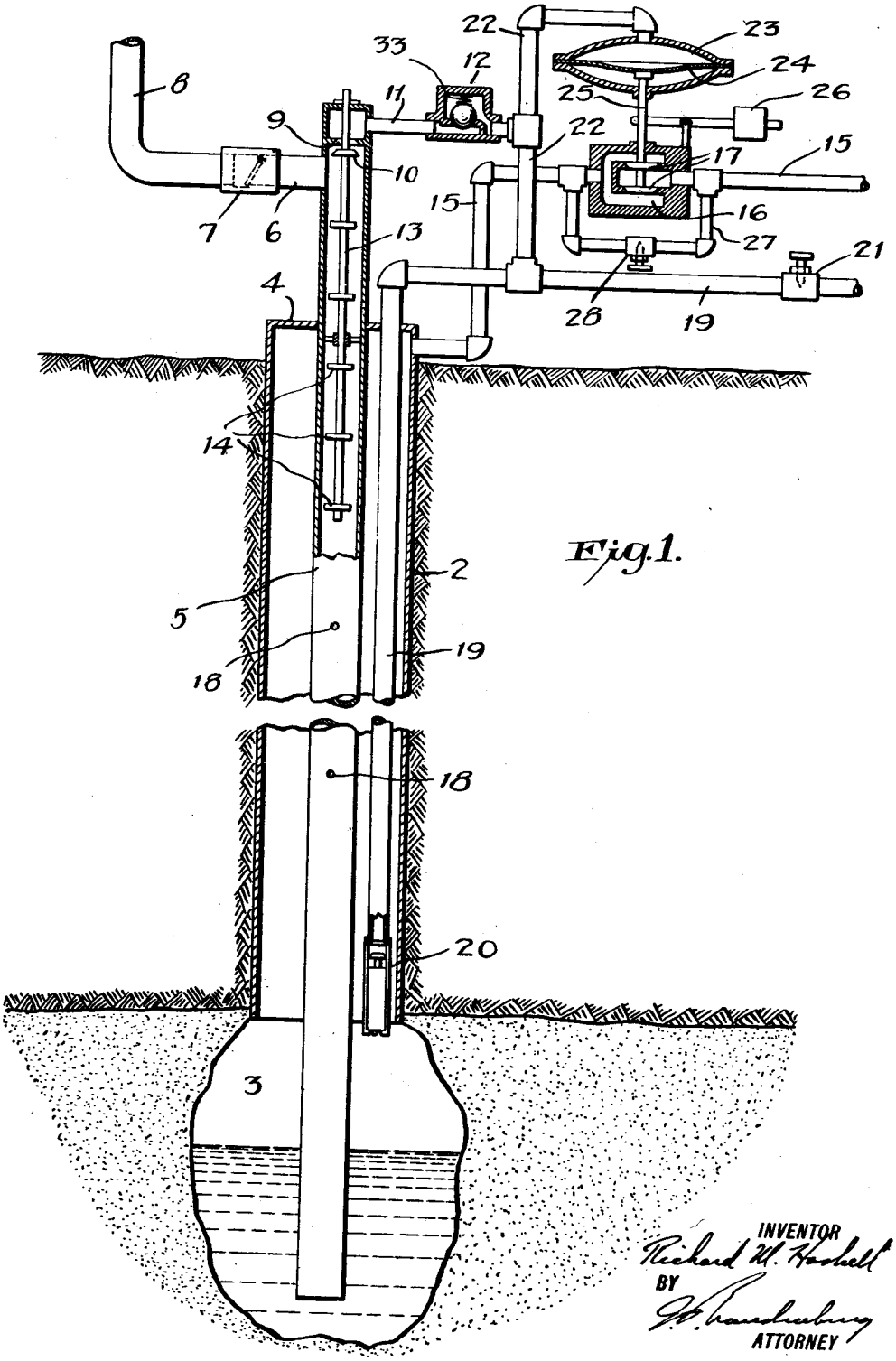


Fig. 1.

INVENTOR
Richard M. Haskell
BY
ATTORNEY

April 15, 1930. R. M. HASKELL 1,754,945

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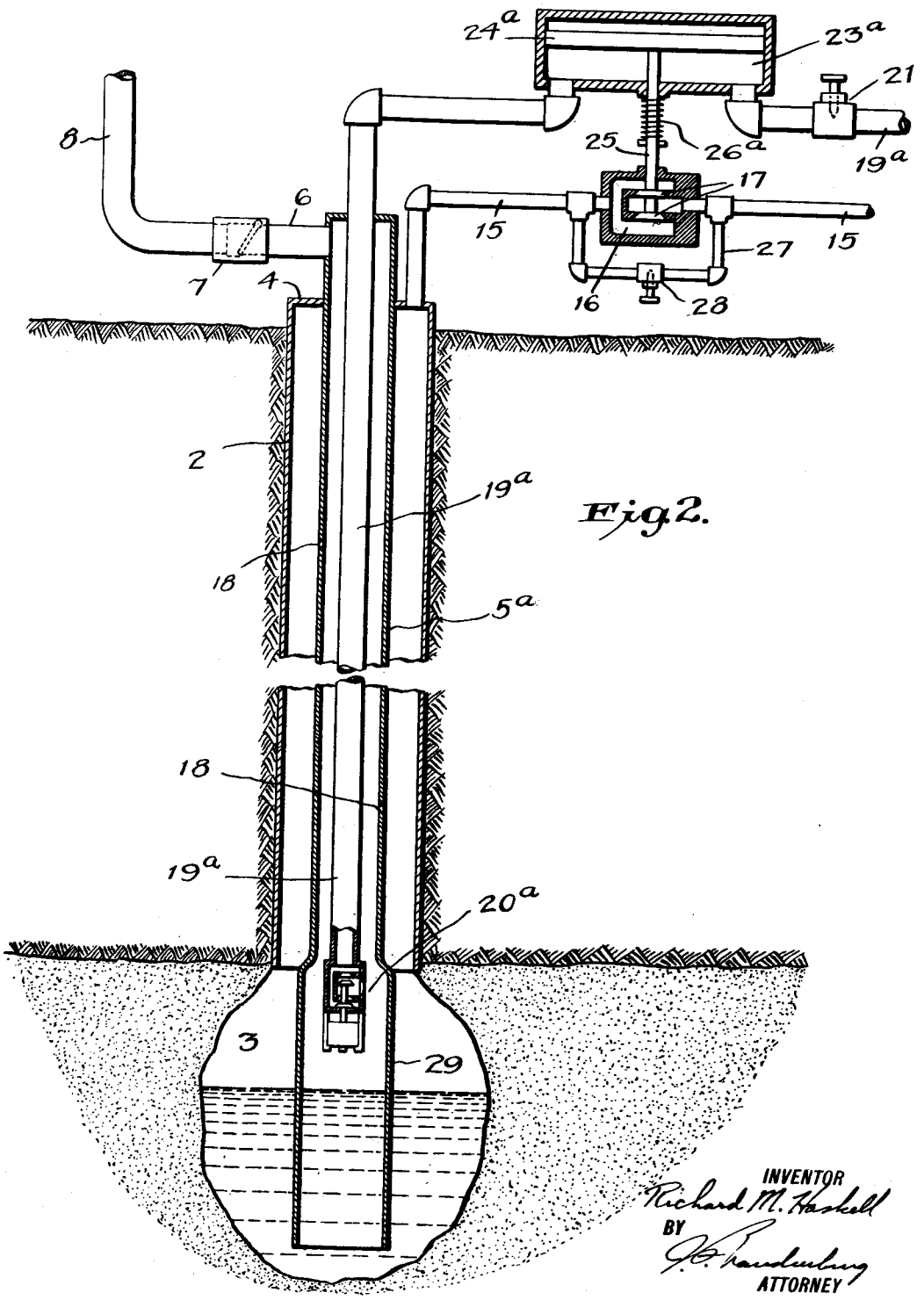


Fig 2.

INVENTOR
Richard M. Haskell
BY
J. B. Sandenburg
ATTORNEY

April 15, 1930. R. M. HASKELL 1,754,945

METHOD AND APPARATUS FOR FLOWING OR PUMPING WELLS

Filed Aug. 5, 1927 4 Sheets-Sheet 3

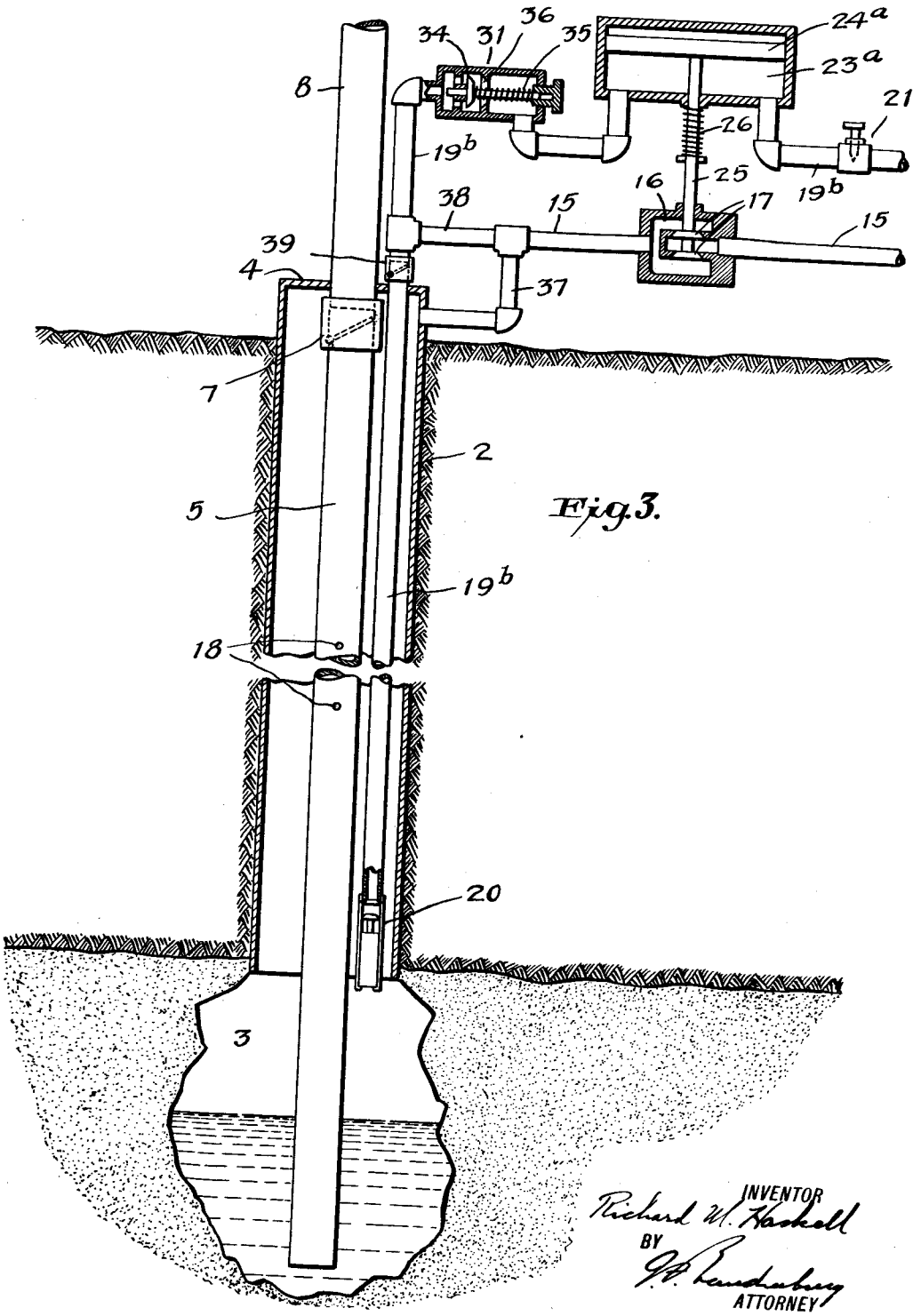


Fig.3.

INVENTOR
Richard M. Haskell
BY
ATTORNEY

April 15, 1930. R. M. HASKELL 1,754,945

METHOD AND APPARATUS FOR FLOWING OR PUMPING WELLS

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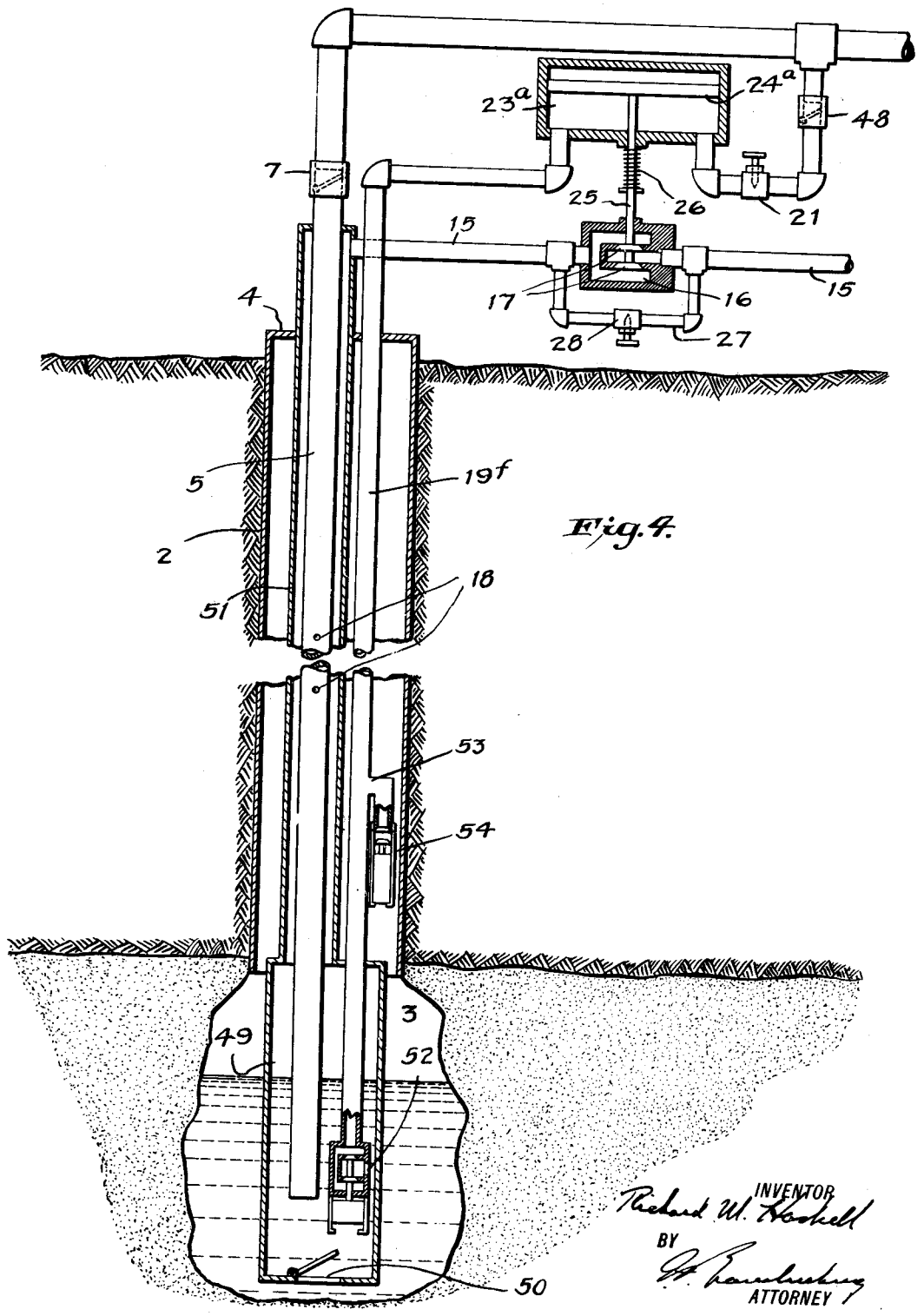


Fig. 4.

INVENTOR
Richard M. Haskell
BY
ATTORNEY

Patented Apr. 15, 1930 1,754,945

UNITED STATES PATENT OFFICE

RICHARD M. HASKELL, OF BRADFORD, PENNSYLVANIA, ASSIGNOR OF THREE-FOURTHS TO TIDE WATER OIL COMPANY, OF BAYONNE, NEW JERSEY, A CORPORATION OF NEW JERSEY

METHOD AND APPARATUS FOR FLOWING OR PUMPING WELLS

Application filed August 5, 1927. Serial No. 210,799.

The invention relates to automatic well-flowing systems, and the object is to provide a simple and effective plan, which is susceptible of numerous embodiments and modes of execution. The invention makes it possible to utilize in a novel manner the flow of natural gas which ordinarily accompanies or urges the flow of petroleum to the shot-hole of an oil well. According to the invention the escape of the gas from the well, regulated by the heading up of the oil in the well, is employed to control an aeriform flowing medium, which from time to time flows the accumulated liquid out of the well. Thus, a cessation or decrease in outflow of gas, or the drop in pressure consequent thereto, resulting from the rise of liquid to a height which closes an exit, causes the turning on of the flowing medium. The path of escape of the gas or operating medium remains closed during the flowing period, and is thereafter automatically reopened.

The invention is also applicable to wells deficient in gas pressure or having no gas, by bleeding into the well some of the flowing medium to serve as an operating medium in the same general manner. Similarly, compressed air or gas from any source may be released into the well from above to act as the operating or control medium.

The operating medium may also be compressed air or other gas applied to an area of an oil field through certain wells therein, for driving or inducing the flow of liquid to other wells known as venting wells, such air entering the venting wells with the liquid in the same way as natural gas occurring with petroleum in a field in which the natural pressure has not been exhausted. In the broad aspect, therefore, the aeriform operating medium employed may be natural gas entering the shot-hole from the oil-bearing sand, air or gas artificially applied under pressure to the sand and entering the well in the same manner, or compressed air or gas bled into the well from the surface of the ground.

Various forms of the invention, involving different features of generic and specific novelty will now be described.

In the accompanying drawings forming part hereof:

Figs. 1 to 4 illustrate schematically four forms or modes of execution of the invention, the views being partly in section and partly in elevation, intermediate portions of the wells of indefinite extent being broken out.

Figure 1

The numeral 2 designates the well casing extending down to the shot-hole 3 in the oil-bearing sand. The top 4 of the casing is closed. A discharge tube 5 extends through the closed top of the casing, where a tight joint is made, downward through the center of the casing to the lower part of the shot-hole. A discharge branch 6 is joined to the vertical portion of the discharge tube above the casing, and contains a check-valve 7 below an upwardly extending leg 8, in order to support and maintain a column of liquid in this part of the discharge conduit, for a purpose which will later appear.

The vertical portion of the discharge tube 5 is preferably extended above the discharge branch 6, and is closed at the top. In this portion of the tube there is a valve seat 9 surrounding a port which is adapted to be closed by a valve 10. A pipe 11 is connected with the upper portion of the tube 5, above the valve seat 9, and contains a check-valve 12, which opens away from the discharge tube and closes toward it.

The valve 10 is on a rod 13, appropriately guided and extending downward for some distance in the tube 5, this rod bearing vanes 14 adapted to be acted upon by liquid flowing up the tube so as to hold the valve 10 closed against the seat 9. At the end of the flow, when the expelling air reaches the vanes 14, the smaller momentum of the air does not sustain the rod 13 with the valve and vanes in the raised position, and the valve consequently drops away from the valve seat 9. Other means may be employed having a like effect.

The numeral 15 designates a compressed air line which is connected with a compressed air supply or distributing system. This line has connected in it a valve chamber 16 containing a valve member 17 for opening and

closing the air conduit. The line 15 enters the upper part of the well casing, and when the valve 17 is opened the air pressure is admitted to the well and acts upon the surface of the liquid present, so as to drive it up the discharge tube 5. In addition, this tube is provided with suitable openings 18, at different heights, and the air entering these openings assists to raise the liquid either by lightening the column or by breaking it up into slugs, or in any other known manner. The well is thus pumped or flowed by the conjoint action of air displacement and some form of air lift in which air is introduced into the column of liquid. However, the invention is not necessarily limited in this respect, and the liquid may be flowed by displacement alone or by some form of air lift without displacement.

A regulator pipe 19 extends through the top 4 and downward within the casing 2 to a point near, or somewhat above, the shot-hole, where its open lower end is commanded by a suitable float valve 20, which is adapted to be closed by a predetermined rise in the liquid level, and to be held closed by the pressure of the flowing medium when the latter is admitted to the well. This pipe or conduit at a point outside the well is constricted to a small aperture, as by means of a needle valve 21. At a point between this constriction and the well, a branch 22 is taken off from the regulator pipe and connected with a diaphragm or piston chamber 23, the diaphragm or piston 24 in this chamber being connected with the stem 25 of the valve 17. A weight 26 or a spring acts upon the valve 17 to open it.

The pipe 11 heretofore referred to is connected with the branch 22.

While the liquid is heading up in the well, the natural gas, which also enters the shot-hole from the oil-bearing strata, finds an escape through the regulator pipe 19 and past the constriction 21, which maintains a suitable back-pressure in the regulator pipe. This back-pressure is communicated through the branch 22 to the diaphragm chamber 23, where it acts upon the diaphragm so as to hold the air valve 17 closed. The gas passing the needle valve 21 might be discharged to atmosphere, though for economy the outer portion of the regulator pipe is preferably either connected with the outer portion of the discharge branch 6 or with apparatus for treating or utilizing the gas. The gas can not escape from the well through the openings 18 and out by way of the discharge tube because of the fact that the check-valve 7 is held closed with sufficient force by the superincumbent column of liquid.

The pipe 11 is provided with an automatic valve 12 capable of opening to a sufficient predetermined pressure acting from the discharge tube 5 toward the pipe 22, but closing against flow or pressure in the opposite direction. This check-valve is normally held closed by a spring or weight 33, adjusted to a sufficient value so that after the float valve 20 is closed by the rise of liquid in the well, any rise in pressure in the interior of the tube 5 that may take place before the flow of the liquid reaches the vanes 14 and closes the valve 10 cannot open the valve 12 and act on the diaphragm 24 to bring about premature closing of the main valve 17.

When the liquid rises in the well to a point at or somewhat below its natural level, or to such point as it may be most economical and advantageous to allow the liquid to head up before flowing it out of the well, the float valve 20 is automatically closed against its seat at the lower end of the regulator pipe 19, thereby cutting off further outflow of gas through this pipe and causing the pressure in the pipes 19 and 22 and in the diaphragm chamber 23 to fall as the gas in the pipe continues to leak past the constriction 21. The main air valve 17 is now automatically opened and the compressed air or other gaseous or aeriform medium is turned on into the closed well through the pipe 15, so as to flow the accumulated liquid out through the pipe 5. This pressure holds the valve 20 closed. While the liquid is flowing through this discharge pipe, its momentum acts upon the vanes 14 so as to close the valve 10 and hold it closed. When the air following the liquid reaches the upper part of the tube 5, its momentum is insufficient to hold the valve 10 closed, and this valve accordingly drops open, the rod 13 and vanes 14 being heavy enough to insure this, permitting the pressure of the flowing medium to act through the pipe 11 and past the check-valve 12. This pressure acts upon the diaphragm 24 so as to close the air valve 17, and also acts downwardly in the regulator pipe 19 so as to unseat the float valve 20 should the latter tend to stick. The remaining pressure of the flowing medium in the well escapes through the release openings 18 and through the regulator pipe, and the liquid and natural gas again enter the shot-hole, the gas finding its way through the regulator pipe 19 and acting to hold the air valve 17 closed, and the liquid eventually rising high enough to close the float valve 20, whereupon the cycle of operations is repeated.

It may be that the strata in which the well is drilled will not have enough pressure either of natural gas or of air or other gas artificially imposed upon the strata, to serve as the operating medium. Such would be the case, for example, in a water well or in an oil well lacking or deficient in pressure. To meet such a condition a by-pass 27 is shown connected with the flowing medium pipe 15 around the valve 17, this by-pass containing a needle valve 28 which can be set to allow of a constant leakage of flowing me-

dium into the well. This leakage of flowing medium into the well either supplements the deficient pressure entering the shot-hole or takes the plate of such pressure. Such portion of the flowing medium introduced into the well serves as an operating medium, passing through the regulator pipe 19 as long as the float valve 20 remains open, and causing the flowing medium valve 17 to stay closed until the path of escape through the regulator pipe is closed by the rise of the liquid, whereupon the change in condition in the regulator pipe is utilized to cause the opening of the valve 17.

It will be understood that the flowing medium may be air or gas, or a mixture of air and gas. It may be termed, generally, an aeriform fluid or medium.

Figure 2

In the method and apparatus here illustrated the discharge pipe or tube 5^a is of larger diameter and has an enlarged lower portion 29. The regulator pipe 19^a extends downward within the tube 5^a and has a float valve 20^a at its lower end within the upper portion of the enlargement 29. This valve is adapted to be held closed by the action of liquid flowing past it through the discharge tube 5^a, but to drop open when the air or other flowing medium following the liquid reaches it, the momentum of the flowing medium being insufficient to hold the valve closed. The upper portion of the regulator pipe 19^a is shown connected with the inlet opening of a piston chamber 23^a, the outer portion of the regulator pipe extending from the outlet of this chamber and being provided with a needle valve or constricted aperture 21.

While the liquid is heading up in the well the gas or other operating medium escapes through the regulator pipe 19^a, and as long as its pressure is sufficiently maintained in the chamber 23^a, the flowing medium valve 17 connected with the piston 24^a remains closed. When the rise of the liquid in the shot-hole and in the lower portion 29 of the discharge tube closes the float valve 20^a, the drop in flow or pressure through the regulator pipe and through the chamber 23^a causes or permits the valve 17 to open and the flowing medium flows the liquid out of the well. A spring 26^a is shown for opening the valve 17.

When the flowing medium has displaced the liquid and reaches the float valve 20^a, this valve is caused to open and the pressure of the flowing medium, acting through the regulator pipe 19^a, causes the valve 17 to close. The remaining excess of flowing pressure in the well leaks out through the openings 18 and through the regulator pipe, and the liquid and operating medium again enter the shot-hole.

As in the other form, a by-pass 27 and constant leakage valve or aperture 28 may be provided to supply operating medium to the well from the pressure in the flowing medium line 15 at the compressor side of the valve 17.

Figure 3

A regulator pipe 19^b is adapted to be closed at its lower end by a float valve 20, which, however, might be omitted. In the upper part of the regulator pipe there is one of the low-pressure high-pressure valves 31. The valve member 34 of this valve is acted upon by a spring 35 to hold it away from its seat 36 against low or moderate pressure acting from the pipe 19^b toward the chamber 23^a, but to be closed by comparatively high pressure acting in this direction. From this valve the regulator pipe proceeds to the inlet of a piston chamber 23^a, the outlet from this chamber being constricted at 21 so as to hold a desired back-pressure of operating medium. The flowing medium line 15, at a point beyond the valve 17, is branched, one branch 37 opening into the well casing 2 and the other branch 38 being connected with the regulator pipe 19^b at a point above or beyond a check-valve 39 in this pipe. In other words the branch 38 connects with the regulator pipe at a point between this check-valve and the low-pressure high-pressure valve 31. The check-valve 39 is arranged to open to pressure or flow acting upwardly through the regulator pipe 19^b and to close to pressure acting in the reverse direction.

While the liquid heads up in the well, operating fluid, which enters the shot-hole from the surrounding strata escapes through the regulator pipe 19^b, past the check valve 39 and the low-pressure high-pressure valve 31 into the piston chamber 23^a, where its back pressure acts upon the piston 24^a to hold the main pressure valve 17 closed. When the liquid rises high enough to close the float valve 20 or to rise above the lower end of the regulator pipe 19^b, the outflow of the operating medium is cut off, with the result that the valve 17 is caused to open. The high-pressure flowing medium is then admitted to the interior of the well through the branch 37. Through the branch 38 and the upper portion of the regulator pipe it also acts upon the low-pressure high-pressure valve 31, closing this valve instantly so that the high pressure can not reach the chamber 23^a to again close the valve 17.

The liquid is then flowed out of the well, and as this operation proceeds the pressure in the well acting upon the low-pressure high-pressure valve 31 diminishes until at or about the moment when all of the liquid has been elevated past the check-valve 7, the pressure has fallen to such a point that the low-pressure high-pressure valve 31 automatically opens, admitting the pressure through the

branch 38, past the low-pressure high-pressure valve, to the operating chamber 23^a, where it causes the closing of the valve 17.

Figure 4

This is a design suitable more particularly for wells in sand too soft to withstand the flowing pressure if applied to the walls of the shot-hole. Accordingly, an enclosed volume chamber 49 is disposed in the shot-hole, this chamber having an automatic inlet valve 50 at the bottom. The upper end of the chamber communicates with the lower end of an air tube 51, by which the volume chamber may be supported. The air tube 51 extends upward through the closed top of the casing 2 and is connected above the latter with the flowing medium line 15. The discharge tube 5 passes centrally through the length of the air tube 51, and downward within the volume chamber 49 to a point near the bottom thereof, this tube being provided with openings 18 and with a check-valve 7 above the highest of these openings.

A regulator pipe 19^f extends downward within the well casing and through the top of the volume chamber 49 to a sufficiently low point therein. A float valve 52 is arranged to close the lower end of this pipe as long as there is a suitable level of liquid in the volume chamber and to open automatically when the liquid in the chamber falls to a comparatively low level. The regulator pipe 19^f also has an inlet 53 above and outside of the volume chamber 49, this inlet being controlled by a float valve 54 adapted to be closed by the liquid when it reaches this level in the well outside of the volume chamber, and to open when the liquid outside the volume chamber falls below this level. The regulator pipe 19^f is connected with the piston chamber 23^a, the outlet of which is restricted by the back-pressure valve or aperture 21, this outlet passage being shown connected with the upper part of the discharge pipe 5 past a check-valve 48.

The liquid and natural gas or other operating medium enter the shot-hole 3, and the liquid enters the volume chamber 49 past the inlet valve 50. The operating medium enters the regulator pipe 19^f, past the float valve 54, until the liquid rises high enough in the well outside of the volume chamber to close this valve, whereupon the escape of the operating medium through the regulator pipe 19^f is cut off and the piston 24^a is allowed to descend, either by its own weight or by the action of a separate weight or spring, thus opening the main pressure valve 17. The flowing medium is thereby admitted to the tube 51, whence it forces the fluid out of the chamber 49 and up the discharge pipe 5. When most of the fluid has been forced out of the chamber 49, the float valve 52 opens, permitting the flowing pressure to act on the piston 24^a, thus closing the valve 17. The flowing medium remaining in the chamber 49 escapes through the openings 18 and through the regulator pipe, allowing the head of liquid in the well outside of the volume chamber to open the inlet valve 50 and to refill or partly fill the volume chamber 49.

As soon as the liquid falls away from the float valve 54, this valve opens, permitting the operating medium, which now enters the shot-hole, to pass through the inlet 53 and through the regulator pipe and the operating chamber 24^a so as to hold the main pressure valve 17 closed. The entrance of liquid filling the volume chamber causes the valve 52 to close, and when the liquid outside of the volume chamber eventually rises high enough to close the float valve 54, the escape of operating medium through the regulator pipe is again cut off, the main pressure valve 17 is again opened, and the liquid in the volume chamber is again discharged upward through the pipe 5.

I claim:

1. The method of flowing wells which comprises maintaining a back pressure on an aeriform operating medium escaping from the well, utilizing the pressure of such medium to keep a flowing medium turned off from the well, and utilizing fall in pressure in said medium due to rise of liquid in the well to bring about turning on of the aeriform flowing medium.

2. The method of flowing wells which comprises maintaining a back pressure on an aeriform operating medium escaping from the well, utilizing the pressure of such medium to keep a flowing medium turned off from the well, utilizing fall in pressure in said medium due to rise of liquid in the well to bring about turning on of the aeriform flowing medium, and utilizing pressure of the flowing medium to bring about turning off of the aeriform flowing medium when liquid has been flowed out of the well.

3. The method of flowing wells which comprises maintaining a back pressure on an aeriform operating medium escaping from the well, and utilizing the fall in pressure in said medium when escape thereof is obstructed by predetermined rise of liquid in the well to turn on an aeriform flowing medium.

4. The method of flowing wells which comprises applying the pressure of an operating medium escaping from the well to cause aeriform flowing medium to be shut off from the well during the period required for the liquid to head up, and obstructing the escape of the operating medium by a predetermined rise of liquid in the well so that the flowing medium then flows the liquid out of the well, while keeping the path of escape of operating medium obstructed during the flowing period.

5. The method of flowing wells which comprises utilizing the fall in pressure in an aeriform operating medium escaping from a well to turn on a flowing medium when the escape of the operating medium is obstructed by predetermined rise of liquid in the well.

6. The method of flowing wells which comprises keeping an aeriform flowing medium shut off from the well during the period required for the liquid to head up, conducting aeriform operating medium from the well during such period, obstructing the escape of said operating medium by rise of liquid in the well, utilizing the resulting change in condition in the path of escape of the operating medium to turn on the flowing medium, keeping the path of escape of the operating medium obstructed during the flowing period, and thereafter reopening said path.

7. Pneumatic well-flowing apparatus having a valve for turning on and off the flowing medium, a conduit for conducting a flow of aeriform operating medium from the well adapted to become obstructed on predetermined rise of liquid in the well, said conduit provided with a restricted escape orifice, and means connected with said conduit for controlling said valve.

8. Pneumatic well-flowing apparatus, comprising a discharge tube extending to the lower part of the well and having entrance openings for flowing medium at one or more points above its open lower end, means for delivering the flowing medium to the well, a valve for turning on and off the flowing medium, a conduit for conducting a flow of operating medium from the well adapted to become obstructed on predetermined rise of liquid in the well, means opposing escape of operating medium through said discharge tube, and means connected with said conduit for controlling said valve.

9. Pneumatic well-flowing apparatus having a valve for turning on and off the flowing medium, a conduit for conducting a flow of operating medium from the well adapted to become obstructed on predetermined rise of liquid in the well, and means connected with said conduit for controlling said valve, there being means whereby said conduit is kept obstructed by the pressure acting to flow the liquid out of the well.

10. Pneumatic well-flowing apparatus having a valve for turning on and off the flowing medium, a conduit for conducting a flow of operating medium from the well, means connected with said conduit for controlling said valve, a valve subject to rise of liquid in the well and to pressure during the flowing period for closing said conduit, and means for automatically applying the pressure at the end of the flowing period to unseat the second-mentioned valve.

11. Pneumatic well-flowing apparatus having a valve for turning on and off the flowing medium, a conduit for conducting a flow of operating medium from the well adapted to become obstructed on predetermined rise of liquid in the well, and means connected with said conduit for controlling said valve, there being means whereby said conduit is caused to remain obstructed during flowing and is thereafter automatically reopened for the escape of operating medium.

12. Pneumatic well-flowing apparatus having a valve for turning on and off the flowing medium, a conduit for conducting a flow of operating medium from the well adapted to become obstructed on predetermined rise of liquid in the well, means connected with said conduit for controlling said valve, and means whereby the pressure of the flowing medium is applied at the end of the flowing period to bring about closing of said valve.

13. Pneumatic well-flowing apparatus having a valve for turning on and off the flowing medium, a conduit for conducting a flow of operating medium from the well adapted to become obstructed on predetermined rise of liquid in the well, means connected with said conduit for controlling said valve, means whereby said conduit is caused to remain obstructed during flowing to be thereafter automatically reopened, and means for automatically applying the flowing pressure at the end of the flowing period to bring about the closing of said valve.

14. Pneumatic well-flowing apparatus having a valve for turning on and off the flowing medium, means for bleeding a portion of the flowing medium into the well to serve as an operating medium, a conduit for conducting a flow of said operating medium from the well adapted to become obstructed on predetermined rise of liquid in the well, said conduit provided with a restricted escape orifice, and means connected with said conduit for controlling said valve.

15. Pneumatic well-flowing apparatus including a discharge tube for conducting liquid from the well, a valve for turning on and off the flowing medium, a conduit for conducting a flow of operating medium from the well, means connected with said conduit for controlling said valve, and means connected with the upper part of the discharge conduit whereby the pressure therein toward the end of the flowing period is utilized to bring about closing of said valve.

16. Pneumatic well-flowing apparatus including a discharge tube for conducting liquid from the well, a valve for turning on and off the flowing medium, a conduit for conducting a flow of operating medium from the well, means connected with said conduit for controlling said valve, and a conduit leading from the upper part of the discharge conduit and connected with said controlling means for communicating pressure from the discharge tube toward the end of the flow-

ing period to bring about closing of said valve.

17. In well-flowing apparatus, an eduction pipe, a conduit for supplying aeriform fluid to the well to flow liquid out through said eduction pipe, a valve in said conduit, and means responsive to increased pressure in the upper part of said eduction pipe to bring about closing of said valve.

RICHARD M. HASKELL.