United States Patent [19]

Dinning

[11] **3,763,932**

[45] **Oct. 9, 1973**

[54] **SURFACE OPERATED, SUBSURFACE SAFETY VALVE ASSEMBLY**

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[21] Appl. No.: **211,906**

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

[51] **Int. Cl.** **E21b 33/03,** E21b 43/12

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

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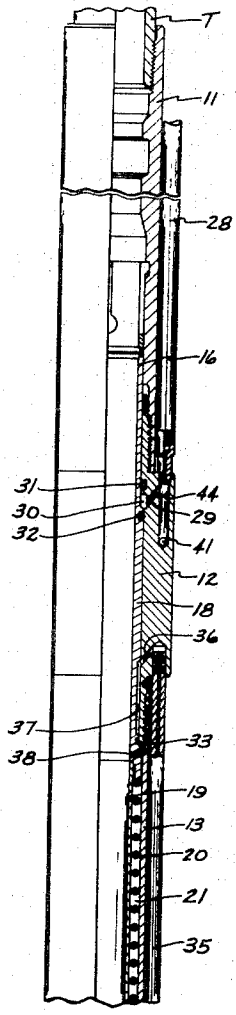
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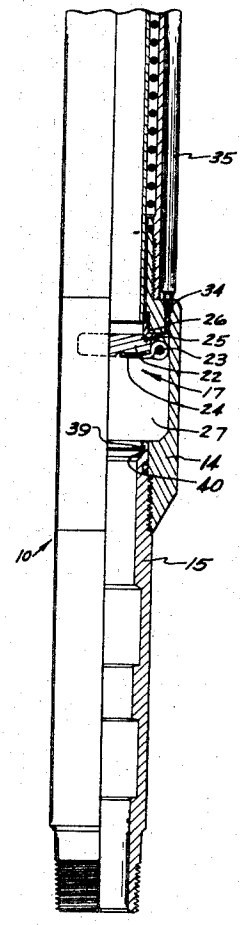
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[57] **ABSTRACT**

Opening and closing of a subsurface safety valve in a well tubing is regulated by control pressure supplied to the valve through a pressure passage extending from the valve to the well surface. Reduction in control pressure in the passage permits the valve to move to its normally closed position under the influence of a compressed spring. Repressuring the passage acts through an expansion chamber to reopen the valve against the force of the spring. A pressure bypass is provided for equalizing pressures above and below the closed valve to ease reopening of the valve. The valve may be permanent or retrievable, and in one form of the invention, a retrievable valve is landed within an inoperative, permanent safety valve. In the latter embodiment, means are provided for regulating opening and closing of the retrievable valve by pressure supplied through the pressure passage previously regulating operation of the permanent valve. In one form of the invention, the passage is provided by a small control line and in another form, the passage is provided between two concentric tubing strings.

18 Claims, 18 Drawing Figures





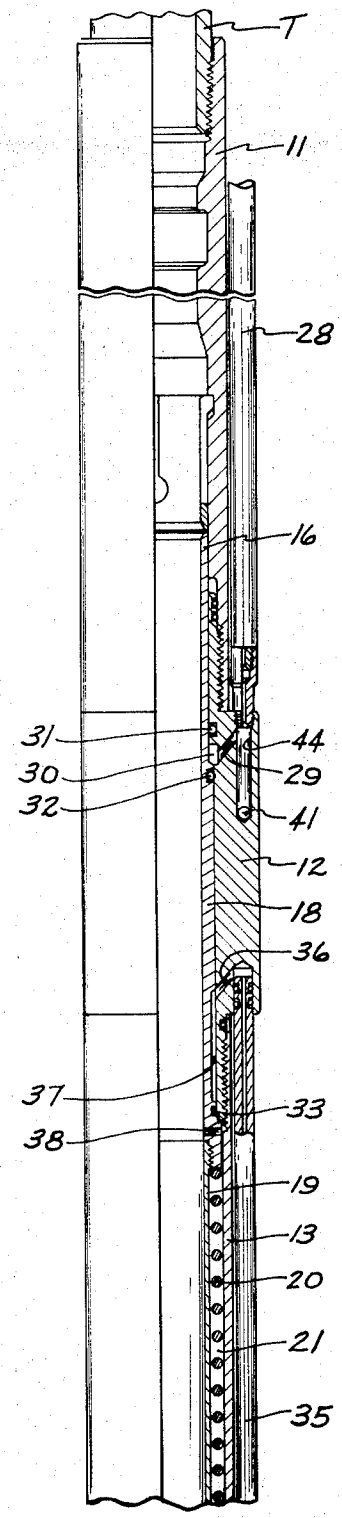


Fig. 1A

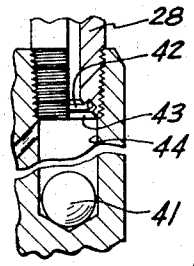


Fig. 10

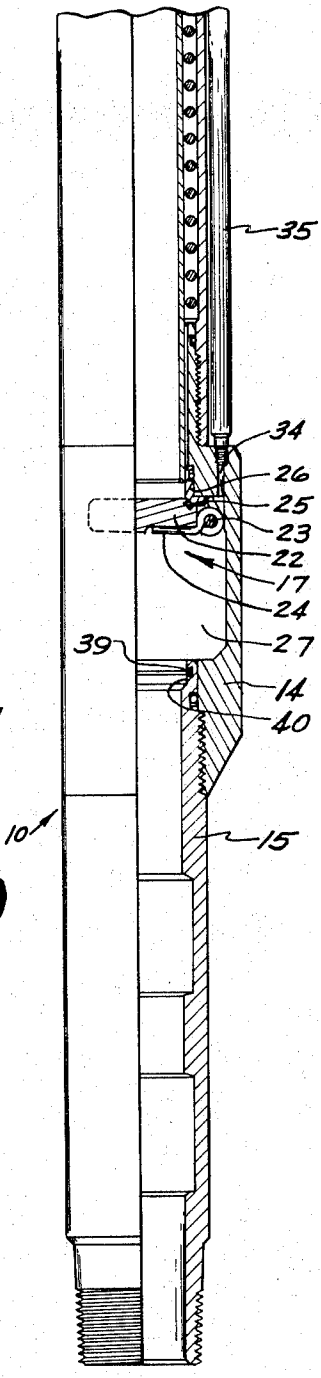


Fig. 1B

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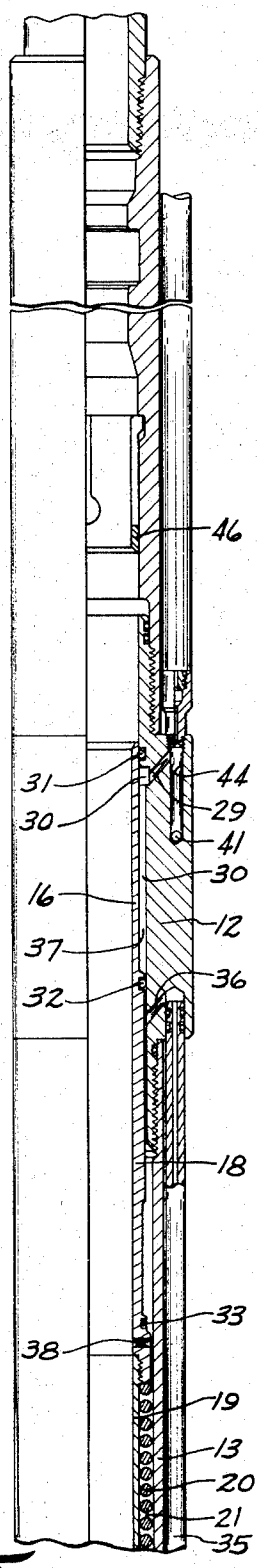


Fig. 2A

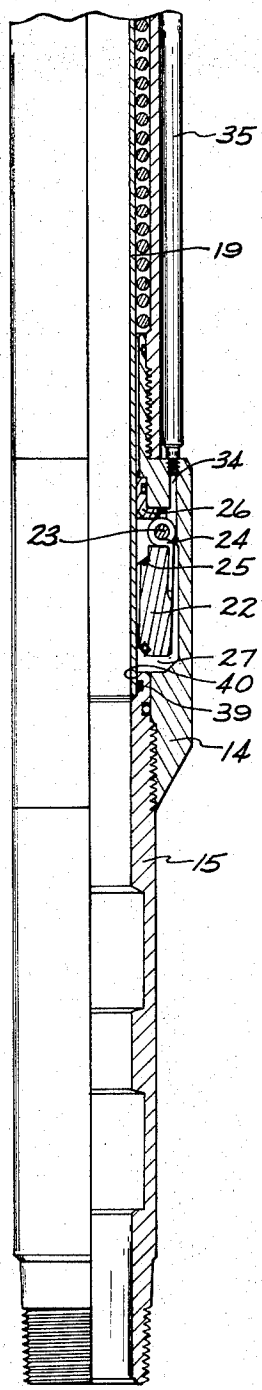


Fig. 2B

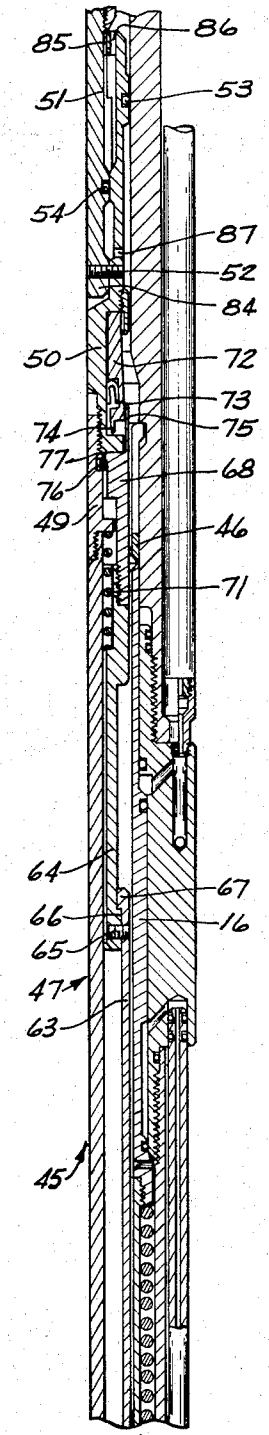
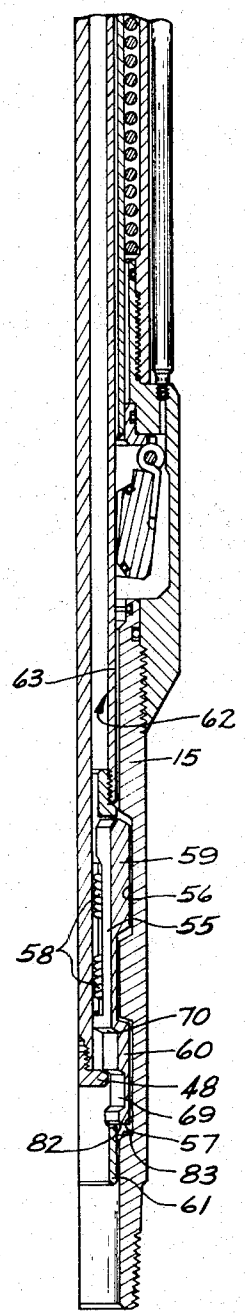


Fig. 3A

Fig. 3B



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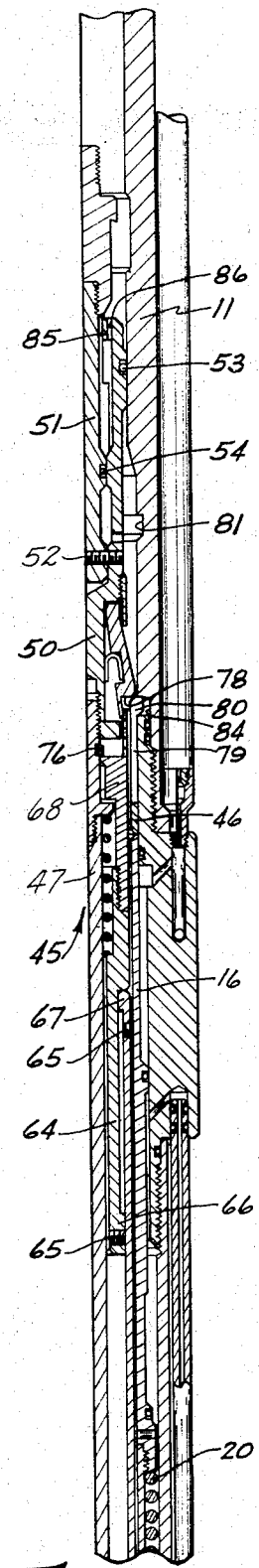


Fig. 4A

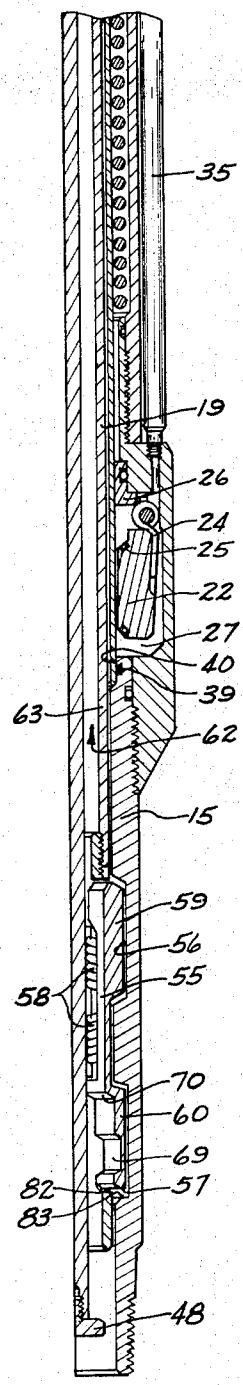


Fig. 4B

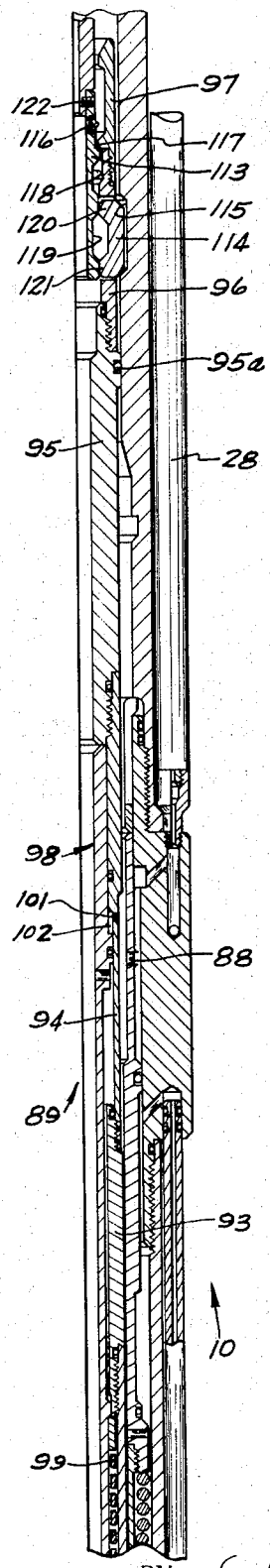
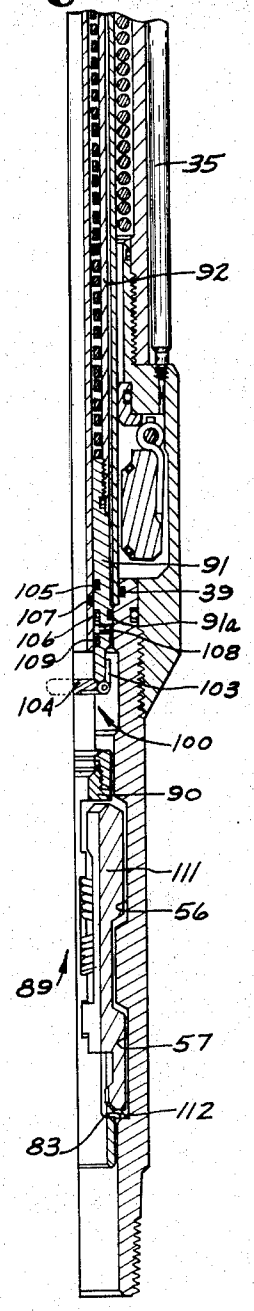


Fig. 5A

Fig. 5B



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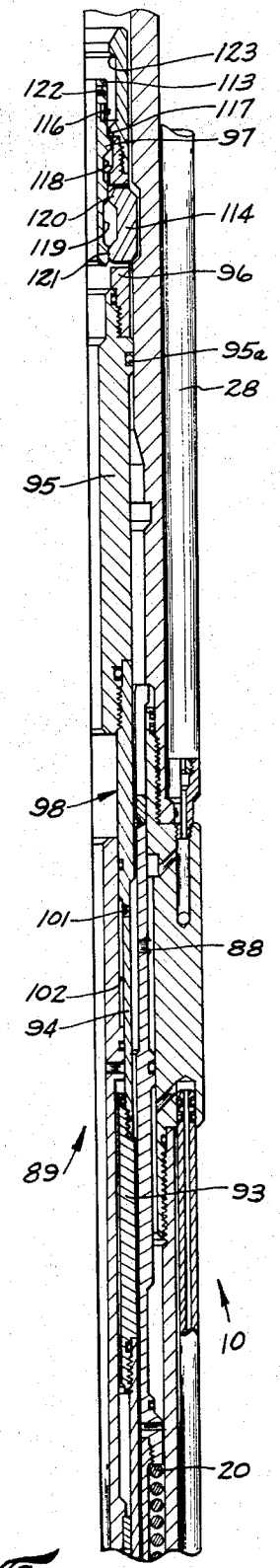


Fig. 6A

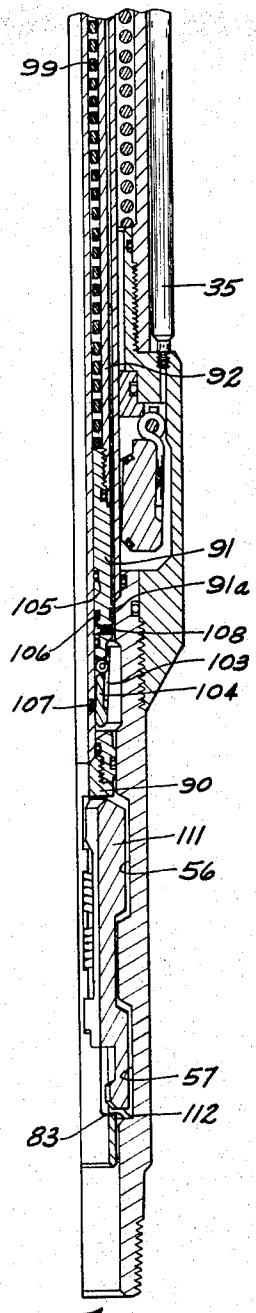
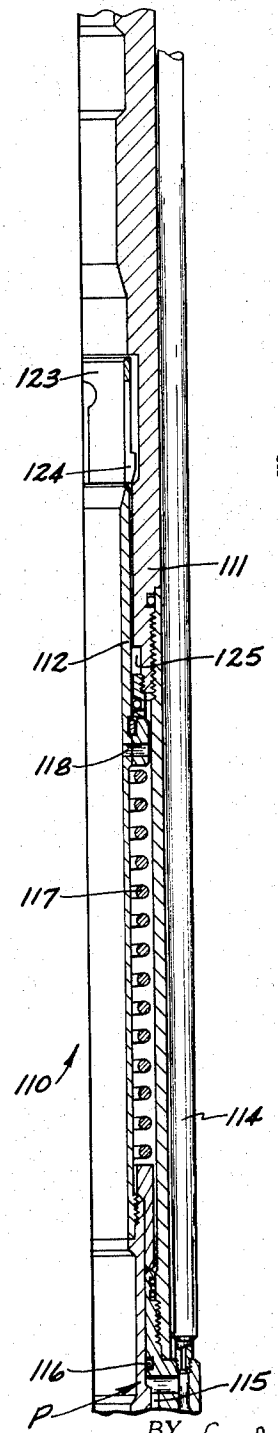


Fig. 6B

Fig. 7A



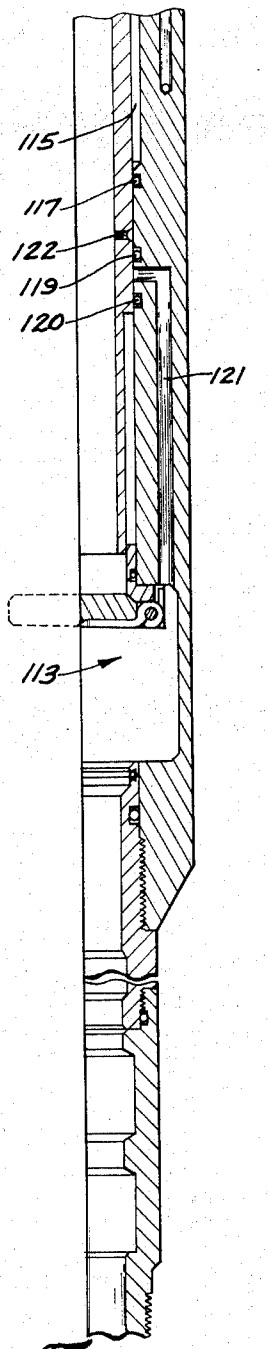


Fig. 7B

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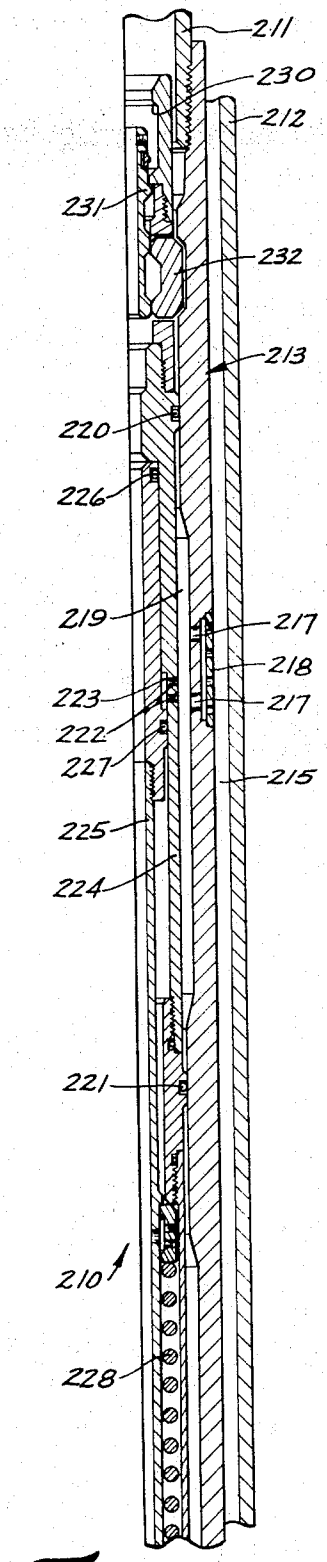


Fig. 8A

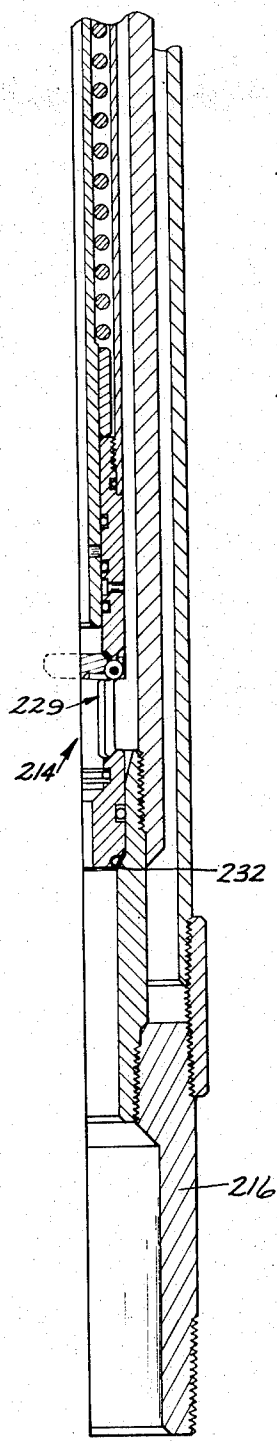


Fig. 8B

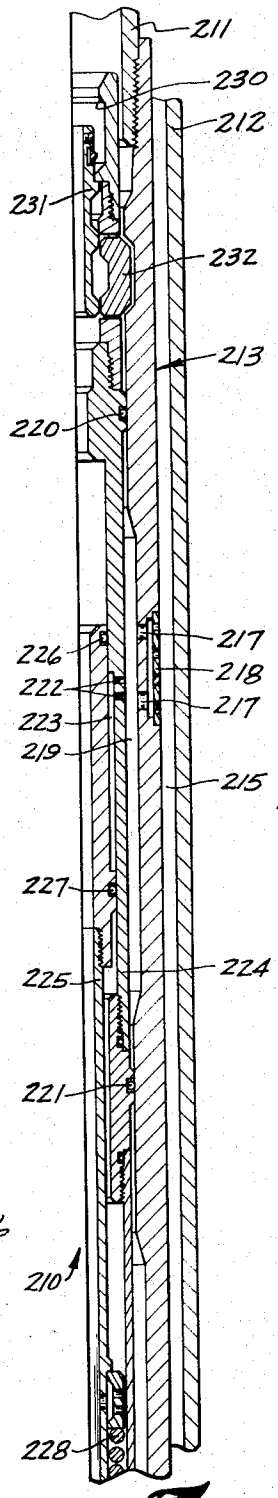
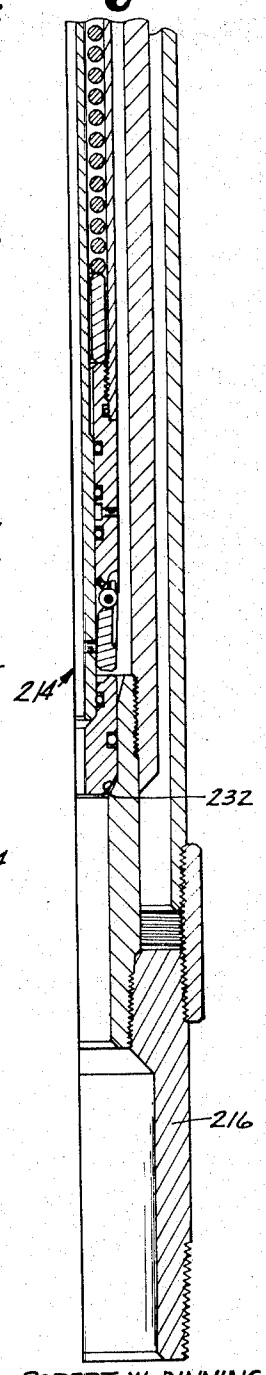


Fig. 9A

Fig. 9B



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SURFACE OPERATED, SUBSURFACE SAFETY VALVE ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to automatic valving means employed to terminate the flow of fluids through a well structure. More specifically, the present invention relates to a subsurface safety valve which is controlled from the well surface to close in the event of damage to the confining structure at the wellhead.

2. Description of the Prior Art

The prior art conventionally employs surface operated subsurface valves which open or close a production tubing string in response to hydraulic pressure supplied through a small control line extending between the subsurface valve and the well surface. In operation, loss of pressure in the control line, which may be caused by damage to the wellhead structure and the attached control line, permits a spring loaded valve in the production tubing string to move to closed position to terminate the flow of well effluents through the string. An example of this type valve is illustrated in U. S. Pat. No. 3,092,135.

Where such valves are "in-place" or permanent valves forming a fixed part of the production tubing string, replacement or repair of the valve requires removal of the entire tubing string. The expense and lost production time associated with complete removal of the tubing string are highly undesirable. Normally, in-place valves are desirable to the extent that they afford the use of large flow passages through the valve elements.

Another problem associated with surface operated, subsurface safety valves of the type previously described is that once closed, such valves are difficult to reopen because of the pressure differential developed across the valve closure elements. Customarily, to reopen such valves, it is necessary to repressure the production tubing string from the wellhead until the pressures above and below the closure elements are equalized.

In some applications, it may not be desirable to employ a separate, small control line which extends from the subsurface valve to the well surface. Such use may be undesirable for example where production is being effected simultaneously through several zones and the small line is carried in the annular area used to produce one of the zones. Flow of sandy effluents through the annular area may eventually cut through the control line permitting loss of pressure which in turn would cause closure of the subsurface valve.

SUMMARY OF THE INVENTION

In the preferred form of the invention, an in-place or permanent surface operated, subsurface safety valve assembly is designed to act as a landing nipple for a retrievable subsurface valve assembly whereby the retrievable valve may provide the safety valving function previously supplied by the in place-valve. In this manner, the desired subsurface safety function may be restored without the need for complete removal of the production tubing string.

In the latter embodiment, both the in-place valve and the retrievable valve are equipped with pressure bypasses which permit equalization of pressure above and below the closed valve elements so that the control pressure is sufficient to reopen the valve.

In one form of the invention, the control pressure passage is formed in the annular space included between two concentric tubing strings which extend between the subsurface valve location and the well surface. In the latter embodiment, a retrievable valve mechanism is movable through the central tubing string and is operable by hydraulic pressure supplied through the annular control passage to terminate effluent flow through the internal tubing string.

From the foregoing it may be appreciated that one object of the present invention is to provide an in-place, subsurface, surface-operated safety valve which, in the event it should become inoperable, may function as a landing nipple for a retrievable valving assembly which is also surface operated.

Another object of the present invention is to provide a control pressure passage in the form of an annular space formed between two concentric tubing strings exending between the subsurface valve and the well surface.

Still another object of the present invention is to provide a pressure equalizing means whereby high pressure differentials existing across closed valve members may be equalized to permit the subsurface valve to be easily reopened.

The foregoing objects of the invention and other features and advantages of the invention will be more readily appreciated from the following specification, drawings and the related claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are elevations, in quarter section, illustrating the upper and lower portions respectively of one form of the surface-operated, subsurface valve assembly of the present invention;

FIGS. 2A and 2B are the upper and lower portions respectively of the valve assembly of FIG. 1 in open position;

FIGS. 3A and 3B are vertical quarter sections of the upper and lower portions respectively of the assembly of FIG. 1 illustrating a lock-out mechanism conditioning the assembly for receipt of a second valve assembly;

FIGS. 4A and 4B are similar to FIGS. 3A and 3B illustrating the operation of the lock out mechanism;

FIGS. 5A and 5B illustrate a retrievable valve assembly landed in the assembly of FIG. 1;

FIGS. 6A and 6B are similar to FIGS. 5A and 5B, illustrating the retrievable valving assembly in open position;

FIGS. 7A and 7B are vertical quarter sections illustrating the upper and lower portions respectively of a modified valve assembly illustrated in closed position;

FIGS. 8A and 8B are vertical quarter sections illustrating the upper and lower portions respectively of another modification of the present invention employing an annular pressure control passage; and

FIGS. 9A and 9B illustrate the assembly of FIG. 8 in open position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One form of the present invention is illustrated in FIGS. 1A and 1B which show the upper and lower portions, respectively, of a surface-operated, subsurface safety valve assembly indicated generally at 10. The as-

sembly **10** is included as part of a production tubing string T which extends between a wellhead (not illustrated) and a subsurface petroleum bearing formation (not illustrated) to convey effluents in the formation to the well surface in a well-known manner. The assembly **10** includes a plural part outer housing body formed by tubular members **11, 12, 13, 14** and **15** which are threadedly connected to each other to form a composite tubular body which is connected at its upper and lower ends into a production tubing string T. O-ring seals are disposed between the mating parts in the outer housing to prevent leakage.

A primary tubular control sleeve **16** carried internally of the outer housing is adapted to be moved axially through the housing to regulate opening and closing of a flapper valve closure assembly indicated generally at **17.** The control sleeve **16** is formed from upper and lower, threadedly engaged segments **18** and **19.** A coil spring **20** extends concentrically within an annular space **21** formed between the lower sleeve section **19** and the outer housing member **13.** The spring **20** is compressed axially between the base of upper sleeve section **18** and the upper end of housing section **14** and biases the sleeve **16** upwardly.

The valve assembly **17** is carried in the outer housing member **14** and includes a flapper closure member **22** which is pivotably mounted about a supporting pin **23.** A spring **24** encircles the pin **23** and biases the closure member **22** to closed position. In its closed position, an O-ring seal **25** carried on the sealing surface of the flapper element **22** engages and seals agianst an annular seat member **26** carried in the housing member **14.** A recess **27** formed along the internal surface of the housing component **14** receives the flapper element **22** when the flapper is rotated into its open position illustrated in FIG. 2B.

In operation, hydraulic pressure is supplied to the assembly **10** through a small control line **28** which is in pressure communication with a port **29** formed through the housing component **12.** Hydraulic fluid in the line **28** flows through the base of the line into the port **29** where it is communicated to an expansion chamber **30** formed between the housing member **12** and the control sleeve segment **18.** Upper and lower O-ring seals **31** and **32,** respectively, form a sliding seal between the control sleeve component **18** and housing component **12.** The cross-sectional area of the sliding seal formed by the O-ring **31** is less than that of the **0**-ring **32** with the result that the control sleeve **16** is moved axially downwardly through the outer housing when the fluid pressure in the chamber **30** is sufficiently greater than the external pressure to compress the spring **20.**

The initial downward movement of sleeve **16** from the position illustrated in FIGS. 1A and 1B moves an O-ring seal **33** out of sealing engagement with the internal surface of the housing member **12** to open a bypass which permits equalization of pressures existing above and below the closed flapper valve **22.** In operation, the bypass functions to communicate the pressure in the assembly **10** below the flapper valve **22** through an axially extending opening **34** formed in the housing component **14** to a bypass line **35** which is in pressure communication with a port **36** opening through the housing component **12** to an annular space **37** formed between the control sleeve **16** and the surrounding outer housing. With the seal **33** below the base of member **12,** the pressure in the annular passage **37** is communicated through a radial port **38** into the assembly **10** above the flapper valve **22.**

Initially, the pressure supplied through the control line **28** is sufficient to lower the control sleeve **16** enough to release the seal formed by O-ring **33** so that fluid pressure below the flapper valve **22** is bypassed around the valve. The sleeve **16** is retained in this position until the pressures above and below the flapper element **22** are substantially equal at which point, the pressure in chamber **30** is sufficient to compress the spring **20** causing the sleeve **16** to move axially downwardly until it engages the flapper **22.** The downwardly moving sleeve rotates the flapper about the pin **23** into the recess **27.** When the sleeve **16** is shifted to its lowermost position, the valve assembly **10** is fully opened as illustrated in FIGS. 2A and 2B. In the latter position, the control sleeve segment **19** engages an O-ring seal **39** carried in a seal **40** so that the sealing surfaces on the flapper element **22** and seat member **26** are protected from the abrading and corrosive effects which may be caused by well effluents flowing through the assembly **10.**

In use, the assembly **10** is normally maintained in its open position as illustrated in FIGS. 2A and 2B. In the event pressure supplied through the line **28** is lost, as may occur for example from wellhead damage, the pressure in chamber **30** falls sufficiently to permit the spring **20** to shift the sleeve **16** upwardly permitting the spring **24** to swing the flapper element **22** into the closed position illustrated in FIG. 1B. When in the closed position, all effluent flow through the tubing string T is terminated. When the wellhead damage or malfunction has been corrected, the valve **17** may be reopened by repressuring the line **28** to shift the sleeve **16** downwardly sufficiently to open the pressure bypass around the valve in the manner previously described. Subsequently, with the pressure across the flapper equalized, the pressure in control line **28** is sufficient to snap the flapper **22** into the fully opened position illustrated in FIG. 2B.

The valve assembly **10** is maintained in its open position when it is initially being run into the well by pressuring the chamber **30** at the well surface. While pressure is being supplied to the chamber **30,** the assembly **10** is inverted which permits a ball **41** to rest and seal against an annular O-ring seal **42** carried in a seating surface **43** formed at the base of the pressure line **28.** When the pressure being supplied through line **28** is released, the back pressure in chamber **30** maintains the ball **41** against the O-ring **42** so that the ball acts as a check valve which prevents loss of pressure in the chamber **30** and maintains the valve **17** in open position. Once the valve assembly has been lowered to its subsurface position, pressure supplied through the line **28** permits the ball **41** to fall to the bottom of an axial retaining bore **44** formed in the housing member **22.**

In the event the valve assembly **17** should become inoperative, the assembly **10** is adapted to receive a second, retrievable, surface-operated safety valve. The assembly **10** is conditioned to receive the retrievable valve by a surface operated lock-down mechanism indicated generally at **45** in FIGS. **3** and **4.** Referring initially to FIG. **3,** the mechanism **45** is designed to shift the sleeve **16** to its lowermost position and to lock it in that position by shifting a hold-down collar **46** downwardly through the outer housing body. To this end, the lock-down mechanism **45** is lowered through the tubing

string T into the position illustrated in FIGS. 3A and 3B. The required axial movement of the assembly **45** may be regulated from the surface by any suitable means, including wireline, hydraulic pumping means, or otherwise.

The assembly **45** includes a rod **47** having an enlarged foot piece **48** secured at its lower end. The upper end of the rod **46** is threadedly engaged with a rod section **49** which is in turn engaged at its upper end to a turular member **50.** A connector member **51** is secured by means of a shear pin **52** within the upper tubular opening of rod member **50.** The upper end of component **51** connects to a conventional wireline (not illustrated) which is employed to return the assembly **45** to the well surface.

In the preferred form, the assembly **45** is pumped into position from the wellhead and for this purpose, suitable annular packing **53** is carried about the external surface of the component **50.** The packing **50** cooperates with an internally positioned O-ring seal **54** to provide a pressure barrier in the tubing string T. Pressure applied from the well surface above the pressure barrier "pumps" the assembly **45** downwardly through the tubing string T until one or more spring loaded dogs **55** register with locating recesses **56** and **57** formed along the internal surface of the housing member **15.** In the latter position, springs **58** snap the dogs **55** radially outwardly so that projections **59** and **60** on the dogs spring into the recesses **56** and **57,** respectively. The dogs **55** are pivotably carried in a tubular support body **61** which forms the lower end of a composite sleeve **62.** The sleeve **62** includes a second tubular body portion **63** which is pinned to an upper tubular portion **64** by means of a shear pin **65.** An externally developed projection **66** at the base of member **64** engages an internally developed projection **67** at the upper end of a component **63** to prevent the two components from separating. The upper end of the sleeve **62** is threadedly engaged to a tubular holding component **68.**

When the assembly **45** has been pumped to the subsurface location illustrated in FIGS. 3A and 3B, the dogs **55** spring open in the manner described to release the foot piece **48** which had been trapped in an internal recess **69** formed along the radially inner surface of the dogs **55.** When thus located and with the rod **47** released, the mechanism **45** is raised by an upward pull exerted by the surface extending wireline connected to the top of the mechanism. A compressed coil spring **71** encircling the rod **47** urges the rod upwardly and the sleeve **62** downwardly when the wireline is raised. The action of the spring **71** cooperates with the partial locking provided by the dogs **55** to permit the rod **47** to be moved upwardly through the sleeve **62.** Upward movement of the rod through the upper sleeve section **38** permits one or more spring loaded dog members **72** to spring radially outwardly under the influence of a U-type spring **73.** A lower projection **74** extending downwardly from the base of the dogs **72** engages an upwardly extending lip **75** on the sleeve component **68** to limit the outward radial expansion of the dogs **72.** Upward movement of the rod through the sleeve component **68** also compresses a snap ring **76** which permits the rod to be raised above a shoulder **77** exending radially inwardly from the sleeve component **68.** The flat base of the ring **76** engages the top of projection **77** and prevents the rod from returning to its original position.

FIG. 4A illustrates the dog **72** extending radially outwardly and the rod **47** shifted upwardly with respect to the surrounding sleeve component **68.** When in the expanded position, a downwardly directed face **78** on the dog **72** engages the top of the lock-down collar **46.** The lock-down collar includes a plurality of upwardly extending resilient collet fingers **79** having enlarged locking heads **80** at their upper end. When the valve **17** is functioning properly, the heads **80** lock with an annular recess **81** formed along the internal wall of the housing member **11** to maintain the collar in the position illustrated in FIGS. 1A and 2A. With the dogs **72** extended as illustrated in FIG. 4A, the assembly **45** is driven downwardly by hydraulic pressure applied from the wellhead or by suitable jarring mechanisms (not illustrated), or otherwise, to shift the hold-down collar **46** from the position illustrated in FIG. 1A to the lower position illustrated in FIG. 4A. The downward force acts through the snap ring **76** against the top of projection **77.** When the force exerted on sleeve **62** is sufficiently great, the pin **65** shears permitting the sleeve segments **64** and **68** to shift downwardly from the position illustrated in FIG. 4A. Downward movement of the lower portions of sleeve **62** is prevented by engagement of a lower face **82** formed along the base of the dogs **55** with a flat face **83** formed at the lower end of the locating recess **57.** Downward shifting of the locking collar **46** brings the collet heads **80** into engagement with an annular recess **84** formed in the internal wall of the outer housing. Lowering of the hold-down collar **46** is also effective to shift the operating sleeve **16** downwardly into the position illustrated in FIG. 4A. The collet heads **80** are provided with flat upper surfaces which engage the flat upper surface of the recess **84** to prevent the collar **46** and sleeve **16** from shifting upwardly under the influence of the coil spring **20.**

With the sleeve **16** thus locked into its lower position, the lock-down assembly **45** may be withdrawn to the well surface. Raising of the surface extending wireline draws the rod **47** and sleeve segments **68** and **64** upwardly until the projection **66** engages projection **67** which draws the lower portion of the sleeve **62** upwardly. With the projections **66** and **67** engaged, the foot piece **48** aligns with the recess **69** and the upward pull exerted on the sleeve **62** draws tapered surfaces on the dogs **55** and recesses **56** and **57** into engagement causing the dogs to close radially inwardly against the spring force to permit the entire mechanism **45** to be withdrawn to the well surface.

If a pressure differential develops across the seal **54** and packing **53** as the mechansim **45** is being raised through the tubing T, the shear pin **52** severs permitting an enlarged base section **85** at the bottom of connecting member **51** to move up to and engage an internal shoulder **85** formed at the top of tubular rod member **50.** In the latter position, the seal provided by O-ring **54** is disrupted and fluid above the assembly **45** is permitted to flow through axial openings **86** and radial openings **87** to prevent development of a pressure differential across the upwardly moving mechanism **45.**

Once the sleeve **16** has locked in its lower position in the manner previously described, a suitable perforating mechanism (not illustrated) is lowered through the tubing string T and operated to form one or more perforations **88** (FIG. 5A) through the wall of control sleeve **16.** Following formation of the perforations, a retrievable, surface operated safety valve assembly indicated

generally at **89** in FIGS. **5A** and **5B** is lowered through the tubing string T and landed within the assembly **1**. A suitable running tool (not illustrated) is employed to lower the retrievable assembly **89** into position and anchor it within the surrounding outer housing of assembly **10**. In operation, the assembly **89** is designed to provide the same valving function previously provided by the assembly **10** with opening and closing of the valve controlled by pressure in the control line **28**.

The valve assembly **89** includes a main body housing formed of threadedly engaged tubular members which include a lower dog holding member **90**, a valve mounting member **91**, a spring housing member **92**, a connecting member **93**, a chamber housing member **94**, an upper connecting member **95**, a locking dog carrying member **96** and an upper retrieving member **97**. At each of the threadedly engaged junctions of the members forming the main body housing, O-ring sals are provided to ensure fluid-tight engagement between the components.

An axially movable, secondary control sleeve **98** is carried within the main body housing. A coil spring **99** concentrically positioned between the control sleeve **98** and the main housing functions to bias the sleeve **98** toward its upper axial position in the manner previously described with reference to spring **20**. Axial movement of the sleeve **98** through the main housing body opens and closes a flapper valve assembly indicated generally at **100**.

Control of the opening and closing of assembly **89** is similar to that previously described with reference to the assembly **10**. Pressure in the line **28** is conveyed through the perforations **88** and through raidal ports **101** to an expansion chamber **102**. Fluid in the annular area between the sleeve **16** and the main housing body is confined at the upper end of the area by an annular O-ring seal **95***a* and at the lower end of the annular area by O-rings **91***a* and **39**. When the pressure in the chamber **102** is great enough to overcome both the external pressure and the force exerted by compressed spring **99**, the sleeve **98** is shifted downwardly into the position illustrated in FIGS. **6A** and **6B**. In the latter position, the valve assembly **100** is in its fully open position where it is received in a recess shielded by the overlying secondary operating sleeve **98**. In the event pressure in the line **28** is lost, the force of spring **99** returns the sleeve **98** to its upper position permitting a spring **103** to pivot a flapper valve closure member **104** into the closed position illustrated in FIG. **5B**.

A pressure bypass is provided for reopening the valve **100**. The bypass means includes O-ring seals **105** and **106** positioned respectively above and below radial port **107** extending through the wall of the sleeve **98** and a radial port **108** extending through the valve mounting member **91** below the O-ring **106** and above a third O-ring **109**. With the valve in the closed position illustrated in FIG. **5B**, the flapper element **104** cooperates with O-rings **109** and O-ring **91***a* to terminate effluent flow through the assembly. Repressuring the fluid in line **28** shifts the sleeve **98** downwardly bringing the port **107** below O-ring **106** to establish a pressure bypass through the ports **107** and **108**. Pressure above and below the flapper **104** begins to equalize through the bypass and when the pressure differential across the flapper is substantially eliminated, the pressure exerted in chamber **102** is sufficient to snap the sleeve **98** downwardly into the position illustrated in FIG. **6B**.

During the initial placement of the assembly **89** within the assembly **10**, spring loaded dogs **111** spring radially outwardly into the locating recesses **56** and **57** when the assembly is properly positioned axially. Movement below this point is prevented by a flat lower surface **112** on the dogs **111** which engages the lower face **83** of recess **57**.

At the upper end of assembly **89**, an axially movable locking collar **113** is employed to shift locking dogs **114** radially outwardly into an annular recess **115**. The collar **113** includes a snap ring **116** which is held axially below an internal shoulder **117** formed on the retrieving head **96** while the assembly **89** is lowered downwardly through the tubing string. When the collar **113** is in the latter position, recesses **118** and **119** formed along the external surface of the collar coincide with internally directed projections **120** and **121** respectively formed on the locking dogs **114** permitting the dogs to remain retracted. When the desired subsurface location is reached, the running tool is manipulated to draw the collar **113** axially upwardly with respect to the stationary main housing body causing the snap ring **116** to be depressed radially inwardly as it is being raised above the shoulder **117** permitting the collar to move into the position illustrated in FIG. **5A**. The upward movement of the collar **113** with respect to the locking dogs **114** draws tapered surfaces at the ends of recesses **118** and **119** against oppositely tapered surfaces on the projections **120** and **121** to force the locking dogs **114** radially outwardly into locking engagement with the annular recess **115**. With the dogs **114** in the latter locking position, the assembly **89** is anchored axially within the assembly **10**.

Once the assembly **89** is locked in place, a shear pin **122** connecting the collar **113** with the running tool is severed to permit the running tool to be returned to the surface. The snap ring **116** prevents the sleeve **113** from falling axially below the projection **117** so that the dogs **114** are maintained in their radially outer position.

In the event it become necessary to retrieve the assembly **89** for any reason, a suitable retrieving mechanism (not illustrated) is lowered into the tubing string T and latched onto a retrieving shoulder **123** formed along the internal surface of the retrieving member **97**. The retrieving mechanism shifts the collar **97** downwardly, until the snap ring **116** is below the projection **117**, which permits radial retraction of the locking dogs **114**. Once the dogs **114** have been freed from engagement with the recess **115**, the assembly **89** may be withdrawn to the surface.

FIGS. **7A** and **7B** illustrate the upper and lower portions respectively of a modified surface operated subsurface safety valve assembly indicated generally at **110**. The assembly **110** is similar in construction and operation to the assembly **10**. The assembly **110** includes an outer assembly housing **111** and an internal operating sleeve **112**. Axial movmeent of the sleeve **112** through the housing **111** regulates opening and closing of a flapper valve assembly indicated generally at **113**. Fluid pressure for controlling movement of the sleeve **112** is supplied from the well surface through a control line **114**. Pressure in line **114** is communicated to an expansion chamber **115**. The upper and lower ends of the chamber **115** are sealed by O-ring seals **116** and **117**, respectively, which form a continuous, sliding sealing engagement between the sleeve **112** and the surrounding housing **111**. Pressure supplied to the

chamber 115 shifts the sleeve 112 downwardly to compress a coil spring 117 and close the flapper valve 112. Loss of pressure in the chamber 115 permits the coil spring to return the sleeve 112 upwardly permitting a spring loaded flapper element in valve 113 to snap to closed position. A port 118 formed through the wall of the sleeve 112 communicates with the annular space between the sleeve 112 and the main housing 111 to prevent a fluid lock from developing during axial movement of the sleeve.

The assembly 110 is equipped with a pressure bypass means provided by axially spaced O-ring seals 119 and 120 and a flow passage 121 formed through the housing 111. When the assembly is in the position illustrated in FIG. 7B, the flow passage 121 is blanked off between the O-rings 119 and 120. With pressure reestablished in the chamber 115, the sleeve 112 is shifted downwardly to bring a radial port 122 formed through the wall of the sleeve 112 below the O-ring 119 and into fluid communication with the passage 121. In the latter position of the sleeve, pressures above and below the flapper element equalize permitting the pressure in chamber 115 to shift the sleeve 112 to its lowermost axial position.

When the assembly 110 becomes inoperative, a lock down tool is employed to shift a lock down collar 123 downwardly until locking heads 124 formed at the base of the collar latch into a recess 25 formed along the internal wall of the outer housing 111. With the collar 123 in the latter position, the sleeve 112 is locked in its lowermost position with the valve 113 fully open. Subsequently, one or more perforations are formed through the sleeve 112 at approximately the location P so that the chamber 115 may be in fluid communication with the pressure control means of a retrievable valve assembly such as the assembly 89 previously described. It will be appreciated that the lock-down mechanism employed to mainpulate the sleeve 123 and the retrievable valve employed in the assembly 110 are similar to those previously described with reference to the assembly 10. In addition, aspects of the assembly 110 not specifically described are similar or analogous to those previously described with reference to the assembly 10.

FIGS. 8 and 9 illustrate a modified form of the present invention indicated generally at 210. The assembly 210 includes concentric, inner and outer tubing sections 211 and 212, respectively, which extend between the subsurface valve location and the well's surface. The inner tubing section 211 connects with a tubular landing section 213 adapted to hold a retrievable, surface operated safety valve assembly indicated generally at 214. In operation, fluid pressure is supplied to the assembly 210 through an annular space 215 formed between the inner and outer tubing members 211 and 212. The lower ends of the sections 211 and 212 threadedly engage the upper end of a connecting sub 216. The lower end of the sub 216 is in turn connected to a tubing string (not illustrated) which is in fluid communication with a subsurface, petroleum bearing formation.

Pressure in annular chamber 215 is communicated through radial ports 217 formed through the walls of the landing section 213. A protective screen 218 encircles ports 217 to prevent debris from clogging or interferring with the workings of the internal components of the assembly 214. Fluid flowing through the ports 217 communicates with an annular passage 219 sealed at its upper and lower ends respectively by O-rings 220 and 221 carried on the retrievable valve assembly 214. The pressure in chamber 219 is in turn communicated through ports 222 to an expansion chamber 223 formed between a tubular valve housing body 224 and an internal tubular operating sleeve 225. Upper and lower sliding O-ring seals 226 and 227, respectively, enclose the expansion chamber 223 to permit the sleeve 225 to move axially through the surrounding housing 224 while maintaining a continuous sliding seal between the two components.

In operation, the fluid pressure in the annular passage 215 is employed to expand the chamber 223 causing the sleeve 225 to shift downwardly compressing a coil spring 228 carried between the sleeve 225 and the valve housing 224. The initial downward movement of the sleeve opens a pressure bypass in the manner previously described with reference to FIGS. 5B and 7B. Subsequent downward movement of the sleeve opens a flapper valve assembly indicated generally at 229 in the manner previously described with reference to other modifications of the invention. With the valve in the closed position illustrated in FIGS. 8A and 8B, the flapper valve assembly 229 cooperates with an O-ring 221 to completely terminate effluent flow through the assembly.

In the event it becomes necessary to retrieve assembly 214 from its subsurface location, a suitable retrieving mechanism is lowered through the tubing 211 and engaged with a retrieving shoulder 230. A locking sleeve 231 is shifted downwardly by the retrieving mechanism to release locking dogs 232, in the manner previously described, to permit the assembly 214 to be removed to the surface.

During placement of the assembly 214, a lower restriction 232 limits the downward axial movement of the assembly to properly locate it with respect to the surrounding landing section 213. When the proper location has been reached, the running mechanism shifts the hold-down sleeve 231 upwardly in the manner described previously with reference to FIG. 5A to lock the dogs 232 radially outwardly which in turn fixes the assembly 214 in position. Other features in the placement, retrieval and operation of the assembly are similar to those described earlier with reference to the assemblies 10 and 110.

While flapper valve closures have been employed to describe the operation of the present invention, it will be appreciated that ball closure members and other closures may be employed without departing from the teachings of the invention. Similarly, it will be understood that the annular control pressure flow passage described with reference to FIGS. 8 and 9 may be employed in the embodiments described in FIGS. 1–7.

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

I claim:

1. A surface operated subsurface valve assembly for use in a well comprising:

a. subsurface valve means responsive to a control pressure for regulating flow of effluents through a well conduit;

b. control pressure passage means extending from said subsurface valve means toward the surface of said well for supplying control pressure to said valve means;

c. biasing means for urging said valve means to normally closed position wherein effluent flow through said well conduit is terminated;

d. opening means operable by said control pressure for opening said valve means against the action of said biasing means;

e. pressure equalizing means operable by said control pressure for reducing the pressure differential across said valve means when said valve means is closed whereby said opening means may fully reopen said valve means; and

f. check valve means openable by control pressure in said control pressure passage means for temporarily holding said subsurface valve means in open position while a relatively low control pressure is present in said passage means.

2. An assembly as defined in claim **1** wherein said valve means is retrievably positioned in said well conduit to permit placement and retrieval of said valve means from the well surface.

3. An assembly as defined in claim **2** wherein said control pressure passage means includes a second well conduit encircling said first named conduit to enclose a substantialy annular control pressure passage between said first mentioned conduit and said second conduit.

4. An assembly as defined in claim **1** wherein said control pressure passage means includes a second well conduit encircling said first named conduit to enclose a substantially annular control pressure passage between said first mentioned conduit and said second conduit.

5. An assembly as defined in claim **1** further including a second valve means retrievably positioned in said first mentioned valve means and operable by said control pressure for regulating flow of effluents through said well conduit.

6. An assembly as defined in claim **5** wherein said second valve means includes;

a. second biasing means for urging said second valve means to normally closed position;

b. second opening means operable by said control pressure for opening said second valve means against the action of said second biasing means; and

c. second pressure equalizing means operable by said control pressure for reducing the pressure differential across said second valve means when said second valve means is closed whereby said second opening means may fully reopen said second valve means.

7. An assembly as defined in claim **5** wherein said first mentioned valve means includes selectively operable means for retaining said first mentioned valve means in open position irrespective of the control pressure value.

8. An assembly as defined in claim **1** wherein said valve means includes selectively operable means for retaining said valve means in open position irrespective of the control pressure value.

9. An assembly as defined in claim **1** further including:

a. a substantially tubular valve housing body means;

b. a substantially tubular control valve means, carried in said housing body means.

c. a flapper valve closure element means operable by axial movement of said control sleeve means to open or close said well conduit to effluent flow;

d. coil spring biasing means carried concentrically between said control sleeve means and said housing means for normally biasing said sleeve means in a direction to move said closure element means to closed position; and

e. expansion chamber means communicating with said control pressure and operable by said control pressure to expand and to move said sleeve means in a direction moving said closure element means to open position.

10. An assembly as defined in claim **9** wherein said bypass means includes means operable upon limited movement of said sleeve means to open a relatively small pressure passage means commucating with the area in said well conduit above and below said valve means.

11. A surface operated, subsurface valve assembly for use in a well comprising:

a. a first subsurface valve means responsive to a control pressure for regulating flow of effluents through a well conduit;

b. control pressure passage means extending from said subsurface valve means toward the surface of said well for supplying control pressure to said valve means;

c. biasing means for urging said valve means to normally closed position;

d. opening means operable by said control pressure for opening said valve means against the action of said biasing means;

e. landing means in said valve means for landing a retrievable, second valve means in said first mentioned valve means;

f. means for operating said retrievable valve means by said control pressure to regulate the flow of effluents through said conduit; and

g. check valves means openable by control pressure in said control pressure passage means for temporily holding said subsurface valve means in open position while a relatively low control pressure is present in said passage means.

12. An assembly as defined in claim **11** wherein said first mentioned valve is in fully open position and said retrievable valve means is landed and locked in said first mentioned valve means.

13. An assembly as defined in claim **12** wherein said second valve means includes:

a. second biasing means for urging said second valve means to normally closed position;

b. second opening means operable by said control pressure for opening said second valve means against the action of said second biasing means; and

c. a second pressure equalizing means operable by said control pressure for reducing the pressure differential across said second valve means when said second valve means is closed whereby said second opening means may fully reopen said second valve means.

14. An assembly as defined in claim **12** wherein said second valve means further includes second pressure equalizing means operable by said control pressure for

reducing the pressure differential across said second valve means when said second valve means is closed whereby said second opening means may fully reopen said second valve means.

15. An assembly as defined in claim **11** wherein said landing means includes selectively operable means for retaining said valve means in open position irrespective of the control pressure value.

16. An assembly as defined in claim **11** wherein said valve means includes:

a. a substantially tubular valve housing body means;

b. a substantially tubular control sleeve means carried in said housing body means; and

c. a flapper valve closure element means operable by axial movement of said control sleeve means to open or close said well conduit to effluent flow.

17. An assembly as defined in claim **11** further including pressure equalizing means operable by said control pressure for reducing the pressure differential across said valve means when said valve means is closed whereby said opening means may fully reopen said valve means.

18. An assembly as defined in claim **1** wherein said check valve means includes a ball, a seat and a ball recess below said ball whereby application of control pressure to said control pressure passage means unseats said ball and permits said ball to fall into said ball recess.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,763,932 Dated October 9, 1973

Inventor(s) Robert W. Dinning

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 31: change "agianst" to --against--.

Column 4, line 18: change "seal" to --seat--.

Column 4, line 56: change "22" to --12--.

Column 5, line 10: change "turular" to --tubular--.

Column 7, line 2: change "1" to --10--.

Column 7, line 18: change "sals" to --seals--.

Column 7, line 33: change "raidal" to --radial--.

Column 12, line 48: after "valve" insert --means--.

Signed and sealed this 1st day of January 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

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