Feb. 19, 1963 L. L. CUMMINGS 3,077,894

GAS LIFT VALVE MECHANISM

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Fig. 1

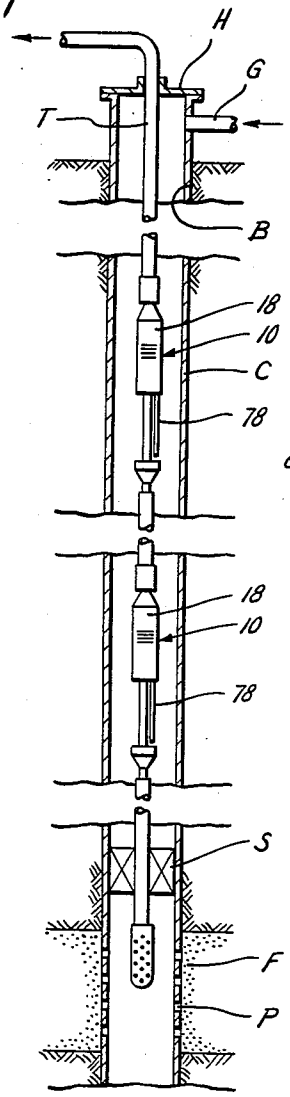


Fig. 2

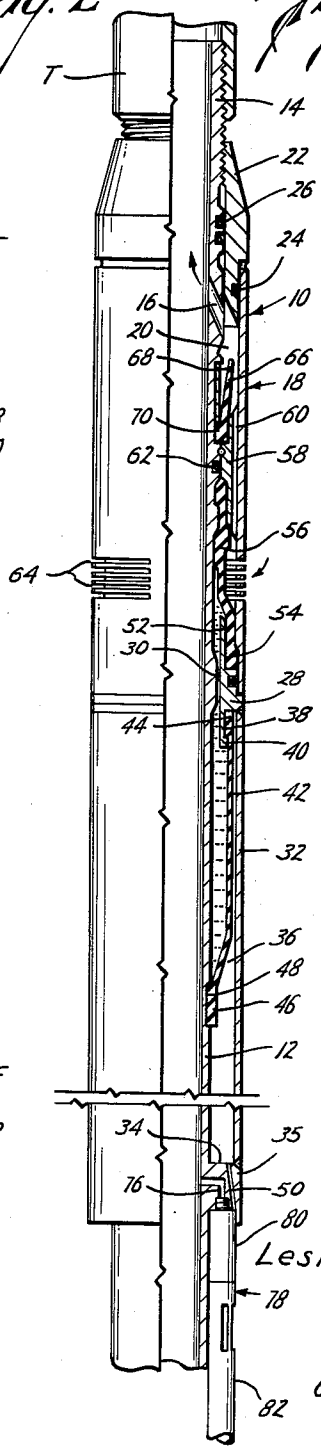
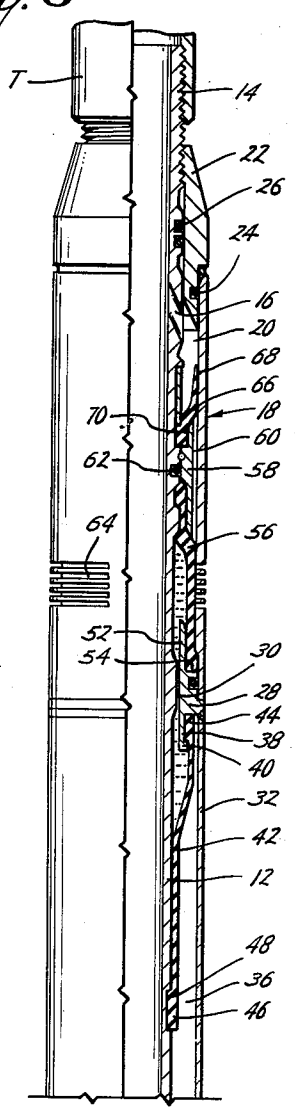


Fig. 3



Leslie L. Cummings
INVENTOR.

BY Charles E. Lightfoot
ATTORNEY

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Fig. 4

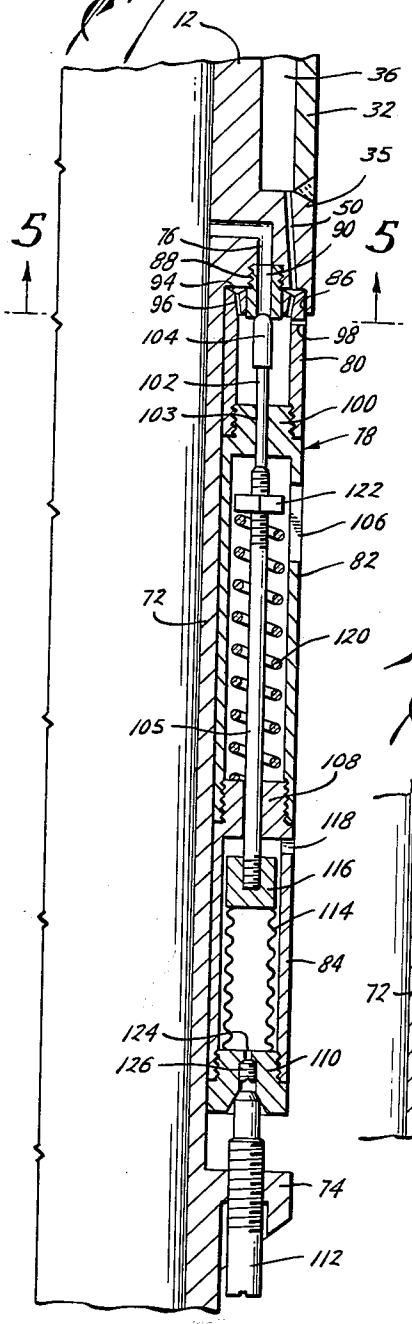


Fig. 5

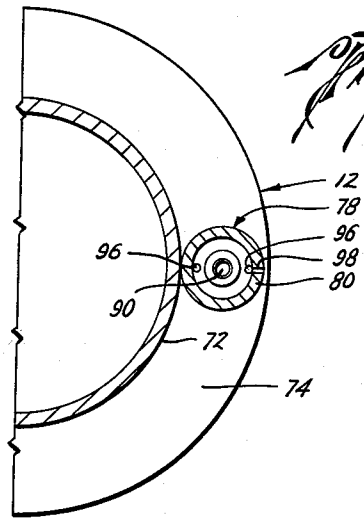


Fig. 6

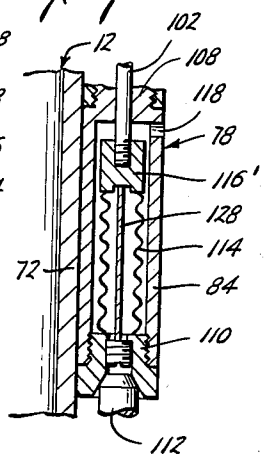
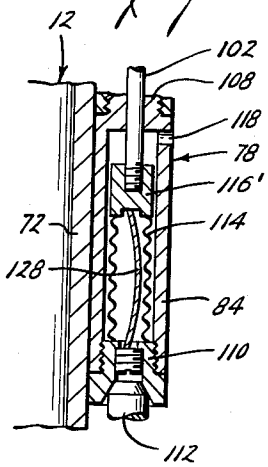


Fig. 7



Leslie L. Cummings
INVENTOR.

BY Charles E. Lightfoot
ATTORNEY

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GAS LIFT VALVE MECHANISM

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Fig. 8

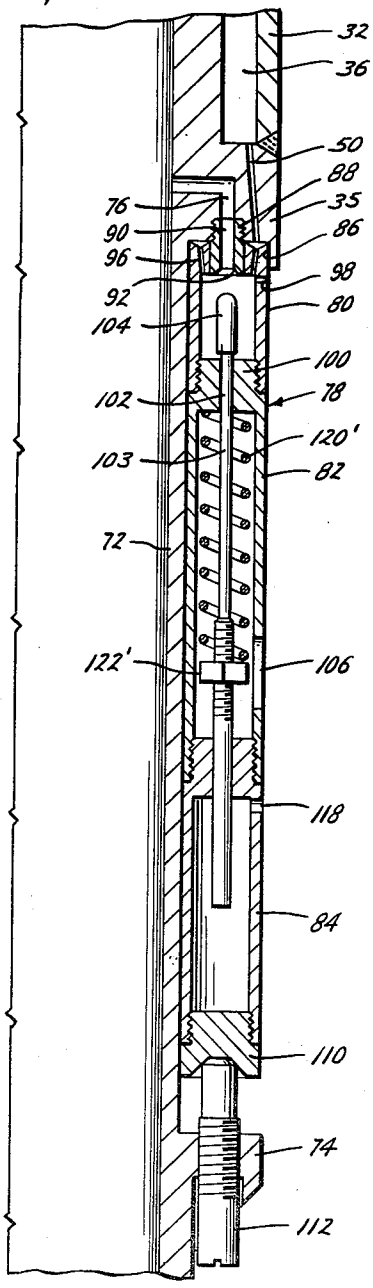
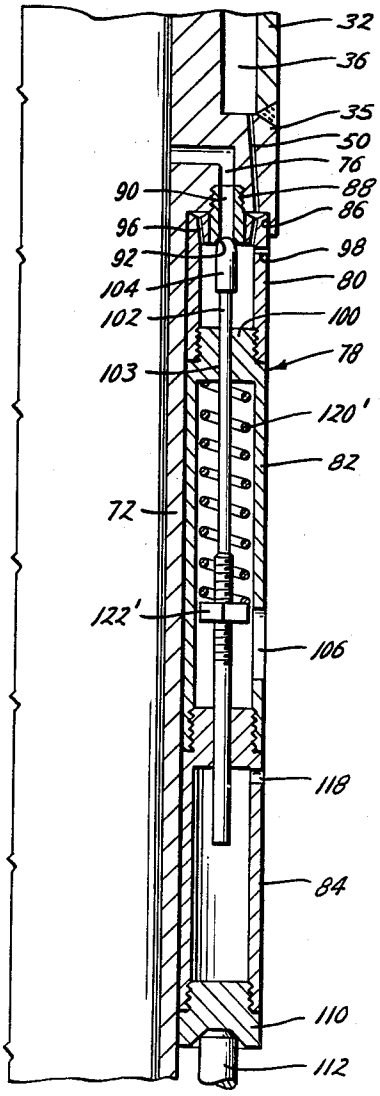


Fig. 9



Leslie L. Cummings
INVENTOR.

BY Charles E. Lightfoot
ATTORNEY

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GAS LIFT VALVE MECHANISM

Leslie L. Cummings, Houston, Tex., assignor to Otis Engineering Corporation, Dallas, Tex., a corporation of Delaware

Filed July 21, 1958, Ser. No. 749,812
3 Claims. (Cl. 137—155)

This invention relates to well production apparatus and more particularly to gas lift valve mechanism for use in oil wells and the like for controlling the admission of gas under pressure into a column of fluid in the well to assist the outflow of the fluid from the well.

In the production of oil wells it is common practice to provide such wells with a well casing within which a string of tubing or production string of smaller diameter than the casing is positioned and through which fluid is removed from the well. Under some conditions, the pressure in the well is insufficient to cause the well to flow and under these conditions gas lift mechanism is often employed to produce an outflow of well fluid through the tubing.

In the conventional gas lift system gas or air under pressure is introduced into the well casing and is injected through suitable gas-lift valves, located at spaced locations along the tubing, into the column of well fluid inside the tubing to lift the well fluid to the surface. The gas-lift valves used for this purpose are constructed and provided with actuating mechanism, whereby the valves are caused to open and close under predetermined pressure conditions in the casing and tubing to control the admission of pressure from the casing into the tubing string.

At times gas lift mechanism is used in wells in which the well bore penetrates oil bearing formations at different depths from which oil may be produced at different rates and under different well pressure conditions. Under these circumstances it is customary to make use of two production strings in the well casing, each of which is arranged to remove the oil from a different formation, this system being commonly known as "dual completion."

Gas lift valves, as heretofore commonly constructed, do not lend themselves well to accurate adjustment for response to varying well pressure conditions, so that it is extremely difficult to adjust the valves throughout the length of the tubing for most economical production. As ordinarily used each valve is separately adjusted before being inserted in the tubing string for operation under the particular pressure conditions which it is expected will be present at the location where the valve will be positioned when the string is inserted in the well, which often results in inefficient operation when the well is subject to substantial variations in well pressure conditions, or when it becomes necessary to vary the casing pressure to obtain more effective production.

Such gas lift valves are usually constructed for operation by variation in the pressure of fluid in the casing, and valves of this type when used in dual completion operations frequently result in unsatisfactory production because of the wide variation in the pressure conditions in the well where the oil bearing formations are at substantially different depths.

The present invention has for an important object the provision of a gas lift valve actuating mechanism which may be preset for response to widely varying pressure conditions to obtain efficient production in wells wherein the pressure conditions vary widely.

Another object of the invention is to provide gas lift valve mechanism which is responsive to the pressure in the tubing to open the valve independently of the pressure in the casing.

A further object of the invention is the provision of

gas lift valve mechanism embodying valve actuating means which is responsive to the differential of the pressures in the tubing and in the casing, and which may be adjusted for accurate response to a predetermined pressure differential to open or close the valve.

Another object of the invention is the provision of gas lift valve mechanism including valve means which is responsive to the pressure in the casing to close the valve and means operable by the pressure in the tubing when the tubing pressure reaches a predetermined value to cause a reduction in the pressure on the valve to permit the valve to open.

A further object of the invention is to provide gas-lift valve mechanism embodying a valve having actuating means which is responsive to the pressure of fluid in the well casing to hold the valve in closed position and including means for reducing the pressure on said actuating means to allow the valve to open in response to certain predetermined pressure conditions in the well casing and tubing to admit pressure from the casing into the tubing and for reapplying casing pressure to said actuating means to cause the valve to close in response to other predetermined pressure conditions in the casing and tubing.

The above and other important objects of the invention may best be understood by the following detailed description, constituting a specification of the same when considered in connection with the annexed drawings, wherein—

FIGURE 1 is a diagrammatic view of a portion of a well showing a plurality of the gas lift valves of the invention installed in a tubing string and illustrating the manner in which the invention is used;

FIGURE 2 is a fragmentary, side elevational view, partly broken away and partly in cross-section, illustrating a preferred embodiment of the gas lift valve of the invention and showing the valve in open condition;

FIGURE 3 is a view similar to that of FIGURE 2, showing the valve in closed condition;

FIGURE 4 is a fragmentary, vertical, central, cross-sectional view, on an enlarged scale, illustrating a preferred embodiment of the pilot valve mechanism of the invention, by which the opening and closing of the gas lift valve is controlled;

FIGURE 5 is a cross-sectional view, taken along the line 5—5 of FIGURE 4, looking in the direction indicated by the arrows;

FIGURE 6 is a fragmentary, vertical, central, cross-sectional view illustrating a somewhat modified form of the pilot valve mechanism of FIGURE 4, showing the mechanism in the closed condition of the pilot valve;

FIGURE 7 is a view similar to that of FIGURE 6, showing the pilot valve mechanism of FIGURE 6 with the pilot valve in open condition;

FIGURE 8 is a fragmentary, vertical, central, cross-sectional view of a modified form of the pilot valve mechanism of the invention showing the pilot valve in open position; and

FIGURE 9 is a view similar to that of FIGURE 8, showing the pilot valve in closed condition.

Referring now to the drawings in greater detail, the invention is illustrated herein in connection with its application to the production of oil from an oil well, such as that illustrated in FIGURE 1, having a bore B in which a well casing C is located which extends into an oil bearing formation F and is provided with perforations P through which well fluid from the formation may enter the casing. The well is provided with the usual production string or tubing T extending downwardly within the casing C and whose lower end is open to permit the outflow of well fluid from the casing through the tubing, and whose upper end extends upwardly through the cas-

ing head H closing the upper end in the casing. Suitable packer means S is provided in the well in position to form a seal between the exterior of the tubing and the interior of the casing at a location above the lower end of the tubing. The casing also has a fluid pressure supply pipe G through which gas under pressure is supplied to the interior of the casing from any suitable source of supply.

The gas lift valves 10 of the invention are connected into the tubing string T at longitudinally spaced intervals in the tubing in the usual manner, as illustrated in FIGURE 1, for the purpose of admitting fluid under pressure from the casing into the tubing at desired locations to cause an upward flow of well fluid in the tubing.

As illustrated in FIGURES 2 and 3 each of the gas lift valves of the invention comprises a tubular body 12, whose upper and lower ends are externally threaded for connection into the tubing string, only one such threaded end 14 being shown. Adjacent its upper end the body 12 is provided with a plurality of ports 16 extending through the wall of the body and spaced about its circumference and forming gas admission passageways to the tubing string. A tubular housing 18 of somewhat larger diameter than the body 12 is concentrically arranged about the exterior of the body to define an annular space between the body and the housing forming a valve chamber 20 which enclose the valve mechanism to be subsequently described. The ports 16 constitute outlet ports for the valve chamber 20. The upper end of the housing 18 extends somewhat above the ports 16 and valve chamber 20 and is closed at its upper end by a tubular bushing 22, whose upper end is internally threaded for attachment to the externally threaded end 14 of the body. Suitable packer means, such as the O-ring 24, positioned in an external groove in the bushing 22, provided for that purpose, forms a seal between the inside of the housing and the exterior of the bushing. The body 12 is also provided with external annular grooves located within the bushing 22, with which suitable packing, such as the O-rings 26, are located to form a fluid tight seal between the inside of the bushing and the exterior of the body.

The lower end of the valve chamber 20 is closed by means of a closure ring 28 which may be welded or otherwise rigidly connected to the housing 18 and whose inner diameter is somewhat larger than the external diameter of the portion of the body 12, located inside of the closure ring to form an annular passageway 30 in communication with the lower end of the valve chamber 20. A lower tubular sleeve 32 surrounds the body 12, which sleeve is connected at its upper end to the closure ring 28, as by means of welding, and at its lower end is similarly connected to an external annular shoulder 34 formed by an annular enlargement 35 on the body. This lower sleeve may have the same external diameter as the housing 18. The sleeve 32 defines the outer wall of an annular diaphragm chamber 36, whose lower end is formed by the shoulder 34 and whose upper end is formed by the closure ring 28.

The lower end of the closure ring 28 has an annular skirt 38 formed with an annular, radially outwardly extending projection 40 on its lower end, about which skirt the upper end of an annular flexible diaphragm 42 extends, which diaphragm is formed with a thickened upper marginal portion 44, positioned above the projection 40 and bonded to the external surface of the skirt 38. The flexible diaphragm 42 may be formed of a suitable material, such as rubber or the like, and is provided at its lower end with an annular thickened marginal portion 46, which fits into an external annular recess 48 in the body and is bonded to the body in the recess. The flexible diaphragm 42 forms the upper portion of the inner wall of the chamber 36, and separates this chamber from the valve chamber 20. The external enlargement 35 of the body 12 has a passageway 50 in communication at its upper end with the chamber 36 and whose lower end leads to the exterior of the body, and through which pressure in the casing may enter the chamber 36 to act upon the diaphragm 42.

The upper end of the closure ring 28 is provided with an upwardly extending annular projection 52 of reduced external diameter forming an annular seat 54 between the exterior of the projection and the inner wall of the adjacent portion of the housing 18. A main valve 56 which takes the form of a tubular sleeve valve, constructed of flexible resilient material, such as rubber or the like, is coaxially disposed in the valve chamber 20, surrounding a portion of the body 12. Sleeve valve 56 has a wall thickness substantially less than the width of the chamber 20, and the lower end of the sleeve valve is disposed in the seat 54 and is tightly clamped therein between the outer surface of the projection 52 and the housing 18 to form a fluid tight seal with the housing. At its upper end the sleeve valve is clampingly engaged between the exterior of the body 12 and the inner wall of an internally thickened portion 58 of the housing 18. This internally thickened portion 58 of the housing 18 has one or more passageways 60, forming a part of the valve chamber 20. Suitable packing means, such as the O-ring 62, is positioned between the external surface of the body 12 and the internal surface of the thickened portion 58, to form a fluid tight seal therebetween.

The housing 18 is provided with a plurality of peripherally elongated slots 64, extending therethrough opposite the midportion of the sleeve valve 56 through which pressure in the casing may enter the housing. The slots 64 provide communication between the exterior or the housing 18 and valve chamber 20, being the inlet ports to the valve chamber.

A tubular check valve 66 is mounted in the chamber 20 surrounding a portion of the body 12 between the ports 16 and the sleeve valve 56. Check valve 66 is composed of flexible resilient material such as rubber, and has an upwardly and outwardly flaring lip portion 68 positioned to be expanded into contact with the internally thickened portion 58 of the housing 18 to close the passageways 60 when the check valve is closed, and which is out of contact with said inwardly thickened portion when the valve is open, to permit the inward flow of fluid through the passageways 60 through the ports 16. The lower end of the valve 66 has a thickened portion 70, which is situated between the exterior of the body 12 and the internal wall of the internally thickened portion 58.

The valve chamber 20 between the valve 56 and the flexible diaphragm 42 is completely filled with a suitable fluid, such as oil or the like, so that upon inward flexing of the diaphragm 42 under the influence of the pressure of fluid entering the chamber 36 from the casing through the passageway 50, the liquid between the flexible diaphragm and the valve 56 will be forced upwardly to move the valve 56 to closed position, closing the openings 64, as shown in FIGURE 3, to shut off the flow of gas from the casing into the interior of the tubing through the passageways 60 and ports 16. The flexible diaphragm 42 is so designed that when the pressure in the chamber 36 beneath the diaphragm is the same as the pressure in the casing exteriorly of the chamber the diaphragm will exert a force on the liquid above the diaphragm to hold the valve 56 in closed position as shown in FIGURE 3, or if desired some additional means, such as a spring or the like, not shown, may be positioned about the diaphragm to yieldingly urge the diaphragm toward the body 12, to exert a force on the liquid above the diaphragm to hold the valve 56 closed when the pressure in the chamber 36 is equal to the pressure in the casing exteriorly of the chamber.

Upon a reduction of the pressure in the chamber 36 below the pressure in the casing, which takes place under the control of pilot valve mechanism hereinafter de-

scribed, the flexible diaphragm 42 will be expanded outwardly, due to the inward pressure of the gas in the casing on the valve 56 through the openings 64 to permit the casing pressure to open the valve 56 to allow fluid to flow from the casing through the passageways 60 and ports 16 into the tubing.

In the event that the pressure in the tubing should exceed the pressure in the casing, the back flow of fluid through the ports 16 will expand the check valve 66 to close the passageways 60, to prevent such back flow from the tubing into the casing.

Beneath the annular enlargement 35 of the body 12 the body has an annular portion 72 of reduced external diameter, which terminates at its lower end in an external annular enlargement 74 and pilot valve mechanism for controlling the operation of the above described valve 56 is disposed between the annular enlargements 35 and 74, as best seen in FIGURES 4, 5, 8 and 9. The body 12 has a passageway 76 in communication at its inner end with the interior of the tubing, and whose outer end is provided with a valve seat forming a part of such pilot valve mechanism.

A preferred form of the pilot valve mechanism of the invention is illustrated in FIGURES 4 and 5 wherein the valve has a tubular valve casing 78, which may conveniently be made up of a number of tubular sections 80, 82 and 84 which are threadably secured together. The upper end of the uppermost section 80 of the valve casing fits within a downwardly opening recess 86 of the enlargement 35 and is provided with an externally threaded upper end or plug 88, threaded into an internally threaded opening in the annular enlargement 35. The plug 88 is provided with a passageway 90 in communication with the passageways 76 in the body 12, and provides a valve seat 92 within the upper section. The upper end of the upper section 80 is also provided with an annular outwardly flaring end groove 94, into which the lower end of the passageway 50 opens, and from which one or more passageways 96 lead to the interior of the section. The upper section 80 is also provided with a small port 98 in communication with the interior of the section and with the interior of the surroundng casing.

The intermediate section 82 of the casing 78 has an externally threaded upper end portion 100, which is threadably connected to the internally threaded lower end of the upper section and which substantially closes the same. The upper end of the intermediate section 82 has a central opening therethrough through which a valve stem 102 is slidably extended, which stem carries a valve 104 at its upper end positioned to move into and out of closing engagement with the seat 92. The intermediate section 82 also has a side opening 106 therethrough. At its lower end, which is internally threaded, the intermediate section 82 is closed by the externally threaded upper end portion 108 of the lower section 84, and this upper end portion 108 has a central opening therethrough through which the stem 102 is slidably extended into the lower section 84. At its lower end the lower section 84 is closed by a screw plug 110, which bears against the upper end of a retainer screw 112, which is threadably extended through an opening in the lower annular enlargement 74, to hold the valve casing securely in position on the body 12 and to permit removal of the valve casing therefrom when desired.

An expansible bellows 114 is positioned in the lower section 84, which bellows is attached at its lower end to the plug 110, and at its upper end to a head 116 carried on the lower end of the valve stem 102. The lower section 84 also has a port 118, in communication with the interior of the section and with the interior of the surrounding casing.

Within the intermediate section 82 a coil spring 120 surrounds the stem 102, which bears at its lower end on the upper end of the lower section 84 and at its upper end against an adjusting nut 122 threadably carried on the stem 102, whereby the force of the spring 120 exerted on the stem 102 tending to move the valve 104 toward closing position may be adjusted.

The lower end plug 110 of the lower section 84 may be provided with an opening 124 closed by a screw plug 126, through which fluid may be introduced into the interior of the bellows 114.

In the operation of the above described pilot valve mechanism, as best illustrated in FIGURE 4, the bellows 114 is filled with gas at a desired pressure, to urge the valve 104 toward closing position. Due to the fact that the interior of the bellows chamber in the lower section 84 is in communication with the interior of the surrounding casing the bellows 114 will be subjected to the pressure of fluid in the casing tending to move the valve 104 toward open position against the pressure of fluid in the bellows. The valve 104 will also be urged toward closing position by the spring 120 and also by the upward force exerted on the valve by the pressure of fluid in the casing entering the upper section 80 through the port 98. When the pressure in the interior of the tubing exerted on the valve 104 through the passageways 76 is sufficiently high to coact with the pressure exerted by the fluid in the casing acting on the head 116 of the bellows 114 to overcome the force exerted by the pressure of fluid in the casing acting on the valve 104 in the upper section 118 and the force of the spring 120, then the valve 104 will be opened. Upon opening of the valve 104 fluid may flow from the chamber 36 beneath the flexible diaphragm 42 through passageway 50 and passageways 96 into the upper section 80, and thence through passageways 90 and 76 into the tubing, so that the pressure of fluid in the casing may enter the housing 18 through openings 64 to move the valve 56 to open position to permit casing pressure to flow into the interior of the tubing through passageways 60 and ports 16. When the pressure in the tubing falls to a point at which the pressure of the fluid in the bellows 114 and the pressure of the spring 120 are sufficient to close the valve 104, then the pressure of fluid in the casing will enter the chamber 36 through the port 98, passageways 96 and passageway 50 to act on the diaphragm 42 to exert a force on the liquid above the diaphragm to cause the valve 56 to close, whereupon the inflow of fluid from the casing into the interior of the tubing will be cut off.

By suitably adjusting the cross-sectional area of the passageway 90, the cross-sectional area of the stem 102, the effective cross-sectional area of the bellows 114 and of the force exerted by the spring 120, the pilot valve 104 may be made to open at any desired differential between the pressure in the casing and tubing.

In gas lift systems of this kind the casing pressure is always maintained substantially higher than the pressure in the tubing, and the port 98 is preferably of very small diameter so that upon opening of the valve 104 the pressure in the chamber 36, which will be higher than the pressure in the tubing upon opening of the valve may bleed off into the tubing to permit the valve 56 to be opened, and upon closing of the valve 104 pressure will again be built up in the chamber 36 to cause the valve 56 to close.

Should it be desired to have the pilot valve operated by the pressure in the tubing, independently of the pressure in the casing, then the pressure in the bellows 114 may be adjusted at or near atmospheric pressure and the cross-sectional areas of the passageway 90 and the stem 102 may be made the same, so that the valve will be opened when the pressure in the tubing acting on the valve 104 is sufficient to overcome the pressure of the spring 120.

Suitable means, such as a check valve, not shown, may be installed in the port 98 to prevent back flow from the tubing into the casing.

A somewhat modified form of the pilot valve actuating

mechanism of the invention is illustrated in FIGURES 6 and 7, wherein means is provided, such as the leaf spring 128 positioned within the bellows 114 in position for coaction with the head 116' and the plug 110 to maintain the bellows in extended condition, as shown in FIGURE 6 until the pressure exerted on the head 116' by the stem 102 is sufficient to cause bending of the spring, as shown in FIGURE 7, whereupon the valve 104 will be suddenly moved to open position with a snapping action. By this arrangement the valve 104 will also be moved to closing position by a snapping action when the pressure on the spring 114 is reduced to a point to permit the spring to snap back to its straight position as seen in FIGURE 6. Other suitable means, such as toggle mechanism or the like, not shown, may of course be substituted for the spring 128 to cause the quick opening and closing movements of the valve 104. In other respects the mechanism illustrated in FIGURES 6 and 7 is constructed and operates in the same manner as that previously described in connection with FIGURES 4 and 5.

The stem 102 may have a guide portion 103 slidably extended through the upper end of the section 82 and this portion 103 may be of any desired cross-sectional area relative to the cross-sectional area of the passageway 90, the cross-sectional area of the valve 104 and the cross-sectional area of the lower part 105 of the stem, and these cross-sectional areas may be varied of course as desired to obtain variations in the operating characteristics of the pilot valve.

Assuming that the cross-sectional area of the stem 102 is the same throughout its length and is the same as the cross-sectional area of passageway 90, the pressure within the section 80 does not exert any opening or closing action on the valve. With the valve closed tubing pressure is being exerted against the cross-sectional area of the stem and casing pressure is being exerted against the cross-sectional area of the bellows 114 minus the cross-sectional area of the stem. When the combination of the forces exerted by the tubing and casing pressures exceed the preloaded force of the spring and the bellows tending to close the valve, then the valve will be opened.

When the pilot valve is opened the pressure in chamber 36 will be reduced and valve 56 will be opened to allow casing pressure to enter the tubing through openings 64, passageways 60 and ports 16.

When the combination of casing and tubing pressures falls below the closing forces exerted by the spring and the bellows then the pilot valve will close and the pressure in the section 80 and in chamber 36 will be built up to casing pressure thereby closing valve 56.

Assuming that the cross-sectional area of the stem portion 103 is smaller than the cross-sectional area of passageway 90, then the pressure in the section 80 will have some effect on the operation of the pilot valve. With the valve closed the forces tending to open the valve will be tubing pressure against the cross-sectional area of passageway 90 plus the casing pressure against the rim area of head 116. When these combined forces exceed the preloaded forces of the spring and bellows the valve will open, thereby bleeding off pressure from chamber 36 and permitting valve 56 to open. The forces tending to hold the valve open when the valve is open will be the tubing pressure against the smaller cross-sectional area of portion 103 and the casing pressure against the larger rim area of the head 116 and when the combination of these forces falls below the preloaded forces of the spring and bellows then the valve will close allowing pressure to again build up in the chamber 36 to close valve 56.

By making the cross-sectional areas of passageway 90 and the stem portion 103 both equal to the cross-sectional area of the head 116 (effective bellows area), the casing pressure will not exert any force on the operation of the pilot valve, and when the tubing pressure against the cross-sectional area of the passageway 76 exceeds the closing forces exerted by the bellows and spring the valve will be opened to allow the pressure in chamber 36 to bleed off and valve 56 to open. With the valve open when the tubing pressure against the cross-sectional area of the stem falls below the forces of the spring and bellows the valve will be closed and pressure will again build up in chamber 36 to close valve 56.

In FIGURES 8 and 9 there is illustrated a somewhat different embodiment of the pilot valve mechanism of the invention, in which the bellows 114 is eliminated and a spring 120' takes the place of the spring 120 previously described. In this arrangement the spring 120' is positioned in the intermediate section 82 and bears at its upper end on the end portion 100 of the section and at its lower end against an adjusting nut 122' threadably carried on the stem 102 and which may be adjusted to regulate the force exerted by the spring urging the valve 104 toward open position. By this arrangement the pilot valve is actuated by the differential of the pressures of fluid in the casing and in the tubing. Thus by making the cross-sectional area of the stem 102 equal to the cross-sectional area of the passageway 90 forming the seat for the valve 104 the areas acted upon by the tubing pressure and casing pressure may be equalized.

In the form of the invention illustrated in FIGURES 8 and 9, with the valve 104 closed tubing pressure is exerted on the valve against the cross-sectional area of the passageway 90 tending to open the valve, and the spring 120' is also exerting a force tending to open the valve. Casing pressure against the cross-sectional area of the passageway 90 tends to hold the valve closed. When the combined opening force of the tubing pressure and spring exceeds the closing force of the casing pressure the valve will open to permit bleeding off of the pressure in chamber 36 and the opening of valve 56. With the valve open, when the pressure in section 80 against the cross-sectional area of the portion 103 of stem 102 and the force of spring 120' falls below the force exerted by casing pressure against the stem area, the valve will close to allow pressure to build up in chamber 36 to close valve 56.

By suitably varying the relative cross-sectional area of the passageway 90, valve 104 and stem 102 as well as adjusting the force of the spring 120' the opening and closing characteristics of the pilot valve may be varied as desired.

The gas lift valve mechanism of the invention has been disclosed herein in connection with certain specific embodiments of the same, but it will be understood that this is intended by way of illustration only and that numerous changes can be made in the construction and arrangement of the various parts within the spirit of the invention and the scope of the appended claims.

Having thus clearly shown and described the invention, what is claimed as new and desired to secure by Letters Patent is—

1. Gas lift valve mechanism comprising a tubular body adapted for coaxial connection into a tubing string for insertion with the string into a well casing, an annular valve chamber concentrically surrounding said body and having longitudinally spaced inlet and outlet ports communicating respectively with the interior of said casing and the interior of said body, a tubular valve member constructed of flexible material surrounding the body, said valve member being annularly expansible and contractible to control the passage of fluid through the valve chamber, a pressure chamber surrounding the body adjacent said valve chamber said valve member forming a common wall between said chambers, an annular diaphragm formed of flexible material in and dividing said pressure chamber to form an upper chamber section between said diaphragm and said valve member and a lower chamber section beneath the diaphragm, a liquid completely filling said upper chamber section, and pilot valve

means actuated by the pressure of the fluid in the casing and pressure of the fluid in the body for controlling the pressure of fluid in said lower chamber section to cause flexing of said diaphragm to increase and decrease the pressure in said upper chamber section to cause opening and closing movement of said valve member, said valve member preventing passage of fluid through said valve chamber when the pressure within the lower chamber section and the pressure within the interior of said casing are equal.

2. Gas lift valve mechanism comprising a tubular body adapted for coaxial connection into a tubing string for insertion with the string into a well casing, an annular valve chamber concentrically surrounding said body and having longitudinally spaced inlet and outlet ports communicating respectively with the interior of said casing and the interior of said body, a tubular valve member constructed of flexible material surrounding the body, said valve member being annularly expansible and contractible to control the passage of fluid through the valve chamber, a pressure chamber surrounding the body adjacent said valve chamber said valve member forming a common wall between said chambers, an annular diaphragm formed of flexible material in and dividing said pressure chamber to form an upper chamber section between said diaphragm and said valve member and a lower chamber section beneath the diaphragm, a liquid completely filling said upper chamber section, means for admitting fluid under pressure from said casing into said lower chamber section to cause said diaphragm to move in one direction to increase the pressure in said upper chamber section to expand the valve element to a position closing off flow through said valve chamber, and pilot valve means operated by the pressure of the fluid in the casing and the pressure of the fluid in the body for controlling admission of fluid under pressure from the casing into said lower chamber section and for exhausting the pressure from said lower chamber section to cause said diaphragm to be moved in the other direction by the pressure in said upper chamber section to allow said valve member to contract, said valve element being in said position closing off flow through said valve chamber when the pressure within said lower chamber section equals the pressure within the interior of said casing.

3. A gas lift mechanism comprising: a tubular body adapted for coaxial connection into a tubing string for insertion with the string into a well casing; an annular valve chamber concentrically surrounding said body and having longitudinally spaced inlet and outlet ports communicating respectively with the interior of said casing and the interior of said body; a tubular valve member constructed of flexible material surrounding the body, said valve member being annularly expansible to close said inlet port and contractible to open said inlet port to control the passage of fluid through the valve chamber; a pressure chamber surrounding the body adjacent said valve chamber, said valve member forming a common wall between said chambers; an annular diaphragm formed of flexible material in and dividing said pressure chamber to form a first chamber section on one side of said diaphragm and between said diaphragm and said valve member and a second chamber section on the other side of said diaphragm; a liquid completely filling said first chamber section; means providing a second valve chamber, a first passage for admitting fluid under pressure from said casing into said second valve chamber, a second passage communicating said second valve chamber with said lower chamber section and a third passage communicating the interior of said body with said second valve chamber; and pilot valve means operated by the pressure of the fluid in the casing and the pressure of the fluid in the body for controlling flow through said third passage, said diaphragm being moved in one direction when fluid under pressure from the casing is admitted into said second chamber section to increase the pressure in said first chamber section to expand said valve member to close said inlet port, said third passage having a larger orifice than said first passage whereby when said pilot valve means is in open position permitting fluid flow through said third passage the pressure from said lower chamber section is exhausted to the interior of said body through said second passage, said second valve chamber and said third passage to cause said diaphragm to be moved in the other direction by the pressure in said first chamber section to allow said valve member to contract to open said inlet port, said valve member being expanded to close said inlet port when the pressure in said second chamber section is equal to the pressure within the interior of said casing.

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