

[54] WELL SAFETY VALVE SYSTEM AND METHOD OF OPERATION
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[51] Int. Cl. **E21b 43/12**
[58] Field of Search **166/72, 224 S, 315**

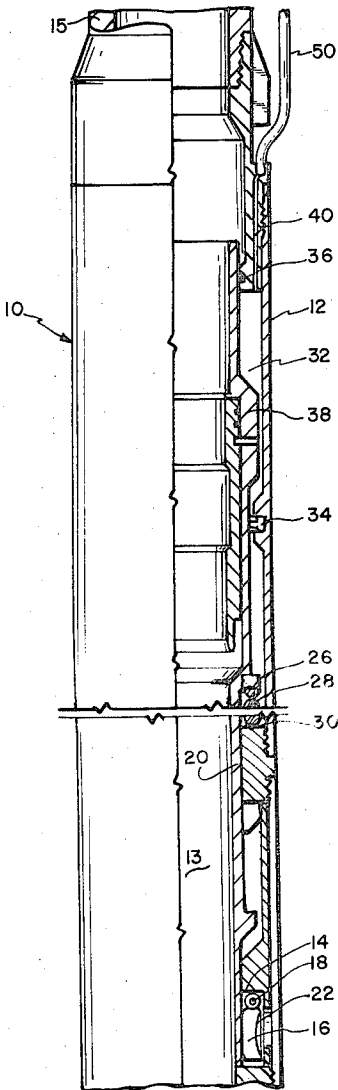
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[57] **ABSTRACT**
A well safety valve which is controlled through a control line leading to the surface which can be set at greater depths in the well by limiting the hydrostatic liquid head in the control line by using gas in the control line and temporarily opening the control line adjacent the lower end for draining the control line of accumulated liquids. Pressurizing the control line with gas while the lower end of the line is open to drive out any liquid therein. A normally closed opening in the control line adjacent the safety valve with means for opening and closing the opening for normally closing the opening for allowing control of the safety valve, but for opening the opening draining any accumulated liquids. A passageway connected between the safety valve and the opening and closing means. The opening and closing means may include various mechanisms such as a sliding sleeve or a sidepocket mandrel having flow control means in the sidepocket for controlling the opening of the passageway.

15 Claims, 7 Drawing Figures



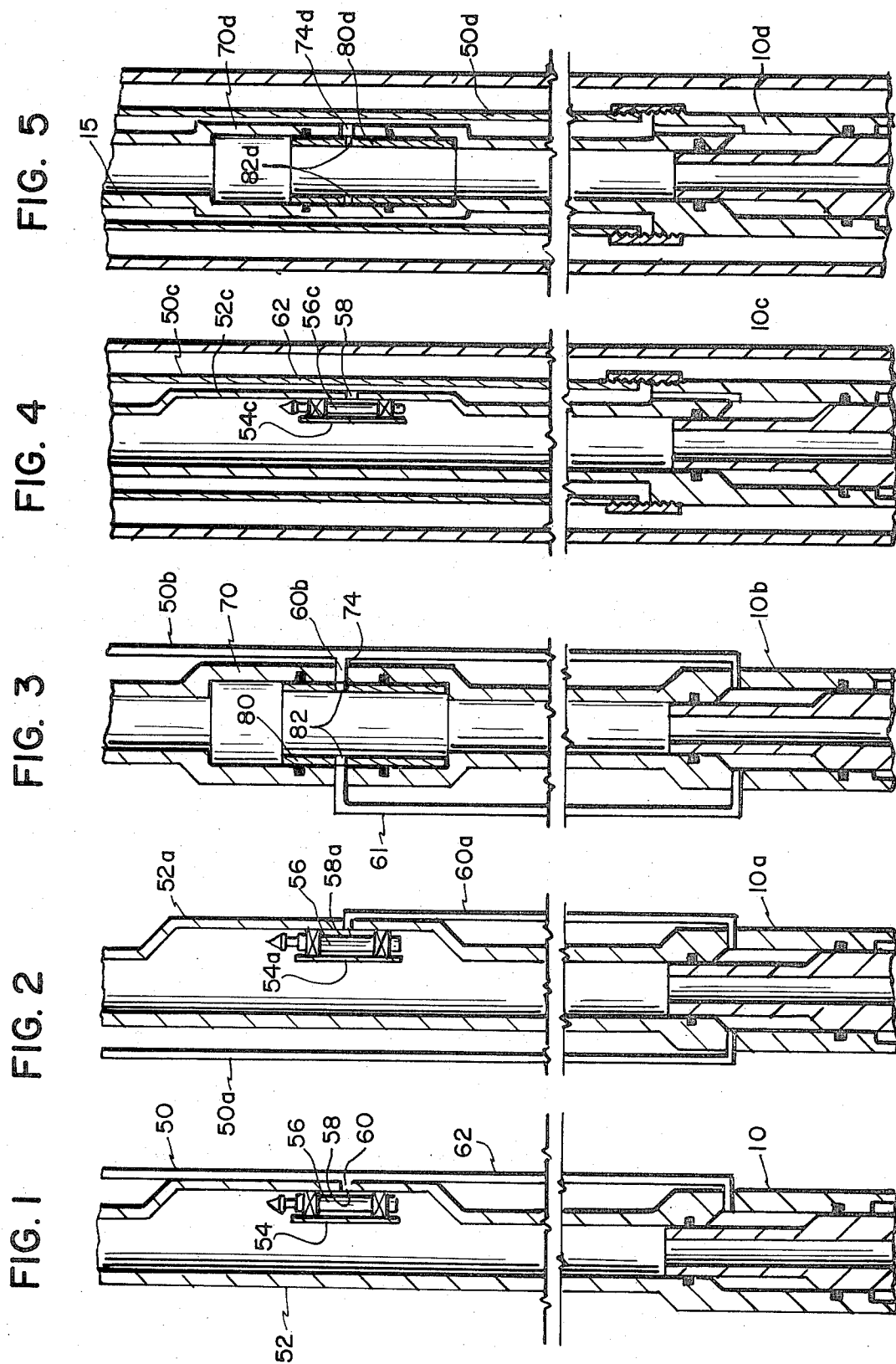


FIG. 6

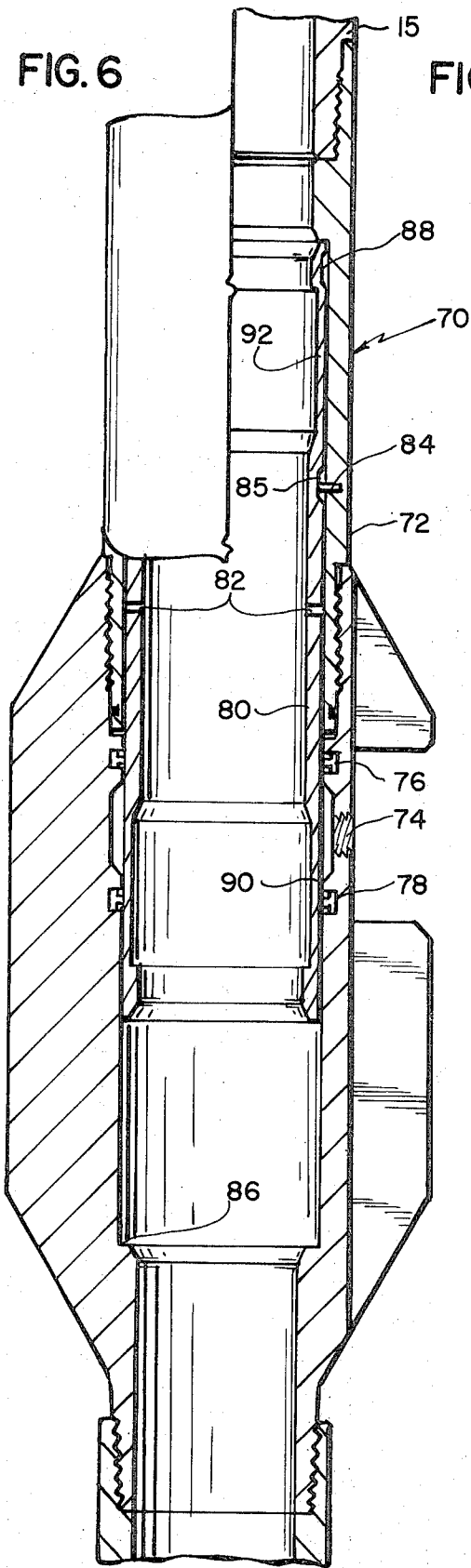
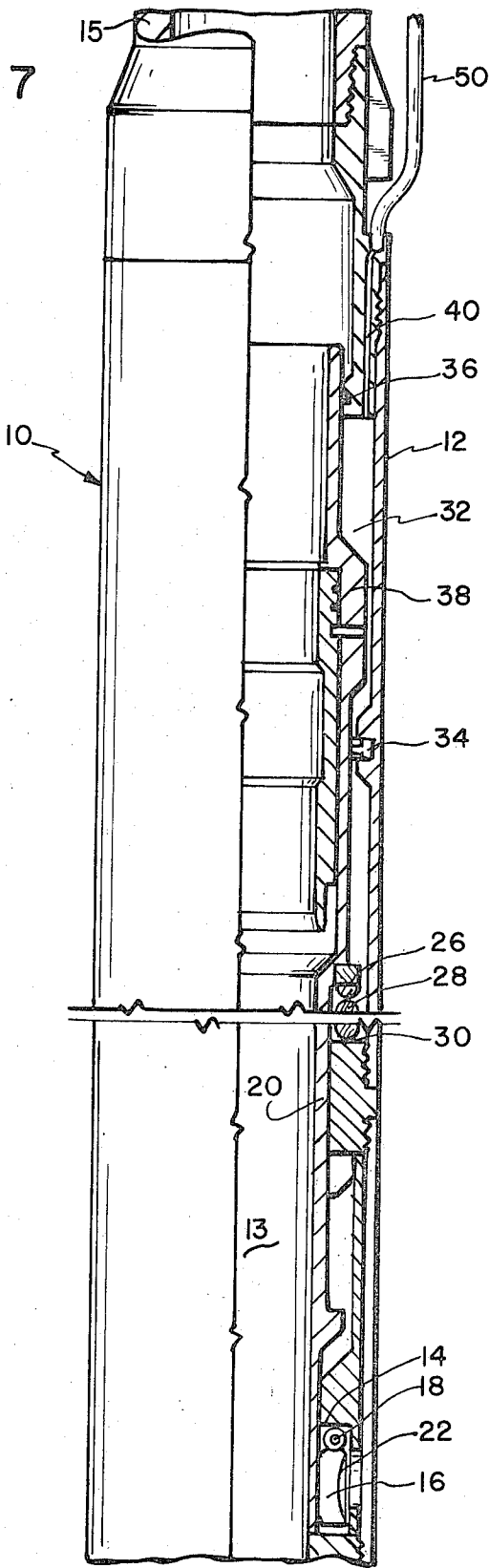


FIG. 7



WELL SAFETY VALVE SYSTEM AND METHOD OF OPERATION

BACKGROUND OF THE INVENTION

Generally, it is old, as shown in U.S. Pat. No. 3,078,923, to control a subsurface well safety valve through a control line or conduit from the well surface which applies hydraulic fluid against the safety valve for controlling its actuation. However, the depths at which a safety valve can be operated has been limited by the hydrostatic head in the control line. That is, the force of the means closing the safety valve, such as a biasing spring or pressurized chamber, must overcome the hydrostatic head of the hydraulic liquid in the control line in order to close the safety valve. Since the closing force is limited by practical considerations, the maximum depth of the safety valve is also limited because of any hydrostatic head.

The present well safety valve and method of operation allow a safety valve to be used at greater depths by limiting or removing any undesirable hydrostatic head in the valve control line so that the safety valve can always operate to close the valve.

SUMMARY

The present invention allows safety valves to be set at greater depths in a well by limiting the hydrostatic liquid head in the control line by using a gas as the control fluid to apply pressure to actuate the safety valve. In addition, the present invention provides a passageway in communication with the control line at a point adjacent to the safety valve with means for opening and closing the passageway for draining the control line of any liquid which might accumulate therein thereby insuring that there will be no undesirable hydrostatic liquid head in the control line, and the valve biasing means may close the safety valve when necessary.

A further object of the present invention is the provision of a well safety valve system in which a control line leads to the well surface for controlling the actuation of the valve by pressure in the control line in which a passageway is provided in communication with the control line adjacent the safety valve and to the interior of the well tubing. Means are provided in the well tubing normally closing the passageway thereby allowing control of the safety valve by gas pressure in the control line, but allowing periodic and temporary opening of the passageway for draining any liquid accumulated in the control line.

A further object of the present invention is opening and closing the passageway to the flow control line by a sliding sleeve positioned in the well tubing.

Yet a still further object of the present invention is the provision of opening and closing the passageway to the flow control line by providing a sidepocket mandrel positioned in the well tubing in which the sidepocket is connected to the passageway with flow control means positioned in the sidepocket for controlling the opening of the passageway. The flow control means may be a removable closure member or a valve with a predetermined opening pressure which is actuated in case the control line fills with a predetermined amount of liquid.

Still a further object of the present invention is the provision of connecting the passageway between the safety valve and the opening and closing means, which is positioned above the safety valve, so that the control

line may be cleared of a liquid by applying pressurized gas through the control line.

Other and further objects, features and advantages will be apparent from the following description of presently preferred embodiments of the invention, given for the purpose of disclosure, and taken in conjunction with accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary elevational view, in cross section, schematically showing the use of a valve in the sidepocket of a sidepocket mandrel for draining liquids from the control line of a well safety valve,

FIG. 2 is a fragmentary elevational view, in cross section, schematically showing the use of a flow control valve in the sidepocket mandrel but with different connections to the flow control line,

FIG. 3 is a fragmentary elevational view, partly in cross section, schematically illustrating a sliding sleeve for opening and closing a draining passageway to the flow control line of a well safety valve,

FIG. 4 is a fragmentary elevational view, in cross section, showing a schematic view in which the flow control line is a concentric well conduit in which the liquid therein is controlled by a valve in a sidepocket mandrel,

FIG. 5 is a fragmentary elevational view, partly in cross section, schematically showing a concentric well conduit flow control tubing being drained of liquid by a sliding sleeve,

FIG. 6 is an enlarged elevational view, partly in cross section, illustrating a suitable sliding sleeve assembly for use in FIGS. 3 and 5, and

FIG. 7 is an elevational view, partly in cross section, of a suitable well safety valve which may be controlled and operated in FIGS. 1 through 5.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

While the present invention may utilize any suitable type of well safety valve for controlling the fluid flow through a well tubing, which is actuated by a control line from the well surface, by way of example only, the well safety valve generally indicated by the reference numeral 10 in FIG. 7 is satisfactory.

The apparatus 10 generally includes a body 12 adapted to be positioned in a well tubing such as an oil and/or gas well to permit production therethrough under normal operating conditions but in which the valve may close or be closed in response to abnormal conditions such as might occur when the well overproduces, blows wild or in the event of a failure of well equipment.

The safety valve 10 generally includes an annular valve seat 14 and a flapper 16 connected to the body 12 by a pivot pin 18. When the flapper 16 is in its upper position seated on the seat 14, the safety valve 10 is closed blocking flow upwardly therethrough the tubing 15.

A sliding tube 20 is telescopically movable in the body 12 and through the valve seat 14. When the sliding tube 20 is moved to a downward position, as shown in FIG. 7, the tube 20 pushes the flapper 16 away from the valve seat 14 and holds the valve in the open position so long as the tube 20 is in the downward position. When the tube 20 is moved upwardly, the flapper 16 is allowed to move upwardly closing the valve by action

of a flapper spring 22 and/or by the action of the fluid flow moving upwardly through the bore 13 of the body 12.

Various forces may be provided to act on the sliding tube 20 to control its movement. Biasing means such as a spring 28 may be provided which acts between a shoulder 30 on the body 12 and a shoulder 26 on the tube 20 to provide a biasing or closing force for moving the tube 20 upwardly allowing the flapper 16 to close shutting off flow through the well tubing 15.

For moving the tube 20 downwardly and overcoming the biasing force of the spring 28 a chamber 32 is provided closed by seals 34 and 36 and a piston 38 is provided connected to the tube 20 and is movable in the chamber 32 in response to the application or removal of fluid pressure through a port 40 which is in fluid communication with a flow control line 50 leading to the well surface. Thus, the actuation of the tube 20 is controlled by the application or removal of fluid pressure through the flow control line 50. If the pressure applied through the control line 50 is of sufficient magnitude, the piston 38 and the tube 20 will be moved downwardly forcing the flapper 16 off of the seat and into the full open position. If the pressure applied in the fluid control line 50 is reduced sufficiently, the biasing spring 28 will move the tube 20 upwardly beyond the seat 14 allowing the flapper 16 to swing and close the valve. The above described well safety valve is generally described in copending patent application Ser. No. 148,607.

The well safety valves of the past have been operated by hydraulic liquid in the control line 50. However, the liquid in the control line 50 creates a hydrostatic head which creates a force acting on the piston 38 tending to open the safety valve even in the absence of applied pressure in the control line 50. Of course, in order for the valve 10 to act as a safety valve and close, the biasing force closing the valve, such as provided by the spring 28, must at all times be sufficient to overcome at least the hydrostatic liquid head in the control line 50. Since the upper biasing force of the spring 28 is limited, the depths at which safety valves may be used in the well tubing 15 has been determined by the force of the biasing means. One method of overcoming the problem of the hydrostatic head in the control line 50 in the past has been the provision of two control lines leading to opposite sides of the piston 38, but the provision of two control lines increases the expense and possibility of damage to the control lines and possible failure.

The present invention is directed to a safety valve installation in which a suitable gas, such as air, is used as the control fluid in the control line 50 thereby eliminating the hydrostatic liquid head in the control line. However, even when gas is used as the control fluid in the control line 50, the control line 50 may accumulate liquid by condensation or leakage into the control system. The accumulation of liquid into the control line 50 could then overcome the closing force of the biasing spring 28 causing the safety valve to become inoperative. Another feature of the present invention is to provide means to suitably drain the control line 50 of excess liquids for reducing any hydrostatic liquid head in the control line 50.

Referring now to FIG. 1, an installation is shown in which a fluid control line or fluid conduit 50 is provided connected to and controlling the well safety valve

10. Connected in the well tubing are suitable means for draining the control line 50 of any liquid accumulated therein for limiting any undesirable hydraulic liquid head in the control line 50. For example, only a conventional mandrel 52 may be provided, preferably positioned above the safety valve 10, although it could also be positioned therebelow. The mandrel 52 includes the usual sidepocket 54 for releasably receiving a suitable flow control device 56. The conventional ports 58 in the mandrel 52 communicate between the inside of the sidepocket 54 and the exterior of the mandrel 52. A passageway or opening 60 is provided in communication between the control line 50 at a point adjacent the safety valve 10 and the mandrel port 58. The mandrel may be a type KBMO mandrel manufactured by Camco, Incorporated and a further description of such a mandrel and means for installing or removing the flow control device 56 from the sidepocket 54 is more fully described in U.S. Pat. application Ser. No. 95,408. For example, the flow control device 56 may be a dummy valve such as the type RD sold by Camco, which blanks off or closes off the port 58 and thus closes communication with the flow control line 50. Such a dummy valve may be pulled out of the sidepocket 50 thereby opening communication of the flow control line 50 with the interior of the well tubing and allow any liquid in the flow control line 50 above the port 58 to drain into the tubing and out of the line 50. After drainage has been accomplished, the dummy valve may be resealed in the sidepocket 54 closing the port 58 and again allowing the safety valve 10 to be controlled from the control line 50 by gas pressure and with only a minor hydrostatic liquid head interference existing in the control line 50 below the port 58.

And if desired, the flow control means 56 may be a valve that opens upon a predetermined opening pressure higher than that used to actuate the safety valve 10, such as a conventional Camco type BK-1 valve. In that event, any liquid in the flow control line 50 above the port 58 may be expelled from the flow control line 50 by pressuring up the control line 50 above that required for actuation of the well safety valve 10 which will therefore open the flow control means 56 expelling any liquid above the ports 58. Pressuring of the control line 50 may occur by accumulation of a hydrostatic head in line 50 or by applying gas pressure through the line or a combination thereof. After the liquid has been expelled, the gas pressure in the control line 50 may be lowered and the hydrostatic pressure head is automatically lowered allowing the flow control pressure opening valve to close.

In the system shown in FIG. 1, the control line 50 can be drained of any liquid above the mandrel port 50, but the section 62 of the control line 50 below the port 58 remains full of liquid. Referring now to FIG. 2, the control line 50a is connected to the well safety valve 10a.

The dumping passageway 60a is connected between the safety valve 10, and in communication between the lower end of the flow control valve 50, and the port 58a of the mandrel 52a. When the flow control means 58 such as a dummy valve Camco type RD is pulled from the sidepocket 54a, liquid in the flow control line 50 above the elevation of the port 58a will drain into the well tubing. In addition, the control line 50 may be pressurized with gas thereby blowing out all of the liquid in the flow control line 50 and the passageway 60a

for substantially eliminating all of the accumulated liquids in the control line 50.

In FIGS. 1 and 2, the well safety system included a sidepocket mandrel and a flow control device in the side-pocket for normally closing the dumping passageway for allowing control of the safety valve 10 by gas pressure in the control line 50, but providing for temporarily opening the dumping passageways 60 and 60a, respectively for draining liquid accumulated in the control line 50. Of course, other and further devices may be used for temporarily closing the dumping opening or passageway from the flow control line 50 and temporarily opening the dumping passageway for draining liquid from the control line 50. Referring now to FIG. 6 an unloading sleeve generally indicated by the reference numeral 70 is shown which may be inserted in the well tubing 15, either above or below the safety valve 10 for draining or dumping liquid from the flow control line 50. The sleeve 70 includes a body 72 having one or more ports 74 communicating between the interior and exterior of the body 72. Seals 76 and 78 are provided on either side of the ports 74. A longitudinally slidable sleeve 80 is provided inside of the body 72 and includes one or more ports 82. As shown in FIG. 6, the sleeve 80 is normally positioned in the upper position and releasably secured there by a detent 84 releasably positioned in groove 85. In the upper position, the ports 82 of the sleeve 80 are out of registry with the ports 74. However, if the sleeve 80 is moved downwardly to seat against a shoulder 86, the detent 84 will engage groove 88 and the ports 82 will be in fluid communication with the body ports 74. Suitable recesses 90 and 92 are provided on the interior of the sleeve 80 for engagement by conventional sliding sleeve actuating tools for, respectively, moving the sleeve 80 downwardly or for moving the sleeve 80 upwardly.

Referring now to FIG. 3, the flow control line 50b is connected to the well safety valve 10b and the sliding sleeve assembly 70 is connected in the well tubing, preferably above the safety valve 10. As shown in FIG. 3, a first dumping passageway or opening 60b is connected to the control line 50 and to a port 74 in the assembly 70. A second dumping passageway 61 may be provided connected in communication between a safety valve 10 and another port 74 in the assembly 70. If desired, one of the drain passageways 60b or 61 may be omitted. If only the drain passageway 60b is used, liquid will be drained from the control line 50, but only above the port 74 when the sleeve 80 is in the downward position aligning the ports 82 with the port 74. However, if the drain passageway 61 is used, substantially all of the liquid in the control line 50 may be expelled therefrom by pressuring up the control line 50 with gas and blowing out any liquid in the control line 50 and the passageway 61. After liquid has been unloaded from the control line 50b, the sleeve 82 may be retracted upwardly, closing the ports 74 and allowing normal operation of the well safety valve 10 by gas pressure in the control line 50.

Referring still to another installation, as best seen in FIG. 4, the control line 50c is a schematic conduit about the tubing and connected to the safety valve 10 for supplying a pressurized control gas down the annulus between the well tubing and the conduit 50c for actuating the safety valve 10c. Similarly, to that shown in FIG. 1, the unloading mechanism may include a well mandrel 52c connected in the well tubing, preferably

above the well safety valve 10c, and in which a flow control means 56c in the sidepocket 54c controls communication of the port 58c with the flow control line 50c. Thus, the flow control means 56c may be actuated by pulling and reinstating a dummy valve or utilizing a valve with a predetermined opening pressure for draining any liquid in the flow control line 50c above the mandrel port 58c.

Referring now to FIG. 5, the sliding sleeve type control may also be used in a well tubing 15, above a well safety valve 10d, which is controlled by a gas pressure in a control conduit 50d. The sliding sleeve 82d is shown with ports 82d aligned with ports 74d thereby dumping any accumulated liquid in the control line 50d above the ports 74d.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as others inherent therein. While presently preferred embodiments of the invention have been given for the purpose of disclosure, numerous changes in the details of construction and arrangement of parts, may be provided without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In a well safety valve for controlling the fluid flow through a well tubing, the valve having a valve closure member moving between open and closed positions, means biasing the valve to a closed position, and a control line leading to the well surface for controlling the actuation of the valve by pressure in the control line, the improvement of means for allowing the safety valve to be used at greater depths by limiting any undesirable hydrostatic liquid head in the control line comprising, said fluid in the control line being a gas, and a normally closed opening in the control line at a point adjacent the safety valve, and

means for opening and closing said opening for draining the control line of any liquid accumulated therein thereby limiting any undesirable hydrostatic liquid head in the control line.

2. In a well safety valve for controlling the fluid flow through a well tubing, the valve having a valve closure member moving between open and closed positions, means biasing the valve to a closed position, and a control line leading to the well surface for controlling the actuation of the valve pressure in the control line, the improvement of means for allowing the safety valve to be utilized at greater depths by limiting any undesirable hydrostatic liquid head in the control line comprising, said fluid in the control line being a gas,

a passageway in communication between the control line at a point adjacent the safety valve and the interior of the well tubing, and means for opening and closing said passageway for draining liquid from the control line.

3. The apparatus of claim 2 wherein the opening and closing means includes,

a sliding sleeve positioned in the well tubing.

4. The apparatus of claim 2 wherein the opening and closing means includes,

a sidepocket mandrel positioned in the well tubing in which the sidepocket is connected to the passageway, and

flow control means positioned in the sidepocket for controlling the opening of said passageway.

5. The apparatus of claim 2 wherein the control line is connected to the safety valve and the passageway is connected to the safety valve and in communication with the lower end of the control line.

6. In a well safety valve for controlling the fluid flow through a well tubing, the valve positioned in the tubing and having a valve closure member moving between open and closed positions, a longitudinally movable tubular member for controlling the movement of the valve closure member, means for biasing the tubular member in a first direction, pressure means for moving the tubular member in direction for opening the valve, a control conduit leading from the well surface to the pressure means for controlling the actuation of the valve, the improvement of means for allowing the safety valve to be used at greater depths by limiting any undesirable hydrostatic liquid in the control line comprising,

said fluid in the control line being a gas,

a passageway in communication between the control line at a point adjacent the safety valve and the interior of the well tubing,

means in the well tubing normally closing said passageway for allowing control of the safety valve by gas pressure in the control line, but for temporarily opening said passageway for draining any liquid accumulated in the control line.

7. the apparatus of claim 6 wherein the closing and opening means includes,

a sliding sleeve positioned in the well tubing above the safety valve.

8. The apparatus of claim 6 wherein the closing and opening means is positioned in the well tubing above the safety valve, and

said passageway is connected between the safety valve and the closing and opening means.

9. The apparatus of claim 6 wherein the closing and opening means includes,

a sidepocket mandrel positioned in the well tubing above the safety valve and in which the sidepocket is connected to the passageway,

flow control means positioned in the sidepocket for controlling the opening of said passageway.

10. The apparatus of claim 9 wherein the flow control means includes,

means for opening on a predetermined pressure.

11. The method of limiting the hydrostatic head in the fluid control line leading from the surface and controlling the actuation of a safety valve in a well tubing comprising,

controlling the safety valve from the surface through the control line by using gas in the control line for limiting the hydrostatic head in the control line, and

opening the control line adjacent the lower end of the control line for draining the control line of liquids accumulating therein for avoiding an undesirable hydrostatic liquid head in the control line thereby allowing the safety valve to be used at greater depths.

12. The method of claim 11 including, opening the control line upon a predetermined pressure in the control line.

13. The method of claim 11 including, pressurizing the control line with gas when the lower end of the control line is opened.

14. The method of controlling fluid flow through a well tubing comprising,

placing a safety valve in the well tubing below the well surface,

controlling the actuation of the safety valve by gas from the surface through a control line thereby limiting the hydrostatic head in the control line, temporarily opening the control line adjacent the lower end of the control line for draining the control line of liquids accumulating therein for avoiding an undesirable hydrostatic liquid head in the control line.

15. The method of claim 14 including, pressurizing the control line with gas while the lower end of the line is open.

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