United States Patent

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[54] **GAS LIFT VALVE**
6 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **137/155,** 103/232
[51] **Int. Cl.** **F04f 1/08**
[50] **Field of Search** 137/155; 103/232; 251/282

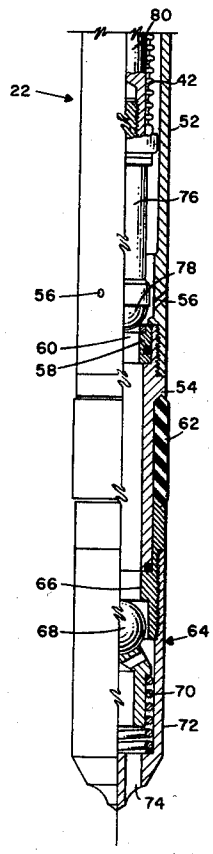
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ABSTRACT: A gas lift valve that is connected in a tubing string and disposed in a cased well bore. The gas lift valve provides communication between the casing and tubing whereby gas in the annular space therebetween can be injected into the tubing to aid in producing oil from the well. The gas lift valve includes a valve member that is responsive to pressure within the tubing for movement between open and closed positions to control the flow of gas into the tubing.



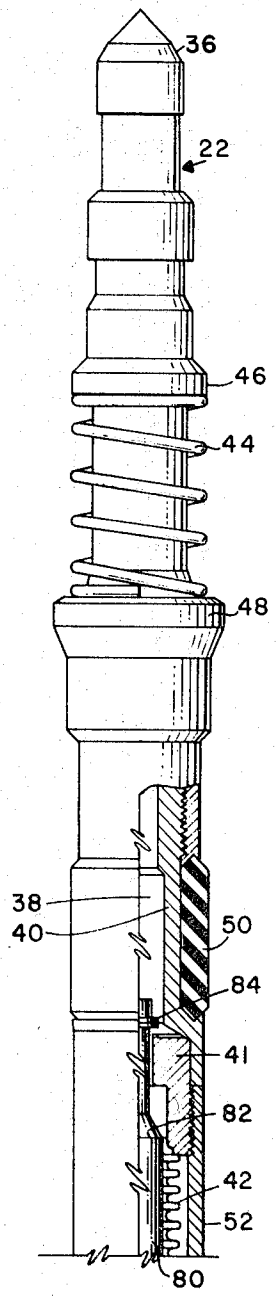


FIG. 2A

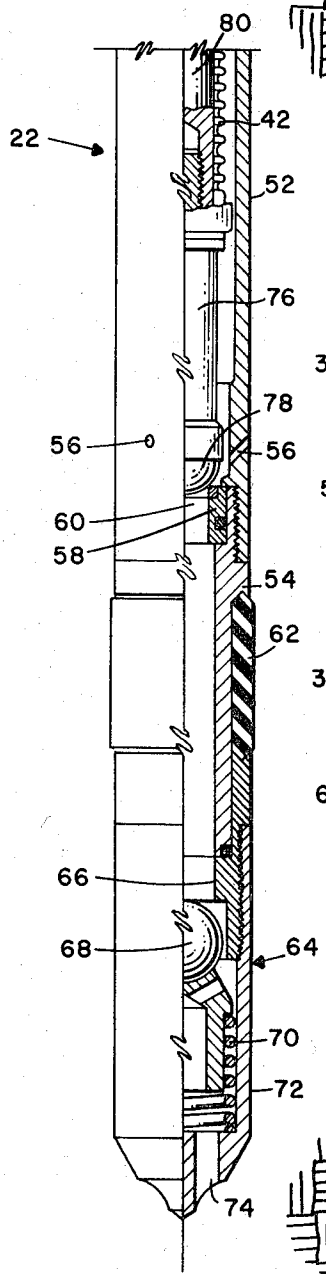


FIG. 2B

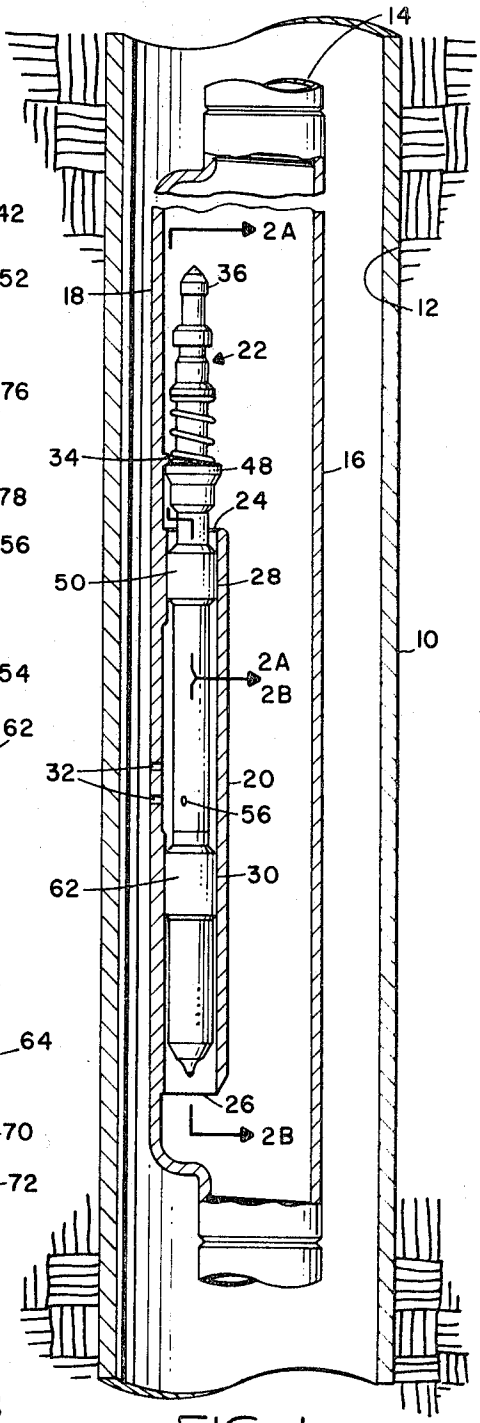


FIG. 1

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GAS LIFT VALVE

BACKGROUND OF THE INVENTION

This invention relates generally to improved gas lift valves for use in well bores. More particularly, but not by way of limitation. this invention relates to an improved gas lift valve for use in a tubing disposed in a cased well bore wherein the gas lift valve is moved between open and closed positions in response to change in the pressure within the tubing.

Gas lift valves utilized in the oil and gas industry in situations wherein the formation pressure alone is not sufficient to lift the oil to the surface of the well. The gas lift valves provide controlled communication between the annulus (the annular space that is between the casing and tubing exterior) and the interior of the tubing to permit gas in the annulus to be injected into the tubing to aid in lifting oil from the formation to the fur surface through the tubing.

Gas lift valves may be divided into two categories, that is, into valves are controlled by the gas pressure within the annulus and into valves controlled by the pressure of fluid, generally oil, that is in the tubing. U.S. Reissue Pat. No. 24,015 issued to R.O. Walton on May 31, 1955 illustrates a gas lift valve of the type that is controlled by gas pressure in the annulus. U.S. Pat. No. 2,982,226 issued to C.M. Peters et al. on May 2, 1961 illustrates a gas lift valve that is controlled by pressure within the tubing.

Tubing pressure controlled gas life valves may be further classified in two groups. One group, as illustrated by the valve in Peters'patent, involves the use of a sliding seal located between the valve stem and the valve body to prevent communication between the pressure in the tubing, which is always imposed on the bellows of Peters' valve, and the pressure in the annulus. The sliding seal serves to balance the valve member with respect to gas pressure in the annulus whereby movement of the valve member is the result of change in the tubing pressure alone. The second group of tubing pressure controlled valves does not have the sliding seal in the vale, but necessarily includes a device known as a "crosshead" in the lower end thereof. The "crosshead"performs the function of imposing the tubing pressure on the valve member so that it is controlled thereby, but this type has a very circuitous flow path for gas passing through the valve. The circuitous flow path results in considerable erosion in the valve as the gas, which frequently has sand entrained therein, flows through the valve.

SUMMARY OF THE INVENTION

This invention provides an improved gas lift valve for use in a well bore, the valve comprising: a hollow valve body having an outlet passageway and having an inlet port that is of smaller cross-sectional area than the outlet passageway; and annular valve seat located in the body between the inlet port and the outlet passageway, the valve seat having a flow area larger than the cross-sectional area of the inlet port; a valve member in the body movable between a closed position, wherein the valve member engages the seat, and an open position, wherein the valve member is out of engagement with the seat; and, pressure responsive means in the body connected with the valve member biasing the valve member toward the seat, the pressure responsive means being exposed to fluid pressure through the inlet port when the valve member is in the closed position and exposed to fluid pressure in the outlet passageway when the valve member is in the open position.

One object of this invention is to provide an improved gas lift valve that eliminates the need for a sliding seal to isolate the tubing and casing pressures.

Another object of the invention is to provide an improved gas lift valve that is controlled by tubing pressure and has a substantially direct flow passageway therethrough reducing erosion in the valve to the minimum.

Another object of the invention is to provide an improved tubing pressure controlled valve that is relatively simple in construction and requires little or no maintenance during its operating life.

The foregoing and additional objects and advantages of the invention will become more apparent as the following detailed description is read in conjunction with the accompanying drawings wherein like reference characters denote like parts in all views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view illustrating a portion of a casing disposed in a well bore, a section of tubing located therein, and a gas lift valve constructed in accordance with the invention disposed in a side pocket in the tubing.

FIG. **2A** is an enlarged view of the upper portion of the gas lift valve, partially in elevation and partially in cross section, taken substantially along the lines **2A–2A** of FIG. **1**.

FIG. **2B** is an enlarged view of the lower portion of the gas lift valve, partially in elevation and partially in cross section taken substantially along the lines **2B–2B** of FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing and to FIG. **1** in particular, shown therein and generally designated by the reference character **10** is a well casing disposed in a well bore **12**. A tubing string **14** extends into the casing and includes a plurality of identical sections that are threadedly connected as is well known in the art.

The tubing string **14** also includes one or more sections **16** having a side projection **18** thereon. Each of the side projections **18** has a tubular pocket **20** formed therein for receiving a gas lift valve assembly **22**. As clearly shown in FIG. **1**, the tubular pocket **20** has open upper and open lower ends **24** and **26**, respectively; spaced upper and lower sealing surfaces **28** and **30**, respectively; and, a plurality of ports **32** extending through the wall of the side projection **18**. The ports **32** are located between the sealing surfaces **28** and **30**. A latch lug **34** extends inwardly from the interior of the projection **18** for purposes that will be described hereinafter.

The enlarged views of FIGS. **2A** and **2B** illustrate the structure of the gas lift valve assembly **22** in more detail. A valve cap and guide nose **36** is located at the upper end of the valve assembly **22**. The valve cap **36** covers a valve (not shown) that is provided to permit filling a chamber **38** formed in valve body **40** with a compressible gas, such as nitrogen. The lower end of the chamber **38** is in communication with a flexible pressure responsive bellows **42** that has its upper end connected to a bellows support member **41**. The bellows support member **41** is suitably connected to and forms a portion of the valve body **40**.

Encircling the upper end of the body **40** of the valve assembly **22** is a helical spring **44**. The helical spring **44** is disposed between a shoulder **46** and a latch ring **48**. The lath latch ring **48** is movable upwardly against the spring **44** and to some extent laterally with respect to the body **40** to permit the valve assembly **22** to move past the latch lug **34** on the projection **18** (see FIG. **1**) so that the valve assembly **22** is securely latched in the tubular pocket **20** when located therein.

Encircling the body **40** below the spring **44** is an upper seal **50** that is arranged to sealingly engage the sealing surface **28** in the tubular pocket **20** as shown in FIG. **1**. The upper seal **50** is shown schematically and may be constructed in any desired manner, such as from a plurality of alternating resilient mate metallic members

A medial portion **52** of the body **40** extends downwardly and is threadedly connected at its lower end with a lower body section **54**. Near the lower end of the medial portion **52** is a plurality of inlet ports **56** of relatively small diameter for purposes which will be explained more fully hereinafter. The ports **56** extend at an angle downwardly and inwardly to provide a direct flow path into the body **40** to reduce erosion in the body **40** to the minimum and to increase valve efficiency by reducing the resistance to fluid flow therethrough.

The medial portion **52** and the lower portion **54** of the the body **40** cooperate to support an annular valve seat **58**. The annular valve seat **58** has a flow passageway **60** extending

therethrough which, in the preferred arrangement, has an area equal to the effective area of the bellows **42** and which is large as compared to the area of the parts **56**. The areas may deviate somewhat from being precisely equal without affecting the operating characteristics of the valve assembly **22**. Also, it is preferred that the ports **56** have a total flow area no more than 75 percent of the area of the flow passageway **60**.

A lower seal **62** encircles the exterior of the lower portion **54** of the body **40** and is arranged to sealingly engage the sealing surface **30** within the pocket **20** (see FIG. **1**). The seal **62** may also be constructed in any suitable configuration.

Connected with the lower body portion **54** is a surge valve assembly **64**. The surge valve assembly includes an annular valve seat **66**, a valve member **68** and a spring **70** that biases the valve member **68** towards the seat **66**. All of the foregoing are located within a surge valve body **72**. The lower end of the surge valve body **72** has a plurality of outlet passageways **74** extending therethrough to permit fluid communication from the interior of the gas lift valve assembly **22** into the interior of the tubing string **14**. It will be noted that the valve member **68** is positioned so that it does not engage the valve seat **66** thus permitting a low unit volume flow thereby or pressure from the tubing string **14** to be applied therethrough. However, if a sudden surge or high volume flow enters the passageways **74** passing upwardly the surge valve assembly **64**, the valve member **68** moves into engagement with the seat **66** preventing flow therethrough in an upwardly direction.

A main valve member **76** is connected at its upper end with the lower end of the bellows **42**. A spherical closure member **78** mounted on the lower end of the valve member **76** sealingly engages the annular valve seat **58** when in the closed position of the valve assembly **22**.

The upper end of the valve member **76** is also connected with a bellows protector member **80** that extends upwardly through the bellows **42** and into the lower end of the chamber **38**. The upper end of the protective member **80** has an upwardly facing shoulder **82** formed thereon that is engageable with the bellows support member **41** to limit the upward movement or collapsing of the bellows **42**. Also, the bellows protective member **82** carries one or more limit rings **84** that are positioned above the bellows support member **41** and are engageable with the support member **41** to limit the downward movement or extension of the bellows **42**. Thus, the protective member **80** controls the travel of the main valve member **76** and the collapsing and extension of the bellows **42** during operation of the gas lift valve assembly **22**.

OPERATION

In the form of gas valve assembly **22** illustrated, the tubing string **14** is first disposed in the well casing **10** and the gas lift valve assembly **22** is lowered therein on a special running-in tool (not shown) that is well known in the art. The running-in tool is arranged to deposit the gas lift valve assembly **22** in the appropriate tubular pocket **20** in the tubing string **14**. It should be pointed out that valve assembly **22** may be constructed for permanent installation on a tubing string as illustrated in the aforementioned Peters et al. Patent.

After the valve assembly **22** is or a plurality of assemblies **22** have been deposited in the tubing string **14**, gas is introduced into the annulus between the casing **10** and the tubing string **14**. The pressurized gas, and initially some liquid, passes through the ports **32** in the projection **18** entering the space within the tubular pocket **20** defined by the upper and lower seals **50** and **62**, respectively.

After entering the space between the seals **50** and **62**, the gas passes through the inlet ports **56** into the body **40**. Since the area of annular valve seat **58** is substantially the same as the effective area of the bellows **42**, the pressure of the gas passing through the inlet ports **56** has little or no effect on the main valve member **76**. Stated in another way, the main valve member is substantially balanced with respect to the gas pressure.

Oil in the tubing string **14** enters the lower end **26** of the tubular pocket **20** passing upwardly through the passageways **74** and the surge valve assembly **64**. Since the pressure of the oil is relatively stabilized, the pressure passes the valve member **68** and is imposed upon the spherical closure member **78** through the flow passageway **60** in the annular valve seat **58**.

When the force on the main valve member **76** developed by the pressure of the oil in the flow passageway **60** becomes sufficient to overcome the force exerted by the nitrogen in the chamber **38**, the main valve member **76** rises off the valve seat **58**. When this occurs, communication between the gas in the body **40**, which has entered through the inlet ports **56** and the oil in the flow passageway **60** occurs.

As previously mentioned, the total area of the flow ports **56** is not more than 75 percent of the area of the flow passageway Thus, the gas entering through the ports **56** will be choked and subjected to a pressure drop as it flows into the valve body **40**. In practice, the ports **56** and flow passageway **60** are sized so that the pressure existing in the area around the main valve member **76** and exterior of the bellows **42** will be the pressure of the oil in the tubing string **14** at the location of the valve assembly **22**.

After the valve member **76** has moved to the open position, the gas flows through the flow passageway **60**, past the surge valve member **68**, downwardly through the ports **74** and the open lower end of **26** of the tubular pocket **20** into the tubing string **14**. The gas then mixes with the oil in the tubing string **14** flowing upwardly therethrough toward the surface of the well and reducing the fluid head until the formation pressure is sufficient to produce the oil and gas mixture at the surface of the well.

As production of the oil occurs through the tubing string **14**, the decrease in pressure, resulting from the oil and gas mixing, is reflected as a decrease of pressure in the valve assembly **22**. When the pressure is reduced to a predetermined value, the nitrogen in the bellows **42** extends the bellows until the spherical closure member **78** engages the annular valve seat **58** closing the flow passageway **60** and preventing the entrance of gas into the tubing string **14** through the valve assembly **22**. When the gas entrained in the column of oil reaches the surface, the density and thus the weight and pressure of the column again increases and is reflected in the gas lift valve assembly **22** as an increase in pressure on the main valve member **76** moving the valve member **76** off the seat **58** to initiate a repetition of the foregoing procedure.

Frequently, there will be sand or other abrasive materials entrained in the gas and liquid which can cause considerable damage in the gas life valve. The valve assembly **22** reduces the possibility of erosion to the minimum since the inlet ports **56** are directed relatively downwardly whereby the flow of gas and liquid with sand entrained therein is directed, without change of direction, into the outlet or flow passageway **60** in the annular valve seat **58**. Thus, and since no change in direction is necessary the greatest cause of erosion is eliminated.

Also, and as can be appreciated from the foregoing detailed description, the valve is of relatively simple construction and due to the balancing of the bellows effective area with the area of the main valve seat, the need for a sliding seal on the valve member has been eliminated. The elimination of the sliding seal avoids not only the danger of leakage across the seal as it wears during operation, but also the chance of trapping sand and other particles above the seal in the vicinity of the bellows which may interfere with proper operation of the gas l8f lift valve.

It will be understood that the foregoing has been presented by way of example only and that many changes and modifications can be made thereof without departing from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

I claim:

1. A gas lift valve for use in a well bore, said valve comprising:

a hollow valve body having an outlet passageway and having an inlet port of smaller cross-sectional area than said outlet passageway;

an annular valve seat located in said body between said inlet port and outlet passageway, said valve seat having a flow larger area larger than the cross-sectional area of said inlet port;

a valve member in said body movable between a closed position, wherein said member engages said seat, and an open position, wherein said member is out of engagement with said seat; and

pressure responsive means in said body connected with said valve member biasing said valve member toward said seat, said pressure responsive means being exposed to fluid pressure through said inlet port when said valve member is in the closed position and exposed to the fluid pressure in said outlet passageway when said valve member is in the open position, and said pressure responsive means having a cross-sectional area exposed to fluid pressure substantially equal to the cross-sectional area of said valve seat, whereby the pressure acting through said inlet port has no substantial effect on said valve member or pressure responsive means.

2. A gas lift valve for use in a cased well bore having tubing disposed therein, said vale comprising:

a hollow valve body adapted for connection with the tubing, said body having an outlet passageway arranged to communicate with the tubing and having an inlet port of smaller cross-sectional area than said outlet passageway providing communication with the casing;

an annular valve seat located in said body between said inlet port and outlet passageway said seat having a flow area larger than the cross-sectional area of said inlet port;

a valve member in said body move movable between a closed position, wherein said member engages said seat, and an open position, wherein said member is out of engagement with said seat; and

pressure responsive means in said body connected with said valve member biasing said valve member toward said seat, said pressure responsive means being exposed to pressure in the casing through said inlet port when said valve member is in the closed position and exposed to pressure in the tubing when said valve member is in the open position, whereby the movement of said valve member between said positions is controlled by the pressure in the tuning tubing acting through said outlet passageway; and said pressure responsive means having a cross-sectional area exposed to fluid pressure substantially equal to the cross-sectional area of said valve seat, whereby the pressure acting through said inlet port has no substantial effect on said valve member or pressure responsive means.

3 The gas lift valve of claims **1** and **2** wherein said pressure responsive means extends across said hollow valve body forming a chamber therein and wherein said valve also includes a compressible gas in said chamber for biasing said pressure responsive means and connected valve member toward said valve seat.

4. A gas lift valve for use in a cased well bore having tubing disposed therein, said valve comprising:

an elongated tubular body adapted for connection with the tubing, said body having

a closed upper end,

a lower end including an outlet passageway proving providing communication with the tubing passageway, and

an inlet port intermediate said ends providing communication with the casing;

an annular valve seat encircling said outlet passageway and having a cross-sectional flow area larger than the cross-sectional area of said inlet port;

A valve member movable between a closed position, wherein said valve member is in engagement with said seat, and an open position, wherein said valve member is not in engagement with said seat;

an expansible and contractible bellows in said body connected with said valve member and forming a chamber with said upper end;

A compressible gas in said chamber biasing said valve member relatively toward said valve seat; and toward said valve seat; and

said bellows being located between said closed end and side inlet port and exposed to fluid pressure from the casing through said inlet port when said valve member is in the closed position and exposed to fluid pressure from the tubing through said outlet passageway when said valve member is in the open position, and said bellows having a cross-sectional area exposed to fluid pressure substantially equal to the cross-sectional area of said valve seat, whereby the casing pressure acting through said inlet port has no substantial effect on said valve member or bellows.

5. The gas lift valve of claims **1**, **2**, or **4** wherein the cross-sectional area of said inlet port is at least 25 percent smaller than the cross-sectional area of said valve seat.

6 The gas lift valve of claims **1**, **2**, or **4** and also including surge valve means located in said outlet passageway said surge valve means including:

a surge valve encircling said outlet passageway between said valve seat and surge valve member;

a surge valve member in said outlet passageway;

resilient means biasing said surge valve member toward, but not into engagement with said surge valve seat, whereby fluid pressure in said outlet is exerted through said outlet passageway and fluid flow thereby toward said valve member is substantially prohibited.