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SUBSURFACE WELL BORE FLUID FLOW CONTROL APPARATUS

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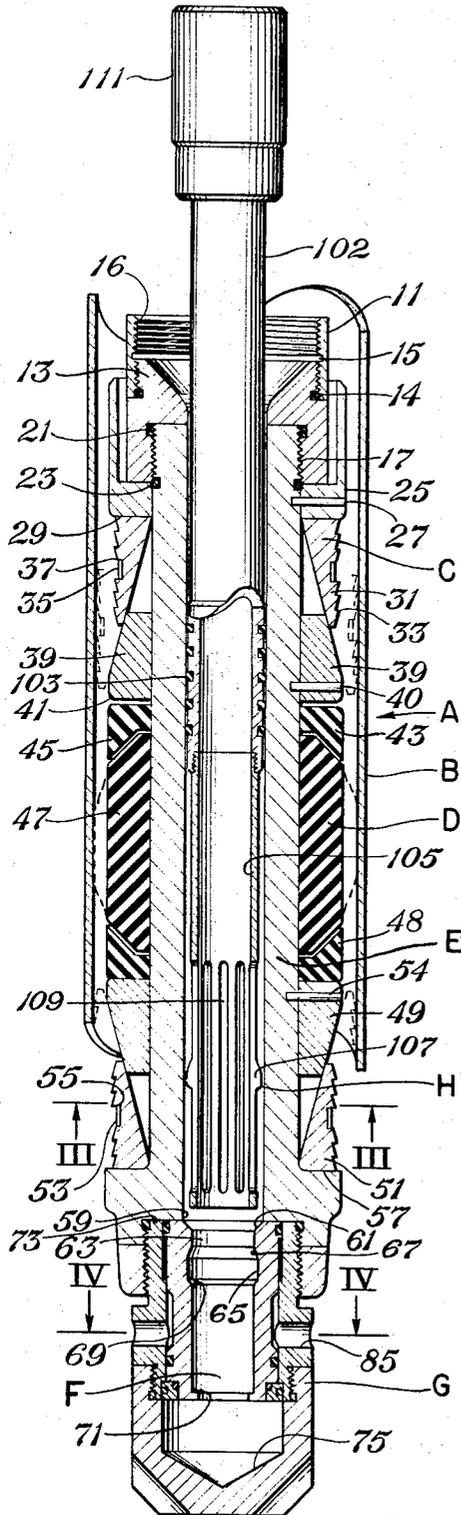


Fig. 1

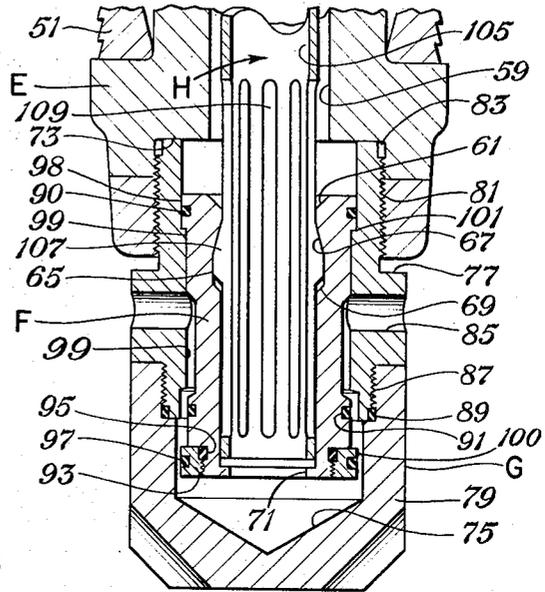


Fig. 2

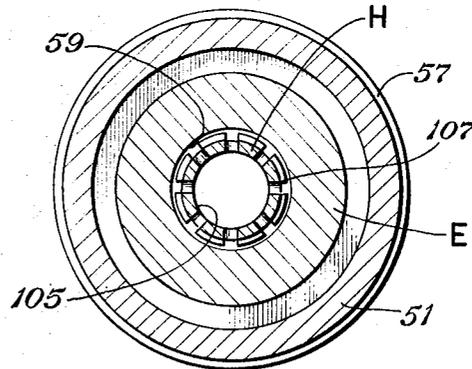


Fig. 3

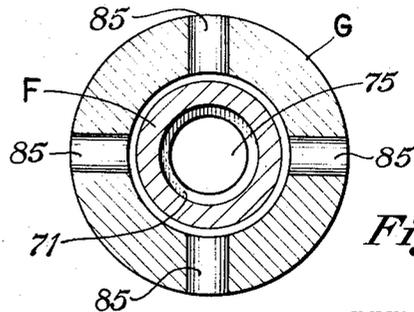


Fig. 4

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SUBSURFACE WELL BORE FLUID FLOW CONTROL APPARATUS

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ABSTRACT OF THE DISCLOSURE

Improved valve means controls fluid flow from and to first and second zones in a well bore, with the zones being isolated except via the valve means. The improved valve means includes a floating valve member reciprocable within a valve retainer which has three cylindrical portions of different diameters each of which is engageable by a respective seal means on the floating valve member. The arrangement is such that, when the floating valve member is closed, fluid impinging on respective seals from either or both of the zones creates unbalance forces that act to maintain the floating valve member in the closed position. Also provided are improved means for moving the floating valve member from the closed to the opened position.

My invention relates in general to subsurface well bore equipment and in particular to well packers adapted to be set in well casings or similar conduit strings.

Previously, well packers were developed that included valve elements that can be selectively closed or opened to control the flow of fluid between axial passages extending through the packers to the exterior thereof below the expansible gripping and packing means. Such previously developed valve elements are generally mechanically operated and have a number of disadvantages. For example, prior art valve elements sometimes fail to function properly when subjected to the adverse conditions encountered in well bores, and occasionally become lodged in an opened or closed position.

It is the general object of my invention to provide improved well packers of the type having valve members movable between opened and closed positions to control the flow of fluid through the axial passages that extended through the packers.

Another object of my invention is to provide in well packers improved valve means for opening or closing fluid passages that extend through the packers to regions below the gripping and sealing means.

These and other objects are effected by my invention as will be apparent from the following description, taken in accordance with the accompanying drawing, in which:
 FIG. 1 is a view of subsurface well apparatus as seen in longitudinal cross section, said apparatus embodying the principles of my invention;

FIG. 2 is an enlarged fragmentary view, as seen in longitudinal section, showing the lower portion of the apparatus of FIG. 1;

FIG. 3 is a cross sectional view of the apparatus as seen looking along the lines III—III of FIG. 1;

FIG. 4 is a cross sectional view of the apparatus as seen looking along the lines IV—IV of FIG. 1.

The packer apparatus A of FIG. 1 is adapted to be lowered into a well casing B by a wire line (not shown). This apparatus has gripping means C and packing means D that are radially expansible to engage the well casing B. Such packing and gripping means are mounted on a body E. A valve member F is disposed to engage the lower portion of body E and is restrained from unlimited axial movement by valve retainer means G. The valve member controls the flow of fluid between an axial passage in the packer to the exterior of the packer below the gripping means C and the packing means D and is urged toward a

closed position by fluid pressure, as will be explained in detail later. A valve member actuator means H is engageable with the valve member F to move valve member F to its opened position.

The packing means D, the gripping means C, and the portions of the apparatus A used to operate these means are illustrated by way of example in the drawing but can be of any desired type. The one illustrated has a release ring 11 with a threaded interior cylindrical surface that is secured to an adaptor 13. A seal ring 14 is provided between the release ring and the adaptor to prevent fluid flow in this region. The release ring 11 has a weakened region 15 that fails when subjected to a predetermined amount of axial force. A conventional setting tool (not shown) is secured to the upper, threaded portion 16 of the release ring. The setting tool and the apparatus A are lowered into the well casing on a wire line until the desired depth or location in casing B is reached.

The adaptor 13 is secured to an upper threaded region 17 of the body E of the apparatus. Seal rings 21, 23 are provided in the threaded region between body A and adaptor 13 to prevent fluid flow therebetween. Adaptor 13 engages a cup 25 that is slidably supported on cylindrical body E and retained thereon by means of a shear pin 27. The shear pin 27 prevents accidental axial movement of the cup 25 with respect to body E.

Cup 25 has a lower, radially extending shoulder 29 that engages a mating shoulder on gripping means C. The gripping means C includes upper segmental, annular slips 31 having upwardly facing teeth 33 that are adapted to engage the casing B to prevent upward movement of the apparatus A when the gripping means are expanded. The slips 31 are held around body E by a plurality of resilient slip rings 35 that are disposed in external annular recesses 37. The upper segmental slips 31 surround the upper end portion of a conical expander or wedge 39, which surrounds the body E and is adapted for axial movement thereon. Accidental movements of expander 39 are prevented by a shear pin 40.

A lower radially extending shoulder 41 of expander 39 engages a mating shoulder on a preferably hard rubber upper shoe 43. This shoe has a downwardly extending annular lip 45 that mates with a beveled region of a soft rubber, resilient packing ring 47 that also surrounds the body E. A lower shoe 48 (also of hard rubber) that is similar to the upper shoe 43, but in an inverted position, engages a lower beveled end of the packing ring 47. A lower expander or wedge 49 engages lower shoe 48 and in turn is engaged by lower segmental slips 51 that are held around body E by a resilient split ring 53 disposed in an annular groove 55. Expander 49 is held in position by a shear pin 54. The body E has a lower shoulder 57 which supports lower slips 51.

To set the gripping means C and packing means D at a selected position in casing B, the setting tool (not shown) is actuated so that a downward force is exerted against cup 25. This downward force is large enough to shear the shear pins 27, 40 and 54, and the upper and lower slips 31, 51; the upper and lower expanders 39, 49; and the upper and lower shoes 43, 48 are moved axially together. The packing ring 47 expands radially into sealing engagement with the casing B, and the upper and lower slips 31, 51 are urged radially outwardly on the conical expanders 39, 49 into gripping engagement with the casing B. Thus the apparatus A is secured in fixed relationship with the casing B since the upper slips 31 prevent upward movement of the apparatus and the lower slips 51 prevent downward movement thereof. At this stage, the setting tool (not shown) may be removed by exerting with conventional means (not shown) a predetermined amount of tension upon release ring 11 until it shears at weakened region 15.

The valve member F and retainer means G, shown in FIGS. 1 and 2 at the lower end of the apparatus A below the gripping means C and packing means D, are used in conjunction with the valve member actuating means H to selectively open or close a fluid passage that extends from an axial passage 59 of body E to the exterior of the apparatus below packing means D and gripping means C. In some situations (for example, when pumping cement or other slurry down well tubing, through the packer apparatus and ultimately into communication with a formation) it is necessary that the valve member F be moved to an open position. In other situations (such as when testing the tubing for leaks) it is necessary that the valve member be moved to a closed position. The valve means illustrated in the drawing is particularly effective in accomplishing these results in an advantageous and reliable manner.

The floating valve member F is tubular, open-ended and coaxially aligned with the fluid passage 59 of body E. Valve member F has a beveled upper interior surface 61 that intersects a cylindrical surface 63. An annular groove 65 is formed at one region of cylindrical surface 63 and this groove has upper and lower camming surfaces 67, 69. The lower end of cylindrical surface 63 has an inwardly extending shoulder 71.

Referring especially to FIG. 2, the exterior of valve member F engages the interior of retainer means G and is axially slidable therein. The upper end of valve member F is adapted to engage a shoulder 73 formed on body E and an exterior shoulder 101 (see FIG. 2) of the valve member is adapted to engage a shoulder on the interior of valve retainer means G. The interior end surface 75 of the valve member retainer means G is never engaged by the valve member F so that fluid can freely flow therebetween even when the valve member is in its open position. Retainer means G of FIGS. 1 and 2 has an upper section 77 and a lower section 79. Upper section 77 is joined to body E by threads 81, and a seal ring 83 is provided to prevent fluid flow through this threaded region. One or more fluid ports 85 are formed in the upper section 77 of retainer means G. The lower section 79 of retainer means G is secured by threads 87 to the upper section 77. A seal ring 89 is provided to prevent the flow of fluid between sections 77, 79.

The area of the downwardly facing surfaces of valve member F is greater than the area of its upwardly facing surfaces. Consequently, fluid pressure inside or outside the apparatus A urges the valve member to the upper closed position shown in FIG. 1. The upper section 77 of valve member retainer means G is confronted with mating cylindrical surfaces on the exterior of valve member F, and upper and lower seal means 90, 91 extend between the cylindrical surfaces to prevent fluid flow therebetween when the valve is moved toward its upper closed position. An assembly ring 93 with interior and exterior seal rings 95, 97 is secured to the lower end of valve member F. The resulting large, radially extending downwardly facing surface, when added to the other downwardly facing surfaces is much larger in area than that of the combined upwardly facing surfaces of the valve member F. Thus the valve member is urged by the fluid pressure inside the retainer means G toward the closed position seen in FIG. 1.

The purpose in having assembly ring 93 formed of a separate piece is to permit assembly of the valve member F inside retainer means G. During assembly, upper and lower sections 77, 79 of retainer means G are separated and valve member F is inserted into upper section 77 through its upper end. This is necessary since valve member F has an upper cylindrical surface 98 that is larger in diameter than the diameter of the smallest interior cylindrical surface 99 of upper retainer section 77. Once valve member F is inserted into upper section 77, the adaptor ring 93 (its outer cylindrical surface 100 is larger in diameter than the diameter of the smallest interior cylindrical surface 99 of upper retainer section 77) may be secured to

the lower end of valve member F by suitable means such as threads. Then, the lower section 79 of retainer means G is secured to the upper section 77 and finally, the entire retainer means G and the valve member F are secured to the lower end of body E of apparatus A.

From the above it may be seen that the valve member F is urged toward its upper closed position when seals 91 and 97 engage the mating interior cylindrical surfaces of upper section 77 of valve member retainer means G. Upon pushing valve member F downward until seals 91 and 97 are below the mating cylindrical surfaces of valve member retainer means G, the upwardly and downwardly directed forces exerted upon valve member F become equalized. Consequently, there is no tendency for valve member F to move under the influence of fluid pressures while in the open position.

When seals 91 and 97 engage the mating surfaces of retainer means G, however, the fluid pressure inside the apparatus pushes the valve member toward its closed position because the diameter of the lowermost region of the valve is larger than that of the uppermost region of the valve. That is, the downwardly facing area of those portions of the valve member exposed to the fluid pressure inside the apparatus is larger than that of the upwardly facing surfaces exposed to such pressure. Also, the diameter of the intermediate region of the valve member (i.e., that region which communicates with fluid ports 85 when seal 91 engages the retainer means G) is smaller than that of the upper region of the valve. Hence, the pressure of the fluid external of the apparatus tends to move the valve member toward its closed positions when seal 91 engages its mating cylindrical surface.

To move the valve to its lower, opened position, the valve member actuator means H is lowered on a tubing string through axial passage 59 of body E into engagement with the valve F. The actuator means H includes a seal nipple 102 that has a plurality of seal rings 103 surrounding its exterior surface to sealingly engage the axial bore 59 of body E. Secured to the lower end of seal nipple 102 is a collet 105 having a plurality of resiliently expandible and retractable protrusions 107 with tapered surfaces for mating with the internally formed annular groove 65 of valve F. Resiliency is obtained by forming axially extending slots 109 on the collet, which is formed of an elastic material such as heat treated steel. The extremity of collet 105 first engages the upper beveled surface 61 of valve F and is thereby centered with respect to the valve. The outside diameter of collet 105 except for protrusions 107 is smaller than the internal diameter of the bore 66 through valve member F so that the collet can be pushed through the valve member. The protrusions 107 move inwardly as they engage cylindrical surface 63 of valve member actuator means H and eventually expand into the annular groove 65 of valve member F. When the downward force exerted on valve F by the collet 105 exceeds the upward force on valve F caused by the fluid pressure (as explained above), the valve F will be moved to a downward, opened position. Movement of the collet is effected by raising or lowering the tubing string (not shown) which is secured to seal nipple 102 by a collar connector 111. With the apparatus positioned as shown in FIG. 2, fluid is pumped through the axial flow passage of actuator means H and to the exterior of apparatus A. Fluid flows through the space between the exterior of valve F and the interior of retainer means G and through valve ports 85 when valve F is in the open position shown in FIG. 2.

To move valve F to its upper, closed position, the tubing string (not shown) is raised so that collet 105 and the valve F (through engagement of protrusions 107 on the collet and the internal annular groove 65) are moved upward. When valve F is in its upper closed position, further upward movement of collet 105 causes the protrusions 107 to move radially inward due to engagement with upper cam surfaces 67 of valve F. Continued upward

movement results in the complete separation of the collet 105 and valve F. Thereafter the collet 105 and the tubing string may be removed from the casing. Due to the imbalance in the upwardly and downwardly facing surface areas when the valve member F is in or adjacent its closed position, the fluid pressure urges the valve to its closed position.

It should be apparent from the foregoing that I have provided an invention having significant advantages. The above described well packer is an improvement over related prior art devices, and has a valve member that is easily and reliably moved between opened and closed positions to effectively control the flow of fluid through the packer. The means for opening the valve member is very simple, involving no complicated mechanisms or movements. Moreover, the configuration of the valve member F utilizes the pressure of the fluid to urge the valve member to a closed position. Thus, the use of springs or other mechanical elements for this purpose is eliminated; as a result the apparatus is further simplified.

Although I have shown my invention in only one form, it should be apparent to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

I claim:

1. In a well apparatus of the type to be disposed in a well casing on a running in string and wherein a body with an axial fluid passage is anchored to the well casing by gripping means, there being on the body packing means adapted to be expanded against the well casing, the combination therewith of:

(a) a tubular, open-ended, floating valve member coaxially aligned and communicating with the axial fluid passage of said body and having upper closed and lower opened positions for closing or opening a fluid passage that extends from the axial fluid passage of said body to the exterior of said apparatus below said gripping and said sealing means, with said valve member having downwardly facing surfaces that are exposed to fluid being larger in area than than the area of its upwardly facing surfaces that are exposed to fluid so that the pressure of the fluid urges said valve member toward its upper closed position, said valve member having an annular groove formed internally therein;

(b) valve member retainer means secured to said apparatus below said gripping and said sealing means to limit the axial movement of said valve member, said retainer means having at least one fluid port extending therethrough to permit fluid flow through said retainer means to the exterior of said apparatus when said valve member is in an opened position;

(c) seal means between said valve member and said retainer means to prevent fluid flow therebetween when said valve member is in its closed position; and

(d) valve member actuator means having an end portion engageable with the interior of said valve

member, said actuator means end portion having resiliently expansible and retractable protrusions for mating and unmating selectively with the internally formed annular groove of said valve member.

2. In a well apparatus of the type to be disposed within a well and having a body which is to be fixed relative to the well bore, with said body having an axial fluid passage, and valve means operable to control fluid flow through said passage to or from a first zone from or to a second zone which is isolated from the first zone except via said valve means, the improvement wherein:

(a) said valve means includes a floating valve member reciprocable within valve retainer means;

(b) said retainer means having a bore including a first cylindrical portion having a first diameter, a second cylindrical portion having a second diameter, and a third cylindrical portion having a third diameter, with said first diameter being greater than said second diameter and said third diameter being greater than said first diameter, with said second cylindrical portion being disposed between said first and third cylindrical portions;

(c) first, second and third seal means on said floating valve member sealingly engageable with said first, second and third cylindrical portions respectively, with each said seal means engaging a corresponding cylindrical portion when the floating valve member is in the closed position, and with only the first seal means engaging a corresponding cylindrical portion when the floating valve member is in the opened position;

(d) first fluid passage means communicating from the exterior of said valve retainer means to its interior at the region between said first and second cylindrical portions so that fluid from said second zone impinges upon said first and second seal means when said floating valve member is in the closed position;

(e) second fluid passage means communicating between said first zone and said first and third seal means when said floating valve member is in the closed position;

(f) whereby, when said floating valve member is in the closed position, pressure force unbalance on respective seals due to fluid from either or both of said first and second zones, will act to maintain said valve member in the closed position.

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JAMES A. LEPPINK, Primary Examiner.