Oct. 3, 1961 J. H. BOSTOCK 3,002,566

FLUID PRESSURE OPERATED SUBSURFACE SAFETY VALVE

Filed Oct. 4, 1957

FIG_1A

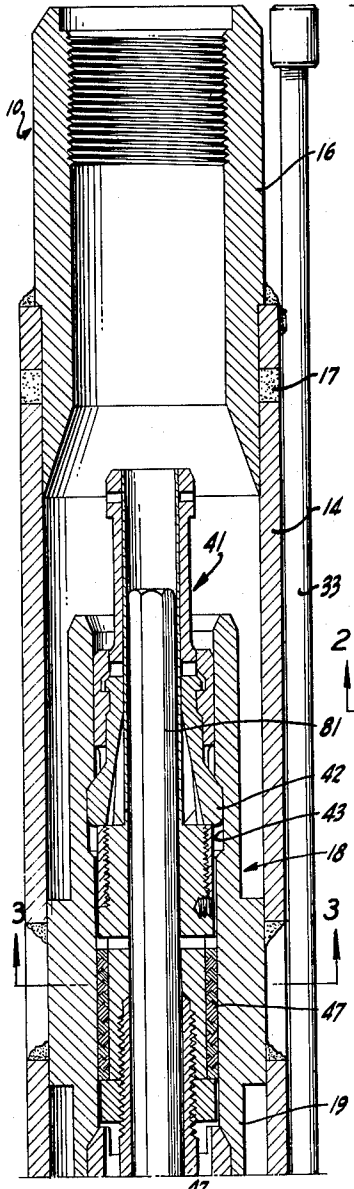


FIG_1B

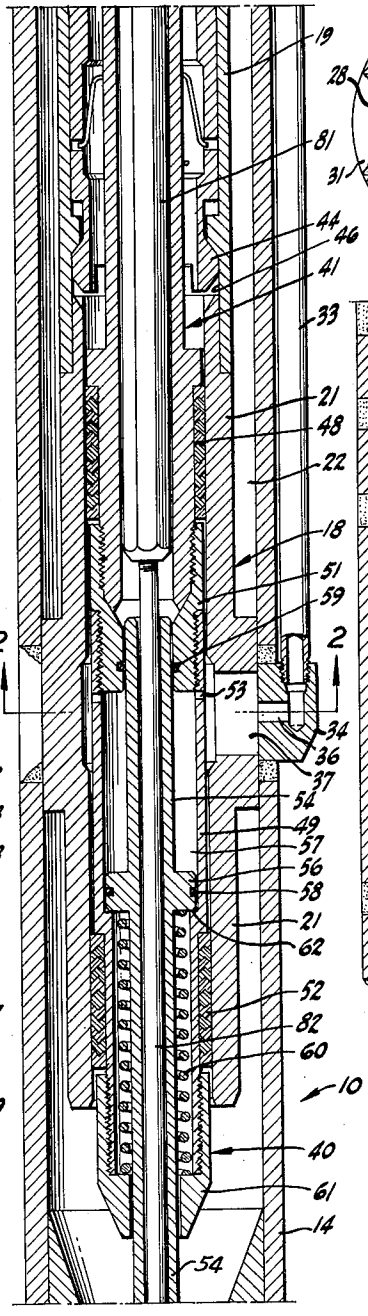


FIG_2

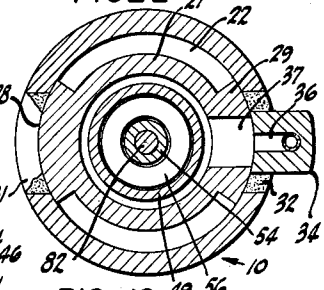
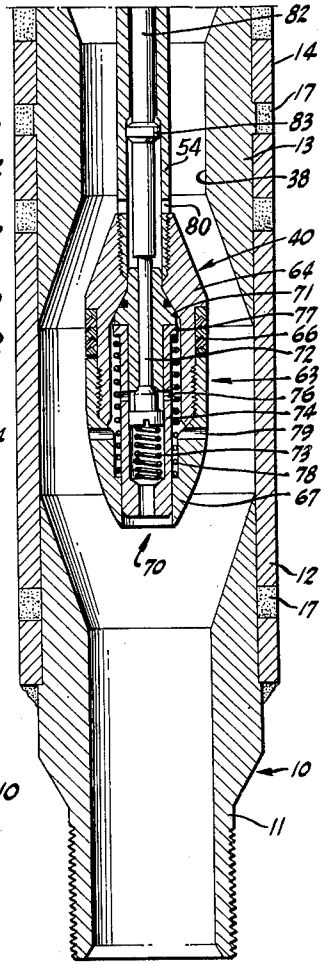


FIG_1C



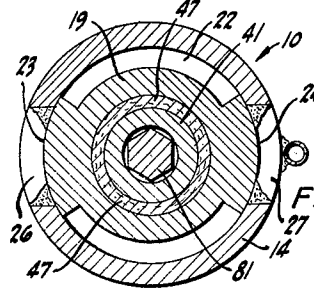


FIG_3

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FLUID PRESSURE OPERATED SUBSURFACE SAFETY VALVE

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This invention relates to valves for use in oil wells, and more particularly to a removable valve adapted to be disposed in an oil well tubing at a subsurface level and which can be hydraulically operated at a remote distance.

It is a primary object of the invention to provide a valve means for securely closing the tubing of a well at a subsurface level and for opening the well tubing thereat by means of a fluid operator which is responsive to fluid pressure exerted from the top of the well.

It is a further object of the invention to provide a fluid pressure operated subsurface valve for well tubing which provides a full flow passageway through the valve body when the valve is in open position.

Another object of the invention is to provide a fluid pressure operated subsurface safety valve for well tubing in which all of the operating parts of the valve can be removed from the well and reinstalled therein, and in which when the operating parts are removed, the well tubing will be unrestricted for the passage of tools therethrough.

Yet another object of the invention is to provide a fluid pressure operated subsurface safety valve for well tubing having a valve member provided with a resilient sealing member which, when the valve is in closed position, will be forced by the well pressure into tight sealing engagement with a valve seat to insure full and effective sealing of the well tubing.

A still further object is to provide a fluid pressure operated subsurface safety valve for well tubing with an equalizing valve operable by wire line tools to equalize pressure across the safety valve when it is in closed position so that the safety valve may be easily moved to open position.

Another object of the invention is to provide a fluid pressure operated subsurface safety valve for well tubing in which limited vertical movement of the valve member can be permitted when the valve is in closed position without any opening of the valve for fluid flow through the tubing.

Other objects and advantages will become apparent in the course of the following detailed description.

In the drawings, forming a portion of this application, and in which like parts are designated by like reference numerals throughout the same,

FIGS. 1A, 1B and 1C are successive cross-sectional views of a fluid pressure operated subsurface safety valve constructed in accordance with the invention, with the valve shown in open position.

FIG. 2 is a sectional view, taken on line 2—2 of FIG. 1B.

FIG. 3 is a sectional view, taken on line 3—3 of FIG. 1A.

Referring now to the drawings, a generally cylindrical housing member 10 is provided, comprising a lower adapter 11, a lower sleeve 12, a valve seat member 13, an upper sleeve 14, and an upper adapter 16, all rigidly interconnected, as by welding 17. A landing nipple 18 is formed within the housing member 10 and comprises an upper sleeve member 19 and a lower sleeve member 21, each sleeve member 19 and 21 having its exterior surface radially spaced from the inner surface of the upper housing member sleeve 14 so as to provide an annular flow passage 22 therebetween.

The upper landing nipple sleeve 19 has radially projecting lugs 23 and 24 engaging the inner surface of the housing member sleeve 14 adjacent the openings 26 and 27 therethrough, enabling the landing nipple to be rigidly affixed to the housing member, as by welding. Similarly, the lower landing nipple sleeve 21 is provided with radially projecting lugs 28 and 29 engaging the housing member adjacent the openings 31 and 32, at which point they are welded together.

A tubing member 33 is threaded into lug member 34, positioned in and welded to the housing member, and a fluid flow path is provided from the tubing 33, through passage 36 in lug member 34, passage 37 in the landing nipple, to the interior of the landing nipple.

The bore of the landing nipple 18 is of a diameter nominally the same as the drift diameter of the tubing in the well, to permit the normal passage of well tools therethrough. Similarly, the valve seat member 13 has an elongated restricted bore 38 therethrough of a diameter nominally the same as the tubing drift diameter.

In the installation of the well, the housing member 10, having the rigidly attached landing nipple 18 and valve seat member 13 therein, is assembled in a string of well tubing, and the tubing member 33 is connected to the externally projecting lug member 34. As additional tubing is added to the string, equivalent lengths of tubing 33 are also added to provide a surface communication through the tubing 33 to the interior of the landing nipple. When the tubing is lowered to the desired depth and the well head connections have been installed, the well may be completed in a conventional manner.

After the well is completed, the removable valve assembly, generally indicated by the reference numeral 40, is landed in the landing nipple 18, the valve assembly being carried by a wire line removable locking and pack-off device, generally indicated at 41. The particular form of the locking and pack-off device forms no part of the present invention, and the specific device illustrated is completely described in the U.S. Patent No. 2,798,559, issued to John V. Fredd and entitled "Hangers for Well Tubing Extensions and the Like." Suffice it to say that the locking and pack-off device 41 has a plurality of locking dogs 42 adapted to lock into an annular locking groove 43 formed in the upper landing nipple sleeve 19, and a plurality of locating keys 44 adapted to fit within a series of annular locating grooves 46 formed in the upper landing nipple sleeve.

As the locking device 41 is lowered into the landing nipple 18, the spring loaded locating keys 44 will engage the landing nipple grooves 46. The locking dogs 42 may then be expanded into the locking groove 43 of the landing nipple by the action of a wire line tool which moves an expander sleeve downwardly behind the locking dogs. Continued jarring will release the wire line tool from the locking device 41, leaving it locked against longitudinal movement relative to the housing member 10.

The locking and pack-off device carries packing 47 and 48 on the exterior thereof to sealingly engage the inner surface of the landing nipple 18 above the passage 37 therethrough.

The valve assembly 40 includes a cylinder 49, connected to the locking device 41 by an adapter 51, and having packing 52 on the exterior thereof sealingly engaging the lower landing nipple sleeve 21 below the passage 37 therethrough. A plurality of ports 53 are formed through the upper end of cylinder 49 to provide fluid communication from the interior thereof to the tubing member 33.

A piston stem 54 extends axially through cylinder 49 and has a radially enlarged flange, or piston head, 56 thereon, slidably engaging the inner wall of the cylinder.

The chamber 57 formed between the piston, above the piston head thereof, and the cylinder wall, is sealed against flow therefrom by an O-ring 58 carried by the piston head and an O-ring 59 mounted in the adapter 51.

A compression spring 60, confined between the piston head 56 and the packing nut 61 normally biases the piston stem from the position illustrated to an upper normal position. The downward movement of the piston stem is limited by the engagement of the piston head with an internal shoulder 62 formed on the cylinder 51.

The piston stem 54 extends downwardly through cylinder 49 and carries at its lower end the valve member 63 having an outer diameter substantially equal to the diameter of the restricted bore 38 of the valve seat member 13. The valve member 63 includes an upper valve element 64 carrying a resilient packing member 66 on the exterior thereof, and a lower valve element 67 connected to the upper valve element to retain the packing member in place. When the piston stem 54 is in its upper position, under the bias of spring 60, the valve member 63 will be positioned within the restricted valve seat bore, with the packing member 66 sealingly engaging the bore to prevent fluid flow therepast. The pressure of the well below the valve member 63 will act upon the lower surface of the resilient packing member 66 to compress it slightly into tight sealing engagement with the valve seat bore 38, such that the greater the well pressure, the tighter the sealing engagement will be.

When the valve assembly 40 is landed in the landing nipple, and locked therein by the locking device 41, the upper end of the external tubing 33 is connected to a source of hydraulic pressure. Sufficient pressure may then be transmitted through the tubing 33 into the interior of the landing nipple to act on the upper face of the piston head 56 in opposition to the force of spring 60 so that the piston stem is forced downwardly to the position illustrated in the drawings, thereby moving the valve member 63 downwardly through the valve seat 13. Well flow may now take place around the valve member 63, upwardly through the valve seat 13 and through the annular flow passage 22 between the landing nipple 18 and the housing member 10. As long as sufficient pressure is maintained in chamber 57, the valve will remain open. When the pressure is released, the spring 60 will move the piston stem 54 upwardly, carrying the valve member 63 therewith to close off the flow through the well. The well may subsequently be re-opened by increasing the pressure within piston chamber 57 to move the valve member downwardly to open position.

It is to be noted that the valve will "fail safe," in case of a loss of pressure with the tubing 33, such that the spring 60 will move the piston stem 54 and valve member 63 upwardly to closed position if there is a failure of pressure within the pressure chamber 57.

In many instances it will be necessary to equalize the pressure existing above and below the valve member 53, so that the valve may be reopened. With the valve 53 in closed position, the full well pressure thereunder will be acting to keep the valve closed, and it may not be possible to open the valve by merely exerting a pressure through tubing 33 on the piston.

An equalizing valve assembly 70 is built within the valve member 63 and includes an equalizing valve member 71 adapted to seat against the beveled seat within the bore of the valve element 64. A bore is formed axially through the equalizing valve member 63 to receive a rod 72 having its lower end enlarged to provide a bearing surface for spring 73 which biases the rod upwardly. The lower end of the equalizing valve member 71, the rod 72 and the spring 73 are housed within a sleeve 77, which has ports 76 intermediate its ends and a flange 77 on its upper end to provide a bearing surface for spring 78. This last spring is supported by an upwardly facing annular shoulder within the bore of the lower valve element 67 and biases the equalizing valve assembly 70 upwardly, to the position shown in the drawings. Lateral ports 79 are formed through the lower valve element 67 and communicate between the exterior of valve member 63 and the interior of sleeve 74 through the lateral ports 76 provided therein. Equalizing ports 80 are formed in the lower end of the piston, above the equalizing valve assembly.

An equalizing prong assembly is positioned within the bore of the removable locking device 41 and the bore of the piston stem 54, and comprises an upper prong section 81 and a lower prong section 82, extending from a point near the upper end of the removable locking device downwardly to the upper end of rod 72. The lower prong section 82 is formed with a radially enlarged flange 83 disposed within an enlarged portion of the bore of the piston stem 54, so as to provide a stop means to limit the upward travel of the prong within the piston bore.

In opening the well by equalizing the pressures on valve member 63, a suitable wire line tool is lowered within the well to depress the prong assembly, thus moving the equalizing valve member 71 downwardly, so that fluid flow may occur between the equalizing valve member and the tapered seat upwardly into the piston bore and out through the ports 80 into the fluid passage 22 of the housing member. Such flow will then reduce the differential pressure across the valve member 63 to in turn reduce the amount of pressure necessary to exert in the hydraulic chamber 57 to move the valve member 63 to open position.

It is contemplated that other types of locking devices 41 may be employed with the removable valve member 40. In such event, the locking device used must be such that the vertical movement of the locking device and valve assembly be limited, when locked within the landing nipple 18, so that the valve member 63 is able to seal off flow when in closed position within the valve seat member 13. However, it is to be noted that some vertical movement can be permitted without altering the effectiveness of the valve member, for the well will be closed whenever the valve member packing 66 is in contact with some portion of the valve seat bore 38. Thus, the valve member may slide within the valve seat, over a limited range of vertical movement, while yet sealing off the well.

If it is necessary to perform some operation at a later time requiring access to the tubing below the valve, or if it is desired to remove the valve assembly for inspection or repair, a suitable wire line tool is lowered into the well to engage and unlock the locking device 41, in a manner fully described in the aforementioned Fredd patent. The locking device and valve assembly is then withdrawn from the well, leaving a full bore passage through the housing member 10, to enable the desired operation to be performed. The locking device and valve assembly may then be re-installed by lowering and locking, as previously discussed.

As may be seen from the foregoing, the housing member 10 is permanently installed in a well tubing string so that the landing nipple 18 and valve seat member 13 form a permanent part of the tubing string. The removable valve assembly 40 comprises all of the elements which are carried by the locking device 41 and which may be installed in and removed from the housing member 10 by wire line manipulations of the locking device 41, as previously described. Thus the removable valve assembly 40 includes the valve member 63 as well as the actuating mechanism therefor and also includes the equalizing valve assembly 70 and the actuating mechanism therefor.

It is to be understood that the form of the invention, herewith shown and described, it to be taken as a preferred embodiment of the same, and that various changes

in the shape, size and arrangement of parts may be resorted to, without departing from the spirit of the invention or the scope of the attached claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A device of the character described comprising: a vertically disposed cylindrical housing member adapted to be connected in a well tubing string, a valve seat member fixedly mounted within said housing member and having an elongated restricted bore therethrough coaxial with said housing member, a landing nipple member fixedly disposed within said housing member and having a bore coaxial therewith, said landing nipple member being vertically spaced from said valve seat member, said housing member and landing nipple member having surfaces thereon forming a flow path by-passing the bore of said landing nipple member, said housing member and landing nipple having a passage formed therethrough from the bore of said landing nipple member to the exterior of said housing member, and a tubing disposed along the exterior of said housing member and connected at one end to said passage; a removable valve assembly seated in said landing nipple member; means mounted on said removable valve assembly to releasably lock said removable valve assembly against vertical movement relative to said landing nipple member; said removable valve assembly comprising a generally cylindrical member coaxially disposed within said landing nipple member and having a piston chamber formed therewithin, an opening through said cylindrical member from the exterior thereof into said piston chamber, said opening being in fluid communication with said housing member and landing nipple passage, a piston disposed within said piston chamber, a piston stem mounted on said piston, a valve member carried by said piston stem and having an external diameter corresponding to the diameter of the restricted bore of said valve seat member, means including a spring to normally bias said piston within said piston chamber to a position such that the valve member carried by said piston stem will be seated within the restricted bore of said valve seat, said piston being movable against said biasing means upon the introduction of fluid pressure through said opening from said tubing to move said valve member through said valve seat member bore.

2. A device of the character described comprising: a vertically disposed cylindrical housing member adapted to be connected in a well tubing string, an annular valve seat member mounted within said housing member and having an elongated restricted bore therethrough coaxial with said housing member, an elongated tubular landing nipple concentrically disposed within said housing member and spaced therefrom to provide a flow passage therebetween, said landing nipple being vertically spaced above said valve seat member, said housing member and landing nipple having a passage formed therethrough from the bore of said landing nipple to the exterior of said housing member, and a tubing fixedly disposed along the exterior of said housing member and connected at one end to said passage; a removable valve assembly removably seated in said landing nipple; means mounted on said removable valve assembly to releasably lock said removable valve assembly against vertical movement relative to said landing nipple; said removable valve assembly comprising a generally cylindrical member coaxially disposed within said landing nipple and having a piston chamber formed therewithin, an opening through said cylindrical member from the exterior thereof into said piston chamber, said opening being in fluid communication with said housing member and landing nipple passage, a piston slidably disposed within said piston chamber, a piston stem mounted on said piston and projecting downwardly therefrom, a valve member carried by the lower end of said piston stem and having an external diameter corresponding to the diameter of the

restricted bore of said valve seat member, said piston having an upper position within said piston chamber wherein the valve member carried by the lower end of said piston stem will be seated within the restricted bore of said valve seat, said piston being movable downwardly to a second position upon the introduction of fluid pressure through said opening from said tubing to move said valve member downwardly through to below said valve seat member bore.

3. A device of the character described comprising: an elongated vertically disposed cylindrical housing member adapted to be connected in a well tubing string, an annular valve seat member mounted within said housing member and having an elongated restricted bore therethrough coaxial with said housing member, an elongated tubular landing nipple disposed within said housing member and having a bore coaxial therewith, said landing nipple being vertically spaced above said valve seat member, said housing member and landing nipple member having surfaces thereon forming a flow path above said valve seat member by-passing the bore of said langing nipple, said housing member and landing nipple having a passage formed therethrough from the bore of said landing nipple to the exterior of said housing member, and a tubing disposed along the exterior of said housing member and connected at one end to said passage; a removable valve assembly seated in said landing nipple; means mounted on said removable valve assembly to releasably lock said removable valve assembly against vertical movement relative to said landing nipple; said removable valve assembly comprising a generally cylindrical member coaxially disposed within said landing nipple and having a piston chamber formed therewithin, an opening through said cylindrical member from the exterior thereof into said piston chamber, said opening being in fluid communication with said housing member and landing nipple passage, packing means for sealing said cylindrical member to the bore of said landing nipple above and below said opening, a piston disposed within said piston chamber below said opening and vertically slidingly engaging the walls thereof, a piston stem mounted on said piston and projecting downwardly therefrom, a valve member carried by the lower end of said piston stem and having an external diameter corresponding to the diameter of the restricted bore of said valve seat member, means to normally bias said piston upwardly within said piston chamber so that the valve member carried by the lower end of said piston stem will be seated within the restricted bore of said valve seat, packing means carried on the outer peripheral surface of said valve member to sealably engage said valve seat bore when said valve seat is seated therein, said piston being movable downwardly against said biasing means upon the introduction of fluid pressure through said opening from said tubing to move said valve member downwardly through to below said valve seat member bore.

4. Apparatus as set forth in claim 3 further including an equalizing flow passage through said valve and piston stem from below to above said valve member packing means, and a remotely controllable equalizing valve member in said equalizing flow passage normally biased to closed position.

5. Apparatus as set forth in claim 3 further including an equalizing flow passage through said valve and piston stem from below to above said valve member packing means and having a valve seat therein, an equalizing valve member in said equalizing flow passage below said equalizing passage valve seat and normally spring biased to seat thereon, and a rod actuator extending longitudinally through said piston stem and engaging said equalizing valve, said rod actuator being longitudinally movable relative to said piston stem and being adapted to be engaged and moved by remotely controllable wire

line tools to move said equalizing valve member to open position.

6. A device of the character described comprising: an elongated cylindrical housing member adapted to be vertically connected in a well tubing string, an annular valve seat member mounted within said housing member and having an elongated restricted bore therethrough coaxial with said housing member, an elongated tubular landing nipple concentrically mounted within said housing member and spaced therefrom to provide a flow passage therebetween, said landing nipple being vertically spaced above said valve seat member, said housing member and landing nipple having a passage formed therethrough from the bore of said landing nipple to the exterior of said housing member, and a tubing fixedly mounted to and along the exterior of said housing member and connected at one end to said passage.

7. A device of the character described comprising: an elongated vertically disposed cylindrical housing member adapted to be connected in a well tubing string, an annular valve seat member mounted within said housing member and having an elongated restricted bore therethrough coaxial with said housing member, an elongated tubular landing nipple disposed within said housing member and having a bore coaxial therewith, said landing nipple being vertically spaced above said valve seat member, said housing member and landing nipple member having surfaces thereon forming a flow path above said valve seat member by-passing the bore of said landing nipple, said housing member and landing nipple having a passage formed therethrough from the bore of said landing nipple to the exterior of said housing member, and a tubing disposed along the exterior of said housing member and connected at one end to said passage.

8. A removable valve assembly comprising a generally cylindrical member vertically coaxially disposable within a vertically disposed tubular landing nipple and having a piston chamber formed therewithin, an opening through the wall of said cylindrical member from the exterior thereof into said piston chamber, a piston disposed within said piston chamber below said opening and vertically slidingly engaging the walls thereof, a piston stem mounted on said piston and projecting downwardly therefrom, a valve member carried by the lower end of said piston stem and having a radially disposed annular sealing surface thereon, and means including a spring to normally bias said piston upwardly within said piston chamber, said piston being movable downwardly against said biasing means upon the introduction of fluid pressure through said opening into said piston chamber to move said valve member downwardly relative to said cylindrical member.

9. A removable valve assembly for use in a well tubing string having an annular valve seat member mounted within said tubing string with an elongated restricted bore therethrough coaxial with said tubing string and an elongated tubular landing nipple concentrically disposed within said tubing string and vertically spaced above said valve seat member, and said tubing and landing nipple having a passage from the bore of said landing nipple to the exterior of said tubing string, said removable valve assembly comprising: a generally cylindrical member coaxially disposable within said landing nipple and having a piston chamber formed therewith, an opening through said cylindrical member from the exterior thereof into said piston chamber, said opening being adapted to be in fluid communication with said tubing string and landing nipple passage, a piston slidably disposed within said piston chamber, a piston stem mounted on said piston and projecting downwardly from said cylindrical member, a valve member carried by the lower end of said piston stem and having an external diameter corresponding to the diameter of the restricted bore of said valve seat member, means to normally bias said piston upwardly within said piston chamber, and packing means carried on the outer peripheral surface of said valve member to sealably engage said valve seat bore when said valve seat is seated therein, said piston being movable downwardly upon the introduction of fluid pressure through said opening into said piston chamber.

10. A removable valve assembly for use in a well tubing string having an annular valve seat member mounted within said tubing string with an elongated restricted bore therethrough coaxial with said tubing string, an elongated tubular landing nipple concentrically disposed within said tubing string and vertically spaced above said valve seat member, and said tubing string and landing nipple having a passage from the bore of said landing nipple to the exterior of said tubing string, said removable valve assembly comprising: a generally cylindrical member coaxially disposable within said landing nipple and having a piston chamber formed therewithin, an opening through said cylindrical member from the exterior thereof into said piston chamber, said opening being adapted to be in fluid communication with said tubing string and landing nipple passage, packing means for sealing said cylindrical member to the bore of said landing nipple above and below said opening, a piston disposed within said piston chamber below said opening and vertically slidingly engaging the walls thereof, a piston stem mounted on said piston and projecting downwardly therefrom, a valve member carried by the lower end of said piston stem and having an external diameter corresponding to the diameter of the restricted bore of said valve seat member, means to normally bias said piston upwardly within said piston chamber so that the valve member carried by the lower end of said piston stem is seatable within the restricted bore of said valve seat when said cylindrical member is disposed within said landing nipple, packing means carried on the outer peripheral surface of said valve member to sealably engage said valve seat bore when said valve seat is seated therein, said piston being movable downwardly against said biasing means upon the introduction of fluid pressure through said opening into said piston chamber to move said valve member downwardly relative to said cylindrical member to below said valve seat member bore when said cylindrical member is disposed within said landing nipple.

11. Apparatus as set forth in claim 10 further including an equalizing flow passage through said valve member and piston stem from below to above said valve member packing means, and a remotely controllable equalizing valve member in said equalizing flow passage normally biased to closed position.

12. Apparatus as set forth in claim 10 further including an equalizing flow passage through said valve member and piston stem from below to above said valve member packing means and having a valve seat therein, an equalizing valve member in said equalizing flow passage below said equalizing passage valve seat and normally spring biased to seat thereon, and a rod actuator extending longitudinally through said piston stem and engaging said equalizing valve, said rod actuator being longitudinally movable relative to said piston stem and being adapted to be engaged and moved by remotely controllable wire line tools to move said equalizing valve member to open position.

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