Jan. 20, 1959 J. H. McCARVELL ET AL 2,869,568

GAS LIFT VALVE

Filed June 18, 1953 2 Sheets-Sheet 1

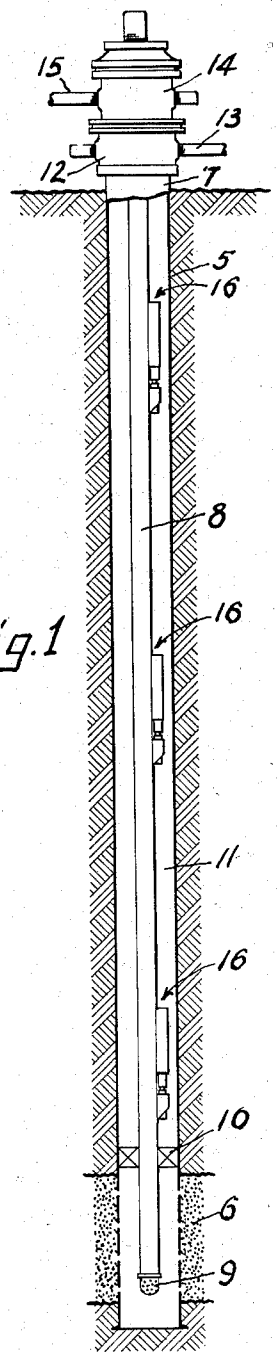


Fig. 1

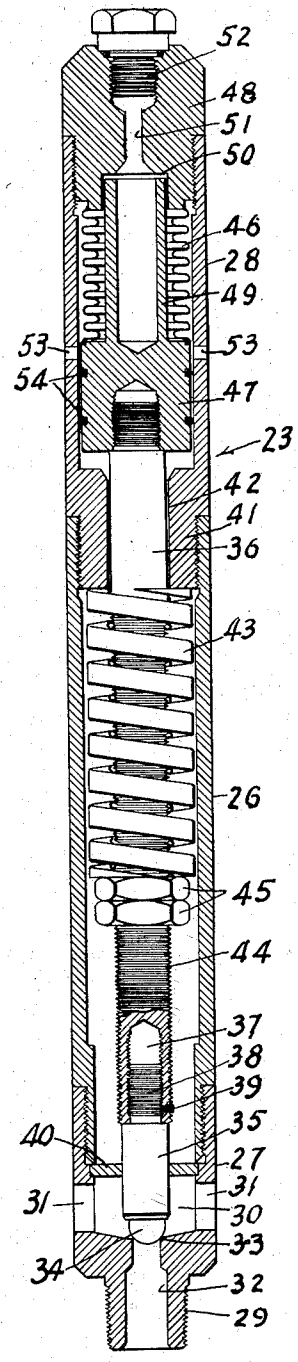


Fig. 2

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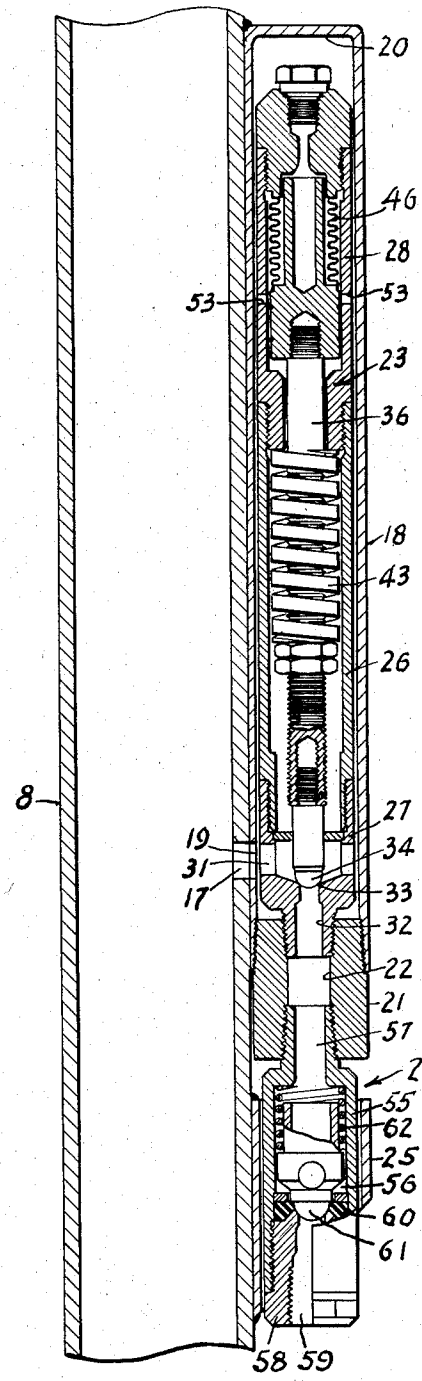


Fig. 3

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GAS LIFT VALVE

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3 Claims. (Cl. 137—155)

This invention relates to new and useful improvements in gas-lift valves.

A primary object of the present invention is to provide an improved gas-lift valve which is highly efficient in operation and relatively simple in construction.

An important object is to provide a gas-lift valve which is operative by differential in pressure between the fluid column to be lifted and the set pressure of the valve.

A further object is to provide a gas-lift valve in which the set pressure of the valve is controlled for all practical purposes solely by the force of a compression spring.

Another important object is to provide a gas-lift valve employing a bellows connected to the valve stem, which bellows is sealed at atmospheric pressure whereby the valve is subjected to minimum variations due to temperature changes in the well.

An additional object is to provide a valve construction employing a bellows sealed at atmospheric pressure, whereby the pressure differential across the bellows will always be in the same direction, namely from the exterior to the interior of the bellows, to thereby substantially reduce mechanical fatigue of the bellows and increase the over-all life of the valve.

Still another object is to provide a valve construction employing a valve casing having a bellows chamber which is provided with one or more pressure-equalizing ports of substantial area communicating directly with the exterior of the valve casing.

Other and more specific objects and advantages of this invention will become apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

In the drawing:

Fig. 1 is a generally diagrammatic view of a well having a string of tubing therein equipped with a plurality of valves in accordance with this invention;

Fig. 2 is a longitudinal sectional view of a valve unit in accordance with this invention; and

Fig. 3 is a view generally similar to Fig. 2 showing a complete valve structure installed on the tubing of a well.

Referring to Fig. 1, there is shown a well bore 5 extending into a producing formation 6. The well bore is lined with the usual casing 7. A string of tubing 8 extends into the well and is adapted to receive fluid from formation 6 through a screen 9. A packer 10 of any conventional form seals the annular space 11 between the casing and tubing at a point above formation 6. A casing head 12 is connected to the upper end of casing 7 and is provided with side connections 13 for the admission of lifting gas into annular space 11. A tubing head 14 of conventional construction is mounted on casing head 12 and connected to the upper end of tubing 8 in the well-known manner and is provided with side connections 15 for the discharge of fluids flowing upwardly through tubing 8. A plurality of gas-lift valves, designated generally by the numerals 16, are connected to tubing 8 at appropriately spaced points, as well understood in the art, for the purpose of admitting lifting gas into the interior of the tubing from annular space 11.

As best seen in Fig. 3, tubing 8 is provided with openings 17 (one shown) in the wall thereof for the admission of lifting gas. Adjacent the opening 17 there is rigidly secured to the side of tubing 8 a cylindrical housing 18 having an opening 19 in the side thereof registering with opening 17. It will be understood that the wall of housing 18 may be made integral with the adjacent portion of the wall of the tubing or so mounted thereon that openings 17 and 19 form a single continuous passageway providing communication between the interior of housing 18 and the interior of tubing 18. The upper end of housing 18 is closed by an end wall 20.

The lower end of housing 18 is arranged to threadedly receive a closure bushing 21 having an axial bore 22 which is internally threaded at its upper end to receive the threaded end of a valve unit, designated generally by the numeral 23. The lower end of bore 22 is also internally threaded for reception of a check valve element, designated generally by the numeral 24, which is enclosed by a guard sleeve 25 rigidly secured to the side of tubing 8 in co-axial alignment with housing 18.

As seen in enlarged scale in Fig. 2, valve unit 23 is composed of a tubular casing 26 having a generally tubular valve cage 27 threadedly secured to its lower end and a generally tubular bellows cage 28 threadedly secured to its upper end. Valve cage 27 and bellows cage 28 are connected in co-axial alignment with casing 26 and preferably have the same external diameters as casing 26 so that the entire valve unit will have a substantially uniform external diameter throughout its length, whereby valve unit 23 may be slidably inserted in its entirety in housing 18.

The lower end of valve cage 27 is reduced in diameter to form a boss 29 which is externally threaded for reception in the upper end of bore 22 in bushing 21. Valve cage 27 encloses a valve chamber 30 having one or more lateral ports 31 in the wall thereof adapted to register with openings 19 and 17 when the valve unit has been installed in housing 18. Boss 29 has an axial bore 32 extending therethrough and communicating with valve chamber 30 through a circular seat 33. A valve 34, which may be hemispherical, as shown, or of other suitable shape is disposed in valve chamber 30 for reciprocation therein relative to seat 33 for opening and closing the inner end of bore 32. Valve 34 is secured to, or formed with, a cylindrical head 35 which is connected to the lower end of an elongated stem 36. The latter has an internally threaded socket 37 to receive an externally threaded extension 38 formed on the upper end of valve head 35, this threaded connection providing means for longitudinal adjustment between head 35 and stem 36. A set screw 39 extends through the wall of socket 37 into engagement with extension 38 whereby to fix the position of valve head 35 relative to stem 36. An axially perforated guide washer 40 is mounted transversely of valve cage 27 about head 35 to center and guide the latter in its reciprocatory movement.

The lower end of bellows cage 28 is provided with a central boss 41 of reduced diameter and externally threaded for insertion into the upper end of casing 26. Boss 41 has an axial bore 42 providing communication between the interior of casing 26 and the interior of bellows cage 28. The upper end of stem 36 extends slidably through bore 42 into the bellows chamber.

A coil spring 43 is mounted in casing 26 about stem 36 and has its upper end abutting the lower end of boss 41. The exterior of the portion of stem 36 within casing 26 is externally threaded at 44 to receive a pair of adjusting nuts 45 which engage the lower end of spring 43 to compress the same, whereby the force of the spring will urge valve 34 toward the closing position on seat 33. By adjustment of nuts 45 the compression exerted

by the spring on valve 34 may be varied to regulate the setting of the valve.

A bellows assembly is mounted in bellows cage 28 and includes a hollow flexible bellows 46 of well known construction, which is closed at its lower end by means of a plug 47 which is threadedly secured to the upper end of stem 36 and is freely reciprocable therewith in bellows cage 28. The upper end of bellows 46 is secured to a closure plug 48 which is threadedly insertible into the upper end of bellows cage 28. Plug 47 is provided with a tubular stop nipple 49, open at its upper end, which extends through the bore of bellows 46 into a recess 50 provided in the inner end of closure plug 48, and serves as a stop to limit upward compression of the bellows when the valve is opened. Sleeve 49 also serves as a guide and support for the bellows during flexure thereof. Closure plug 48 is provided with an axial passageway 51 which communicates with recess 50 and with the interior of the bellows. The outer end of passageway 51 is closed by means of a screw cap 52. One or more radial ports 53 are provided in the wall of bellows cage 28 adjacent the lower end of bellows 46 to provide communication between the interior of the bellows cage and the exterior thereof. A pair of resilient metal snap rings 54—54 are circumferentially mounted in the exterior of plug 47 to resiliently engage the wall of bellows cage 28 whereby to cushion or damp the vibration of the stem and bellows. This damping feature is disclosed in greater detail in our U. S. Patent No. 2,610,644, issued September 16, 1952.

Check valve element 24 comprises a tubular body 55 threadedly secured to bushing 21 and enclosing a valve chamber 56 communicating with bore 22 through a passageway 57. A seat bushing 58 is inserted in the lower end of body 55 and has an axial passage 59 providing communication between the exterior of body 55 and the interior of valve chamber 56 through a valve seat 60. A valve element 61 is resiliently urged toward seat 60 by means of a coil spring 62 to normally close passage 59 against the return flow of fluid through the valve while permitting entrance of pressure fluid into the valve unit from the exterior thereof.

Before installation of valve unit 23 in housing 18, screw cap 52 is screwed into the end of plug 48 to seal the interior of bellows 46 at the ambient atmospheric pressure existing at the time of assembly or installation of the valve unit. It is an essential feature of the present valve that the normal pressure inside bellows 46 be such ambient atmospheric pressure. Nuts 45 are adjusted to compress spring 43 sufficiently to maintain the pre-determined closing pressure on valve 34. Valve unit 23, having bushing 21 secured to the lower end thereof, is then inserted into housing 18 and secured therein by screwing bushing 21 into the lower end of the housing, as shown. Check valve element 24 is then inserted in guard sleeve 25 and screwed into bushing 21 to complete the assembly.

Valves constructed as above described will open only when the column of fluid in tubing 8 rises above the valve to a height such that the head of fluid exceeds the set pressure of the valve as determined by the loading of spring 43. When the valve opens, lifting gas, held under pressure in casing annulus 11, will flow therefrom through check valve element 24 into valve chamber 30 and thence through ports 31, 19 and 17 into the interior of tubing 8 to lift the column of fluid therein toward the surface. The head pressure of the fluid in tubing 8 will work through the annular space between valve unit 23 and housing 18 and will enter the bellows cage through ports 53, thereby quickly equalizing the pressures in the valve chamber and the bellows cage.

By the arrangement herein described, including particularly the employment of the pressure equalizing ports 53, throttling effect on the valve is eliminated, allowing the valve to open fully with a rapid snap action which is very desirable in order to admit quickly into tubing 8 a large charge of lifting gas. Similarly, by the use of equalizing ports 53, the valve will close quickly when the head pressure in the tubing drops below the closing pressure of spring 43.

By providing only atmospheric pressure in the interior of bellows 46, a number of advantages result. The effect of temperature on the bellows is reduced to a minimum. The loading of valve 34 which determines its operating pressure is confined to the force of spring 43. The pressure externally of the bellows will always be higher than atmospheric pressure, hence the pressure differential across the bellows wall will be uni-directional, that is, from the exterior toward the interior of the bellows, thereby greatly reducing the degree of flexure of the bellows, which will, in turn, greatly reduce the mechanical fatigue of the bellows and correspondingly increase its useful life.

By the valve construction described, all of the several valves in a string can be set to operate at the same pressures and once in the well, require no adjustment. Since the valves will open only when the fluid head in the tubing above each valve exceeds the set pressure of the valve, operation of the valves is not dependent upon maintenance of some fixed pressure or volume in the casing annulus and the need for the relative expensive and troublesome intermitter devices commonly employed is eliminated.

It will be understood that various changes and modifications may be made in the details of the illustrative embodiment within the scope of the appended claims without departing from the novel principles of this invention.

What we claim and desire to secure by Letters Patent is:

1. In a well flow valve, the combination with a tubular housing closed at its ends and mountable on a well pipe, said housing having a gas discharge opening in the wall thereof adapted for communication with the interior of the well pipe, and an axially disposed gas inlet passage in the lower end thereof, a valve unit enclosed within said housing, said valve unit comprising a tubular casing closed at its ends and having an internal partition member defining therein a lower valve chamber and an upper bellows chamber, outlet ports in the wall of the valve chamber communicating with the interior of the housing, an axial inlet port means in the lower end of the valve chamber connected into said gas inlet passage, a valve member reciprocable in the valve chamber to open and close said port means, a stem connected to said valve member and extending slidably through said partition member into said bellows chamber, spring means mounted in said valve chamber in compression between said partition member and said stem to resiliently bias said valve member toward the position closing said port means, a hollow bellows member charged to the ambient atmospheric pressure existing when said unit is assembled mounted in said bellows chamber to resiliently connect the upper end of said stem to said casing, and openings in the wall of said bellows chamber above the partition member providing communication between the interior of the bellows chamber and the interior of said housing.

2. In a well flow valve as defined by claim 1, adjustable means mounted on said stem for adjustably varying the compression of said spring means.

3. In a well flow valve as defined by claim 1, inwardly opening check valve means in said gas inlet passage.

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