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Mott

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[45] **Dec. 17, 1974**

[54] **METHOD AND APPARATUS FOR AN EQUALIZING VALVE**

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[73] Assignee: **Hydril Company,** Houston, Tex.

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[21] Appl. No.: **381,481**

Related U.S. Application Data

[63] Continuation of Ser. No. 214,685, Jan. 3, 1972, abandoned.

[52] **U.S. Cl.** ..... **137/629,** 166/224 A

[51] **Int. Cl.** **F16k 11/16**

[58] **Field of Search** . 137/629, 630, 630.14, 630.15; 166/224

[56] **References Cited**

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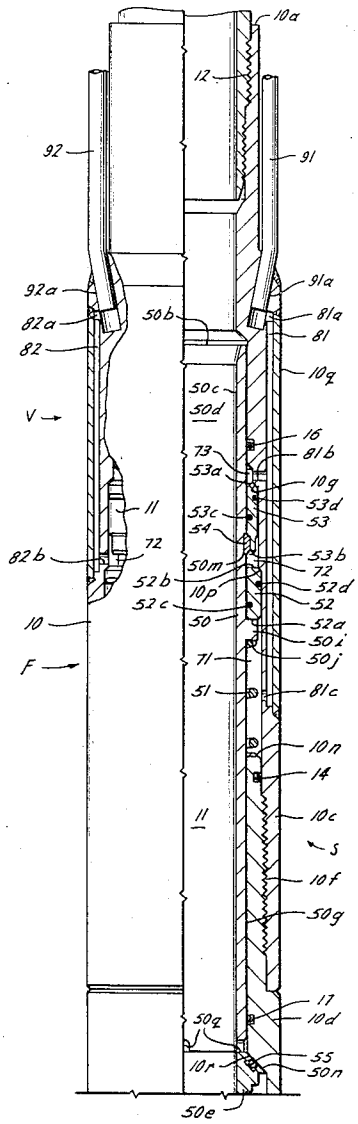
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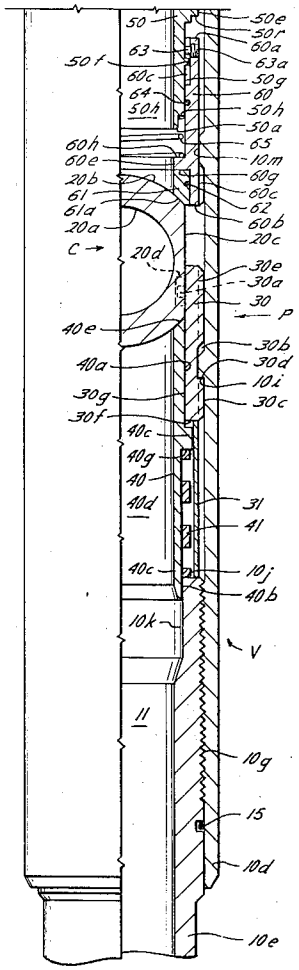
Primary Examiner—Robert G. Nilson

[57] **ABSTRACT**

An apparatus for a surface controlled subsurface safety valve including a rotatable ball closure member for controlling flow of fluid through the valve and a by-pass flow means for equalizing fluid pressure about the closed ball when desired. The by-pass flow means is operable either by opening the flow means while blocking opening rotation of the ball or automatically when rotating the ball open to enable flow through the valve. A method of operating the equalizing valve is also disclosed.

13 Claims, 6 Drawing Figures





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SHEET 1 OF 3

Fig. 1A

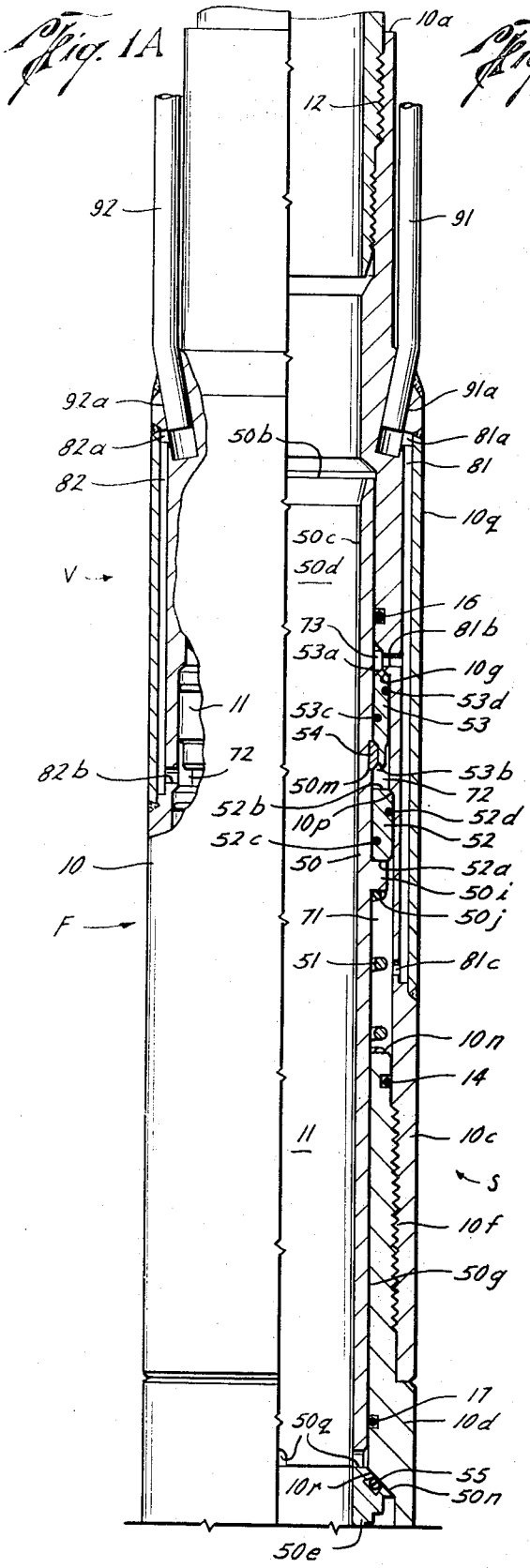


Fig. 1B

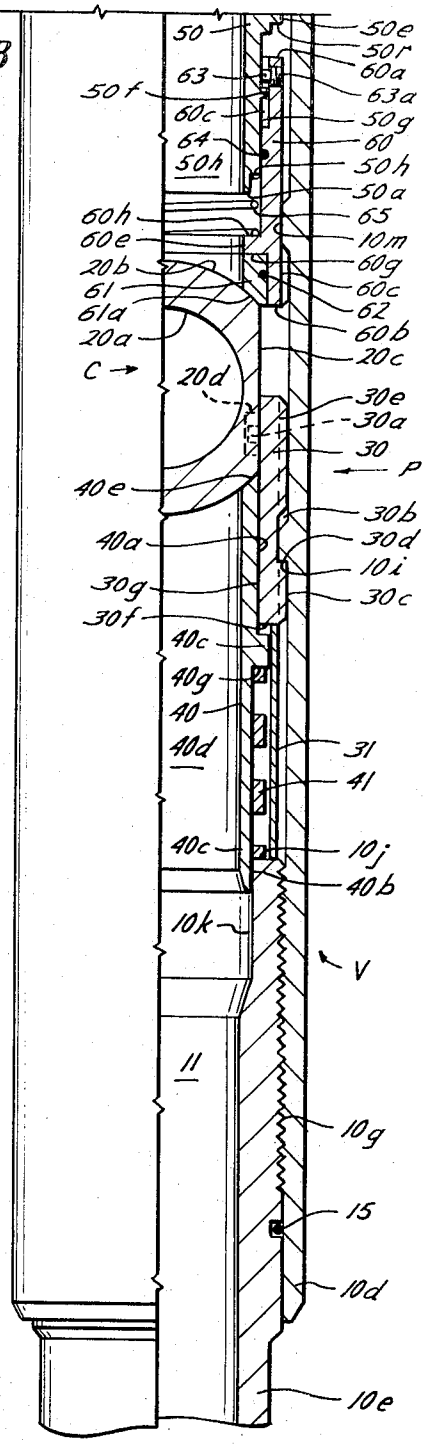


Fig. 2A

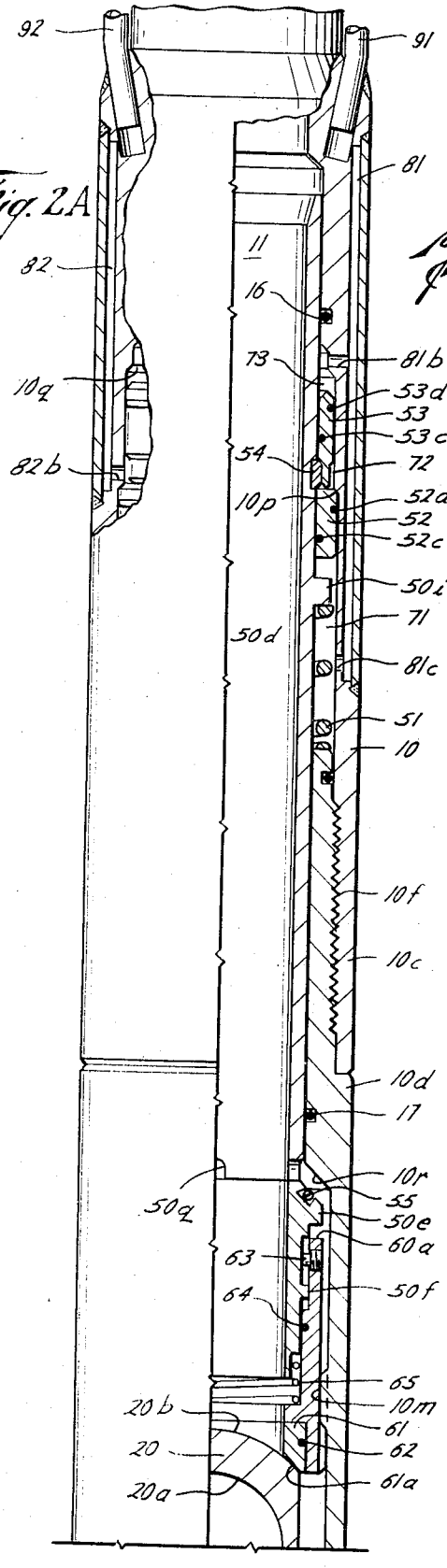

92
91
81
11
82
16
73
81b
10q
53d
53
53c
82b
54
72
10p
52d
52
52c
50i
71
50d
81c
51
10
10f
10c
10d
17
50q
10r
55
50e
60a
63
50f
64
65
20b
10m
61
20
62
20a
61a

Fig. 2B

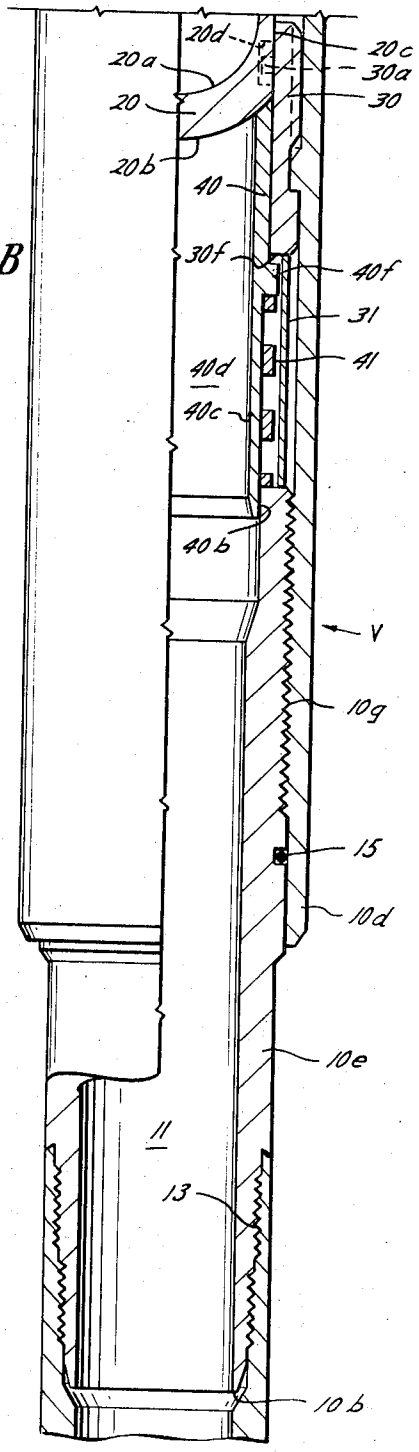

20d
20c
20a
30a
20
30
20b
40
30f
40f
31
40d
41
40c
40b
V
10g
15
10d
10e
11
13
10b

Fig. 3A

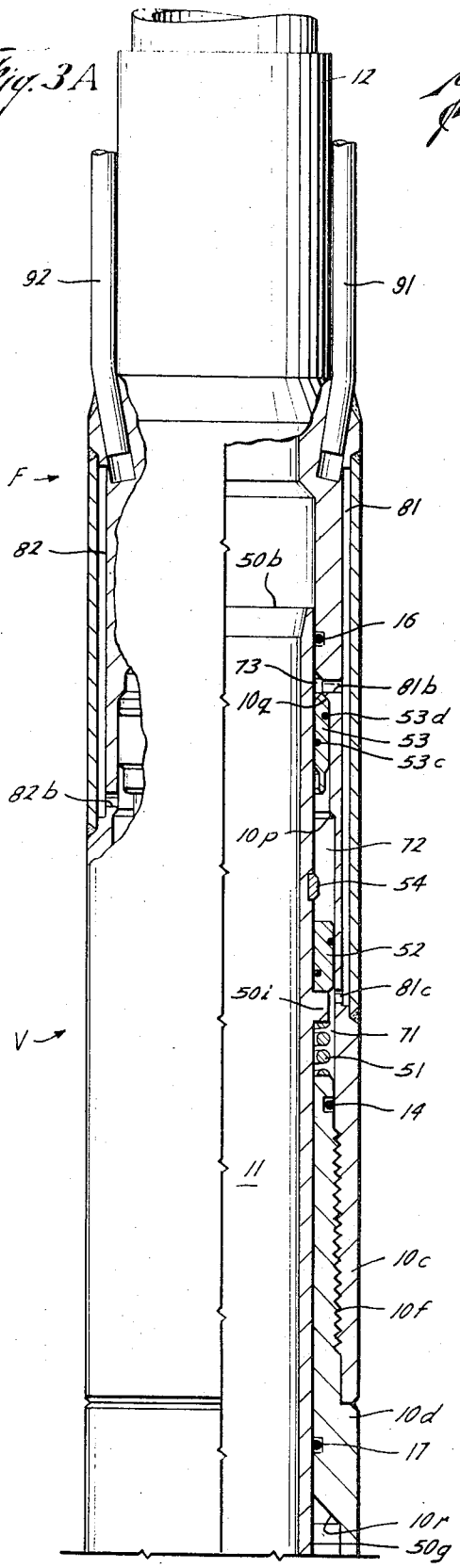
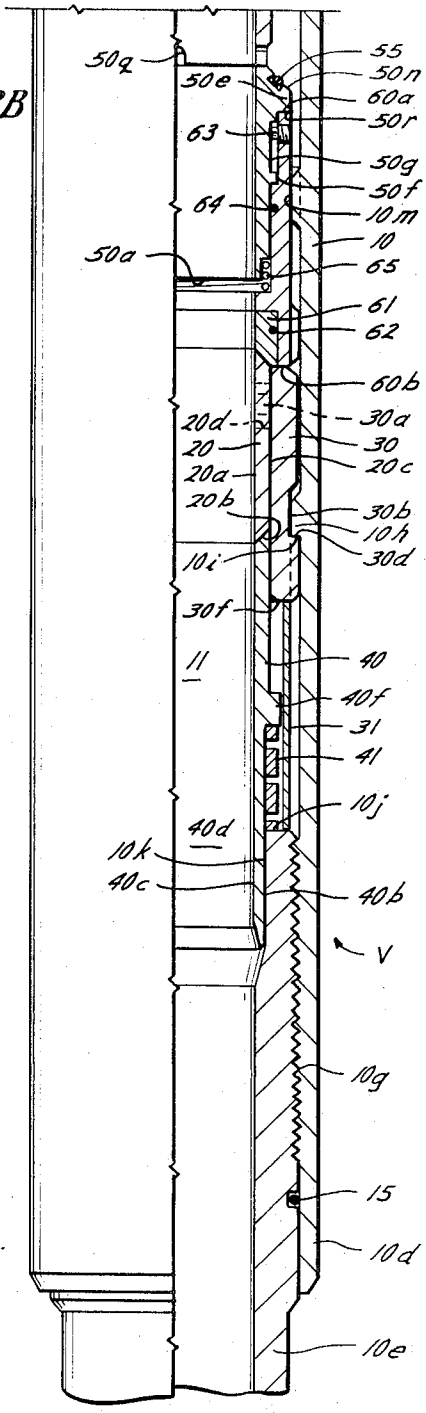

12
92
91
F
81
82
50b
16
73
81b
10q
53d
53
53c
82b
10p
72
54
52
50i
81c
V
71
51
14
11
10c
10f
10d
17
10r
50g

Fig. 3B


50q
55
50e
50n
60a
50r
63
50g
50f
64
10m
10
50a
65
61
62
60b
30a
20d
30
20
20c
20a
20b
30b
10h
30d
10i
30f
11
40
40f
31
41
10j
40d
10k
40c
40b
V
10g
15
10d
10e

METHOD AND APPARATUS FOR AN EQUALIZING VALVE

This is a continuation of application Ser. No. 214,685, filed Jan. 3, 1972, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates generally to the field of a valve and more particularly to a subsurface safety valve having a rotatable ball closure means and a flow by-pass means for equalizing fluid pressure urging on the ball.

Prior art production tubing retrievable valves have sought, until now unsuccessfully, to provide a long and reliable operating life for a safety valve to shut in a well at a subsurface location. The cost in time and in lost production from the well along with the expense incurred in pulling the tubing to replace defective valves have been prime factors in limiting widespread use and acceptance of these valves. More importantly, the failure of a faulty safety valve to operate could result in a catastrophic well blow-out with all of the attendant hazards to life and property therefrom as well as in environment damage from the escaping hydrocarbons and other well fluids.

Having sealing surfaces shielded from the well flow, a low inherent flow resistance and numerous other desirable characteristics have made rotatable ball valves a preferred type of valve for subsurface well service. One drawback in using rotatable ball valves has been that when the ball was rotated to the open position while holding a large pressure differential thereacross, the ball and valve sealing surfaces were frequently scored, galled or otherwise damaged which would thereafter enable leakage through the valve. The initial high velocity flow, as the ball was rotated open, cut, eroded or otherwise damaged the valve sealing surfaces which would also enable leakage through the valve. Prior attempts to incorporate a flow by-pass to equalize the fluid pressure about the ball prior to rotating open the ball such as disclosed in my co-pending United States Patent Application, Ser. No. 72,034, now abandoned, utilized the same operating means to effect operation of the ball and the flow by-pass. With such arrangement, an operator at the well head was unable to ascertain that pressure equalization across the ball was effected by the by-pass valve or by the potentially damaging partial rotation of the ball.

SUMMARY OF THE INVENTION

A method of operating and apparatus for a surface controlled subsurface safety valve including a flow housing having a bore therethrough and a rotatable ball type bore closure member movably disposed in the bore to control flow of fluid therethrough. The valve also includes a by-pass flow means for equalizing the fluid pressure about the ball that is operable either independently when desired of the ball operation or automatically when rotating open the ball. The method includes the steps of blocking movement of the ball while flowing fluid about the ball to equalize the fluid pressure and thereafter releasing and rotating the ball to the open position for enabling flow through the valve.

An object of the present invention is to provide a new and improved apparatus for an equalizing valve.

Another object of the present invention is to provide a new and improved method for operating an equalizing valve.

A further object of the present invention is to provide a new and improved apparatus for an equalizing valve having independent modes of operation for effecting pressure equalization and for operating the valve.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are side views, partially in section, illustrating the equalizing valve of the present invention with the ball rotated closed;

FIGS. 2A and 2B are views, similar to FIGS. 1A and 1B, respectively, illustrating the equalizing valve of the present invention enabling pressure equalization about the closed ball while blocking movement of the ball; and

FIGS. 3A and 3B are views, similar to FIGS. 1A and 1B respectively, illustrating the equalizing valve of the present invention, with the ball rotated to the open position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The equalizing valve of the present invention, generally designated V, is illustrated in the Figs. with the upper portion thereof illustrated in the A reference figure and the lower portion thereof in the B reference figure. The equalizing valve V includes a flow control housing or assembly F and a movable bore closure means C operably connected therewith for controlling flow of fluid through the valve V. The flow control housing F further includes means for moving the bore closure means C to and from open and closed positions for controlling the flow of fluid through the valve V and a means for equalizing the fluid pressure urging on the bore closure means C before moving the bore closure means C to enable flow of fluid through the valve V.

The flow control housing F includes a tubular member **10** which extends downwardly from an upper annular shoulder **10***a* (FIG. 1A) to a lower annular shoulder **10***b* (FIG. 2B) and which has a longitudinally extending bore **11** formed therethrough. The tubular member **10** mounts suitable fastening means for securing the tubular member **10** with a well conduit or production tubing T above and below the valve V such as an upper threaded box connection **12**, adjacent the shoulder **10***a*, and a threaded lower pin connection **13**, adjacent to the shoulder **10***b*. The threaded connections **12** and **13** enable connection of the tubular member **10** in the production tubing T at any desired subsurface location in a well to form a portion of the production tubing T with the bore **11** of the tubular member **10** communicating with a bore X of the production tubing T above and below the tubular member **10** to enable flow of fluid through the bore X of the production tubing T to flow through the bore **11** of the tubular member **10** in producing or flowing hydrocarbons and the like from the well.

Preferably, both for simplicity and ease of assembly, the tubular member **10** includes an upper sleeve member **10***c*, an intermediate sleeve member **10***d* and a lower sleeve member **10***e* which are secured together by suitable fastening means to provide the single tubular member **10** unit. The intermediate sleeve **10***d* is fastened to the upper sleeve **10***c* and the lower sleeve **10***e* by threaded engagement at **10***f* and **10***g* respectively,

and is secured thereto against inadvertent disengagement by suitable anti-rotation members (not illustrated). The sleeve **10***d* and the sleeve **10***e* mount O-rings **14** and **15** thereon, respectively, adjacent the threads **10***f* and **10***g* to block leakage of fluid along the engaged threads **10***f* and **10***g* about the sleeve **10***d*.

The bore closure means C includes a ball member **20** having a flow port or opening **20***a* formed therethrough and which is movably disposed in the bore **11** of the tubular member **10** between an open position (FIG. 3B) for enabling flow of fluid through the bore **11** of the tubular member **10** and a closed position (FIG. 1B) blocking flow of fluid through the bore **11** of the tubular member **10.** The flow control housing F includes a pivot means P and an operator assembly S for co-acting together to effect movement of the ball **20** to and from the open and closed positions.

The pivot means P includes a pivot sleeve **30** positioned in the bore **11** of the tubular member **10** and secured thereto concentrically adjacent the lower portion of the ball **20.** The ball **20** includes a spherical outer sealing surface **20**b with two separate portions of the ball **20** removed to form a pair of parallel flat surfaces **20***c* with each of the circular flat surfaces **20***c* having an elongated, radially extending recess **20***d* formed therein for receiving an eccentrically positioned inwardly extending pin **30***a* secured with the sleeve **30** for operably connecting the ball **20** with the tubular member **10.** Movement of the center of the ball **20** relative to the eccentric pins **30***a* will rotate the ball **20** to the closed position when the center of the ball **20** is above the pivot pins **30***a* (FIG. 1B) and to the open position when the center of the ball **20** is below the pivot pins **30***a* (FIG. 3B). One skilled in the art may vary this arrangement to close the ball **20** in the lower position and to rotate the ball **20** open in the upper position.

Reference is made to my co-pending U.S. Pat. application Ser. No. 72,034, entitled "PRESSURE OPERATED SAFETY VALVE WITH LOCK MEANS," filed Sept. 14, 1970, for a more detailed disclosure of the rotational operation of the ball **20.**

The sleeve **30** may be secured to the tubular member **10** by any suitable fastening means, such as the lug receiving slot system illustrated. The intermediate sleeve **10***d* of the tubular member **10** includes a plurality of inwardly projecting lugs **10***h* with each lug **10***h* having a flat downwardly facing locking shoulder **10***i* formed thereon for engaging the pivot sleeve **30.** The sleeve **30** includes an annular recess **30***b* formed in the outer surface **30***c* thereof having a flat upwardly facing annular shoulder surface **30***d* thereof for engaging the locking surface **10***i* of the lugs **10***h* to block upward movement of the sleeve **30** relative to the tubular member **10.** The outer surface **30***c* of the sleeve **30** has a plurality of longitudinally extending recesses **30***e* formed therein for enabling the movement of the sleeve **30** relative to the lugs **10***h* to enable the locking shoulders **10***i* and **30***d* to be brought into engagement by relative rotation of the sleeve **30** and the tubular member **10** when the annular recess **30** *b* is aligned with the lugs **10***h*. The locking shoulders **10***i* and **30***d* are maintained in engagement by a spacer sleeve **31,** positioned below the sleeve **30** and engaging a lower annular shoulder **30***f* thereof and an upwardly facing annular shoulder **10***j* of the sleeve **10***e* to block downward movement of the sleeve **30** relative to the tubular member **10.**

The operator assembly S includes a sleeve or wash pipe **40** movably disposed in the bore **11** below the ball **20** and in engagement therewith and a spring or urging means **41** for effecting longitudinal operating movement of the ball **20.** The wash pipe **40** includes an upper constant diameter outer surface **40***a* adjacent an inner diameter surface **30***g* of the sleeve **30** and a lower constant diameter surface **40***b* adjacent a bore **11** defining surface **10***k* of the sleeve **10***e* concentrically positioning the wash pipe **40** in the bore **11** for guiding longitudinal movement of the wash pipe **40** in the bore **11** between an upper position (FIG. 1B) and a lower position (FIG. 3B). The wash pipe **40** further includes a constant diameter inner surface **40***c* defining a longitudinal bore **40***d* extending through the wash pipe **40** communicating with the bore **11** for enabling flow of fluid through the equalizing valve V and an upwardly facing arcuate annular shoulder **40***e* in engagement with the spherical surface **20***b* of the ball **20.** The wash pipe **40** includes an annular collar **40***f* formed thereon above the guide surface **40***b* having a downwardly facing annular shoulder **40***g* formed thereon engaging the spring **41** concentrically positioned between the tubular member **10** and the wash pipe **40** above the upwardly facing shoulder **10***j* to provide an upwardly urging to the washpipe **40** to move the wash pipe **40** and the ball **20** to the upper position for rotating the ball **20** closed.

As illustrated in FIG. 1B, the operator assembly S further includes an upper or first operating sleeve **50** and a second or lower operating sleeve **60** both of which are located in the bore **11** above the ball **20.** The lower operating sleeve **60** extends downwardly from an upwardly facing annular shoulder **60***a* to a downwardly facing annular shoulder **60***b* adjacent the ball **20.** The sleeve **60** includes a constant diameter outer surface **60***c* in engagement with an inwardly projecting annular collar **10***m* of the tubular member for concentrically positioning the sleeve **60** in the bore **11** and for guiding longitudinal movement of the lower sleeve **60** between an upper position (FIG. 1B) and a lower position (FIG. 3B). The sleeve **60** includes an inner surface **60***d* having an inwardly projecting valve seat ring mounting annular collar **60***e* formed thereon adjacent the ball **20** and an annular recess **60***f* formed therein adjacent the annular shoulder **60***a*. The collar **60***e* provides a downwardly facing annular shoulder surface **60***g* for mounting a seat ring **61** with the sleeve **60** to effect an annular seal between the spherical surface **20***b* of the ball **20** and a downwardly facing sealing surface **61***a* of the seal ring **61.** The seal so effected blocks upward flow of fluid through the bore **11** between the ball **20** and the seat ring **61.** The seat ring **61** mounts an O-ring **62** thereon for effecting a seal with the sleeve **60** to block leakage of fluid therebetween.

The upper operating sleeve **50** extends upwardly from a lower annular shoulder **50***a*, adjacent the sleeve **60** (FIG. 1B), to an upper annular shoulder **50***b* and includes a constant diameter inner surface **50***c* defining a bore **50***d* aligned longitudinally with and communicating with a bore **60***h* formed by the surface **60***c* of the sleeve **60** to enable flow of fluid through the bore **11** above the ball **20.** The sleeve **50** is also longitudinally moveable between an upper position (FIGS. **1A** and **1B**) and a lower position (FIGS. **3A** and **3B**).

The operating sleeves **50** and **60** are operably connected to enable limited longitudinal relative com-

pound movement therebetween by a pair of spaced annular collars **50***e* and **50***f* (FIG. 1B) formed on the outer surface **50***g* of the sleeve **50** for receiving therebetween a portion of a pin member **63**, secured to the sleeve **60** by suitable fastening means such as threaded engagement at **63***a*. The pin **63** is in engagement with the collar **50***f* when the sleeves **50** and **60** are in the relative extended positions (FIG. 1B) and which move toward the annular collar **50***e* when the sleeve **50** telescopes into the bore **60***h* of the sleeve **60.** In the fully compressed or engaged positions (FIG. 3B) the annular collar **50***e* is brought into engagement with the upwardly facing shoulder **60***a* of the sleeve **60** to block further telescoping movement of the sleeve **50** into the bore **60***h* of the sleeve **60.**

As illustrated in FIG. 1A, the operator assembly S includes an urging means or spring **51** for urging movement of the sleeve **50** to the upper position which is concentrically mounted about the exterior surface **50***g* of the sleeve **50** between a collar **50***i* formed thereon to provide a downwardly facing annular shoulder **50***j* and an upwardly facing annular shoulder **10***n* of the tubular member **10.**

The operator assembly S further includes a first or operating piston ring member **52** and an equalizing flow or bypass operating piston ring **53** which are concentrically mounted about the sleeve **50** and movable relative thereto which are located above the collar **50***i*. The rings **52** and **53** are movable relative to both the tubular member **10** and the slide **50** in response to fluid pressure urgings thereon to effect operation of the equalizing valve V. The collar **50***i* also forms an upwardly facing annular shoulder **50***k* which engages a downwardly facing annular shoulder **52***a* of the piston ring member **52** which is blocked from longitudinal upward movement by partial engagement of an upwardly facing annular shoulder **52***b* with the downwardly facing annular shoulder **10***p* of the tubular member **10** to provide an upward movement limit stop for the sleeve **50.** The ring **53** is blocked from upward movement when an upwardly facing annular shoulder **53***a* partially engages the downwardly facing annular shoulder **10***q* of the tubular member **10.** The second piston ring **53** includes a downwardly facing annular shoulder **53***b* partially engaging a detent **54** secured in an annular recess **50***m* formed in the outer surface **50***g* of the sleeve **50** to block downward movement of the piston ring **53** relative to the sleeve **50.** The operating piston ring **52** includes a pair of O-rings **52***c* and **52***d* for slidably sealing with the sleeve **50** and the tubular member **10** to block leakage of fluid between the piston ring **52** and the sleeve **50** and the tubular member **10,** respectively. The ring **53** is slidably sealed to the sleeve **50** and the tubular member **10** by O-rings **53***c* and **53***d*, respectively, to block leakage of fluid about the piston **53.** The operator assembly S further includes a pair of O-rings **16** and **17** for slidably sealing between the tubular member **10** and the sleeve **50** above the piston ring **53** and below the spring **51,** respectively.

By sealing against leakage of fluid in this manner, the operator assembly S thus includes three annular expansible chambers for providing pressure urging on the piston rings **52** and **53** to effect valve operating movement of the piston rings **52** and **53.** The fluid seals effected by the O-rings **52***c* and **52***d*, **14** and **17,** define an annular expansible chamber **71** formed between the sleeve **50** and the tubular member **10** below the piston ring **52** for enabling fluid pressure in the chamber **71** to urge on the pressure responsive annular shoulder **52***a* for urging upward movement of the piston ring **52.** The fluid seals effected by the O-rings **52***c*, **52***d*, **53***c* and **53***d* define an annular expansible chamber **72** formed between the sleeve **50** and the tubular member **10** between the piston rings **52** and **53.** Fluid pressure in the chamber **72** will urge on the upwardly facing annular shoulder **52***b* of the piston ring **52** for urging the piston ring **52** to move downwardly and also urges on the downwardly facing annular shoulder **53***b* of the piston ring **53** for urging the piston ring **53** to move upwardly. The seals effected by the O-rings **53***c*, **53***d* and **16** form a third annular expansible chamber **73** between the sleeve **50** and the tubular member **10** which is located above the piston ring **53.** Fluid pressure in the expansible chamber **73** urges on the upwardly facing shoulder surface **53***a* of the piston ring **53** for urging the piston **53** to move downwardly in response to the fluid pressure urging thereon.

The operator assembly S provides a means for controlling the fluid pressure communicated into the expansible chambers **71, 72** and **73** to effect desired operation of the equalizing valve V, including a pair of control fluid conduits **81** and **82** formed in the tubular member **10** and a pair of tubings **91** and **92** communicating with a fluid pressure means, such as a pump and the like (not illustrated) at the surface. Tubings **91** and **92** independently communicate fluid pressure from the surface to the subsurface location of the equalizing valve V, for controlling the operation thereof as is well known in the art.

The tubing **91** communicates with the expansible chambers **71** and **73** through the flow channel **81,** which is preferably formed in the tubular member **10** to communicate the controlled fluid pressure introduced into the tubing **91** at the surface directly into both chambers **71** and **73.** The flow channel **81** extends downwardly from the threaded engagement **91***a* of the tubing **91** with tubular member **10** to a location adjacent the spring **51** and includes an enlarged portion **81***a* adjacent the threaded portion **91***a* of the conduit **91** for enabling communication therebetween and a pair of horizontally disposed ports **81***b* and **81***c* for communicating the flow channel **81** with the expansible chamber **73** above the piston ring **53** and the expansible chamber **71** below the piston ring **52** respectively. Thus, fluid pressure communicated through the conduit **91** will urge on the annular surface **53***a* to move the piston ring **53** downwardly and will urge on the annular surface **52***a* for moving the piston ring **52** upwardly.

As illustrated in FIG. 1A, the flow channel **82** extends downwardly from an enlarged area **82***a* communicating with the conduit **92** adjacent the threaded engagement **92***a* of the conduit **92** with the tubular member **10** to a horizontally disposed flow port **82***b* for communicating the control fluid pressure in the conduit **92** into the expansible chamber **72.** The control fluid pressure introduced into the conduit **92** and the expansible chamber **72** urges on the shoulder **53***b* for imparting movement to the piston **53** and also urges on the shoulder **52***b* for moving the piston ring **52** downwardly. By controlling the pressure differential across the piston rings **52** and **53,** the operation of the equalizing valve is also controlled.

With the control fluid pressure in the conduit **92** and the expansible chamber **72** greater than the fluid pres-

sure in the conduit **91** and the expansible chambers **71** and **73**, a pressure differential urging across the piston ring **52** is established for moving the piston ring **52** downwardly. The downward movement of the piston ring **52** by engagement of the surface **52***a* with the collar **50**i will also overcome the spring **51** and move the sleeve **50** downwardly in response to the fluid pressure in the expansible chamber **72.** The piston ring **53** will move upwardly in response to the pressure differential also established thereacross until it engages the shoulder **10***g*.

When the control fluid pressure in the conduit **91** communicated into the expansible chamber **71** is greater than the pressure in the chamber **72**, the pressure differential will urge upwardly on the shoulder **52***a* of the O-ring **52** to maintain the ring **52** in engagement with the shoulder **10***p* of the tubular member **10.** This same greater control fluid pressure is communicated into the expansible chamber **73** to urge on the shoulder **53***a* of the piston ring **53** for moving the piston ring **53** downwardly which by engagement with detent **54** will move the sleeve **50** downwardly until the lower shoulder **53***b* of the piston ring **53** engages the upper shoulder **52***b* of the piston **52.** The piston ring **52** includes a greater radial thickness than the piston ring **53** for providing a greater effective surface area upon which the fluid pressure communicated through the conduit **91** may urge on. Thus, the piston ring **53** will move downwardly into engagement with the piston ring **52** where it will be blocked from further downward movement by the same greater fluid pressure. Therefore, the fluid pressure in the conduit **91** will effect downward movement of the sleeve **50** to an intermediate position while insuring that the sleeve **50** may not move below this intermediate position.

As illustrated in FIG. **1**A, the sleeve **50** includes an upwardly facing tapered annular shoulder **50***n* formed on the collar **50***e* and mounting an O-ring **55** in recess thereon for effecting a fluid seal with a tapered downwardly facing annular sealing shoulder **10***r* of the tubular member **10** when the sleeve **50** is in the upper position. The sleeve **50** includes a flow equalization means or by-pass ports **50***q* formed through the sleeve **50** immediately above the annular shoulder **50***n*. Downward movement of the sleeve **50** to either the lower or intermediate position will space the O-ring **55** from the surface **10***r* to eliminate the seal therebetween and enable flow of fluid through the ports **50***q*.

In the use and operation of the present invention, the equalizing valve V is connected in the desired location in a production tubing using the box and pin threaded connections **12** and **13,** respectively, as is well known in the art, for enabling the equalizing valve V to form a portion of the production tubing T. The control fluid pressure tubings **91** and **92** are connected and the equalizing valve V is lowered into the well with the production tubing T. When the equalizing valve V is at the desired subsurface location, the production tubing T is suitably supported and the well is enabled to produce through the bore X of the production tubing T.

When it is desired to produce hydrocarbons and other fluids from the well, the control fluid pressure in the conduit **91** is increased while venting the fluid in the conduit **92** to establish pressure differentials across the piston rings **52** and **53.** The pressure in the expansible chamber **73** urges the piston ring **53** to move downwardly from the upper position (FIG. **1**A) into engagement with the piston ring **52** (FIG. **2**A) where it is blocked from further downward movement by the same fluid pressure communicated into the expansible chamber **71** urging upwardly on the piston ring **52.** The limited downward movement of the piston ring **53** moves the sleeve **50** by engagement with detent **54,** to the intermediate position (FIGS. **2**A and **2**B) which spaces the O-ring **55** from the surface **10***r*. This movement thus enables fluid flow through the plurality of by-pass ports **50***q* about the ball **20** to equalize the pressure differential across the ball **20** while insuring that the ball **20** is blocked from rotating open. The leakage of fluid about the wash pipe **40** between the ball **20** and the tubular member **10** is sufficient to communicate the well pressure below the closed ball **20** to the area between the sleeve **60** and the tubular member **10** where it will flow through the ports **50***q* into the bore **11** above the ball **20.** When the operator observes that the well shut in pressure has been achieved at the surface, the control fluid pressure in the conduit **91** is reduced and the sleeve **50** will be moved back to the upper position by the urging of spring **51.**

With the sleeve **50** back in the upper position fluid pressure in the conduit **92** is increased, while venting the conduit **91** for introducing fluid pressure into the expansible chamber **72** to establish pressure differentials across the piston ring **53** and the piston ring **52.** The pressure differential across the piston ring **53** will maintain the piston ring **53** in engagement with shoulder **10**q of the tubular member **10.** The pressure differential across the piston ring **52** will overcome the upwardly urging of the spring **51** to move the sleeve **50** downwardly in a telscoping relation with the sleeve **60.** Initially, the O-ring **55** is spaced from the wall **10**r of the tubular member **10** to automatically equalize the fluid pressure in the bore **11** above and below the ball **20** through the ports **50***q* when rotating the ball **20** open. Continued downward movement of the sleeve **50** brings a downwardly facing annular shoulder **50***r* of the collar **50***e* into engagement with the shoulder **60***a* of the sleeve **60** while overcoming the upwardly urging of the spring **65** for moving the sleeves **50** and **60** to the lower position as a unit. Subsequent downward movement overcomes the urging of the spring **41** for moving the wash pipe **40** and the ball **20** longitudinally downward along with the sleeves **50** and **60** for effecting opening rotation of the ball **20.** In addition to reducing wear and possible damage to the spherical surface **20***b* of the ball and the seating surface **61***a* of the seat ring **61** during rotation of the ball, the by-pass port **50***q* also enables the ball **20** to move downwardly with a smaller urging pressure in the expansible chamber **72** by reducing the effect of the well pressure resisting movement of the ball **20.**

When it is desirable to rotate the ball **20** closed to block the flow of well fluids through the bore X of the production tubing T, the pressure in the conduit **92** is vented or otherwise reduced for enabling the urging of the strongest spring **41** to urge the engaged ball **20** upwardly for rotating the ball **20** closed.

When the ball **20** is rotated closed, the annular seals effected between the ball **20** and the seat ring **61** and by the O-rings **55** and **64,** block upwardly flow of fluid through the bore **11** of the tubular member **10.** It will also be appreciated that by sealing the sleeve **60** with the O-ring **64** in the position illustrated, the pressure differential urging on the sleeve **60** to move the sleeve

60 upwardly will be quite small and the urging of the weakest spring 65 will be more than sufficient to maintain the sealing surface 61*a* of the seat ring 61 in engagement with the ball 20.

Whenever there is a substantial pressure differential across the ball 20, the pressure should be equalized thereacross by injecting or introducing control fluid pressure into the conduit 91 for equalizing the fluid pressure urging on the ball 20 prior to introducing control fluid pressure through the conduit 92 for rotating the ball 20 open to enable the well to produce.

The foregoing disclosure and description of the invention are 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 without departing from the spirit of the invention.

What is claimed is:

1. A subsurface safety valve adapted for mounting with a well conduit for controlling flow of fluid through the well conduit at a subsurface location in the well including:
   a. a flow housing having a bore therethrough communicating with a flow passage of the well conduit above and below the safety valve;
   b. bore closure means mounted with said flow housing for movement to and from an open position for enabling flow of fluid through the flow passage and a closed position for blocking flow of fluid through the flow passage of the well conduit;
   c. means with said flow housing for effecting operating movement of said bore closure means to and from the open and closed positions, said means for effecting movement moving said bore closure means to the open position in response to a first control signal communicated from the surface through a first control means;
   d. fluid pressure equalizing means for enabling desired fluid communication about said bore closure means when said bore closure means is in the closed position to substantially balance the urging of the fluid pressure on said bore closure means; and
   e. means for operating said fluid pressure equalizing means to equalize the fluid pressure about said bore closure means in response to a second control signal communicated to said flow housing from the surface through a second control means independent of the well conduit and said first control means wherein fluid pressure urging on said bore closure means may be equalized.

2. The structure as set forth in claim 1, wherein:
said means for effecting movement of said bore closure means operates said fluid pressure equalizing means to balance the urging of the fluid pressure on said bore closure means prior to commencing to move said bore closure means to the open position wherein the fluid pressure urging is automatically offset prior to opening movement of said bore closure means.

3. The structure as set forth in claim 1, wherein:
said bore closure means includes a ball member rotatable to and from the open and closed positions and having a flow port formed therethrough for enabling fluid communication through said flow port when said ball is in the open position and with said flow port moving to a position for enabling said ball member to block flow of fluid when said ball is rotated to the closed position wherein said ball member rotates to control the flow of fluid.

4. The structure as set forth in claim 3 wherein said means for effecting movement of said bore closure means includes:
   a. pivot means for rotating said ball to and from the open and closed positions; and
   b. an operator assembly movably disposed in said bore of said flow housing for co-acting with said pivot means to effect rotation of said ball when said operator moves a predetermined distance wherein the safety valve is operated.

5. The structure as set forth in claim 4, wherein:
said fluid pressure equalizing means is mounted with said operator assembly to enable the desired fluid communication about said ball member when said operator moves less than the predetermined distance to effect opening rotation of said ball wherein the fluid pressure is offset before said ball rotates open to enable flow.

6. A subsurface safety valve adapted for connection in a well conduit to form a portion thereof;
   a. a flow housing having a bore therethrough communicating with a flow passage of the well conduit above and below the safety valve;
   b. a ball-type bore closure means mounted in said bore of said flow housing which is movable to and from an open position enabling flow of fluid through said bore and to and from a closed position blocking flow of fluid through said bore;
   c. means with said flow housing for effecting operating movement of said bore closure means to and from the open and closed positions;
   d. fluid pressure equalizing means for enabling desired fluid communication about said bore closure means when said bore closure means is in the closed position to substantially balance the urging of the fluid pressure on said bore closure means;
   e. means for operating said fluid pressure equalizing means while blocking operating movement of said bore closure means from the closed position;
   f. pivot means for rotating said ball to and from the open and closed position; and
   g. an operator assembly movably disposed in said bore of said flow housing for co-acting with said pivot means to effect rotation of said ball when said operator moves a predetermined distance,
   h. said operator assembly and said flow housing forming an expansible by-pass operating chamber therebetween, with said operator assembly having a pressure responsive surface thereon in communication with said by-pass operating chamber for urging movement of said operator assembly a sufficient distance to operate said fluid pressure equalizing means to enable desired fluid communication about said ball while blocking movement of the operator assembly to the predetermined distance to effect operation of said ball in response to the urging of the fluid pressure in said by-pass operating chamber wherein the pressure urging on the ball is offset.

7. The structure as set forth in claim 6 wherein:
said operator assembly and said flow housing forming a second expansible ball operating chamber therebetween, said operator assembly having a second pressure responsive surface thereon communicat-

ing with said second chamber for urging movement of said operator assembly to operate said fluid pressure equalizing means to enable the desired fluid communication about the said ball before rotating open said ball in response to the urging of the fluid pressure in said second chamber wherein the pressure urging on said ball is offset prior to rotating open said ball.

8. The structure as set forth in claim **7,** including:

a. by-pass control means for controlling the fluid pressure in said by-pass operating chamber urging on said operator assembly; and

b. ball operating control means for controlling the fluid pressure in said second chamber urging on said operator assembly wherein the movement of said operator mechanism is controlled.

9. The structure as set forth in claim **7,** including:

a. said operator assembly having a first member operably connected to a second member for enabling limited relative movement therebetween with said first member mounting said first and said second pressure responsive surfaces and said second member operably engaging said ball; and

b. said fluid pressure equalizing means mounted with said first member for enabling the desired fluid communication prior to said first member effecting movement of said second member to rotate open said ball wherein the fluid pressure urging on said ball is offset.

10. A safety valve adapted to be mounted with a well conduit for controlling flow of well fluids through the well conduit at a subsurface location in a well, including:

a flow housing having a bore therethrough communicating with a flow passage of the well conduit above and below the safety valve;

bore closure means mounted with said flow housing for movement to and from an open position for enabling flow of well fluids through the flow passage of the well conduit and a closed position for blocking flow of well fluids through the well conduit;

first expansible chamber means for effecting operating movement of said bore closure means to the open position in response to a first control fluid pressure communicated into said first expansible chamber;

fluid pressure equalizing means for enabling desired well fluid communication about said bore closure means when said bore closure means is in the closed position to substantially balance the urging of well fluid pressure on said bore closure means; and

second expansible chamber means for operating said fluid pressure equalizing means to substantially balance the urging of well fluid pressure on said bore closure means in response to a second control fluid pressure communicated into said second expansible chamber wherein well fluid pressure urging on said bore closure means may be equalized.

11. The structure as set forth in claim **10,** wherein:

said bore closure means including a member rotating to and from the open and closed position.

12. The structure as set forth in claim **11,** wherein:

said rotating member moving downwardly in said bore when rotating to the open position.

13. The structure as set forth in claim **10,** including:

first control fluid conduit means for communicating the first control fluid pressure into said first expansible chamber from the surface; and

second control fluid conduit means for communicating the second control fluid pressure into said second expensible chamber from the surface wherein the safety valve is controlled from the surface.

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