

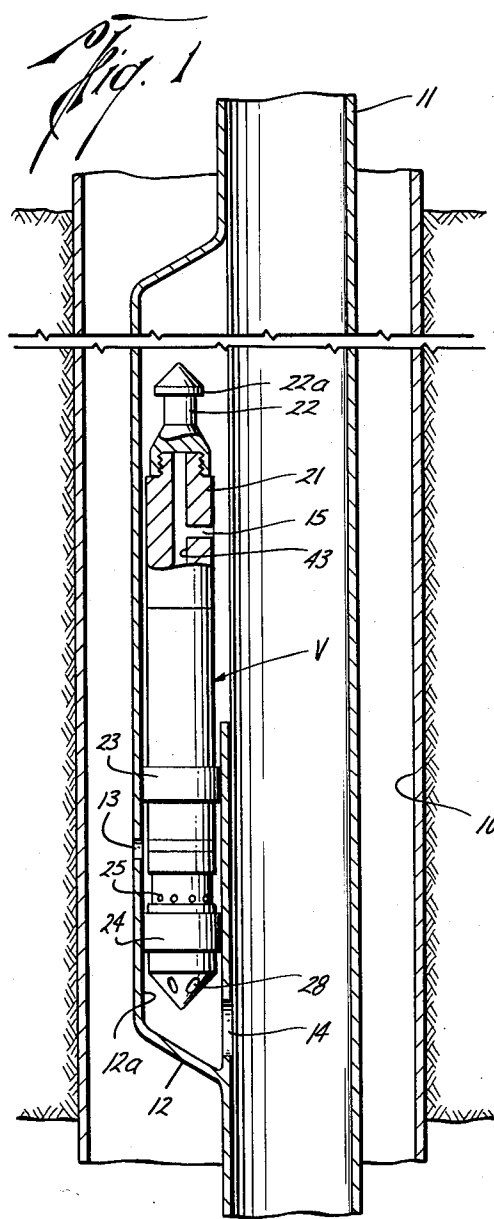
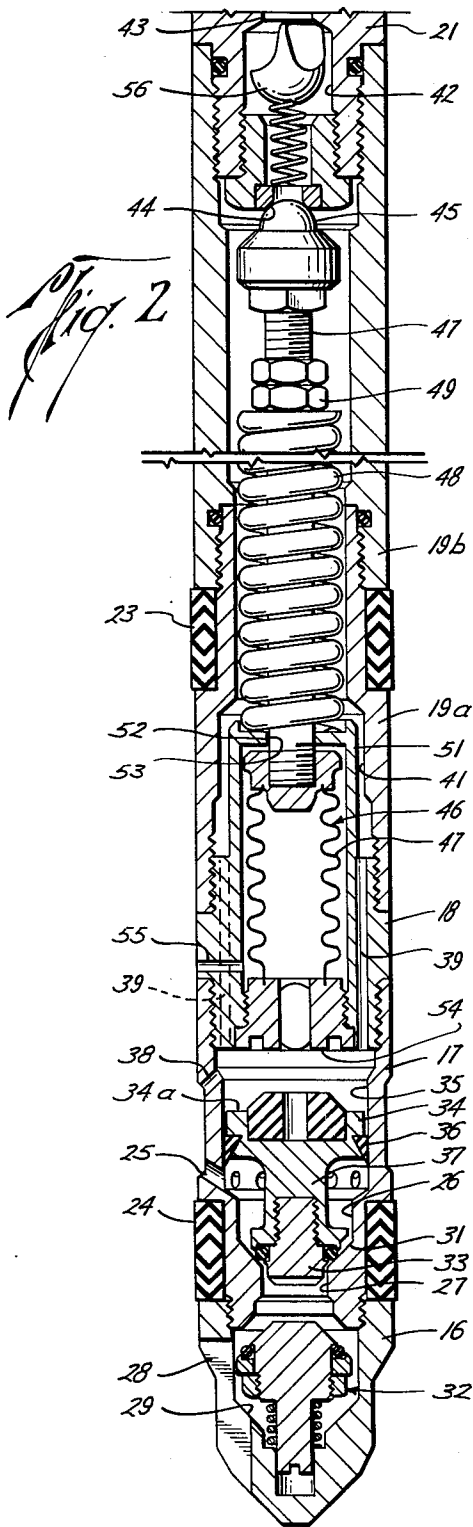
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GAS LIFT VALVE

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## GAS LIFT VALVE

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This invention relates to valves, and more particularly to wireline operated gas lift valves.

An object of this invention is to provide a gas lift valve of the pilot operated type in which the pressure responsive motor for the main valve member does not have to be leak tight.

Another object is to provide a gas lift valve of the pilot operated type in which the main valve operator piston does not require a positive seal.

Another object is to provide an improved bleed port location in a wireline valve of the pilot operated type.

Other objects, features and advantages of this invention will be apparent from the drawing, the specification and the claims.

In the drawing, wherein an illustrative embodiment of this invention is shown, and wherein like reference numerals indicate like parts:

FIGURE 1 is a view partially in vertical cross-section and partially in elevation through a well having a valve constructed in accordance with this invention mounted in the side pocket of the tubing; and,

FIGURE 2 is a view in vertical cross-section on an enlarged scale of the valve shown in FIGURE 1 except for the upper end thereof which is shown in section in FIGURE 1.

Referring first to FIGURE 1, a section of casing 10 is shown in a well bore. Tubing 11 is suspended within the casing and includes a side pocket 12 for receiving a gas lift valve. This side pocket has an inlet port 13 for admitting gas from the tubing-casing annulus. Gas entering through the port 13 passes through the valve V and is principally exhausted into the tubing through the port 14 in the tubing wall in the lower end of the side pocket 12. As will appear in the description of operation of valve V, a small amount of gas will also flow into the tubing through the outlet port 15 in the upper section of valve V.

FIGURE 2 illustrates in detail the preferred form of valve. A multi-piece housing is provided and includes a bottom cap 16, an inlet thimble 17, a bellows housing 18, a two-piece pilot valve and spring housing 19a and 19b, a seat and check adapter 21 and a top cap 22 which also provides a retrieving overshot 22a. It will be noted that the multipiece housing is tubular in form with the exception, of course, of the top and bottom caps.

Spaced seal means 23 and 24 are provided on the exterior of the housing for sealing at spaced points with the cylindrical wall 12a of the side pocket 12 to seal between the valve V and the side pocket 12 and define an intermediate section of the housing between the two seals.

A main gas passageway is provided through the housing. The main gas passageway includes an inlet provided by a plurality of ports 25, a counterbore 26 in the inlet thimble, a bore 27 in the inlet thimble and an outlet 28 in lower cap 16 which communicates with the bore 27 via the bore 29 in the lower cap. It will be noted that the outlet 28 is outside of the intermediate section defined by the two seals and the inlet and outlet are separated by the lower seal 24, thus forcing gas entering through ports 13 to pass through the main gas passageway to reach port 14 in tubing 11.

A valve seat 31 is provided across said main gas passageway by the frusto-conical shoulder interconnecting bore 27 and counterbore 26 in inlet thimble 17.

A back check valve indicated generally at 32 is pro-

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vided in the lower end of the main gas passageway and prevents reverse flow of fluid through the gas lift valve in the event pressure within the casing-tubing annulus falls below that necessary to keep the valve V closed.

A main valve member 33 cooperates with valve seat 31 to control flow through the main gas passageway.

A pressure responsive member, such as motor piston 34, is provided in the housing for controlling operation of the main valve member 33. As noted, it is preferred to use a piston and the piston may have a sliding and sealing engagement with the internal surface 35 of section 17 of the housing. Means are preferably provided for sealing between the piston 34 and thimble 17 such as the annular seal 36 on the exterior of piston 34.

Means are provided for connecting said main valve member and pressure responsive member together. Such means may be provided by a depending extension 37 on piston 34, which extension also provides a portion of the valve assembly 33.

Means are provided for exposing one side of the pressure responsive member 34 to the intermediate section of the housing defined by seals 23 and 24. Preferably, this means is the inlet ports 25 and the lower section of bore 35 in which the piston 34 reciprocates. Thus, pressure fluid entering inlets 25 is effective on both the motor piston 34 and the main valve 33.

A pilot gas passageway is provided and includes an inlet bleed port 38 in the intermediate section of the housing defined by the seals 23 and 24. The pilot gas passageway also includes the upper section of bore 35 in which piston 34 reciprocates, as well as the upper surface of piston 34. It is noted that the bleed inlet 38 is upstream of the motor piston 34, and thus the motor piston will be controlled by the pressure conditions downstream of bleed 38.

The pilot gas passageway further includes a plurality of passages 39 in bellows housing 18, the inner bore 41 through the two-piece pilot valve and spring housing 19a and 19b, the counterbore 42 and bore 43 through seat and check adapter 21 and the outlet 15 from the check adapter. It is noted that the pilot gas passageway throughout its entirety has a substantially greater cross-sectional area than the bleed inlet 38. The outlet 15 of the pilot gas passageway is outside of said intermediate section defined by said spaced seals 23 and 24 and is preferably on the opposite end of the valve V from the main gas outlet 28. This arrangement of the main and pilot gas outlets provides for convenience and economy in construction of the valve.

A pilot valve seat 44 is carried by the seat and check adapter across said pilot gas passageway. The seat 44 is positioned downstream of the pressure responsive member 34 and thus control of flow of pilot gas through seat 44 determines whether casing or tubing pressure will be present on the upper pressure surface 34a of pressure responsive member 34.

A pilot valve member 45 controls flow through the pilot gas passageway.

Bellows means are provided for controlling the pilot valve member 45. The bellows means may be provided by a bellows assembly indicated generally at 46. The assembly is mounted in the lower end of the bellows housing section 18. The bellows is connected to the pilot valve 45 through a connecting stem 47. A spring 48 is held in compression between a nut 49 on stem 47 and the end of bellows guide sleeve 51. It will be noted that the bellows guide sleeve forms an extension of the bellows housing section 18 and the upper end of the sleeve is closed by an inwardly extending flange 52 having a bore 53 therein in which the connecting stem 47 reciprocates. The bore 53 is substantially closed by the stem 47. The other end of the bellows housing section 18 is closed by

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the bellows end closure 54, thus providing about the bellows 47 a substantially sealed chamber.

Means are provided by a port 55 in the bellows housing section 18 for establishing fluid communication between the exterior of bellows 47 and the intermediate section of the housing defined by seals 23 and 24. The port 25 is of a size to maintain casing pressure about bellows 47 with slight leakage of fluid through bore 53 in the upper end of the bellows guide sleeve 51.

A back check valve 56 is provided in counterbore 42 in the seat and check adapter section 21 of the housing to prevent back flow of fluid from the tubing to the casing-tubing annulus.

The operation of the valve will be explained assuming a closing pressure of 550 p.s.i. and an opening pressure of 600 p.s.i. As the casing pressure builds up to 600 p.s.i., the effect of casing pressure on the bellows assembly overcomes the force exerted by spring 48 and the pilot valve 45 moves to open position, uncovering seat 44. As the pilot valve opens, casing pressure is discharged from the pilot gas passageway faster than it can enter the passageway through bleed port 38 until the pressure within the pilot gas passageway approaches or becomes tubing pressure. It should be noted that if no positive seal is provided between the valve stem 47 and bellows guide sleeve 51, some slight leakage may now occur at this point.

When pressure within the pilot gas passageway approaches tubing pressure, the forces acting on the main valve piston become unbalanced. We now have casing pressure underneath the motor piston 34 and tubing pressure on the upper surface of motor piston 34. Of course, tubing pressure is also effective on the portion of the valve member 33 defined by valve seat 31. This unbalancing of the forces acting on motor piston 34 causes the main valve to snap to full open position and remain there until the pilot valve closes. Once the main valve 33 begins to move off of its seat, the area of the valve member previously exposed to tubing pressure begins to, at least in part, be exposed to casing pressure and this sudden increase in pressure on a surface previously exposed to tubing pressure causes the valve to snap to full open position.

With the valve member in full open position, it will be recalled that casing pressure is present below the motor piston and tubing pressure is present above the motor piston 34. As the pilot gas passageway is much larger through its entire length than the bleed inlet 38, it will be appreciated that an absolute seal is not necessary between the motor piston 34 and the inlet thimble bore 35. Of course, when in new condition a complete seal is preferred, but with use it is possible for leakage to occur across seal 36. By this invention, however, this leakage will not affect operation of the valve until it becomes very substantial, as this leakage may be exhausted through the pilot gas passageway and tubing pressure maintained on top of the motor piston 34 by the expedient of placing the bleed section of the pilot gas passageway upstream of the motor piston 34.

After lift gas has passed through the main gas passageway and into the tubing string to lift fluid to the surface until the pressure in the casing-tubing annulus has been reduced to about 550 pounds, the valve V begins to close. At about 550 p.s.i. the effect of casing pressure on the bellows 46 is overcome by the force of spring 48 and pilot valve member 45 moves to closed position. When this happens, the pressure within the pilot gas passageway upstream of pilot seat 44 rapidly becomes casing pressure and we have casing pressure effective above and below motor piston 34. Thus, the pressure forces across the motor piston and main valve member 33 become substantially balanced. When this occurs, the gravitational effect of piston 34 and main valve assembly 33 and the velocity effect of the casing pressure flowing past the valve assembly 33 causes the main valve to snap to closed

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position. The main valve is then held in closed position by the effect of differential between casing pressure and tubing pressure thereacross until the pilot valve opens again.

At this time it will be noted that casing pressure is effective on both sides of the pressure responsive member 34 and therefore no differential is present across the motor piston, and there is no possibility of leakage past the piston finding its way into the tubing when the valve V is in closed position.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A gas lift valve comprising, a tubular housing, spaced seal means on the exterior of the housing defining therebetween an intermediate section of the housing, a main gas passageway through the housing having an inlet in said intermediate section and an outlet outside of and on one side of said intermediate section, a valve seat across said main gas passageway, a main valve member cooperable with the valve seat to control flow through the passageway, a pressure responsive member mounted in the housing, means connecting said main valve member and pressure responsive member together, means exposing one side of said pressure responsive member to said intermediate section of the housing, a pilot gas passageway having an inlet in said intermediate section and an outlet outside and on the other side of said intermediate section, the other side of said pressure responsive member forming a part of said pilot gas passageway, said pilot gas passageway having a bleed section upstream of said pressure responsive member, a pilot valve seat across said pilot gas passageway downstream of said pressure responsive member, a pilot valve member controlling flow through the pilot gas passageway, bellows means arranged between said main and pilot gas valve seats controlling said pilot valve member, and means exposing said bellows means to said intermediate section of the housing.

2. A gas lift valve comprising, a tubular housing, spaced seal means on the exterior of the housing defining therebetween an intermediate section of the housing, a main gas passageway through the housing having an inlet in said intermediate section and an outlet in one end of the housing outside said intermediate section, a valve seat across said main gas passageway, a main valve member cooperable with the main valve seat to control flow through the passageway, a piston connected to the main valve member and in sliding engagement with the internal surface of the housing on the side of the main valve member remote from the main gas outlet, the side of said piston adjacent the main valve member forming a part of said main gas passageway, a pilot gas passageway having an inlet in said intermediate section and an outlet outside said intermediate section and in the other end of the housing, the other side of said piston forming a part of said pilot gas passageway, said pilot gas passageway having a bleed section upstream of said piston, a pilot valve seat across said pilot gas passageway downstream of said piston, a pilot valve member controlling flow through the pilot gas passageway, bellows means in the housing between said piston and pilot valve seat and controlling said pilot valve member, and means exposing said bellows means to said intermediate section of housing.

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