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McGowen, Jr. et al.

[11] **3,760,832**

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[54] **HEAT CONTROLLED GAS LIFT VALVE**

[75] Inventors: **Harold E. McGowen, Jr.; Gilbert H. Tausch,** Houston, Tex.

[73] Assignee: **Camco Cincorporated,** Houston, Tex.

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[52] **U.S. Cl.** **137/155,** 251/11, 417/112

[51] **Int. Cl.** **F04f 1/08**

[58] **Field of Search** 137/155; 251/11; 417/112

[56] **References Cited**

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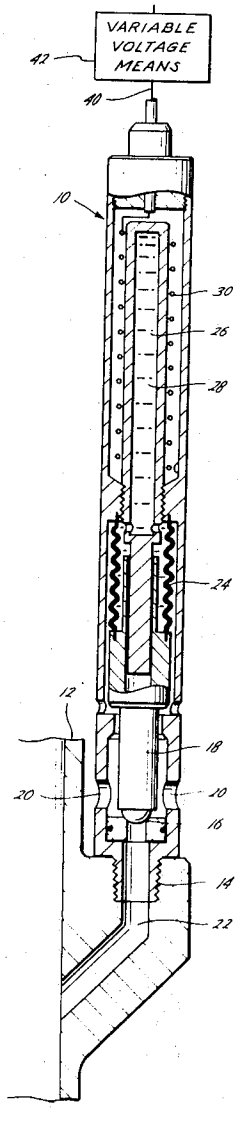
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Primary Examiner—Alan Cohan
Attorney—James F. Weiler et al.

[57] **ABSTRACT**

A gas lift valve having a seat and a valve element for admitting pressurized fluid into a well conduit in which the operation of the valve is controlled by heat. A closed chamber having a fluid therein which is exposed to the valve element for moving the element in one direction as the fluid expands, said fluid being expandable and the pressure increases when heat is applied thereto, and the fluid pressure decreases on removal of heat therefrom. Means for applying and/or removing heat from the closed chamber for controlling the actuation of the valve. An electrical or fluid heating coil positioned adjacent the closed chamber and a control line leading to the well surface for controlling the heat applied to the closed chamber. A cooling coil positioned adjacent the closed chamber with a control line leading to the surface for controlling the heat removed from the closed chamber.

8 Claims, 4 Drawing Figures



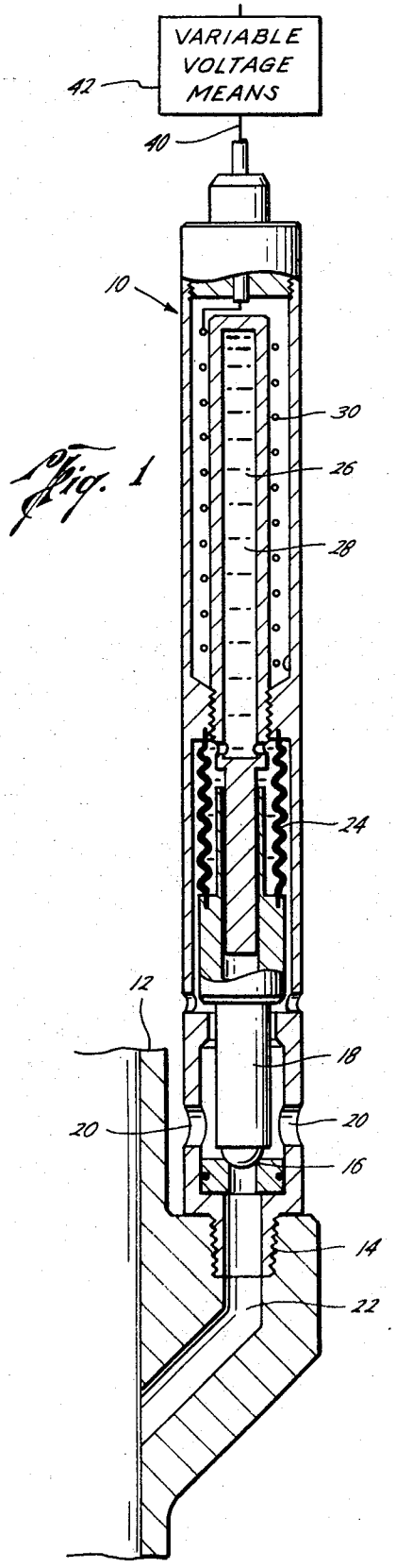

VARIABLE VOLTAGE MEANS
42
40
10
30
26
28
24
12
18
20
20
16
14
22

Fig. 1

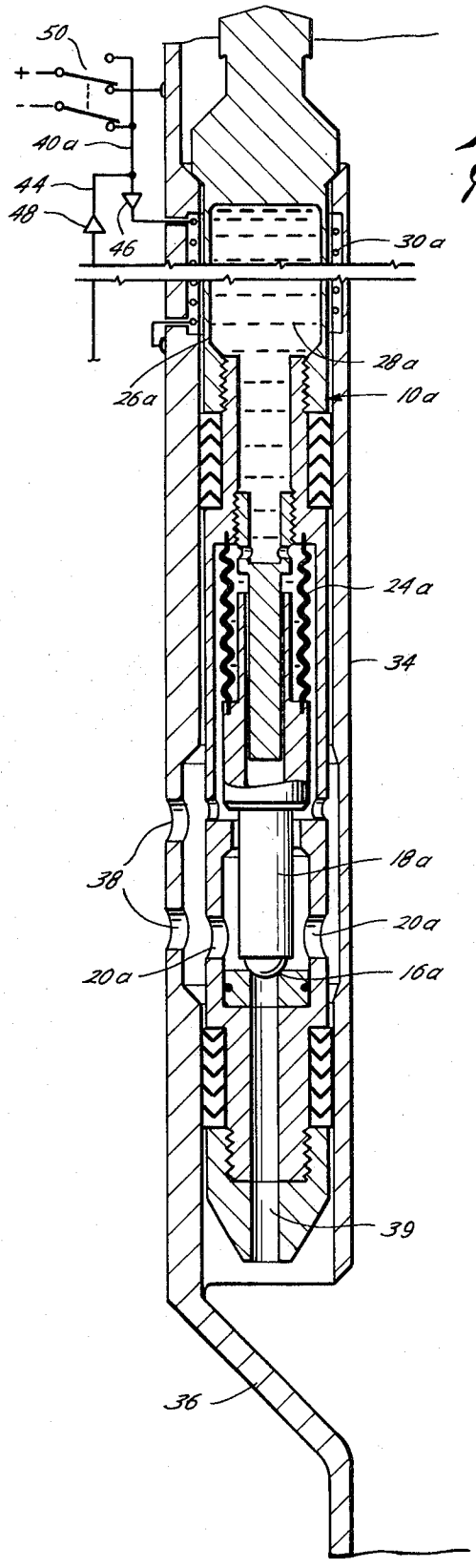

50
+
-
40a
44
48
46
30a
28a
26a
10a
24a
34
38
18a
20a
20a
16a
39
36

Fig. 2

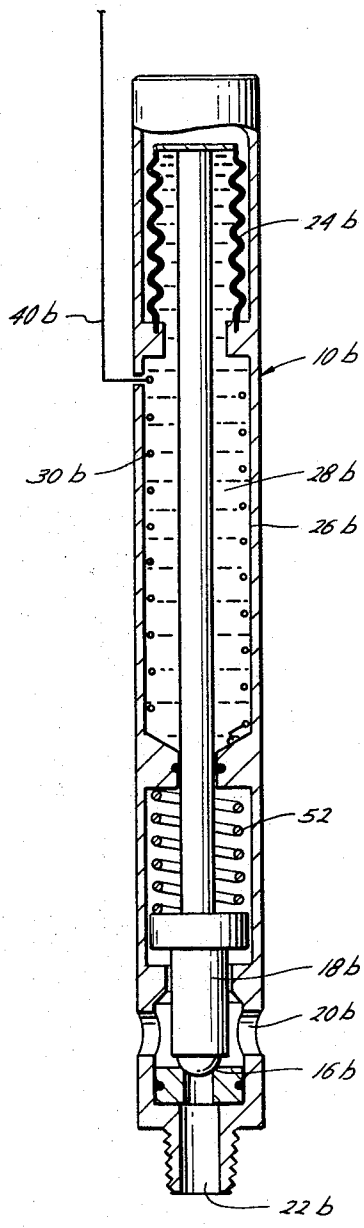

40b
24b
10b
30b
28b
26b
52
18b
20b
16b
22b

Fig. 3

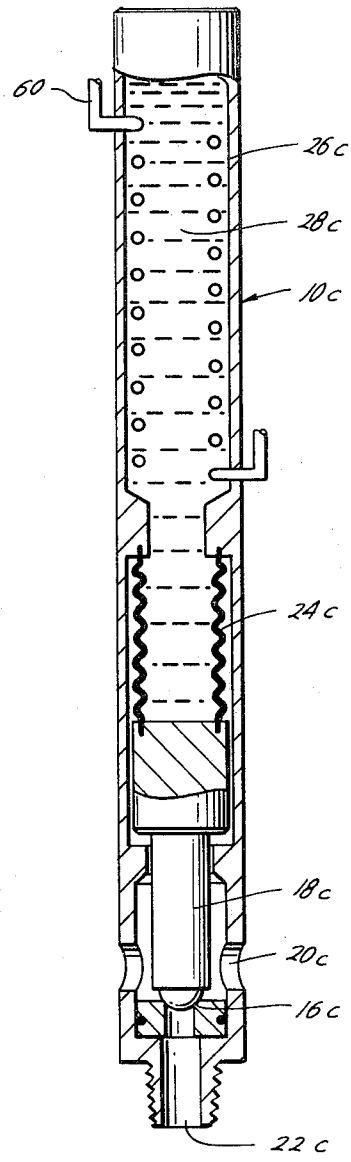

60
26c
28c
10c
24c
18c
20c
16c
22c

Fig. 4

HEAT CONTROLLED GAS LIFT VALVE

BACKGROUND OF THE INVENTION

Generally, it is old to provide a subsurface gas lift valve located in a well bore and connected to a well tubing for injecting pressurized gas from outside the well conduit to inside the well conduit to provide a gas lift for fluid in the well conduit. Generally, gas lift valves are pressure operated in which a fixed closing force is obtained from a pressure charged bellows and the valve is controlled by the injection gas pressure.

The present invention is directed to improvements in a gas lift valve in which the valve opening and/or closing, as well as the degree of opening, can be controlled by providing a heat controlled well safety valve which can be operated and controlled from the well surface.

SUMMARY

The present invention is directed to a heat controlled subsurface gas lift valve connected to a well conduit which may be controlled by the application and/or removal of heat.

A further object of the present invention is the provision of a heat controlled gas lift valve having a seat and valve element for admitting pressurized fluid into a well conduit by providing a closed chamber having a fluid therein which is exposed to the valve element for moving the valve element in one direction as the fluid expands. The fluid is expandable when heat is applied thereto and contractable when cooled and means are provided for controlling the heat of the closed chamber thereby controlling the actuation of the valve.

Yet a still further object of the present invention is the provision of control means for controlling the heat of a heat actuated gas lift valve which is variable thereby controlling the valve opening and closing and the degree of opening.

Still a further object of the present invention is the provision of a bellows operated gas lift valve by providing a closed chamber having a fluid therein which is exposed to the bellows for moving the valve in one direction and means for controlling the heat of the fluid thereby controlling the actuation of the valve, and said heat control means extends the well surface.

Yet a further object of the present invention is the provision of controlling a heat actuated gas lift valve in which the controlling means is an electrical or fluid heating coil adapted to be positioned adjacent the closed fluid chamber.

Yet a further object of the present invention is wherein the control means for a heat controlled gas lift valve is a cooling jacket positioned adjacent the closed fluid chamber.

A still further object of the present invention is the provision of a retrievable gas lift valve actuated by heat in which a heating coil is positioned in the well conduit adjacent the seated position of the valve and a control line extends to the well surface for controlling the amount of heat applied to the valve.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary elevational view, partly in cross section, illustrating a heat operated gas lift valve of the present invention of the nonretrievable type,

FIG. 2 is a fragmentary elevational view, partly in cross section, illustrating a retrievable type gas lift valve mounted in the sidepocket of a mandrel,

FIG. 3 is a schematic elevational view of an embodiment of a gas lift valve which closes on reduction of heat, and

FIG. 4 is a schematic elevational view of a heat controlled gas lift valve which is controlled by a fluid control line.

DESCRIPTION OF THE PREFERRED EMBODIMENT

While the present improvement in a subsurface gas lift valve will be shown, for purposes of illustration only, as incorporated in a bellows type valve, it will be understood that the present heat controlled gas lift invention may be used in other types of gas lift valves.

Referring now to the drawings, and particularly to FIG. **1**, one type of gas lift valve is shown utilizing the present invention, and generally indicated by the reference numeral **10**. The valve **10**, as shown in FIG. **1**, is of a nonretrievable type gas lift valve which is mounted on the side of a well tubing **12** such as by threaded connection **14**. The valve **10** generally includes a valve seat **16** and a valve element **18** for controlling the flow of a pressurized injection fluid from outside of the tubing **12** through ports **20** and into passageway **22** leading to the interior of the well conduit **12**.

As is conventional, a bellows **24** is connected to the valve element **18** and subjected to pressure in a closed chamber **26**. In the embodiment shown in FIG. **1**, the pressure in the closed chamber **26** acts over the effective area of the bellows **24** to seat the valve element **18** on the valve seat **16** thereby closing the gas lift valve. The valve is opened by the injection of pressurized gas which flows through the ports **20** and acts against the effective area of the bellows less the area of the valve seat **16** although the opening force is assisted by the tubing pressure in the well tubing **12** acting through the passageway **22** against the bottom of the valve element **18**. Of course, the pressure in the chamber **26** in a conventional gas lift valve is fixed and cannot be varied to control the closing or opening force or the degree of opening the valve.

The present invention is directed to providing an improved gas lift valve which is heat controlled. Thus, the present invention is directed to providing a fluid **28** in the chamber **26**, either liquid or gas, which expands or vaporizes as the temperature in the chamber **26** is increased thereby increasing the fluid pressure in the chamber. Similarly, the fluid **28** will contract and lower its pressure on removal of heat. While any suitable fluid such as hydrocarbons may be used, refrigerants such as halogenated hydrocarbons such as sold under the trademark Freon are preferred because of their higher pressure upon vaporization and their safety and availability although other fluids such as carbontetrachloride may be used. Thus, as heat is applied to the chamber **26**, the pressure of the fluid **28** is increased to provide a greater closing force against the bellows **24** and the valve element **18** to cause the valve element **18** to seat more firmly on the valve seat **16** require a thus to requirea greater opening force. And conversely, when heat is removed from the chamber **26**, the fluid **28** therein will cool and the pressure will decrease thereby decreasing the closing pressure of the bellows **24** seating the element **18** on the seat **16**. And, of course, by varying the amount of heat applied to the fluid **28**, the amount of closing force which the closed chamber **26**

exerts on the bellows **24** and the valve can be varied to meet changing well conditions.

Any suitable heating means may be used to apply heat to the closed fluid chamber **26** such as steam conduit. However, the preferred form of the heating means is by the use of a heating coil **30** preferably built in the housing of the valve **10** and surrounding the chamber **26.** The coil **30** may be electrically energized by a single electrical conductor **40** with the tubing **12** used as the other electrical conductor thereby requiring only a single insulated conductor **40** leading to the well surface. The application of heat may be initiated, stopped, or varied by a suitable variable voltage means **42** located at the well surface. Therefore, the amount of heat applied to the fluid **28** in the chamber **26** can be varied by varying the variable voltage means **42.** Thus, the pressure in the chamber **26** may be increased or decreased to control the closing and opening of the valve element **18** on the seat **16** as well as controlling the degree of opening.

Of course, other and further embodiments and modifications may be made, such as shown in FIGS. **2, 3** and **4,** where like parts to those shown in FIG. **1** are given corresponding numbers with the addition of a suffix *a*, *b*, and *c*, respectively.

The heat controlled gas lift valve **10***a* shown in FIG. **2** is of a retrievable type such as one that can be seated in a sidepocket **34** of a mandrel **36** which is installed in a well conduit. Thus, the fluid **28***a* which is expandable when heat is applied thereto acts against the bellows **24***a* to provide a force for closing the valve element **18***a* on the valve seat **16***a*. Ports **38** are provided in the sidepocket **34** in communication with the valve ports **20***a* to admit injection pressurized fluid when the valve **10***a* is opened to flow through passageway **39** and into the interior of the mandrel **36** and well tubing. Preferably, the heating coil **30***a* is positioned in the mandrel **36** so as to be adjacent the closed chamber **26***a* when the valve **10***a* is seated in the sidepocket **34.** As in FIG. **1,** a single electrical conductor **40***a* may be used to provide the electrical energy to the heating coil **30***a* for controlling the actuation of the valve **10***a*. In addition, the single electrical conductor **40***a* may be utilized to control an additional gas lift valve through electrical line **44** by placing a first diode **46** connected to the coil **30***a* and a second diodd **48** in a reverse position in line **44** to a second gas lift valve. Thus, a switch **50** may be alternately energized to control the transmission of electrical energy to line **40***a* and through either diode **46** or **48** to control the amount of heat and thus the actuation of two gas lift valves.

The embodiments of FIGS. **1** and **2** illustrate gas lift valves in which heat is applied thereto in a manner that an increased application of heat closes the valve. The embodiment shown in FIG. **3** illustrates a heat controlled gas lift valve of the present invention in which an increase of heat to the closed fluid chamber acts in a direction to open the valve. Thus, in FIG. **3** the bellows **24***b* is connected to the closed chamber **26***b* such that an increase in pressurein the fluid **28***b* acts in a direction to unseat the valve element **18***b* off of the seat **16***b*. If desired, a spring **52**may be provided to provide an additional closing force. By increasing the electrical voltage transmitted over line **40***b* to the electrical coil **30***b* the temperature of the fluid **28***b* is increased in a direction to provide an opening force on the valve **10***b* or to decrease the opening force required by the injection fluid. Of course, by decresing the electrical energy transmitted to the coil **30***b* the amount of heat applied to the closed chamber **26***b* will be decreased thereby decreasing the opening force of the bellows **24***b*.

Referring now to another embodiment as best seen in FIG. **4,** the means for controlling the heat of the closed chamber **26***c* and the fluid **28***c* therein is a fluid conduit coil **60** extending to the well surface. In one use, steam may be supplied from the well surface through the conduit coil **60** to apply heat to the fluid **28***c* and against the bellows **24***c* in a direction to seat the valve element **18***c* on the valve element **16***c* to provide a closing force acting to close the valve **10***c*.

However, the embodiment of FIG. **4** may also be used for removing heat from the closed chamber **26***c* to decrease the pressure of the fluid **28***c* therein. As is well known, the temperature in a well bore at a sufficient depth may be sufficiently great in some environments to provide sufficient heat to the fluid **28***c* in the closed chamber **26***c* to provide the desired closing force on the valve **10***c*. Under such conditions, means may be provided for removal of heat from the closed chamber **26***c* for controlling the operation of the valve **10***c*. In that event, the fluid conduit **60** may be supplied with a cooling fluid, such as cooling water from the well surface, to control the amount of heat applied to the fluid **28***c* and thus control the operation of the valve **10***c*. Of course, when the flow of cooling fluid through the conduit coil **60** is stopped, the natural heat in the well bore will then be applied to the fluid **28***c* to increase thepressure and the closing force therein.

The present invention, therefore, is well adaptedto carry out the objects and attain the ends and advantages mentioned as well as other inherent therein. While presently preferred embodiment of the invention are given for the purpose of disclosure, numerous changes in the details of construction and arrangement of parts will readily suggest themselves to those skilled in the art and are encompassed within the spirit of the invention and the scope of the appended claims.

What is claimed is: **9**

1. A heat controlled gas lift valve for admitting pressurized fluid into a well conduit comprising,

a well mandrel for connection to a well conduit in a well below the well surface, said mandrel including a passageway extending between the interior and the exterior of the mandrel,

a gas lift valve having a seat and a valve element secured to the mandrel for controlling the opening and closing of the mandrel passageway, said element exposed to pressure exteriorly of the mandrel acting to move said element to an open position,

a closed chamber in the valve having a fluid therein which is exposed to the valve element for moving the element in one direction as the fluid expands, said fluid being expandable when heat is applied thereto, and

coil means positioned adjacent the closed chamber and extending to the well surface for controlling the heat of the closed chamber thereby controlling the actuation of the valve.

2. The apparatus of claim **1** wherein the heat of the coil means is variable.

3. The apparatus of claim **1** wherein the coil means includes a cooling jacket positioned adjacent the closed chamber.

4. The apparatus of claim 1 wherein the coil means includes a fluid heating jacket positioned adjacent the closed chamber.

5. The apparatus of claim 1 wherein the coil is an electrical heating coil positioned about the closed chamber.

6. The apparatus of claim 1 wherein the fluid is a halogenated hydrocarbon.

7. The apparatus of claim 1 wherein the mandrel includes an offset internal sidepocket receiving the valve and the coil is positioned in the mandrel about the closed chamber.

8. A heat controlled gas lift valve for admitting pressurized fluid into a well conduit comprising,

a well mandrel for connection to a well conduit in a well below the well surface, said mandrel including a sidepocket having a fluid passageway extending between the interior and the exterior of the mandrel,

a gas lift valve positioned in the side-pocket and having a seat and valve element for opening and closing the fluid passageway, said element exposed to pressure exteriorly of the mandrel acting to move said element to an open position,

a closed chamber in the valve having a pressurized fluid therein which is exposed to the valve element for moving the elementin one direction as the fluid expands, said fluid being expandable when heat is appliedthereto,

an electrical heating coil positioned in the internal sidepocket and about the closed chamber and leading to the well surface for controlling the heat applied to the fluid in the closed chamber thereby controlling the actuation of the valve.

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