United States Patent [19]

True

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[54] **WIRELINE OPERATED SAFETY VALVE SYSTEM**

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[52] **U.S. Cl.** **166/72**, 166/224

[51] **Int. Cl.** **E21b 43/12**

[58] **Field of Search** 166/72, 224

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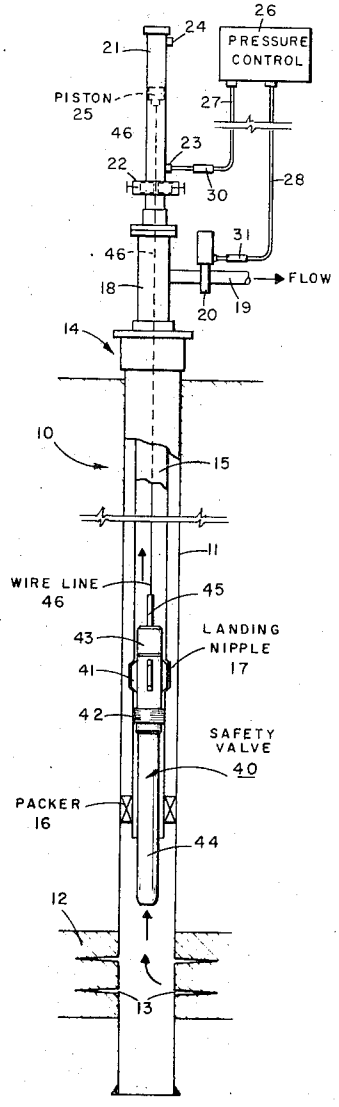
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[57] **ABSTRACT**

A subsurface safety valve system for controlling the flow of oil and/or gas production fluids through a well pipe. A valve assembly is installed in the well pipe a predetermined depth below the surface. A wire-line connects the valve assembly to surface facilities which include apparatus for maintaining sufficient tension on the wireline to hold a movable valve element in the valve assembly in open position and for releasing tension on the wireline to permit the valve element to move to closed position to prevent flow of fluids through the valve assembly. A spring exerts a downward force to move the valve element to its closed position.

12 Claims, 9 Drawing Figures



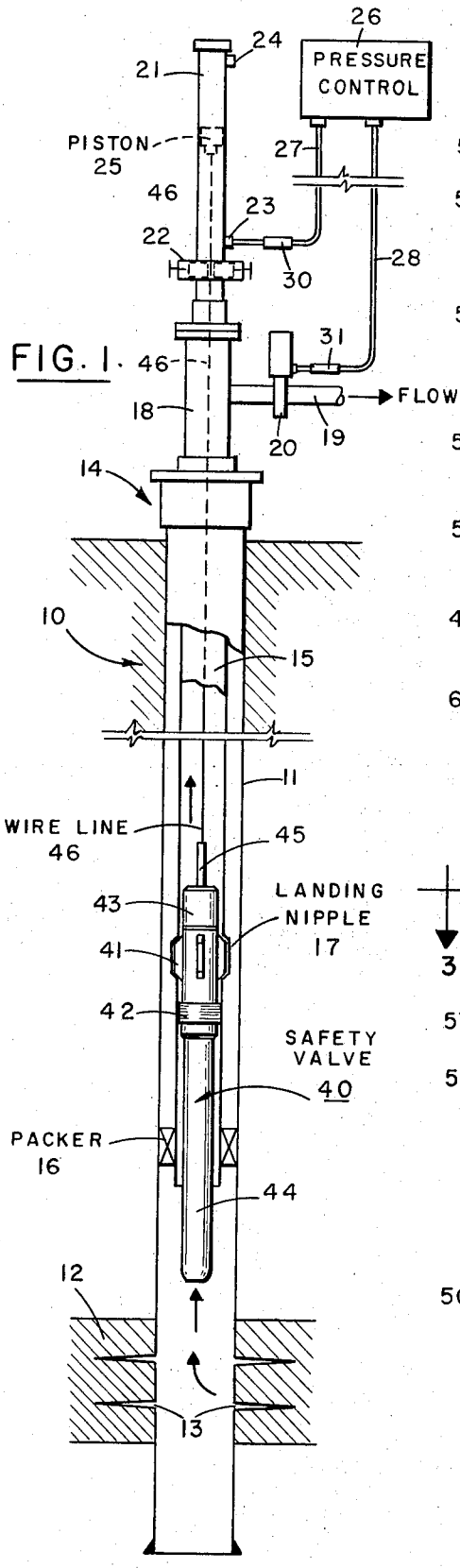


FIG. 1.

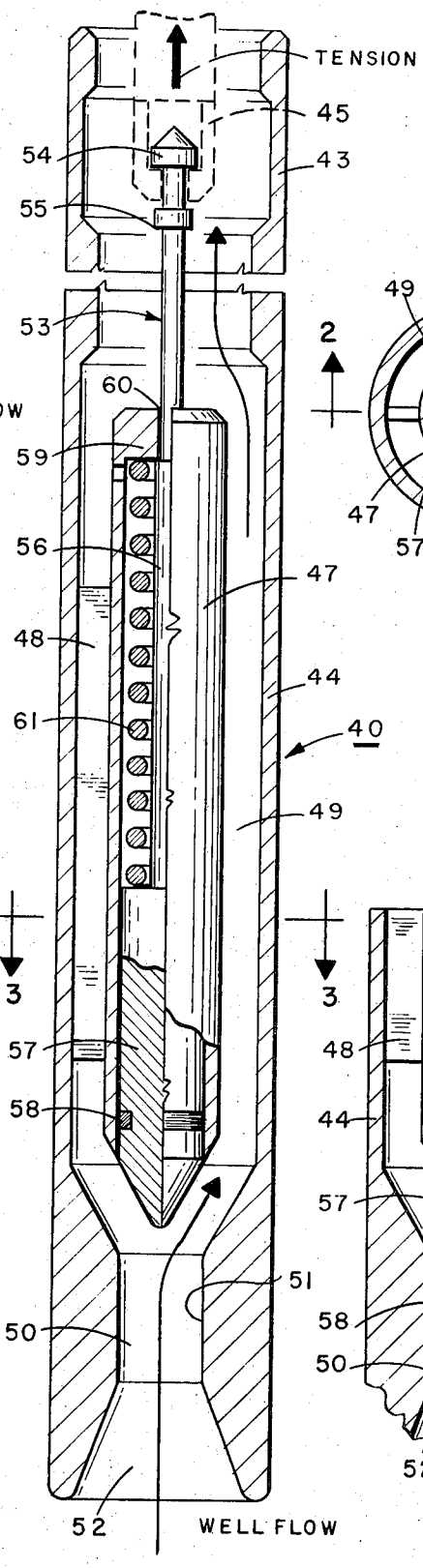


FIG. 2.

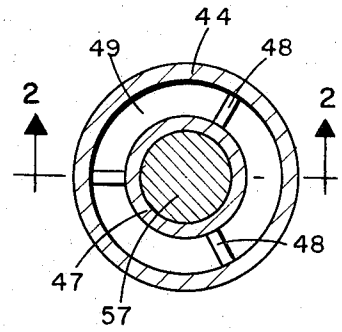


FIG. 3.

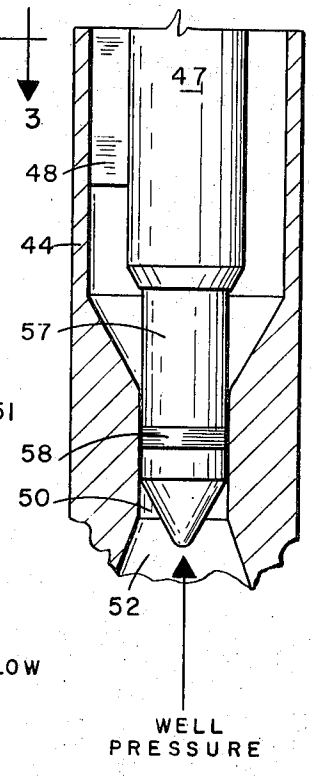
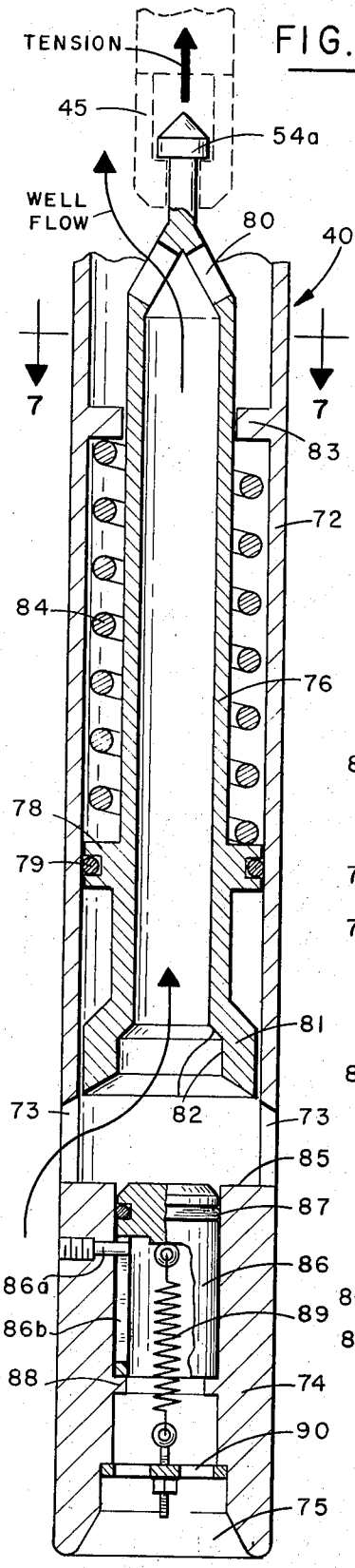


FIG. 4.

FIG. 6.



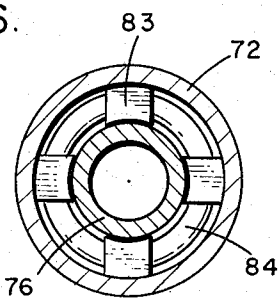
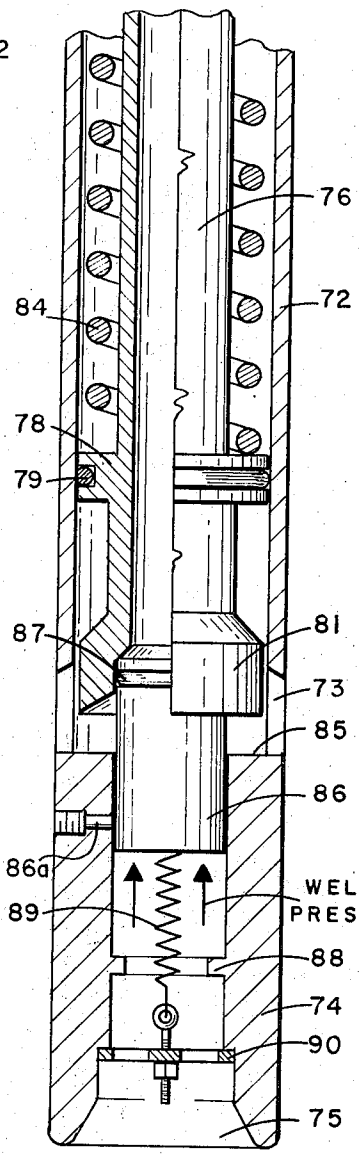


FIG. 7.

FIG. 8.



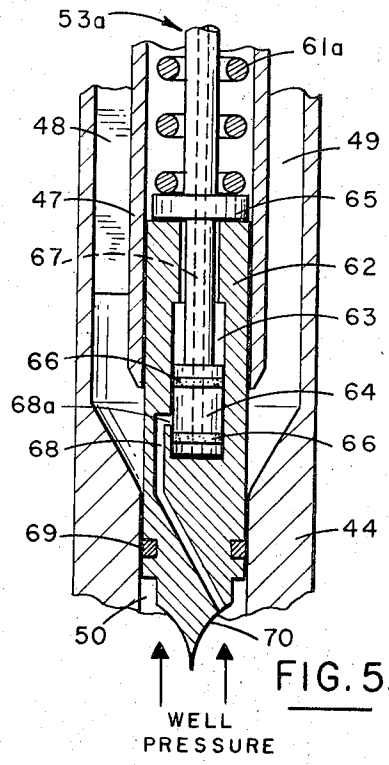
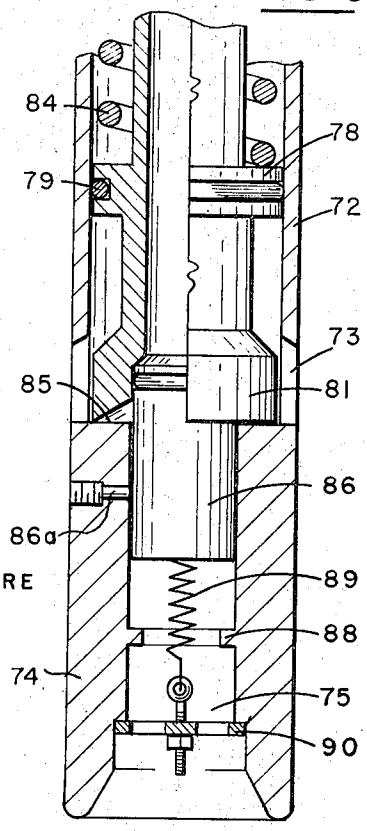


FIG. 5.

FIG. 9.



WIRELINE OPERATED SAFETY VALVE SYSTEM

BACKGROUND OF THE INVENTION

The present invention concerns subsurface safety valves for use in well production pipe strings and, in particular, subsurface saftey valves controlled from the surface by a wireline. The well production pipe string provides a flow path to the surface for well fluids produced from subsurface formations.

Many of the present methods for controlling subsurface safety valves from the surface require recompletion procedures which are often very expensive. Subsurface valves which are controlled by hydraulic communication from the surface through a control pipe or line are seriously limited as to depth because of the hydrostatic pressure created by the control liquid in the control pipe (unless precharged gas loading is used to overcome the hydrostatic pressure). In addition undetected leaks in the control pipe may prevent valve closure. The velocity and pressure sensitive type valves have only limited use because proper settings must be made and proper well conditions must exist for dependable operation. In the present invention, a subsurface valve is operated by a wireline which connects the valve to the surface. It is controlled at the surface but does not require the complicated equipment required in the hydraulic power systems used to control subsurface valves from the surface. It has general applicability and the advantageous features of being operable independent of the pressure in the well and independent of the depth at which it is located and it avoids expensive downhole operations.

SUMMARY OF THE INVENTION

A subsurface safety valve system for use in controlling oil and/or gas fluids produced through a well pipe comprises a tubular member arranged in the well pipe and means for directing flow of fluids through the tubular member. A valve means within the tubular member has an open position and a closed position which permits and prevents, respectively, flow through the well pipe. Biasing means is arranged within the tubular member for biasing the valve means downwardly to close off flow of fluids through the tubular member and the well pipe. A wireline extends through the well pipe and is connected to the valve means for raising the valve means upwardly against the bias of the biasing means to open the tubular member to permit flow of fluids therethrough when a predetermined tensional force is applied to the wireline. Means are connected to the wireline at the surface for releasably maintaining the tensional force on the wireline.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates the safety valve apparatus of the present invention positioned in a well production pipe string;

FIG. 2 is a vertical view, partly in section, of the safety valve assembly shown in FIG. 1;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 2;

FIG. 4 is a sectional view showing the valve member of the valve assembly in closed position;

FIG. 5 is a sectional view showing a modified valve member in closed position;

FIG. 6 is a vertical view, partly in section of another embodiment, of the safety valve apparatus of the present invention in open position;

FIG. 7 is a sectional view taken along lines 7—7 of FIG. 6;

FIG. 8 is a vertical view showing the safety valve assembly of FIG. 6 in its closing position; and

FIG. 9 is a vertical view showing a safety valve of FIG. 6 in its fully closed position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a wall casing pipe 11 is shown in a well 10. Casing pipe 11 penetrates a subsurface formation 12 which is, along with casing pipe 11, perforated as at 13. The casing pipe supports a surface well head assembly 14 and a tubing string 15. A packer 16 seals the annulus between casing pipe 11 and tubular string 15. A landing nipple 17 is located in the wall of tubing string 15 above packer 16. A christmas tree 18, mounted on well head 14, is provided with a flow-line 19 containing a wing valve 20.

A lubricator tube 21 is connected to the upper end of tree assembly 18. Lubricator 21 is provided with a wireline sealing means 22, a fluid inlet connection 23 above sealing means 22 and a vent opening 24 at the upper end of lubricator 21. A piston 25 is slidably arranged in lubricator 21 above sealing means 22.

A source of control fluid under pressure, indicated at 26, is connected by conduit 27 to inlet connection 23 to supply hydraulic pressure to the underside of piston 25. A conduit 28 is connected to a control for hydraulically-openable and spring-closable wing valve 20. Hydraulic pressure from control source 26 maintains valve 20 in its open position. Heat sensitive connectors 30 and 31 are provided in conduits 27 and 28 respectively to open those conduits to the atmosphere to release fluid pressure in lubricator 21 below piston 25.

A safety valve assembly, generally designated 40, is positioned in the lower end of tubing string 15 and is locked in landing nipple 17 by locking dogs 41. Seal means 42 closes off the annulus between the valve assembly and the tubing string. An internal running and retrieving collar 43 (see FIG. 2) is positioned at the upper end of valve assembly 40. A suitable collar of this typs is illustrated on page 3,882 of the 1970–1971 edition of the *Composite Catalog of Oil Field Equipment and Services*, published by World Oil. The lower portion 44 of valve assembly 40 houses the valve components as illustrated in FIGS. 2 to 4. An overshot latch 45, internally connected into valve assembly 40, is attached by a wireline or cable 46 to piston 25 in lubricator 21 (see FIG. 1).

As seen in FIGS. 2 to 4, valve assembly 40 includes spaced apart concentric tubular members 44 and 47 connected together by webbing members 48. A flow path 49, indicated by the arrowed lines, is provided through inlet 52 and the space formed between tubular members 44 and 47. The lower end of tubular member 44 has a reduced inside diameter section (wall 51) which forms a sealing bore 50. A rod member 53 extends through an opening 60 in the upper end 59 of tubular member 47. A latching spear 54 is formed on the upper end of rod 53. A stop collar 55 is arranged on rod 53 below latching spear 54 to limit downward movement of rod 53 by engagement with the upper end 59

of tubular member 47. The lower portion 56 of rod 53 is larger in diameter than the upper portion thereof and is connected to a still further enlarged in diameter cylindrical valve element 57 at its lower end. The upper surface of the enlarged portion 56 abuts the underside of upper end 59 to limit upward movement of rod 53 and valve element 57 connected thereto. The lower outer periphery of valve element 57 is provided with a seal ring 58. As shown in FIG. 2, seal ring 58 is within tubular member 47 in the open position of the safety valve. A compression spring 61 surrounds rod 53 in tubular member 47 and is confined between the upper end 59 of tubular member 47 and the upper surface of valve element 57. Spring 61 urges valve element 57 downwardly to the closed position of the safety valve. Valve element 57 remains withdrawn within tubular member 47 so long as sufficient upward force is applied to rod 53 by means of latch 45 and the tensional force on wireline 46. FIG. 4 illustrates valve element 57 moved down and out of the lower end of tubular member 47 into bore 50 with seal ring 58 engaging the wall 51 of bore 50 to close the safety valve. The operation of the embodiment of the safety valve illustrated in FIGS. 1 to 4 is as follows.

Valve assembly 40 is run in tubing string 15 and latched therein in accordance with conventional procedures. In the running in operation valve element 57 is in its lowermost position under the bias of spring 61 which seals off the bore 50 of tubular member 44. Wireline seal 22 is lubricator 21 is open and overshot latch 45 is run on wireline 46 and latched to spear 71 of rod 53. Piston 25 in lubricator 21 is attached to wireline 46. Seal 22 is closed on wireline 46 and hydraulic pressure from source 26 is supplied through conduit 27 and inlet 23 to the underside of piston 25 moving piston 25 upwardly in lubricator 21 and applying thereby a tensional force to wireline 46. The upward force on wireline 46 causes rod 53 and valve element 57 to move upwardly against the bias of spring 61 to retract valve element 57 into tubular member 47 and open bore 50 of tubular member 44 to open the safety valve to its full open position shown in FIG. 2. A predetermined tensional force is maintained on wireline 46 by fluid pressure supplied from source 26 to maintain bore 50 open. Hydraulic fluid is also supplied through conduit 28 to wing valve 20 which is a hydraulically opened-spring closed valve to maintain valve 20 in the open position. Well fluids flow from formation 12 through open safety valve 40, tubing string 15 and flowline 19. Loss of fluid pressure from lubricator tube 21 below piston 25 releases the tensional force on wireline 46 which permits spring 61 to move rod 53 and valve element 57 downwardly to seal and close bore 50 as illustrated in FIG. 4. While connectors 30 and 31 in conduits 27 and 28 are described as heat sensitive in that they dissolve or disintegrate under a high temperature to cause release of fluid pressure from lubrication tube 21 and wing valve 20 and the resulting closure of the subsurface valve assembly and the wing valve, other connector devices sensitive to, for example, increased pressure of impact might be used to cause release of fluid pressure.

Another modification of the safety valve of the invention is illustrated in FIG. 5. Only the lower portion of the valve assembly illustrated in and described with respect to FIGS. 2 to 4 has been changed. The upper portion of the valve assembly, not shown in FIG. 5, is the same as the upper portion of the valve assembly illustrated in FIGS. 2 to 4. A valve element 62 contains a cylindrical piston chamber 63. A piston 64, provided with spaced apart seal rings 66, is slidably arranged in chamber 63. A rod 53*a* is connected to the upper end of piston 64 and extends through the upper end of valve element 62 (and tubular member 47, not shown). A spring retainer ring 65 is attached to rod 53*a* and in the closed position of valve element 62 shown in FIG. 5 abuts the upper end of valve element 62. A spring 61*a* surrounds rod 53*a* within tubular member 47, biases valve element 62 downwardly to close off bore 50 and also biases piston 64 downwardly to its lowermost position, as shown in FIG. 5. A fluid passageway 67 extends entirely through piston 64 and rod 53*a*.Another fluid passageway 68 extends from the lower end of valve element 62 through valve element 62 and communicates by way of a port 68*a* with chamber 63. In the closed position of the safety valve port 68*a* is closed by piston 64 and spaced apart seal rings 66. The lower outer periphery of valve element 62 is provided with a seal ring 69 (corresponding to valve element 57 and seal ring 58 of FIGS. 2 and 4) which engages the wall of bore 50.

In operation of the embodiment of FIG. 5 safety valve rod 53*a* together with retainer ring 65 is forced upwardly by applying tension to wireline 46 (not shown) which is attached to rod 53*a* in the same manner wireline 46 is attached to rod 53 as discussed with respect to the embodiment illustrated in FIGS. 2 to 4. Upward movement of rod 53*a* and retainer ring 65 compresses ring 61*a* and also forces piston 64 to move upwardly in chamber 63. Once the lower seal ring 66 is raised above port 68*a*, passageways 68 and 67 are in fluid communication, pressure is equalized above and below valve element 62, and further upward movement of rod 53*a* requires only sufficient force to overcome the force of spring 61*a*. Rod 53*a* continues to move upwardly until piston 64 abuts the upper wall of chamber 63. Continued upward movement of rod 53*a* raises valve element 62 from sealing bore 50 and into tubular member 47 to open the safety valve. The lower end 70 of valve element 62 is stepped inwardly and curved, as shown, to form a flow path which directs the flow of well fluids away from seal ring 69 and prevents well fluids from impinging thereon during the closure travel of valve element 62 between bore 50 and tubular member 47.

A still further embodiment of the safety valve of the present invention is illustrated in FIGS. 6 to 9. As shown in these Figs. a cylindrical housing 72 is provided with side entry ports 73 in the wall thereof above a lower nose section 74. A bore 75, which extends through lower section 74, is smaller in diameter than the bore of the upper portion of housing 72. A cylindrical mandrel 76 is arranged in housing 72 above lower section 74. The lower end 81 of mandrel 76 is flared outwardly, as shown, to provide an annular downwardly facing seating surface 82. Above flared end 81 mandrel 72 is provided with an outwardly extending annular shoulder 78 to form a piston containing a seal ring 79 which engages the inner wall of housing 72.

Attached to the upper end of mandrel 76 is an upwardly extending latching spear 54*a*. Openings 80 are provided in the upper end of mandrel 76. Inwardly facing lugs 83 formed on the upper inner wall of housing 72 act as mandrel guides. The lugs also act as upper retainer means for a compression spring 84 which sur-

rounds tubular member **76** and is confined in housing **72** between lugs **83** and the upper surface of piston **78**. The upper surface **85** of lower section **74** functions as a stop to limit downward movement of mandrel **76**. A cylindrical valve plug **86** in the open position of the safety valve is positioned in the upper end of bore **75** (its upper end is flush with surface **85**) and is provided with a seal ring **87** which sealingly engages the wall of bore **75**. Valve plug **86** seats on a shoulder **88** formed on the wall of bore **75**. A tension spring **89** which is connected to valve plug **86** and a flow-through spider plate **90** in the lower end of bore **75** retains valve plug **86** on shoulder **88** in the open position of the safety valve. Well flow through housing **72** is indicated by the arrowed lines in FIG. **6**.

In operation, when tensional force on wireline **46** is reduced or lost, spring **84** moves mandrel **76** downwardly toward surface **85**. As the opening through ports **73** is reduced by the flored end **81** more well pressure is diverted into bore **75** and against the underside of plug **86**, forcing it into contact with the seating surface **82** of the flared end **81** of mandrel **76**, thereby closing off flow of well fluids through housing **72**, as illustrated in FIG. **8**. Mandrel **76** continues to move down until it abuts surface **85** as illustrated in FIG. **9**. When mandrel **76** is again raised by applying tensional force to wire-line **46** tension spring **89** moves plug member **86** to its seat on shoulder **88**. A lateral stop pin **86***a* in section **74** extends into a slot **86***b* in plug **86** and acts to retain plug **86** in bore **75** as mandrel **76** is pulled upwardly by wireline **46**.

Instead of the piston-cylinder-fluid pressure arrangement for maintaining a correct tension on the wireline other arrangements are possible. For example, the wireline could be directly connected to a winch or drum on which the torque and thereby the correct tension on the wireline may be maintained by, for example, a hydraulic gear pump of other suitable means. Other means such as pressure or impact responsive means, for automatically releasing tension on the wireline may be substituted for or used together with the heat sensitive means illustrated. Also, tensional force on the wireline may be released manually. Other changes and modifications may be made in the illustrative embodiments of the invention shown and/or described herein without departing from the scope of the invention as defined in the appended claims.

Having fully described the apparatus, objects, advantages, and operation of my invention, I claim:

1. A safety valve system for use in controlling the flow of fluids through a well pipe which provides a flow path for well fluids from subsurface formations to the surface comprising:

a valve assembly arranged in said well pipe comprising a tubular member arranged in said well pipe, valve means within said tubular member having an open position to permit flow of fluids through said flow path and a closed position to prevent the flow of fluids through said flow path, and actuating means connected to said valve means for moving said valve means upwardly to open position and downwardly to closed position thereof;

a wireline extending through said well pipe and connected to said actuating means for moving said valve means upwardly to said open position thereof when a predetermined tensional force is applied to said wire-line and for permitting said valve means to move to said closed position thereof upon release of said tensional force on said wireline; and

means for sealing off the space between said valve assembly and said well pipe to prevent flow of fluids through said space.

2. A valve system as recited in claim **1** in which said tubular member is provided with a narrowed bore sealing surface and said valve means comprises a valve element having a seal ring thereon engageable with said sealing surface to close off flow of fluids through said valve assembly.

3. A valve system as recited in claim **1** including openings formed in the lower end of said tubular member, and a valve plug provided with a seal ring arranged in said tubular member, said valve plug having a lower position below said openings and an upper position adjacent said openings;

said valve means comprising a valve seat engageable with said seal ring when said valve plug is in its upper position to close off the flow of fluids through said openings.

4. A valve system for controlling the flow of fluids through a well pipe comprising:

first and second spaced apart concentric tubular members connected to each other arranged in said well pipe;

a rod member extending through said second tubular member;

valve means arranged on the lower end of said rod member and containing seal ring;

biasing means surrounding said rod member and confined within said second tubular member for urging said valve means downwardly;

a narrowed bore formed on the lower end of said first tubular member;

said valve means having a retracted position in which said seal ring is within said second tubular member permitting flow of fluids through said first tubular member and an extended position in which said seal ring engages the wall of said narrowed bore to prevent flow of fluids through said first tubular member; and

a wireline extending through said well pipe and attached to said rod member for raising said valve means upwardly to its retracted position against the bias of said biasing means to open said narrowed bore when a predetermined tensional force is applied to said wireline, said biasing means moving said valve means downwardly to its extended position upon release of said tensional force on said wireline.

5. A valve system as recited in claim **4** wherein said first tubular member is spaced from said well pipe and including means for sealing off the space between said first tubular member and said well pipe to prevent flow of fluids through said space.

6. A valve system as recited in claim **5** including means connected to said wireline for releasably maintaining said tensional force to said wireline.

7. A valve system as recited in claim **4** wherein:

said valve means comprises a cylindrical valve element containing a chamber, a piston slidably arranged in said chamber between upper and lower positions and containing spaced apart seals, said valve element being provided with a fluid passageway extending from the lower end of said valve element below said seal ring to said chamber; and

said rod containing a passageway extending therethrough, the upper end of said valve element passageway terminating in a port located between said seals on said piston when said piston is in its lower position, said port being located below said piston when said piston is in its upper position.

8. A valve system as recited in claim **7** in which the lower end of said valve element is stepped and curved.

9. A valve system for controlling the flow of fluids through a well pipe comprising:

a first tubular member arranged in said well pipe;

a second tubular member concentric and movable relative to said first tubular member;

ports formed in the lower end of said first tubular member;

a shoulder formed on the upper inner wall of said first tubular member;

a first valve element formed on the lower end of said second tubular member,

a shoulder formed on said second tubular member above said valve element and provided with a seal ring engageable with and slidable on the inner wall of said first tubular member;

first biasing means surrounding said second tubular member and confined between said shoulder on said first tubular member and said shoulder on said second tubular member for biasing said second tubular member downwardly;

a wireline extending through said well pipe and attached to the upper end of said second tubular member for raising said second tubular member upwardly against the bias of said first biasing means when a predetermined tensional force is applied to said wire-line;

a second valve element provided with a seal ring arranged in the lower end of said first tubular member adjacent said openings therein; and

second biasing means for urging said second valve element downwardly to a position below said openings in said first tubular member, release of said tensional force on said wireline permitting said first biasing means to move said second tubular member downwardly partially closing said openings in said first tubular member and thereby permitting well fluids to move said second valve element upwardly against the bias of said second biasing means until said seal ring on said second valve element engages said first valve element.

10. A valve system as recited in claim **9** including means connected to said wireline for releasably maintaining said tensional force on said wireline sufficient to maintain said first valve element in a position above said openings in said first tubular member.

11. A valve system as recited in claim **10** wherein said first valve element comprises a flared portion of said second tubular member for sealingly engaging said seal ring on said second valve element.

12. A valve system as recited in claim **11** wherein said first tubular member is spaced from said well pipe and including means for sealing off the space between said first tubular member and said well pipe to prevent flow of fluids through said space.

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