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SAFETY VALVE, SEALING RING AND SEAL ASSEMBLY

This invention relates to a surface controlled subsurface safety valve (SCSSV) such as may be used in the oil and gas industry, in particular, to a hydraulically operated valve with metal-to-metal seal systems, which utilize a sealing ring and/or seal assembly to accomplish an effective fluid barrier.

It is common practice to complete oil and gas producing wells with safety systems including a subsurface safety valve controlled from the well surface to shut off fluid flow in the well tubing string. Generally, such a valve is controlled in response to fluid pressure conducted to the valve from a remote location at the well surface via a small diameter conduit (control line) permitting the well to be selectively shut in as well conditions require. The surface controller is typically equipped to respond to emergency conditions such as fire, broken flow lines, oil spills, etc. Frequently, it is necessary to conduct well servicing operations which may require extending a wireline tool string through the subsurface safety valve. Examples of such services are pressure and temperature testing, and the retrieval of damaged downhole equipment. These procedures result in periodic opening and closing of the safety valve. Subsurface safety valves are shown in the following US Patent Nos. 3,860,066; 3,882,935; 4,344,602; 4,356,867; and 4,449,587. US Patent 3,860,066 teaches

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that a longitudinally movable operator tube may control the opening and closing of ball, poppet, or flapper type valve closure means within a subsurface safety valve. For some well completions, it is desirable to install the safety valve at great depth. For these completions a small piston area is one way to minimize the effect of hydrostatic fluid pressure from the control line leading to the well surface. Pistons having a small cross-section in comparison to the cross section of the complete valve assembly have been used in SCSSV's. Examples of such pistons are shown in:

US Patent	Title
2,780,290	Surface Controlled Subsurface Tubing Pressure Shut-Off Valve
2,798,561	Blowout Preventer for Wells
4,049,052	Subsurface Annulus Safety Valve
4,161,219	Piston Actuated Well Safety Valve
4,444,266	Deep Set Piston Actuated Well Safety Valve
4,716,969	Hydraulic Valve Actuating Means for Subsurface Safety Valve
4,796,705	Subsurface Well Safety Valve

Since a tubing retrievable safety valve cannot be easily removed from the well bore for routine maintenance, any failure of a fluid seal or accumulation of debris within the safety valve can be very expensive to correct. All sealing systems are subject to failure depending upon the operating environment and design of the seals. Often a seal between two metal members is

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desired. For some environments these "metal-to-metal" seals produce longer life compared to elastomeric materials; however, elastomeric materials and other non-metal, non-elastomeric materials provide unique advantages as well. Elastomeric, polymeric, and metal-to-metal seal systems have all been used in SCSSV's. Examples of metal-to-metal seal systems are shown in:

US Patent	Title
4,452,310	Metal-to-Metal High/Low Pressure Seal
4,467,870	Fluid Pressure Actuator for Subterranean Well Apparatus
4,475,598	Ball Valve Actuating Mechanism
4,527,630	Hydraulic Actuating Means for Subsurface Safety Valve
4,583,596	Dual Metal Seal for a Well Safety Valve

There is a need for one of more continuous seals between the rod and the inside wall of the safety valve or some other member which will prevent leakage of both hydraulic pressure fluids and well fluids as well as pressure from above and below the rod into the interface between the rod and the inside wall of the safety valve and the bore. Leakage control is necessary so that the rod will maintain sufficient pressure to shift downward and upward, and then remain seated as desired, thus facilitating the opening and closing of the valve.

A sealing ring is desired which will effectively seal against fluid and pressure leakage in some type of well system such as a safety valve or packer. Also

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desired is a seal mechanism to retard fluid and pressure leakage from within the well.

What is desired is a dynamic seal which provides a continuous seal which retards fluid and pressure leakage and yet is unaffected by high temperatures and pressures of a well for a period of many years.

The previously listed patents are incorporated by reference for all purposes in this application.

The present invention relates to a safety valve for downhole use in a well, comprising a housing having an axial bore opening outwardly through top and bottom ends of the housing, and an interior fluid passageway laterally offset from and generally parallel to said bore, valve closure means mounted in said housing for movement relative thereto between first and second positions respectively permitting and blocking fluid flow through said bore, an operator tube disposed in said housing and being axially movable relative thereto to shift said valve closure means from said second position to said first position, rod means generally coaxially disposed in said offset passageway for longitudinal movement therein relative to said housing for moving said operator tube from said second position to said first position in response to fluid control pressure exerted on the upper end of said rod means, and sealing means for forming a fluid seal between upper and lower portions of said offset passageway, said sealing means including a hollow sleeve member coaxially anchored within said

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offset passageway and slidably receiving said rod means, said rod means having an upper end portion extending upwardly beyond a top end of said sleeve member and a longitudinal portion received within said sleeve member, first cooperating means forming a first static seal between said longitudinal rod means portion and an open bottom end of said sleeve member that substantially precludes downward fluid flow through said sleeve member in response to downward driven movement of said rod means relative to said sleeve member, and second cooperating means forming a second static seal between said upper rod means end portion and an interior surface portion of said offset passageway above said upper rod means end portion that substantially precludes upward fluid flow through said sleeve member in response to upward driven movement of said rod means relative to said sleeve member, said second cooperating means comprising a seating ball member forming said second static seal with said interior surface portion of said offset passageway.

The invention will be further described with reference to the accompanying drawings. In the drawings:

Figure 1 is a schematic view in section and elevation of a typical well completion including a tubing-retrievable subsurface safety valve with a flapper type value closure means,

Figures 2A, 2B and 2C taken together form a longitudinal view in section with portions broken away of the subsurface safety valve and operator tube showing the

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safety valve in its closed position,

Figure 3 is a drawing in longitudinal section with portions broken away of the subsurface safety valve shown in Figures 2A, 2B and 2C in its closed position,

Figure 4 is a drawing in section showing the sealing ring around the rod,

Figure 5 is an enlarged view in section with portions broken away showing an alternative embodiment of the sealing ring around the rod,

Figures 6A, 6B and 6C show various views of the sealing ring,

Figures 7A, 7B and 7C show various views of the sealing ring with threaded joints,

Figure 8 is a drawing in section showing the combination of sealing ring, rod means, and rod retainer and seal means,

Figure 9 is a quarter sectional view of a portion of an embodiment of the safety valve according to the invention, and

Figure 9A is an enlargement of the dotted line area "9A" of Figure 9.

In the following description, like parts are designated throughout the specification and drawings with the same reference numerals. The drawings are not necessarily to scale. Portions of some parts have been exaggerated to better illustrate details of the present invention.

Referring to Figure 1, well completion 20

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includes casing string 28 extending from the well surface to a hydrocarbon producing formation (not shown). Tubing string 21 is concentrically disposed within casing 28 and extends from wellhead 23 through production packer 22 which seals between tubing string 21 and casing 28. Packer 22 directs formation fluids such as oil, gas, water, and the like into tubing string 21 from perforations (not shown) in casing 28 which admit formation or well fluids into the well bore. For purposes of this application, "fluid" includes oil, gas, water and the like, whether in the liquid or gaseous state. Well fluids frequently carry sand or other debris which may accumulate at locations in tubing string 21 having low fluid velocity. Flow control valves 24a and 24b at the well surface control fluid flow from tubing string 21. Wellhead cap 27 is provided on wellhead 23 to permit servicing well 20 via tubing string 21 by wireline techniques which include the installation and removal of various downhole tools (not shown) within tubing string 21. Other well servicing operations which may be carried out through tubing string 21 are bottom hole temperature and pressure surveys.

Surface controlled subsurface safety valve 30 is installed in well completion 20 as a part of tubing string 21 to control fluid flow to the well surface via tubing string 21 from a downhole location. Safety valve 30 is operated by control fluid conducted from hydraulic manifold 25 at the well surface via control line conduit

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26 which directs the control fluid signal to safety valve 30.

Safety valve 30 includes flapper type valve closure means 31 mounted on hinge 34 for swinging between its closed position schematically represented in Figure 1 and its open position in Figure 8 which permits fluid flow through tubing string 21. When a predetermined pressure signal is applied to safety valve 30 through control line 26 from manifold 25, valve closure means or flapper 31 is maintained in its first or open position. When control pressure signal is released, valve 30 is allowed to move to its second or closed position.

Details for construction of one form of valve 30 are shown in Figures 2A, 2B and 2C. Subsurface safety valve 30 has housing means 60 formed by housing subassemblies 61, 62 and 63 which are suitably interconnected by threaded joints 65. Subassemblies 61, 62 and 63 could be interconnected by welded joints or by a combination of threads and elastomeric seals. Welding is sometimes unsatisfactory due to requirements for heat treating before and after. Elastomeric seals in some environments (high pressure, high temperature gas) have a tendency to fail during pressure transients. Threaded joints 65 are preferred because they have mechanical strength comparable to a welded connection and a metal-to-metal seal. US Patent 2,992,019 discloses threads and a metal-to-metal seal system similar to threaded joint 65. Threaded joint 65 is sometimes referred to as a two-

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step thread because the diameter of threaded portion 65a is substantially larger than threaded portion 65b.

Housing means 60 can be generally described as a long thick walled cylinder with longitudinal bore 67 extending therethrough. The ends of housing subassemblies 61 and 63 may be internally or externally threaded to provide means on opposite ends of housing means 60 for connection with tubing string 21. A lockout sleeves (not shown) could be incorporated into safety valve 30 if desired to hold valve closure means 31 open.

Housing subassembly 61 has threaded connection 29 to attach control line 26 to safety valve 30. Control fluid pressure signals are communicated from the well surface via control line 26, threaded connection 29, drilled passageway 66, and offset passageway 80. Passageway 80 is machined in the wall of housing subassembly 61 parallel with but offset from longitudinal bore 67.

Operator tube 40 is slidably disposed within longitudinal bore 67 to shift valve closure means 31 from its second, closed position as shown in Figure 2C to its first, open position as shown in Figure 8. Operator tube 40 is constructed from two or more generally hollow, cylindrical sections designated 40a and 40b. Rod means 90 may be a piston in a rod-piston arrangement, disposed in housing means 60 offset from longitudinal bore 67, moves operator tube 40 in response to control fluid pressure from the well surface. A portion of rod means

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90 is slidably disposed in offset passageway 80.

Rod means 90 has two main components - seal assembly 91 and cylindrical rod 100. Seal assembly 91 includes seat insert 92. Seat insert 92 is a threaded rod.

The exterior of operator tube 40 and the interior of housing subassembly 62 partially defines annulus 50 therebetween. Cylindrical rod 100 extends from the lower end of housing subassembly 61 into annulus 50. Cylindrical rod 100 and seal assembly 91 are then threaded together to form rod means 90 and partially disposed within offset passageway 80 of housing subassembly 61.

Biasing means or spring 54 is carried on the exterior of operator tube 40 in spring chamber 53 which is a portion of annulus 50. Biasing means 54 applies a force to slide operator tube 40 longitudinally opposite from the force of control fluid pressure in piston chamber 82 acting on piston means 90. When control fluid pressure in chamber 82 is decreased below a preselected value, spring 54 moves operator tube 40 longitudinally upward to allow valve closure means 31 to return to its second, closed position. Spring 35 coiled around hinge 34 assists in moving flapper 31 to its closed position.

Operator tube 40 could be designed to allow spring 54 to directly contact a shoulder on its exterior. Such design is frequently used in commercially available subsurface safety valves. Compression of spring 54 and

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expansion of spring 54 produces torsionally forces in addition to longitudinal forces.

Longitudinal force from spring 54 is transmitted to the exterior of operator tube 40. Longitudinal force from rod means 90 is transmitted to the exterior of operator tube 40.

Longitudinal force to shift valve closure means 31 to its open position is initiated by supplying a preselected amount of control fluid pressure to piston chamber 82. Rod means 90 converts control fluid pressure to a longitudinal force which is transferred via rod 100. Belleville spring washers or some other suitable spring 157 is positioned below load ring 106. Longitudinal force on load ring 106 via springs 57 is transferred to operator tube 40. The longitudinal force moves operator tube 40 to open valve closure means 31.

At the same time as load ring 106 is applying longitudinal force, longitudinal force is also being applied to spring 54 via thrust bearing assembly 120. Thus, torsional forces from compressing spring 54 are isolated from rod means 90.

Longitudinal force to shift operator tube 40 in the opposite direction to allow valve closure means 31 to move to is closed position is supplied primarily by biasing means or spring 54. First control fluid pressure in rod chamber 82 is decreased below a preselected value. Spring 54 can then expand. Longitudinal force from expansion of spring 54 is applied to operator tube 40 via

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bearing assembly 120 and load ring 106. During expansion of spring 54, load ring 106 contacts the bottom of flange 41 to return operator tube 40 to its second position. Bearing assembly 120 isolates operator tube 40 and rod means 90 from torsional forces generated by expansion of spring 54.

Referring to Figure 3, rod means 90 comprises a seal assembly 90 and either a cylindrical member, piston or rod 100. Rod 100 is partially disposed within a passageway offset from the longitudinal bore and a seal assembly is secured to one end of the rod. Rod 100 may contain an undercut to provide a reduced diameter portion 242 of rod 100 below a spherical or angular surface 243 and an adapter portion 234 to assist in forming a fluid barrier.

Sealing ring 224 is shown around rod 100. Rod retainer and seal means 226 surrounds at least a portion of the length of rod 100. Adapter 234 seats against lower static seat 236 when flapper 31 is closed and spherical or angular surface 243 seats against upper static seat 238 when flapper 31 is open.

Referring to Figures 6A, 6B and 6C, sealing ring 224 has a flange portion 233 which is directed radially outward from sealing sleeve 228. Lip 232 has a smaller diameter than the diameter of support sleeve portion 228 so that each lip 232 sealingly engages the external surface of cylindrical member 100.

Figure 6B shows an end view of sealing ring 224,

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with sealing ring aperture 225, lip 232, flange portion 233 and sleeve 228. Sleeve 228 has a larger inside diameter than the inside diameter of lip 232, and extends axially and surrounds a cylindrical member 100.

Figures 7A, 7B and 7C show sealing ring 224 with threaded joints ("threads") 235. Threads 235 may be optionally used to facilitate interconnection between sealing ring 224 and at least one stationary member within safety valve 30 or some other valve or apparatus including but not limited to a packer, although threads 235 are not required. Sealing ring 224 is attached to some stationary member so ring 224 is stationary relative to rod or cylindrical member 100, so that sealing ring 224 does not move but rod 100 does.

Sealing ring 224 fits around cylindrical member 100, rod 100 or piston 100. Rod 100 fits within sealing ring aperture 225, and lip 232 of sleeve 228, having a smaller diameter than the diameter of sleeve 228, and sealingly engages the internal lip of sealing ring 224.

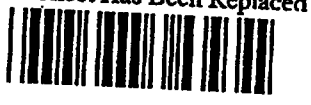
At least a portion of cylindrical member 100 is sufficiently smooth and hard so as to slide within the lips 232 of sealing ring 224. This surface hardening can be accomplished by any one of a variety of methods including, but not limited to, a ceramic coating, a diffusion coating, an iron nitride coating, plating with hard metals, chromium/gold plating, diamond coating, surface heat treatment and the like. Cylindrical member 100 may be made of hardened tool steel, alternatively. A

bare metal rod typically has a surface hardness of Rockwell C 29-36. Preferably the cylindrical member of this invention has a surface hardness Rockwell C of at least 50 and most preferably of at least 75. A bare metal rod with a Rockwell C hardness of 35 may be used but the mean time to failure (MTTF) or lifetime of the rod might only be about ten (10) years whereas the MTTF for a rod with a Rockwell C of 75 approximates thirty (30) years.

Some surface treatments not only improve the life of cylindrical member or rod but help inhibit corrosion as well. The rod hardness helps to elastically deform lips 232 of sealing ring 224 so that lips 232 fit sufficiently tight against cylindrical member 100 to form a pressure and fluid barrier but not so tightly that cylindrical member 100 cannot slide through sealing ring 224.

The cylindrical member or rod 100 should be sufficiently smooth and round so as to slide within bore 225 of sealing ring 224. The smoothness of cylindrical member 100 in combination with the smoothness of the lips 232 of sealing ring 224 provides a better fluid barrier than would a rough surface. The smoothness of cylindrical member 100 also reduces friction, thus lowering operating pressure requirements. The smoothness also allows cylindrical member 100 to move flapper 31 by way of operator tube 40 to a closed position more easily and faster.

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Preferably, sealing ring 224 is designed so as to fit a subsurface safety valve rod with a diameter from about one-fourth inches to about 2 inches (6-50mm).

Lips 232 conform to each cylindrical member 100 to provide a fluid barrier. Space 240 in Figure 4 or 5 remains between rod 100 and the inside of sealing sleeve portion 228 and rod 100, although lips 232 contact rod 100 and conform to same.

This seal also acts as a hydraulic pressure barrier to keep pressure from leaking. For example, hydraulic pressure from control line 26 enters offset passageway 80 and pushes cylindrical member 100 down through passageway 80 to compress biasing means or spring 54 within spring chamber 53. This moves operator tube 40 at section 40a down so that section 40b of operator tube 40 contacts surface 141 of valve closure means or flapper 31 and pushes flapper 31 open. In the event that the pressure from control line 26 leaks past cylindrical member 100 into passageway 80, cylindrical member 100 will not push adequately through passageway 80 nor will it adequately compress spring 54, which results in flapper 31 remaining closed. Thus, it is important that a good barrier seal be formed within passageway 80 between cylindrical member 100 and the housing of safety valve 30.

Pressure and fluids are prevented from leaking from below cylindrical member or rod 100. As the pressure from above cylindrical member 100 decreases and

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becomes less than the well pressure, spring 54 moves operator tube 40 longitudinally upward to allow valve closure means 31 to return to its closed position. A fluid and pressure tight barrier is desired below cylindrical member 100 in order to keep well fluids and gases below cylindrical member 100 from leaking into the control line 26.

Thus, a first fluid and pressure barrier may be formed by sealing ring 224 and rod 100. A second fluid barrier may be formed by a rod retainer and seal means or metal sleeve 226 and rod 100. Sleeve 226 is placed within passageway 80 in contact with housing means 60 so as to be stationary relative to cylindrical member 100 and which surrounds at least a portion of the length of cylindrical member 100. Preferably, sleeve 226 surrounds cylindrical member 100 partway down cylindrical member 100. Cylindrical member 100 is provided with a spherical or angular surface 243. Cylindrical member 100 has reduced diameter portion 242 below surface 243. Sleeve 226 has upper static seat 238 and lower static seat 236 which may be created by angular or straight cuts in sleeve 226. Any suitable undercut will create seats 236 and 238. There need not be any specific configuration to create reduced diameter portion 242. Spherical or angular surface 243 contacts upper static seat 238 when pressure from control line 26 pushes cylindrical member 100 downward. Surface 243 and upper static seat 238 are both positioned on cylindrical member 100 and rod

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retainer and seal means or sleeve 226, respectively, so that the end of the operator tube 40 contacts and fully opens flapper 31 when surface 243 contacts upper static seat 238. A fluid and pressure barrier or seal is formed at upper static seat 238 and lower static seat 236. This barrier or seal is preferably metal-to-metal but may be other materials as well. These barriers reduce the amount of electrolytic and chemical corrosion to the rod 240 and seal assembly 91.

Rod means 90 preferably includes rod 100, most preferably rod-piston 100, and seal assembly 91. Seal assembly 91 includes seat insert 92 and adapter 234. Adapter 234 has adapter seat surface 239 which contacts lower static seat 236. When the pressure from the control line 26 decreases, operator tube 40 shifts upward because of spring 54. Adapter 234 of cylindrical member 100 moves up to contact adapter seat surface 239 with lower static seat 236, forming a barrier to fluids and pressure. Thus, a first barrier may be formed by use of (1) sealing ring 224 and (2) cylindrical member 100.

Or, as an alternative, a second barrier may be formed by use of (1) rod retainer and seal means or sleeve 226 which has upper static seat 238 and lower static seat 236 and (2) cylindrical member or rod 100 which has spherical or angular surface 243, reduced diameter portion 242, and adapter 234.

Or, both the first barrier and second barrier may be formed where (1) sealing ring 224, (2) cylindrical

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member or piston-rod 100 with surface 243 and reduced diameter portion 242, as well as (3) rod retainer and seal means or sleeve 226 with lower static seat 236 and upper static seat 238 are used in combination.

Preferably, sealing ring 224 is made from the materials, or a combination thereof, consisting of metals, elastomers, polymers and advanced composites. Preferably, sealing ring 224 is metal although elastomers, polymers such as Teflon, a polymer available from Dupont, and advanced composites could be used. The metal seal may also be coated with a thin layer of titanium nitride/titanium carbide, diamond, gold, or other coating to improve the life of the seal by reducing friction or increasing hardness.

Cylindrical member or rod 100 is preferably equal to or greater than Rockwell C 35 and most preferably equal to or greater than 70 Rockwell C in hardness so as to not be too soft and scratch easily. Cylindrical member or rod 100 may be made of a metal such as stainless steel; however, rod 100 may be coated with ceramic coating 101 as shown in Fig 4. Ceramic coating 101 preferably extends no further down rod 100 than the upper edge of surface 243. Other coatings may be used as long as the coatings do not unduly scratch and scar and they can be polished to be sufficiently smooth.

Referring to Figure 5, an alternative embodiment of sealing ring 224 of Figure 4 is shown. Sealing ring 224 has flange portion 233 which has tapered edge 227 and

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tapered sleeve 228. Lips 232 contact cylindrical member or rod 100 with space 240 between cylindrical member or rod 100 and sealing ring 224 wherein only lips 232 of sealing ring 224 contact cylindrical member or rod 100.

The ratio of the thickness of flange portion 233 to the thickness of lips 232 may vary from about 2 to 1 to about 10 to 1 although other ratios may work as well. As the diameter of rod 100 increases, a thicker flange 233 and lips 232 may be used. As the diameter of rod 100 decreases, a thinner flange 233 and lips 232 may be used.

As an example, for a one-half inch (12mm) rod, a ratio of the thickness of flange portion 233 to the thickness of lips 232 is preferably from about 4 to 1 to about 7 to 1. One of ordinary skill in the art can design sealing ring 224 with appropriate dimensions so as to substantially conform with the above preferred tolerances.

The rod and seal structure of an alternative embodiment 30a of safety valve according to the invention is illustrated in Figures 9 and 9A. For purposes of ready comparison with the valve 30, the components in valve 30a similar to those in valve 30 have been given the same reference numerals, but with the subscripts "a".

The sealing sleeve 226a is coaxially and captively retained within the offset passageway 80a, with the sealing ring 224a being captively retained within the offset passageway 80a between the upper end of the sleeve 226a and an annular ledge formed in the offset passageway

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80a above the upper end of the sealing sleeve 226a. The rod 100a is slidably received in the sealing ring 224a and the sealing sleeve 226a, and an annular undercut surface 243a is formed on the rod 100a.

When pressurized control fluid is forced downwardly through the control passage 66a,69a that communicates with the upper end of the offset passageway 80a, the rod 100a is driven downwardly relative to the sealing sleeve 226a, against the yielding resistance of the spring 54a, until the undercut rod area 243a is brought into engagement with the upwardly facing annular seating area 238a on the lower end of the sleeve 226a to form a static seal therewith at the lower end of the sleeve.

In this form of safety valve, however, the previously described adapter 234 (Figure 2B) is omitted from the lower end of the rod 100a, and a second static seal formed within the offset passageway 80a is located above the upper end of the sleeve 226a and the sealing ring 224a. This second static seal, effected by upward movement of the rod 100a relative to the sleeve 226a, is provided via the cooperation of a seating ball 250, preferably formed from a suitably hard material such as a ceramic material, carried on the upper end of the rod 100a and an annular seating area 252 coaxially disposed within the offset passageway 80a, above the upper rod end, and formed integrally with the body 60a of the valve 30a.

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The ball 250 is retained captive on the upper end of the rod 100a using a cylindrical metal insert 254 threaded into an axial bore 256 formed in the upper end of the road 100a. The radially enlarged upper end of insert 254 has a generally hemispherical depression 258 formed therein to receive a lower radial portion of the ball 250 as best illustrated in Figure 9A. Ball 250 is retained captive in depression 258, with an upper radial portion of the ball projecting upwardly beyond the upper end of the insert 256, using an annular upstanding top lip portion 260 of the insert 254 inwardly swaged around the periphery of the ball 250.

When the rod 100a is driven to its upper limit position shown in Figure 9A, the ball 250 sealingly engages the annular seating area 252 to form an upper static seal in the offset passageway 80a above the sleeve 226a and the sealing ring 224a. The positioning of this second static seal above the sealing ring 224a causes the dynamic seal provided by the ring 224a to be interposed between the static seal interface area 250,252, thereby forming a barrier to the upward flow of well fluid debris to the seating area 252. By protecting the seating area 252 in this manner from well fluid debris, fouling of the seating area 252, which could permit undesirable upward leakage of well fluid into the control passage 69a,66a, is substantially prevented.

The foregoing detailed description is to be clearly understood as being given by way of illustration and example only.

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CLAIMS:

1. A safety valve for downhole use in a well, comprising:

a housing having an axial bore opening outwardly through top and bottom ends of the housing, and an interior fluid passageway laterally offset from and generally parallel to said bore;

valve closure means mounted in said housing for movement relative thereto between first and second positions respectively permitting and blocking fluid flow through said bore;

an operator tube disposed in said housing and being axially movable relative thereto to shift said valve closure means from said second position to said first position;

rod means generally coaxially disposed in said offset passageway for longitudinal movement therein relative to said housing for moving said operator tube from said second position to said first position in response to fluid control pressure exerted on the upper end of said rod means; and

sealing means for forming a fluid seal between upper and lower portions of said offset passageway, said sealing means including:

a hollow sleeve member coaxially anchored within said offset passageway and slidably receiving said rod means, said rod means having an upper end portion

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extending upwardly beyond a top end of said sleeve member and a longitudinal portion received within said sleeve member;

first cooperating means forming a first static seal between said longitudinal rod means portion and an open bottom end of said sleeve member that substantially precludes downward fluid flow through said sleeve member in response to downward driven movement of said rod means relative to said sleeve member; and

second cooperating means forming a second static seal between said upper rod means end portion and an interior surface portion of said offset passageway above said upper rod means end portion that substantially precludes upward fluid flow through said sleeve member in response to upward driven movement of said rod means relative to said sleeve member;

said second cooperating means comprising a seating ball member forming said second static seal with said interior surface portion of said offset passageway.

2. The safety valve of Claim 1 wherein:

said first cooperating means include an undercut portion of said longitudinal rod portion defining a downwardly facing annular surface, and an upwardly facing annular seating surface formed on said open bottom end of said sleeve member.

3. The safety valve of Claim 1 or Claim 2 wherein:

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said interior surface portion of said offset passageway is configured to define an annular seating surface disposed above said upper rod means end portion; and

said second co-operating means include said annular seating surface and an upper end surface portion of said rod means configured to sealingly engage said annular seating surface in response to upward driven movement of said rod means relative to said sleeve member.

4. The safety valve of Claim 3 wherein:

said rod means comprises an elongate member having an upper end on which the seating ball member is captively retained to project upwardly beyond said upper end, an exterior surface portion of said seating ball member defining said upper end surface portion of said rod means.

5. The safety valve of Claim 4 wherein:

said seating ball member is formed from a ceramic material.

6. The safety valve of Claim 4 or Claim 5 wherein:

said seating ball member is captively retained on said upper end of said rod member by means of an insert member coaxially threaded into said upper end of said rod member and having an upper end depression

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receiving said seating ball member, and an annular top end lip portion inwardly swaged against the periphery of said seating ball member.

7. A safety valve for downhole use in a well, comprising:

a housing having axially spaced top and bottom ends, an axial bore opening outwardly through said top and bottom ends, and an interior fluid passageway laterally offset from and generally parallel to said bore;

valve closure means mounted in said housing for movement relative thereto between first and second positions respectively permitting and blocking fluid flow through said bore;

an operator tube disposed in said housing and being axially movable relative thereto to shift said valve closure means from said second position to said first position;

rod means generally coaxially disposed in said offset passageway for longitudinal movement therein relative to said housing for moving said operator tube from said second position to said first position in response to fluid control pressure exerted on the upper end of said rod means; and

sealing means for forming fluid seals within said offset passageway, said sealing means including:

a hollow sleeve member coaxially anchored within

said offset passageway and slidably receiving said rod means, said rod means having an upper end portion extending upwardly beyond an open top end of said sleeve member and a longitudinal portion received within said sleeve member;

first cooperating means forming a first static seal between said longitudinal rod means portion and an open bottom end of said sleeve member that essentially precludes downward fluid flow through said sleeve member in response to downward driven movement of said rod means relative to said sleeve member;

second cooperating means forming a second static seal between said upper rod means end portion and an interior surface portion of said offset passageway above said upper rod means end portion that substantially precludes upward fluid flow through said sleeve member in response to upward driven movement of said rod means relative to said sleeve member;

said second cooperating means comprising a seating ball member forming said second static seal with said interior surface portion of said offset passageway; and

sealing ring means, captively retained in said offset passageway and circumscribing said rod means, for forming a sliding dynamic seal extending around said rod means and disposed between the first and second static seal areas.

8. The safety valve of Claim 7 wherein:

said first cooperating means include an undercut portion of said longitudinal rod portion defining a downwardly facing annular surface, and an upwardly facing annular seating surface formed on said open bottom end of said sleeve member.

9. The safety valve of Claim 7 or Claim 8 wherein:

said interior surface portion of said offset passageway is configured to define an annular seating surface disposed above said upper rod means end portion; and

said second cooperating means include said annular seating surface and an upper end surface portion of said rod means configured to sealingly engage said annular seating surface in response to upward driven movement of said rod means relative to said sleeve member.

10. The safety valve of Claim 9 wherein:

said rod means comprising an elongate member having an upper end on which a seating ball member is captively retained to project upwardly beyond said upper end, an exterior surface portion of said seating ball member defining said upper end surface portion of said rod means.

11. The safety valve of Claim 10 wherein:

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said seating ball member is formed from a ceramic material.

12. The safety valve of Claim 10 or Claim 11 wherein:

said seating ball member is captively retained on said upper end of said rod member by means of an insert member coaxially threaded into said upper end of said rod member and having an upper end depression receiving said seating ball member, and an annular top end lip portion inwardly swaged against the periphery of said seating ball member.

13. The safety valve of Claim 7 wherein:

said rod means include an elongate member, and said sealing ring means include:

a tubular body portion coaxially disposed in said offset passageway having at least one annular lip projecting radially inwardly beyond an interior side surface of said body portion and having a circular, radially inner edge surface slidingly and coaxially receiving said elongate member and forming a dynamic fluid seal around a portion of the exterior side surface thereof; and

an annular flange portion circumscribing and projecting radially outwardly beyond said exterior side surface of said body portion, said flange portion being held in contact with the offset passageway wall structure

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in a manner creating therewith a static fluid seal outwardly circumscribing said body portion.

14. The safety valve of Claim 13 wherein:

said at least one annular lip includes a first annular lip formed on a first open end of said tubular body portion, and a second annular lip formed on a second, opposite open end of said body portion.

15. The safety valve of Claim 13 or Claim 14 wherein:

said annular flange portion is disposed on an axially intermediate section of said tubular body portion.

16. The safety valve of any one of Claims 13 to 15 wherein:

said annular flange portion is threaded into said offset passageway.

17. The safety valve of any one of the preceding claims wherein:

said sealing ring means are disposed at the upper end of said sealing sleeve.

18. A safety valve constructed and arranged for use and operation substantially as described herein with reference to the accompanying drawings.