

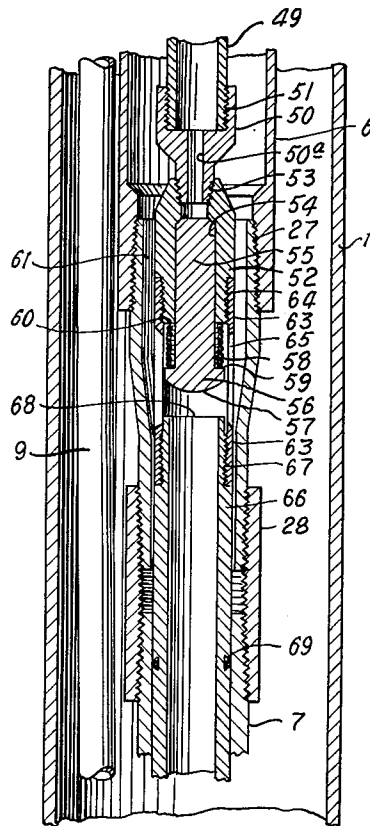
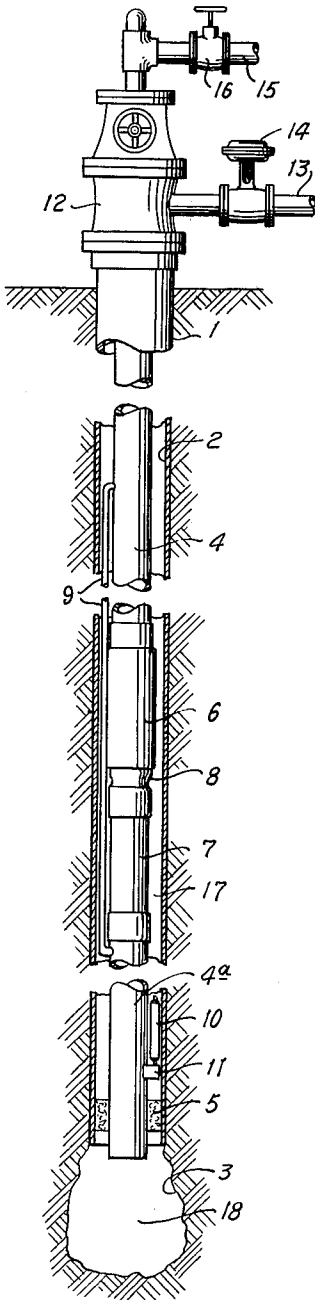
May 14, 1963

R. C. DAVIS  
GAS LIFT CHECK VALVE

3,089,431

Filed Feb. 25, 1958

3 Sheets-Sheet 1



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**3,089,431**

## GAS LIFT CHECK VALVE

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**3 Sheets-Sheet 2**

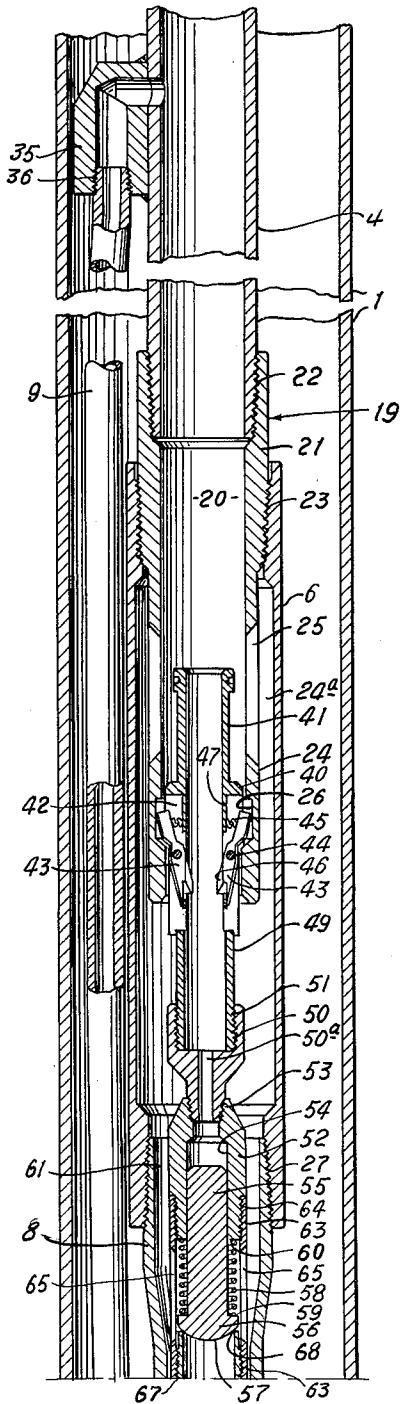


Fig. II

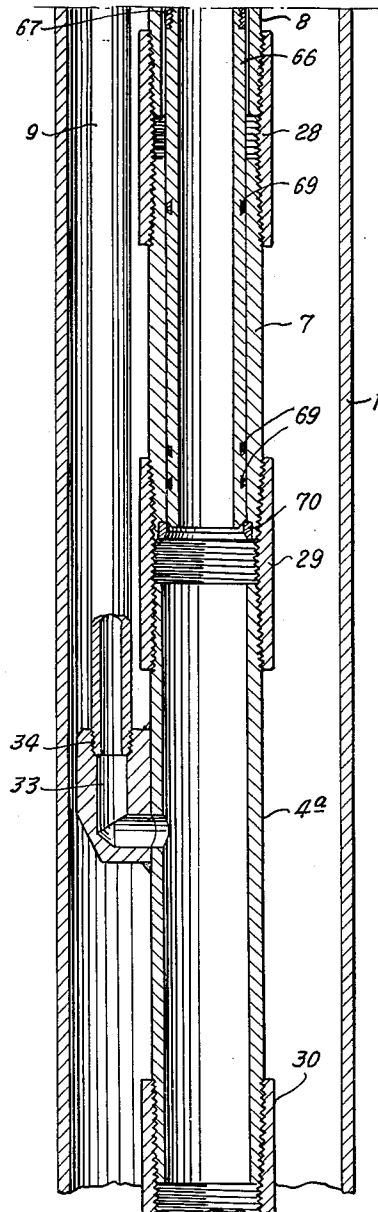


Fig. II-A

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GAS LIFT CHECK VALVE

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3 Sheets-Sheet 3

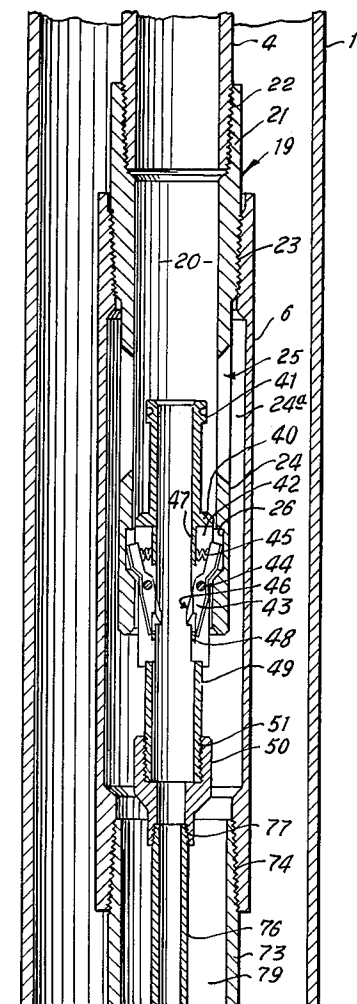


Fig. IV

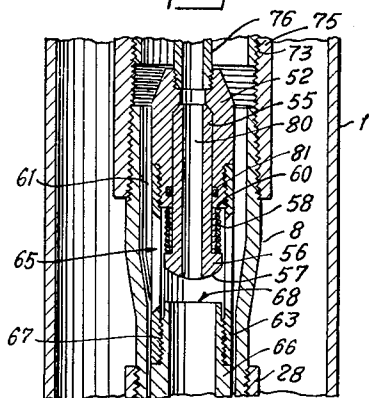


Fig. V

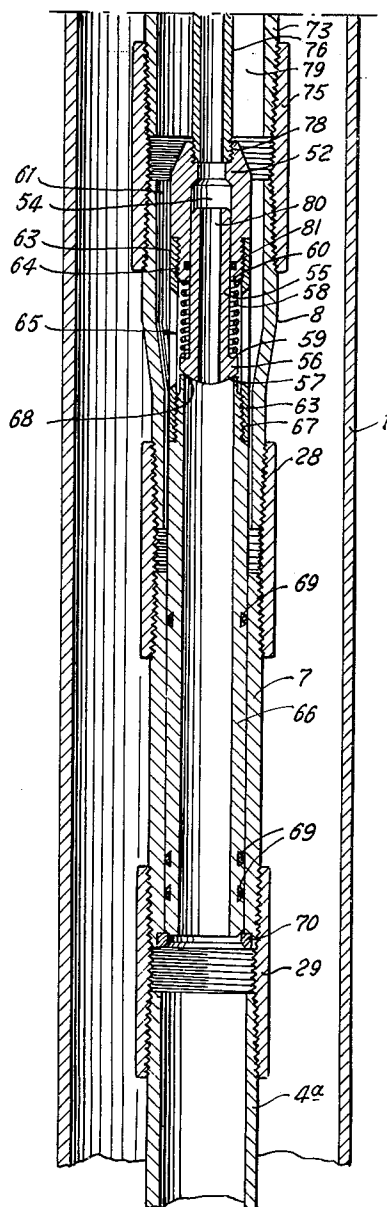


Fig. IV-A

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3,089,431

## GAS LIFT CHECK VALVE

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Filed Feb. 25, 1958, Ser. No. 717,460

8 Claims. (Cl. 103—232)

This invention is concerned with improvements in gas lifting liquids such as oil and/or water from wells bored into the earth's strata, and is particularly concerned with means to prevent the fall back of liquid into the tubing adjacent the producing formation between cycles of gas injection into the tubing, to thereby allow fluid to more rapidly fill into the well bore from the producing formation, thus permitting more frequent cycles of injection of gas into the tubing, and increasing the productivity of the well over a given period of time.

In gas lifting fluids, such as oil and/or water, from a well, one or more gas lift valves are disposed on, or in, the tubing string and the gas is injected through one of the valves, commonly referred to as the working valve, into a column of fluid which has risen into the tubing from the producing formation. Such gas is usually injected through the gas lift valve from the tubing-casing annulus by a pressure build up of such gas which opens the gas lift valve at a pre-determined pressure.

The gas is usually injected into the tubing-casing annulus at timed intervals, by appropriate surface controls such as a time-cycle intermitter and a motor valve, and the frequency of injection into the tubing-casing annulus is determined by the time which it takes for liquid from the reservoir to rise into the tubing or eductor tube to a pre-determined level for most efficient gas lifting of such fluid.

When gas is injected into the tubing under a column of fluid the fluid is lifted to the surface through the tubing by the expanding gas.

At the end of the cycle of injection of gas into the tubing-casing annulus, the pressure in the tubing-casing annulus decreases, the gas lift valve closes, and no further gas is injected into the tubing to lift the fluid therein to the surface.

When the injection of gas into the tubing ceases, the pressure falls in the tubing and a portion of the liquid fails to reach the surface and therefore falls back into the tubing adjacent the producing formation. It has been found that the percentage of the fluid which is not lifted to the surface during each cycle of gas injection increases as the depth of gas injection increases.

One of the principal reasons for this fall back of fluid is the fact that a portion of the liquid is deposited along the wall of the conduit. The amount of liquid so adhering to the wall of the conduit is determined by the depth of the conduit, and such deposited liquid will return to the bottom of the well by gravity after the lifting gas has expanded and passed out of the tubing. Such liquid is commonly called "fall back" or "slippage."

This fall back fluid constantly exerts additional pressure against the producing formation, thus increasing the fill-in time from the producing formation into the tubing.

The fill-in time is that period of time required for a pre-determined quantity of fluid to flow from the producing formation into the tubing, and the rate of flow from the producing formation into the tubing for most efficient gas lifting, is determined by the pressure differential between the formation and the well bore. The rate of flow into the well bore from the producing formation decreases as the column of fluid rises in the tubing, which increases the pressure on the producing formation.

Since the fill-in time determines the frequency of in-

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jection of gas into the tubing, it is desirable that the fill-in time be decreased, thereby permitting more frequent cycles of injection of gas into the tubing.

By eliminating the fall back of fluid to the producing formation between cycles of gas injection the pressure of such fluid on the producing formation is eliminated, thereby permitting fluid to more rapidly fall into the well bore and the tubing from the producing formation, and permitting more frequent injections of gas into the tubing. In other words, the fill-in time and frequency of injections of gas determines the productivity of the well by gas lift.

The fall-back of fluid between cycles of gas injection constitutes a particular problem in wells having a low pressure differential between the producing reservoir and the well bore. In such wells the rate of flow or fill-in from the reservoir to the well bore and tubing decreases as the column of fluid rises in the tubing due to the lowering of pressure differential between the reservoir and the well bore.

As explained above, the fluid which falls back between cycles of injection of gas exerts an increasing pressure on the producing formation, increases the fill-in time, and thereby decreases the number of cycles of gas injection in a given period, thus materially lowering the productivity of the well.

This invention has utility in all gas lift systems regardless of the productivity characteristic of the well, but has particular utility in wells having low pressure differential between the producing reservoir and the well bore.

It is therefore a primary object of this invention to provide means to eliminate the pressure exerted on a producing formation in a well caused by fall back of fluid into the tubing between cycles of gas injection.

A further object of this invention is to decrease the time required for a given amount of fluid to flow into the well bore and tubing string after a cycle of gas injection into the tubing.

A still further object of this invention is to provide means to permit more frequent cycles of gas injection into the tubing.

Still another object of the invention is to carry out the foregoing objects by apparatus which may be removably inserted in the tubing string after the tubing is run into the well.

An additional object of the invention is to provide means for preventing fall back of fluid adjacent the producing formation between cycles of gas injection but which will permit gas from the producing formation to escape about or through the control apparatus to thereby prevent build-up of pressure in the well bore and tubing below the control apparatus.

A general object of the invention is to provide means in a gas lift system for producing greater quantities of oil and/or water by gas lift in a given period of time.

Other and further objects of the invention will become apparent upon reading the detailed specification hereinafter following and by referring to the drawings annexed hereto.

Preferred embodiments of the invention are shown in the attached drawings in which:

FIGURE I is a partially diagrammatic, partially sectionalized, fragmentary view of a gas lift installation in a well bore, incorporating the preferred form of the invention disclosed herein.

FIGURES II and II-A shows a fragmentary cross-sectional, elevational view of the preferred form of the invention incorporated in a tubing string extending into the casing of a well.

FIGURE III shows a fragmentary cross-sectional view

of the fall back check valve inserted in the tubing string, with the valve shown in open position.

FIGURES IV and IV-A show a fragmentary cross-sectional, elevational view of a modified form of the invention incorporated in a tubing string extending into a casing of a well.

FIGURE V is a fragmentary cross-sectional elevational view of the fall back check valve shown in FIGURE IV-A, with the valve in open position.

Numerical references are employed to designate the various parts of the devices shown in the drawings and like numerals indicate like parts throughout the various figures of the drawings.

Referring to FIGURE I, a well casing 1 extends into the well bore 2, and is cemented in place in the usual manner, with the lower end thereof terminating above a producing formation 3, said casing being supported at the surface by a well head 12.

A tubing string, which is made up of an upper section 4 and a lower section 4a, extends into the casing, with the lower end thereof in communication with the producing formation 3. A conventional packer 5, such as a hook wall packer, is incorporated as a part of tubing string and is expanded between the tubing string and the casing 1, adjacent the lower end of the tubing, to seal and isolate the producing formation 3 from the tubing casing annulus 17 above. It will thus be seen that fluid from the producing formation 3 may flow into the well bore 18 and upwardly into the tubing string from whence it may be gas lifted to the surface in the manner herein described.

A flow coupling 6, a seating nipple 7 and a swage nipple 8, which form parts of the invention described herein, are assembled and attached between the sections of tubing 4 and 4a in the manner hereinafter described. A by-pass tube 9 communicates at opposite ends with the tubing sections 4 and 4a to provide a by-pass for gas produced from the producing formation 3, about the fall back check valve, in the manner and for the purpose hereinafter described.

A conventional gas lift valve 10, the opening of which is controlled by gas pressure injected into the tubing-casing annulus 17, is mounted on the exterior of the tubing section 4a so as to communicate therewith. It will be understood that a plurality of such gas lift valves 10 may be mounted at spaced intervals along the tubing string in the usual and customary manner for the purpose of unloading the well of fluid. The valve 10 is commonly referred to as the working valve through which gas is injected into the tubing from the tubing-casing annulus 17, after the well has been unloaded of fluid down to the working valve, and put on gas lift production. The valve 10 is mounted on the tubing string by a fitting or mandrel 11 of conventional construction, which communicates with the interior of the tubing string.

Gas is supplied to the tubing-casing annulus 17 through a supply line 13, flow through which is controlled by a conventional motor valve 14. The gas may be admitted through the supply line 13 and motor valve 14 at timed intervals by a time controlled surface intermitter (not shown) which opens the motor valve 14 in the usual and customary manner, not necessary to describe in connection with this invention. Oil and/or water from the producing formation is lifted to the surface by gas injected through the gas lift valve 10 and flows outwardly at the surface through the production line 15, flow through which is controlled by a manually operated valve 16.

The detailed construction of the preferred form of the invention is shown in FIGURES II, II-A and III. In such form a tubular landing nipple 19, having a bore 20 therethrough, and an enlarged head 21 thereon, is threadedly engaged, as indicated at 22, to the upper tubing section 4, and is threadedly engaged to the tubular flow coupling 6 by threads, as indicated at 23.

The landing nipple 19 has a reduced lower portion 24,

which is provided with a plurality of ports 25 through the wall thereof, and an annular space 24a is thus formed between the lower end 24 of the landing nipple 19 and the inner wall of the enlarged flow coupling 6 so as to permit fluid to freely flow through such annular space 24a and through the ports 25 into the tubing string 4 above.

An annular recess 26 is formed on the inner side of the reduced extension 24 of the landing nipple 19 for the purpose of receiving the upper ends of the latches 43 to thereby removably position the fall-back check valve assembly in the tubing string in the manner hereinafter described.

The enlarged flow coupling 6 is threadedly engaged to the swage nipple 8 by companion threads 27.

The reduced diameter of the swage nipple 8 is connected to the seating nipple 7 by a coupling 28, and the seating nipple 7 is connected to the lower section of tubing 4a by means of a coupling 29. The lower section of tubing 4a may be engaged to another section of tubing (not shown) below by means of a coupling 30.

A lower hollow fitting 33 is secured, as by welding to the outer side of the lower section of tubing 4a so as to communicate with the interior of the tubing section, and the lower end of the by-pass tube 9 is threadedly engaged in said fitting by means of companion threads 34.

The by-pass tube 9 extends upwardly past the fall back check valve assembly and is threadedly engaged at 36 to a downwardly facing hollow fitting 35, secured on the outer side of the upper tubing section 4 so as to communicate therewith. The by-pass tube 9 permits gas emanating from the producing formation 3 to by-pass the fall back check valve assembly to prevent pressure from building up below said check valve while the valve is closed to such an extent as to prematurely open the check valve and thereby permit fall back fluid trapped thereabove to enter the tubing string below the valve. By-pass tube 9 also prevents formation gas from accumulating and building up pressure on the producing formation, thus offsetting the advantage gained by the fall back check valve.

It is desirable that the fall back check valve assembly, hereinafter described, be removably insertable in the tubing string, so that the outer housing for the fall-back check valve assembly may be installed in the tubing string when it is initially run and the fall back check valve assembly may be later removably inserted by wire line operation. Furthermore it is desirable that the check valve assembly be removable for the purpose of replacement or repair.

For the purpose of providing for removable insertion of the fall back check valve in the tubing string a conventional locking device 40 is provided.

The locking device 40 includes a fishing neck 41 with which a conventional wire line running and retrieving tool may be detachably engaged for the purpose of running and retrieving the tool on a wire line.

The locking device 40 includes diametrically opposed recesses 42 in the wall thereof in which the latching dogs 43 are pivotally mounted by means of pivot pins 44. The upper ends of the dogs 43 are normally urged outwardly by the springs 45, and when in outward position the lower ends 46 extend inwardly of the bore of the body of the locking device. The inward movement of the upper ends of the dogs 43 is limited by the wall portion 47, and the inward movement of the lower ends 46 of the dogs is limited by engagement of the dogs with a wall portion 48 of the body of the locking device.

As the locking device 40 with the check valve attached thereto, is lowered into the tubing on a wire line, the upper ends of the dogs 43 are urged inwardly against the springs 45 to allow the dogs to slide down the tubing. When the dogs 43 reach the recess 26, the springs 45 urge the upper ends of the dogs into recess 26 so that they will engage the upper edge of the recess and prevent upward

movement of the locking device, and valve attached thereto, until the dogs are retracted.

The dogs 43 may be retracted to disengage them from the recess 26 for retrieving the tool by means of a cylindrical member, (not shown) attached to a wire line retrieving tool (not shown), which cylindrical member enters the bore of the locking device 41, as the retrieving tool engages the fishing neck 41, and presses the lower ends 46 of the dogs 43 outwardly, causing the upper ends of the dogs to move inwardly out of engagement with the recess 26.

The locking device 40 is provided with the tubular extension 49 which is threadedly engaged to a reducer coupling 50 by means of companion threads 51. The reducer coupling 50 is provided with a concentric passage 50a therethrough to provide communication between the enlarged bore 54 of the connector head 52 and the upper section of tubing string 4 so as to prevent fluid from being trapped within the enlarged bore 54, which might prevent movement of the valve stem 55.

The reducer coupling 50 is threadedly engaged to the connector head 52 by means of a threaded connection 53.

The connector head 52 has an enlarged bore 54 therein, in which a valve stem 55 is slidably disposed.

Formed integrally on the lower end of the valve stem 55 is an enlarged valve head 56, having a conical seating surface 57 thereon. A coil spring 58 is disposed about the valve stem 55 between a shoulder 59, formed on the upper surface of the valve head 56, and the lower end 60 of the connector head 52. The spring 58 normally urges the valve stem 55 downwardly into seating position.

A tubular valve housing 63 is threadedly engaged to the lower end of the connector head 52 by means of companion threads 64. The valve housing 63 is provided with a plurality of apertures 65 formed through the wall thereof to permit fluid to flow outwardly through such apertures and upwardly through the annular space 61, provided between the upper enlarged end of the swage nipple 8 and the connector head 52, when the valve head 56 is lifted from its seat.

A tubular sealing nipple 66 is threadedly engaged to the lower end of the valve housing 63 by companion threads 67. The upper end of the sealing nipple 66 provides a valve seat 68 with which the valve head 56 is normally engaged to close the bore through the sealing nipple 66, the said valve head being urged into engagement with the seat 68 by the spring 58.

The spring-urged valve stem 55 and head 56, with valve seat 68, constitutes an upwardly opening, pressure actuated, back flow check valve to prevent fall back of fluid into the tubing string therebelow between cycles of gas injection.

The sealing nipple 66 is provided with O-ring seals 69 carried in appropriate grooves in the outer wall thereof to provide a fluid seal between the sealing nipple 66 and the seating nipple 7.

A stop ring 70 is secured in the lower end of the seating nipple 7 so as to extend inwardly thereof and provide a stop for the downward movement of the sealing nipple 66 when inserted in the seating nipple 7.

The assembly, operation and function of the preferred embodiment of the invention hereinbefore described is as follows:

The casing 1 is run into the well bore 2 and cemented in place in the usual manner. The tubing string 4—4a, which is composed of a multiplicity of joints attached by couplings, is then made up and run into the well with the packer 5 positioned and sealed between the casing and the tubing at the desired level above the producing formation 3.

As the tubing string is made up and run into the well the desired number of gas lift valves 10 are mounted on the tubing in the usual manner to communicate therewith.

For the purpose of illustration of this invention only the lowermost working valve 10 is shown.

At the desired position above the gas lift valve 10 the seating nipple 7, swage coupling 8, enlarged flow coupling 6, and landing nipple 19 are assembled and incorporated in the tubing string in the manner hereinbefore described, such assembly constituting a housing for the retrievable check valve assembly, having a flow course therethrough defined by the annular spaces 61 and 24a and ports 25 and apertures 65 communicating therewith.

The position of the gas lift valve 10 with relation to the packer 5 is determined in a manner well known in the art, depending on the characteristics of the producing formation. Normally in low production type wells, in which this invention has particular advantage, the gas lift valve 10 will be located immediately above the packer 5 and the packer will be located immediately above the producing formation 3.

Knowing the depth of the gas lift valve 10, the amount of slippage or fall back of fluid between gas injections can be closely estimated by mathematical computation. The seating nipple 7 and the flow coupling 6 will be positioned above the gas lift valve 10 a suitable distance so as to permit the desired fill-in of fluid between gas lift cycles without the fluid rising to the level of the fall back check valve. This will be determined by the pressure of the lifting gas and the depth of the operating valve 10.

The by-pass tube 9 is incorporated in the tubing string with the lower end in communication with the tubing section 4a, below the check valve assembly, and the upper end in communication with the tubing section 4, above the check valve assembly. The upper end of the by-pass tube 9 should communicate with the tubing string above the check valve assembly at a position above the level of the fall back fluid which will be trapped above the check valve, so that the fluid cannot flow back into the producing formation through the by-pass tube while the check valve is closed.

The well head 12, flow line 13, motor valve 14 and production line 15 are assembled at the surface after the casing and tubing string has been run in the manner described.

The housing for the retrievable check valve assembly may be incorporated in the tubing string when it is initially run, and the valve assembly run into, and removably attached, in the housing at a later time when the productivity of the well decreases to such an extent as to require such a fall back check valve, or the check valve may be attached and run at the time of installation of the tubing.

Although it is desirable that the check valve be retrievable by wire line, it will be understood that such a check valve could be fixedly attached in the tubing string and perform the function herein described.

For running the check valve assembly in the well it is secured to the locking device in the manner hereinbefore described and run into the well on a wire line. The seating nipple 66 is inserted in the sealing nipple 7 until the lower end contacts the stop ring 70, at which time the locking dogs 43, on the locking device 40, have entered the recess 26 to removably latch the check valve assembly in place.

When gas lift valve 10 opens, gas is injected into the tubing string through the gas lift valve. Such injection is made at the lower end of the column of fluid which has filled into the tubing from the producing formation 3. The fluid is aerated and lightened by the gas and caused to rise in the tubing.

The increase in pressure, and the upward movement of the fluid in the tubing string, moves the valve head 56 from its seat 68, and allows the fluid and gas to pass outwardly through the apertures 65, upwardly through the annular space 61, and through the annular space 24a in the flow coupling 6. Such lightened fluid passes through the ports 25 in the wall of the landing nipple

19 above the locking device 40 and upwardly through the tubing to the surface.

When the check valve opens, the fall back fluid previously trapped above the check valve joins in the upward movement.

As the liquid column moves through the tubing toward the surface, a certain volume of liquid adheres to, and is deposited along, the inner surface of the tubing 4, due to "wetting action" previously described, and this liquid falls back into the tubing and is trapped above the check valve when it closes after a cycle of gas injection. Such "wetting action" and "slippage" is the principal cause of fall back of liquid between cycles of gas injections, but it will be understood that other factors, such as reduction of pressure in the tubing when the gas lift valve closes, contribute to such fall back.

When the cycle of injection of gas into the tubing-casing annulus 17 ceases, the pressure is lowered to such an extent as to allow the valve 10 to close, thus preventing further injection of gas into the tubing string. The pressure in the tubing string drops rapidly as the gas therein expands and passes out of the tubing at the surface. The spring 58 forces the valve stem 55 downwardly, causing the valve head 56 to contact the valve seat 68 and close the passage through the seating nipple 8. The liquid deposited along the wall of the tubing and liquid which has failed to reach the surface above the valve assembly will fall back down the tubing. Since the check valve is closed such fluid is trapped above the check valve so that it cannot fall back into the lower section of tubing 4a and exert pressure on the formation 3. This allows fluid to fill in from the formation to the well bore 18, and rise upwardly in the tubing below the check valve, at a more rapid rate. Therefore, the interval between gas injections is materially decreased, thereby increasing the productivity of the well by gas lift over a given period of time.

Any gas produced from the formation 3 while the check valve is closed will rise in the tubing and pass through the flow-by tube 9 and enter the upper section of tubing above the valve and rise to the surface. Therefore such gas does not build up pressure below the valve between cycles of injection to such an extent as to open the check valve or exert pressure on the producing formation.

When it is desired to remove the check valve assembly from the tubing string, such may be done by wire line tools in the manner hereinbefore explained.

In FIGURES IV, IV-A and V a modified form of the invention is disclosed in which a passage for formation gas is provided concentrically through the valve stem 55.

In such modified form the housing for the check valve assembly is elongated in that the flow coupling 6 is spaced from the swage nipple 8 and seating nipple 7 by a section of tubing 73, which may be made up of a plurality of joints. The section of tubing 73 is connected between flow coupling 6 and swage nipple 8 by the threaded connection 74 at the upper end and a threaded coupling 75 at the lower end.

A bleed-off tube 76 is connected between the reducer coupling 50 and the connector head 52 to provide a passage for gas passing through the valve stem 55. The bleed-off tube 76 is connected between such members 50 and 52 by the threaded connections 77 and 78. An annular passage 79 is provided between the tubing section 73 and the bleed-off tube 76 for flow of fluids from the producing formation, such annular passage becoming a part of the flow course through the check valve housing as described above.

A concentric passage 80 is provided through the valve stem 55 so that gas from the producing formation rising in the tubing may pass through the passage 80 and bleed off tube 76 and rise to the surface when the valve is closed. The passage 80 and bleed-off tube 76 provide a flow-by passage past the check valve when closed.

An O ring seal 81 is provided about valve stem 55 to slidably seal between the valve stem and the bore 61 of connector head 52.

The section of tubing 73 and the bleed-off tube 76 space the check valve 55 from the locking device 40 a sufficient distance so that the upper end of the locking device 40 will be above the surface of the column of fall back fluid trapped above the check valve, when the valve is closed, whereby fall back fluid is prevented from flowing back into the producing formation through the locking device and the concentric passage 80 through the check valve. The length of the fall back column determines the spacing between the locking device 40 and the check valve.

In such modified form, when gas is injected into the tubing string, increasing the pressure below the check valve, the valve head 56 is moved upwardly from the seat 68 and production fluid will pass outwardly through the apertures 65, through the annular space 24a and through the ports 25 into the tubing string and to the surface. A part of the production fluid will also pass upwardly through the concentric passage 80 and through the bleed-off tube 76.

When the gas injection ceases and the pressure decreases in the tubing the check valve will again close, trapping the fall-back fluid above the check valve, between the check valve and the locking device 40. While the check valve is closed any gas emanating from the producing formation will flow by the check valve through the passage 80 and bleed-off tube 76.

The ratio of the I.D. of the flow-by passages 9 and 80 to the I.D. of the tubing string is approximately 1 to 4, as shown in the drawings. However, it will be understood that these ratios may vary, either greater or less, depending upon the amount of formation gas to be by-passed and the rate of flow of fluid into the tubing from the formation. For instance, the ratio between the I.D. of the by-passes 9 and 80 to the I.D. of the tubing could be as high as 1 to 2 and still be operable.

The important fact is that the area of the by-passes 9 and 80 are considerably less than the area of the tubing above and below the check valve, so that when gas under pressure is injected into the tubing string through the gas lift valve below the check valve, an immediate pressure drop is created across the check valve, whereby the increased pressure below the check valve will act on the face of the valve member and raise it off its seat.

Gas lift valves are normally set to open at a pressure of several hundred pounds, and sometimes up to 700 or 800 lbs., so that it requires a pressure build-up in the tubing-casing annulus of several hundred pounds to overcome the pressure setting of the gas lift valve. When the gas lift valve opens, gas under pressure is injected into the tubing below the column of fluid, which has accumulated therein. A large volume of pressure gases is quickly released into the tubing, quickly increasing the pressure therein below the check valve. At the same time the liquid in the tubing is rapidly expanded, and seeks exit from the tubing. The liquid is expanded and aerated and moves rapidly upwardly in the tubing, striking the check valve member with considerable impact, tending to open same. Since the flow-by passages 9 and 80, as the case may be, are smaller in area than the area of the tubing string above and below the check valve, there is instantly caused a pressure differential across the check valve which acts on the face of the check valve member, overcoming the bias of the spring, opening the valve, allowing the aerated fluid below the valve to move upwardly in the tubing string. The velocity of the aerated fluid also tends to open the valve, and such velocity, combined with the pressure of gas injected into the tubing below the valve, serves to hold the valve open as long as gas under pressure is injected into the tubing string below the valve. Some of the fluid and gas might flow through the flow-by passages 9 and 80,

but this is of no consequence because the pressure differential and fluid velocity will hold the valve open. Of course, the bias of the check valve is set to cause the valve to open at whatever calculated pressure differential there may be between injected pressure and the fall-back fluid column head above the check valve.

Although the flow-by passages for formation gas, such as 9 and 80—76, are desirable in most installations it will be understood that they could be eliminated in some installations where formation gas is of negligible quantity, and the fall back check valve would still perform its intended function.

It will be understood that other and further forms of this invention may be devised without departing from the spirit and scope of the appended claims.

I claim:

1. In a gas lift system for wells, a string of tubing having an axial bore therethrough; a gas lift valve mounted in the tubing in communication with the bore; a housing attached in the tubing in spaced relationship above the gas lift valve; a latching recess provided in the housing; a retrievable locking device arranged to latch in said recess; a check valve suspended below the locking device, and having a tubular extension therebelow in removable sealing engagement with the housing and in communication with the tubing string bore therebelow; an upwardly opening valve member in axial alignment with the bore, forming a part of the check valve, normally seating in the upper end of the tubular extension; a flow passage through the housing about the valve member and above the tubular extension arranged to communicate with the tubular extension and the tubing string thereabove when the check valve is open the said valve member normally closing the flow passage to the flow of fluid therethrough; the said valve member being movable from its seat by gas pressure injected into the tubing through the gas lift valve so as to establish communication through the flow passage and the tubular extension between the tubing string bore above and below the housing; and another flow passage communicating with the tubing above and below the check valve to provide communication between the tubing string above and below the check valve when the check valve is in closed position, said another flow passage being less in cross-sectional area than the bore of the tubing string.

2. The combination called for in claim 1 wherein the said another flow passage extends outside of the tubing string.

3. The combination called for in claim 1 wherein the said another flow passage extends through the valve member and the locking device.

4. In a gas lift system for wells, a tubing string having a bore therethrough; a gas lift valve mounted in the tubing string; a back flow check valve housing incorporated in the tubing string above the gas lift valve; an upwardly opening back flow check valve removably carried in the housing and normally closing the bore of the tubing string, below the check valve, said check valve being openable by gas pressure injected into the tubing string through the gas lift valve, and being closable when such gas pressure injection ceases; a passage through the housing about the check valve normally closed by the check valve but establishing communication between the bore of the tubing string above and below the check valve when the check valve is open; and a separate flow-by passage communicating with the bore of the tubing string above and below the check valve when the check valve is in closed position, said flow-by passage being less in cross-sectional area than the bore of the tubing string.

5. The combination called for in claim 4 wherein the

separate flow-by passage extends outside of the tubing string.

6. The combination called for in claim 4 wherein the separate flow-by passage extends through the check valve.

7. In a gas lift system for wells; a string of tubing having a bore therethrough; a gas lift valve mounted in the tubing string in communication therewith; a back flow check valve housing attached in the tubing string above the gas lift valve; an upwardly movable valve member mounted in the housing; valve seat means in the housing; spring means normally urging the valve member against the seat to close off the tubing string bore below the housing; a passage through the housing about the check valve normally closed by the check valve, but being arranged to establish communication between the bore of the tubing string above and below the check valve when the check valve is open the said valve member being movable away from the seat by gas pressure injected into the tubing through the gas lift valve to establish communication through the passage between the tubing string bore above and below the housing; a separate a flow-by passage communicating with the tubing string bore above and below the housing to allow formation gas to flow about the valve member when in closed position, said flow passage being less in cross-sectional area than the bore of the tubing string.

8. In a gas lift system for wells; a string of tubing; a gas lift valve mounted in the tubing string in communication therewith; a back flow check valve housing attached in the tubing string above the gas lift valve; a locking recess provided in the housing; a locking device insertable in the housing and having dogs thereon releasably engageable in the recess; a back flow check valve suspended below the locking device and including a valve seat and a downwardly urged valve member normally in engagement with the seat and being movable away from the seat by gas pressure injected into the tubing through the gas lift valve; a tubular extension below the seat in slidable sealing engagement with the wall of the housing, and communicating with the well tubing therebelow; an annular passage in the housing above the valve seat and about the valve member and locking device establishing communication between the tubing string above and below the housing when the valve member is moved away from the seat; and another flow passage communicating with the tubing string above and below the housing to bleed off formation gas when the valve member is closed, said flow passage being less in cross-sectional area than the bore of the tubing string.

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