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SUBSURFACE WELL TUBING SAFETY VALVE

Filed May 31, 1960

2 Sheets-Sheet 1

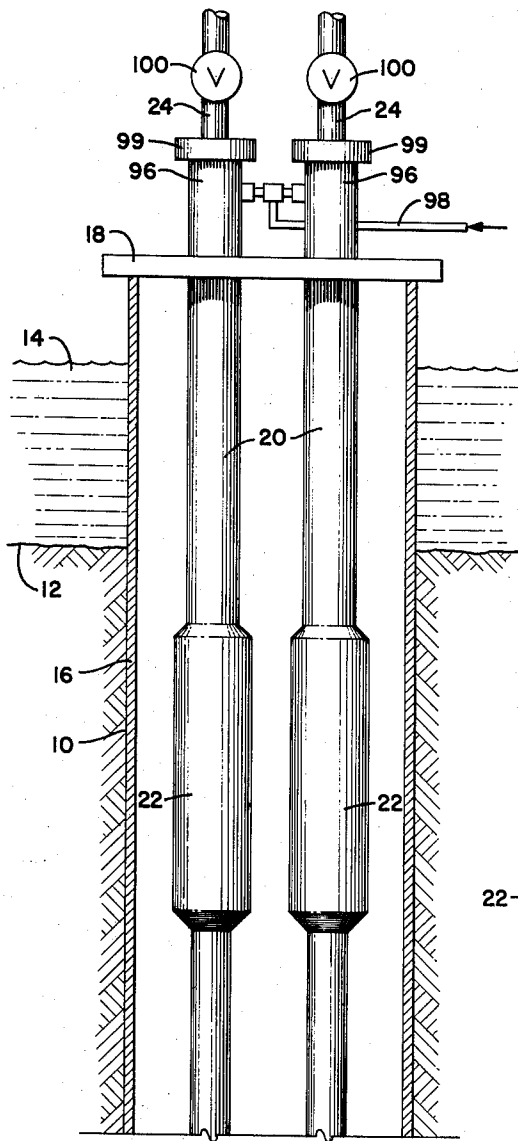


FIG. 1

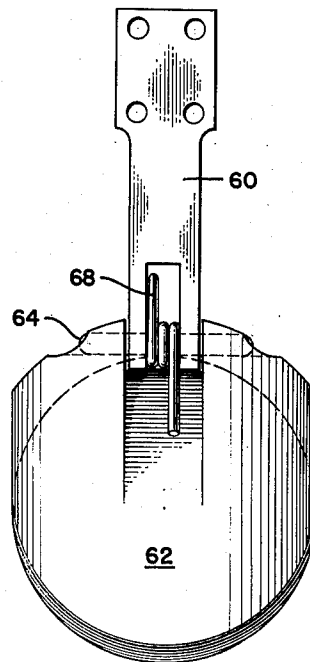


FIG. 4

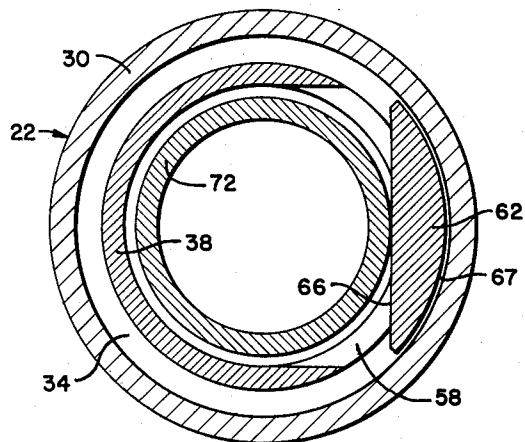


FIG. 5

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2 Sheets-Sheet 2

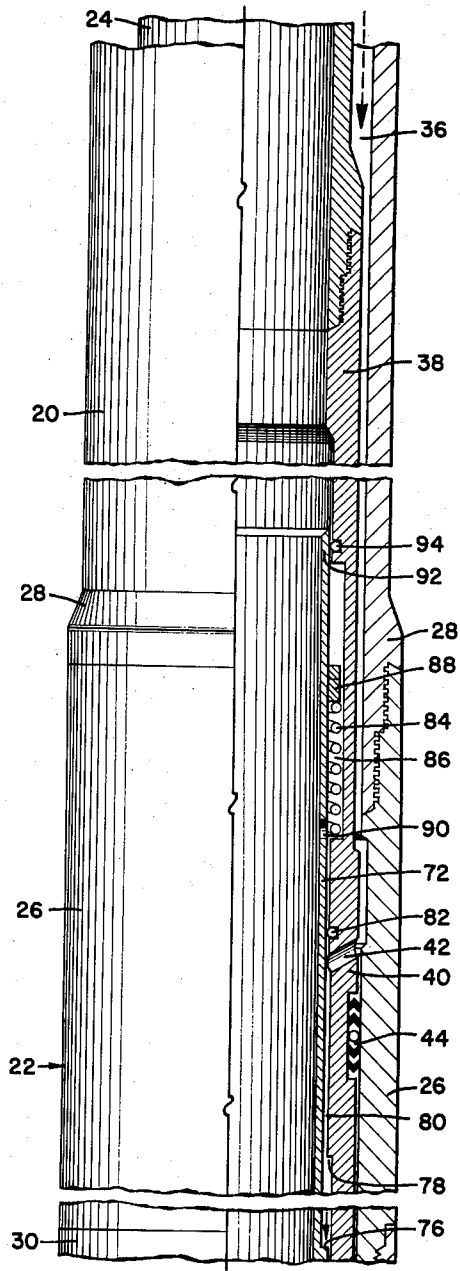


FIG. 2

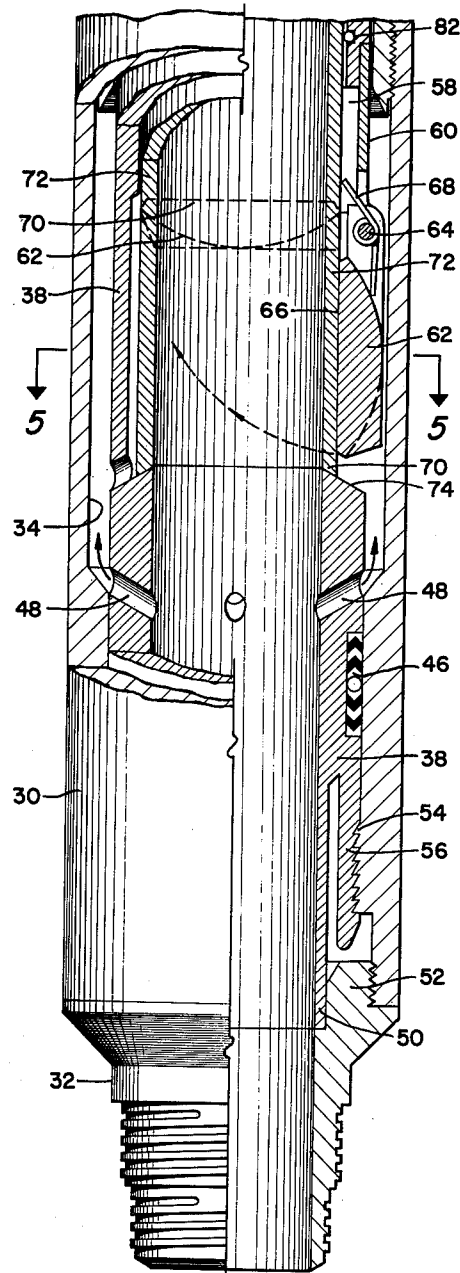


FIG. 3

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SUBSURFACE WELL TUBING SAFETY VALVE
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This invention relates generally to improvements in the art of flowing oil and gas wells, and more particularly to a subsurface safety shutoff for an oil or gas well production tubing through which well fluids are conveyed upwardly in a well installation.

As it is well known in the oil industry, control must be maintained over the flow of oil and gas from a well in order that the well can be shut in in the event of fire or the like. Most oil and gas wells are provided only with surface control valves placed at the wellhead for controlling the flow of oil and gas from the well. These surface valves are exposed and easily damaged to such an extent that flow of oil and gas from the well cannot be controlled. On land installations, the control valves may be broken off through vehicle collisions, sabotage, etc. Surface control valves on marine installations are particularly susceptible to damage by storms and ship collisions.

In view of the foregoing, many workers in the art have devised safety valves which are installed in the well tubing a substantial distance below the wellhead for the purpose of shutting in the well in the event of damage at the wellhead. The most popular type of subsurface safety valve is what is known as a "storm choke" which is ordinarily installed and removed from the well tubing by means of a wire line. Most of these storm chokes are operable to close the well tubing and shut in the well in the event an excessive flow of well fluids through the well tubing occurs. In other words, most of these storm chokes are operated in accordance with the rate of flow of well fluids through the well tubing. As a result, such valves are not closed until excessive damage occurs at the wellhead, and these valves will not be closed in the event of minor leakage at or near the wellhead.

Other workers in the art have devised subsurface safety valves for installation in a well tubing which are actuated by a control fluid provided by a suitable power unit at the surface of the well. In this type of installation, the safety valve is closed in the event of a reduction in the pressure of the control fluid, and such installations provide appreciably more protection than most storm choke type of safety valves. Heretofore, however, subsurface safety valves operated by a control fluid have required the installation of a separate tubing string adjacent the well tubing for conveying the control fluid to the subsurface safety valve. These separate control fluid tubing strings must be pulled whenever the well tubing is pulled, and they are easily damaged by pulling an adjacent well tubing in a multiple string well installation. Also, prior subsurface safety valves operable by a control fluid have been relatively expensive, are usually of a size and so constructed as to restrict the opening through the well tubing, and such valves have not been widely accepted in the oil industry.

The present invention contemplates a novel subsurface safety shutoff for a well tubing operable by a control fluid, but wherein the control fluid is conveyed to the valve shutoff assembly without the use of a separate tubing string extending alongside the well tubing. The shutoff valve assembly includes a flapper type valve pivotally supported in the well tubing in such a position to provide substantial clearance through the tubing when the valve is an open position, and yet the valve will be quickly moved to a closed position and prevent further upward flow of well fluids through the well tubing in the event

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the pressure of the control fluid is reduced, as by damage at the wellhead. The flapper type valve is controlled by a novel valve actuator responsive to the control fluid and which is preferably in the form of a sleeve slidably supported in the well tubing in such a position as not to interfere with the passage of tools through the well tubing. The control fluid is conveyed to the valve mechanism through an annular passage provided around a control tubing positioned concentrically in the well tubing, such that an installation according to the present invention will occupy the minimum space in a well bore and will facilitate the use of the invention in multiple string well installations.

An important object of this invention is to provide increased safety in oil and gas well installations.

Another object of this invention is to provide a subsurface well tubing safety valve which will occupy the minimum space in a well bore and which is particularly adaptable to multiple, parallel tubing string well installations.

Another object of this invention is to provide a subsurface well tubing safety valve which allows the passage of tools through the well tubing when the valve is in an open position.

A further object of this invention is to provide a subsurface well tubing safety valve which will effectively stop the flow of well fluids through the well tubing in the event of substantially any damage at the wellhead.

Another object of this invention is to provide a subsurface well tubing safety valve which is easily adapted for manual operation at the wellhead or operation by remote means, such as by radio.

Another object of this invention is to provide a subsurface well tubing safety valve which may be easily closed and opened from the wellhead for periodic operational checks and the like.

A still further object of this invention is to provide a subsurface well tubing safety valve which is simple in construction, may be economically manufactured, may be easily serviced, and which will have a long service life.

Other objects and advantages of the invention will be evident from the following detailed description, when read in conjunction with the accompanying drawings which illustrate my invention.

In the drawings:

FIGURE 1 is a schematic vertical sectional view through a portion of a well bore illustrating installation of a valve constructed in accordance with this invention in a multiple string well installation.

FIGURE 2 is a vertical sectional view through the upper portion of a subsurface well tubing shutoff assembly constructed in accordance with this invention, with a portion of the assembly being shown in elevation to more clearly illustrate the invention.

FIGURE 3 is a view similar to FIG. 2 of the lower portion to the shutoff assembly and is a continuation from the lower end of FIG. 2.

FIGURE 4 is an elevational view of the flapper valve and the support therefor.

FIGURE 5 is a sectional view as taken along lines 5-5 of FIG. 3.

Referring to the drawings in detail, and particularly FIG. 1, reference character 10 designates a well bore extending downwardly from the floor 12 of a body of water 14, such as the ocean. It will be understood that the well bore 10 extends downwardly through the earth to an oil and/or gas producing strata. The usual well casing 16 is secured in the well bore 10 in any desired manner and extends vertically through the ocean 14 to support a suitable wellhead 18 above the ocean 14. One or more well tubing strings 20 are supported in the casing 16 from the wellhead 18 and extend downwardly

through the casing 16 to the respective producing zones (not shown) in the well bore 10. For simplicity, and for stressing one of the advantages of this invention, I have shown two of the well tubing strings 20, although it will be understood that a well installation may contain only one well tubing string or a plurality of well tubing strings, depending upon whether or not the well is producing from only one zone or from a plurality of zones.

In accordance with the present invention, a housing 22 is interposed in each well tubing string 20 below the ocean floor 12, and a control tubing 24 is telescoped into the upper end of each well tubing string 20, as will be described in more detail below. It may also be noted here that the upper section of each string 20, that is, that portion above the respective housing 22, is larger in diameter than the remainder of the string.

As shown in FIGS. 2 and 3, each housing 22 comprises an upper section 26 threadedly secured to the lower end 28 of the adjacent upper section of the well tubing 20, and a lower section 30 threadedly secured to the lower end of the upper section 26. A suitable connector 32 is threadedly secured in the lower end of the lower housing section 30 for connection of the housing 22 to the lower portion of the respective well tubing 20. The inner diameter of the housing 22 is substantially equal to the inner diameter of that portion of the well tubing string 20 positioned above the housing 22. However, an enlarged diameter chamber 34 (FIG. 3) is provided in the central portion of the housing 22, preferably at the upper end of the lower housing section 30, for purposes to be described.

As shown in FIG. 2, the outer diameter of the control tubing 24 is less than the inner diameter of the adjacent section of the well tubing 20 to provide an annular passageway 36 between the well and respective control tubings. The control tubing 24 extends downwardly through the well tubing 20 into proximity with the upper end of the housing 22 and has a tubular housing 38 secured on the lower end thereof. The outer diameter of the housing 38 is slightly larger than the outer diameter of the control tubing 24, but is less than the inner diameter of the well tubing 20 from the upper end of the housing 38 to a point 40 on the housing 38 positioned within the upper end portion of the housing 22. The remainder of the outer diameter of the housing 38 is of a size to provide a sliding fit of the housing 38 in the housing 22. Therefore, the annular passageway 36 provided between the power tubing 24 and well tubing 20 is extended on downwardly around the upper portion of the inner housing 38 into the upper end portion of the outer housing 22.

A plurality of ports 42 (only one of which is shown) are formed at an angle transversely through the inner housing 38 immediately above the point 40 to provide communication between the inner periphery of the housing 38 and the passageway 36, for purposes to be described. It should also be noted that two suitable packing units 44 and 46 are carried in mating recesses around the outer periphery of the inner housing 38 above and below the enlarged chamber portion 34 of the outer housing 22 to prevent communication between the annular passageway 36 and the enlarged chamber 34, as well as prevent direct communication between the well tubing 20 disposed below the housing 22 and the enlarged chamber 34. However, a plurality of ports 48 are formed transversely through the inner housing 38 at the lower end of the enlarged chamber 34 to provide communication between the interior of the inner housing 38 and the chamber 34, for purposes to be described.

The extreme lower end 50 of the inner housing 38 slidably fits in a counterbore 52 formed in the upper end of the connector 32, as shown in the lower portion of FIG. 3. Also, suitable serrations 54 are formed in the lower end of the housing 22 to be engaged by serrated latch fingers 56 carried by the inner housing 38, such

that the housing 38 may be secured in a fixed position in the outer housing 22. The serrations 54 and latch fingers 56 are preferably formed to provide connection thereof upon turning of the inner housing 38 in one direction, such that the inner housing 38 may be easily disconnected from the outer housing 22 by turning the inner housing in an opposite direction.

An enlarged opening 58 (see FIGS. 3 and 5) is formed in one side of the inner housing 38 at the level of the enlarged chamber 34 of the outer housing 22. An arm 60 is suitably secured to the housing 38 at the upper edge of the opening 58 and extends downwardly about halfway through the height of the opening 58. A suitable flapper valve 62 is pivotally secured to the lower end of the arm 60 by means of a pin 64 for pivoting movement of the valve 62 in and out of the inner housing 38, as illustrated by the dashed lines and arrows in FIG. 2. The flapper valve 62 is of a size to extend substantially vertically in the enlarged chamber 34 with the inner face 66 of the valve protruding only slightly into the housing 38 when the valve is in an open position, as shown in full lines in FIGS. 3 and 5. The outer face 67 of the valve 62 is curved to mate with the walls of the chamber 34 in the open position of the valve as shown in FIG. 5. The flapper valve 62 is urged inwardly with respect to the housing 38 (by means of a suitable spring 68) toward a closed position over the lower end 70 of a sleeve 72.

The sleeve 72 forms an actuator for the flapper valve 62 and is movable vertically in the inner housing 38 between a lower position (as shown in full lines in FIG. 3) and an upper position (as indicated by the dashed line position of the flapper valve 62 in FIG. 3). The lower end 70 of the sleeve 72 is tapered downwardly and outwardly to form a valve seat for the flapper valve 62 when the sleeve is raised to its upper position, as well as to conform to an inclined shoulder 74 formed around the inner periphery of the inner housing 38 when the sleeve is in its lower position. It may also be noted in FIG. 3 that the inner diameter of the sleeve 72 is preferably equal to the smallest inner diameter of the housing 38. Furthermore, the smallest inner diameter of the housing 38 is substantially equal to the inner diameter of the portion of the well tubing 20 extending downwardly from the housing 22, such that the sleeve 72 will not interfere with the passage of tools and the like (not shown) downwardly through the well tubing. It may also be noted here that the flapper valve 62 will also not interfere with the passage of tools through the well tubing 20 when the valve is in an open position as illustrated in full lines in FIGS. 3 and 5. When the sleeve 72 is in its lowermost position, it contacts the inner face 66 of the flapper valve 62 and holds the flapper valve in an open position within the enlarged chamber 34 against the action of the spring 68. The spring 68 is wound around the pin 64 and has its opposite ends in contact with the flapper valve 62 and the outer periphery of the sleeve 72 for continually urging the flapper valve 62 inwardly and upwardly about the axis of the pin 64, as previously indicated.

The sleeve 72 extends upwardly from the flapper valve 62 through the inner housing 38 into proximity with the lower end of the respective control tubing 24. The outer diameter of the sleeve 72 is reduced a short distance above the opening 58 to provide an upwardly facing shoulder 76 (FIG. 2) around the outer periphery of the sleeve. The shoulder 76 is of a size to contact a downwardly facing shoulder 78 formed in the housing 38 and limit the upward movement of the sleeve 72, as will be described. Also, the relative sizes of the sleeve 72 and housing 38 between the shoulder 76 and the ports 42 is such to provide an annular passageway 80 between the sleeve and housing for conveying a control fluid from the annular passageway 36 against the upwardly facing shoulder 76. Sealing rings 82 are carried by the inner periphery of the housing 38 below the lowest position of the shoulder 76 and a short distance above the ports 42 to provide seals

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against the outer periphery of the sleeve 72. Therefore, a control fluid directed into the annular passage 80 will react on the upwardly facing shoulder 76 and urge the sleeve 72 into its lowermost position, as illustrated in full lines in FIGS. 2 and 3.

A suitable coil compression spring 84 is telescoped over the sleeve 72 a short distance above the ports 42 and is received loosely in a spring cavity 86 formed in the inner periphery of the housing 38. The spring 84 is anchored against the lower end of the spring cavity 86 and against rings or nuts 88 secured around the sleeve 72 to constantly urge the sleeve 72 in an upward direction. It may also be noted that ports 90 are formed in that portion of the sleeve 72 adjacent the spring 84 to prevent the entrapment of liquid in the spring cavity 86 as the sleeve 72 is raised and lowered. The upper end 92 of the sleeve 72 extends above the upper end of the spring cavity 86 through a suitable sealing ring 94 and in sliding contact with an adjacent portion of the inner periphery of the housing 38.

As shown in FIG. 1, the upper end portion 96 of each well tubing 20 is connected to a supply conduit 98 extending from a suitable source (not shown) of control fluid, preferably liquid. The conduit 98 therefore communicates with the upper end of the annular passage 36 (FIG. 2) extending downwardly into the housing 22 as previously described. It will also be understood that suitable packing gland 99 is provided on the upper end 96 of each well tubing 20 around the respective control conduit 24 to prevent the leakage of control fluid upwardly out of the well tubings 20. Suitable control valves 100 are interposed in the control tubings 24 adjacent the wellhead 18, by which flow of fluid through the control tubings may be regulated as desired, as will be readily understood by those skilled in the art.

Operation

In a normal operation of a well installation having the present invention incorporated in each well tubing thereof, the well fluids flowing upwardly through each well tubing 20 are directed into the respective inner housing 38 and flow on upwardly through the respective sleeve 72 and control tubing 24 to the top of the well. A control fluid under a suitable pressure is fed through the conduit 98 and into the upper end portion 96 of each well tubing 20. This control fluid flows downwardly through the annular passageway 36, ports 42 and annular passageway 80 to react in a downward direction on the upwardly facing shoulder 76 of the valve actuating sleeve 72. It will be apparent that when the control fluid is continuously available from the conduit 98, the pressure of the control fluid will be continually exerted on the upwardly facing shoulder 76. It will also be apparent that the area of the shoulder 76 may be related to the normal pressure of the control fluid such as to overcome the upwardly acting force of the spring 84 and retain the sleeve 72 in its lowermost position on the upwardly facing shoulder 74 of the housing 38. As previously indicated, the sleeve 72 retains the flapper valve 62 open in this position of the sleeve 72 for the free passage of well fluids upwardly through the housing 38 and sleeve 72.

In the event the pressure of the control fluid should be decreased below a predetermined minimum for any reason, such as damage to the conduit 98 or to the entire structure around the wellhead 18, the force acting in a downward direction on the upwardly facing shoulder 76 of the sleeve 72 will be reduced. When this force on the upwardly facing shoulder 76 is reduced to below the force provided by the spring 84, the spring 84 raises the sleeve 72 in the housing 38 until the shoulder 76 contacts the downwardly facing shoulder 78 in the housing 38. As the lower end 70 of the sleeve 72 is raised above the flapper valve 62, the spring 68 pivots the valve 62 clockwise (as viewed in FIG. 3) until the valve 62 seats on the lower end 70 of the sleeve 72. It may also be noted that well fluid present in the housing 38 below the flapper valve 62 has access to

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the enlarged chamber 34 through the ports 48 to balance the pressure forces on the flapper valve 62 and allow pivoting of the valve by the spring 68. When the valve 62 extends any appreciable distance into the housing 38, the upwardly flowing well fluids will create a pressure on the valve 62 and quickly close the valve 62 on the lower end 70 of the sleeve 72. With the flapper valve 62 in a closed position, as indicated by dashed lines in FIG. 3, well fluids will be prevented from flowing on upwardly through the sleeve 72. It may also be noted that the lower sealing ring 82 prevents leakage of the well fluids around the sleeve 72, and the upper packing 44 prevents leakage of the well fluids between the housing 38 and the housing 22. Therefore, the well tubing 20 will be effectively closed substantially below the ocean floor 12 and the well fluids will not discharge through the control tubing 24 to create a hazard around the well installation.

In the event it is desired to remove the flapper valve 62 and sleeve 72, the control tubing 24 is turned to turn the inner housing 38 in a direction for disconnecting the latch fingers 56 from the serrations 54. Before turning of the control tubing 24, however, the conduit 98 should be closed to decrease the pressure of the control fluid in the annular passageways 36 and 80. Therefore, the spring 84 will raise the sleeve 72 and the spring 68 will move the flapper valve 62 inwardly in the housing 38. When the housing 38 is disconnected from the housing 22, the control tubing 24 may be raised to remove all of the elements attached to the control tubing 24. It will be noted that since the inner diameter of the housing 22 is substantially equal to the inner diameter of the well tubing 20 extending above the housing 22, the housing 38 may be easily raised through the upper portion of the well tubing 20.

At any time it is desired to check the operation of the flapper valve 62, the control fluid being supplied through the conduit 98 is discontinued to reduce the force applied by the control fluid on the upwardly facing shoulder 76. When this occurs, the spring 84 will raise the sleeve 72 and the spring 68 will close the flapper valve 62 in the manner previously described. In this connection it may also be noted that any desired type of control valves may be provided in the conduit 98 for closing the conduit 98 and discontinuing the supply of control fluid pressure to the annular passageway 36. When the test is completed, the tubing 24 is filled with water or the like from the valve 62 upwardly, and the water is pressurized sufficiently to substantially balance the forces across the valve 62. Control fluid is then again supplied through the conduit 98, annular passageway 36, ports 42 and annular passageway 80 against the upwardly facing shoulder 76. The resulting downwardly acting force overcomes the action of the spring 84 to move the sleeve 72 downwardly in the housing 38. The sleeve 72 therefore forces the flapper valve 62 in a counterclockwise direction, as viewed in FIG. 3 to move the flapper valve 62 through the opening 58 into the enlarged chamber 34 and allow a complete seating of the sleeve 72 on the upwardly facing shoulder 74. When the sleeve 72 and flapper valve 62 are in the positions shown in full lines in FIG. 3, normal operation of the well tubing 20 is resumed.

From the foregoing it will be apparent that the present invention provides a novel subsurface well tubing safety valve which will efficiently close off the respective well tubing when desired for preventing the discharge of well fluids from the upper end of the well tubing. The safety of well installations will be materially increased by use of the present invention. The present safety valve is particularly adaptable to multiple tubing string well installations, since it requires a minimum of space and provides no projections beyond the outer periphery of the well tubing. It will also be apparent that when the present valve is in an open position, any desired tools can be lowered through the valve which can be lowered through the normal well tubing. The apparatus may also be adapted for operation of the valve upon the occurrence of substantially any type of damage at the surface of the well installation and

the valve can be easily checked during an operational check of the well installation. It will further be apparent that the present valve is simple in construction, may be economically manufactured, may be easily serviced and will have a long service life.

Changes may be made in the combination and arrangement of parts or elements as heretofore set forth in the specification and shown in the drawings, it being understood that changes may be made in the precise embodiment disclosed without departing from the spirit and scope of the invention as defined in the following claims.

I claim:

1. A safety shutoff for fluid conducting tubing which comprises:

- a control tubing positioned within the fluid conducting tubing and having a first end thereof terminating within the fluid conducting tubing, said control tubing having an outer diameter less than the inner diameter of the fluid conducting tubing to form an annular passage between the control and fluid conducting tubings;
- a source of control fluid connected to a first end of the fluid conducting tubing for directing control fluid through said annular passage toward said first end of the control tubing;
- a fluid-responsive valve assembly secured to said first end of the control tubing, said valve assembly including:
 - a housing having an opening therein, said housing being secured to the control tubing adjacent the second end of said fluid conducting tubing, packing between the housing and the adjacent fluid conducting tubing for directing fluids into and through the housing and control tubing toward the second end of the control tubing;
 - a closure pivotally mounted on the housing and movable in a given path through said opening in the housing into and out of the central portion of the valve assembly,
 - means in operative engagement with a portion of the closure for biasing the closure toward the central portion of the valve assembly to prevent the flow of fluid therethrough,
 - reciprocal means movable within a portion of the housing toward and away from the path of said closure, said reciprocal means being in operative engagement with the closure and having a pressure receiving surface thereon in communication with the annular passage,
 - means for directing said control fluid from the annular passage against the pressure receiving surface for moving the reciprocal means toward the path of the closure to move said closure away from the interior of said valve assembly to permit passage of fluid therethrough, and
 - means carried by the housing for biasing the reciprocal means away from the path of the closure to permit movement of the closure into the interior of the valve assembly, said biasing means exerting a force insufficient to overcome the force exerted by the control fluid on the pressure receiving surface during normal operation of the valve.

2. A shutoff as defined in claim 1 wherein said reciprocal means comprises an actuating sleeve, wherein said pressure receiving surface comprises a shoulder and wherein said closure includes a flapper valve which seats on the lower end of the sleeve when the sleeve is moved away from the path of movement of the closure and which is held in an open position by the sleeve when the sleeve is moved toward said path.

3. A shutoff as defined in claim 2 wherein the means for directing control fluid against the shoulder comprises a port through the housing for providing communication between the annular passage and the shoulder.

4. A shutoff as defined in claim 2 wherein said means for biasing the reciprocal means includes a spring and wherein the means for biasing the closure includes a spring.

5. A shutoff as defined in claim 4 wherein said packing is in two units, one positioned above and one positioned below said flapper valve, and wherein the housing has ports therein below said flapper valve to direct well fluids against opposite faces of said flapper valve when it is outside the interior of the valve assembly.

6. A subsurface safety shutoff for a well installation, comprising

- a well tubing through which well fluids are conveyed upwardly through the well, said well tubing having an upper section of larger diameter than the remaining length thereof;
- a first housing interposed in the well tubing at the lower end of said upper section having an inner diameter substantially equal to the inner diameter of said upper section and having an enlarged chamber in the central portion thereof;
- a control tubing having an outer diameter less than the inner diameter of said upper section of the well tubing telescoped into said upper section and extending into proximity with said first housing to form an annulus between the well tubing and control tubing from the upper end of the well tubing down to said first housing;
- a second housing secured on the lower end of the control tubing and extending to the lower end of said first housing, said second housing being open at its lower end, and having an opening in one side thereof at the level of said enlarged chamber, and having a port therethrough spaced apart from the level of said enlarged chamber;
- fastening means detachably securing the lower end of the second housing in the lower end of the first housing;
- a flapper valve pivotally secured to the second housing at the upper edge of said opening for movement to an open position in said opening and to a closed position across said second housing;
- a spring anchored to the second housing and the flapper valve urging the flapper valve toward a closed position;
- a source of control fluid connected to the upper end portion of the well tubing and communicating with the annulus between the control and well tubings;
- a packing unit secured in said annulus at the upper end of said first housing below the port in the second housing;
- a fluid-responsive valve operator having an upwardly facing, fluid-contacting surface formed thereon, said operator being carried by said second housing and said surface being in communication with said annulus through said port in the second housing for holding said flapper valve in an open position as long as control fluid is supplied to said annulus;
- means disposed between said operator and said second housing above and below the port in the second housing for preventing the flow of control fluid between the operator and second housing; and
- means carried by the second housing for biasing the operator upwardly to release said flapper valve upon failure of said source to supply control fluid to said annulus.

7. A shutoff as defined in claim 6 wherein said fastening means comprises serrations formed in the inner periphery of said first housing, and serrated latch arms on said second housing positioned to engage said serrations upon turning of said second housing in one direction.

8. A shutoff as defined in claim 6 wherein said valve operator comprises a sleeve carried by said second housing and movable vertically between an upper position and a lower position, and wherein the means for biasing

the sleeve upwardly comprises a spring between said second housing and said sleeve.

9. A shutoff as defined in claim 8 wherein said sleeve is disposed inside of said second housing and has an inner diameter as large as the inner diameter of that portion of the well tubing below said first housing. 5

10. A shutoff as defined in claim 9 wherein the lower end of said sleeve is adapted and positioned to receive said valve in the closed position of said valve when said sleeve is in its upper position, and characterized further to include a sealing ring above the sleeve biasing spring and between said sleeve and the inner periphery of said second housing. 10

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