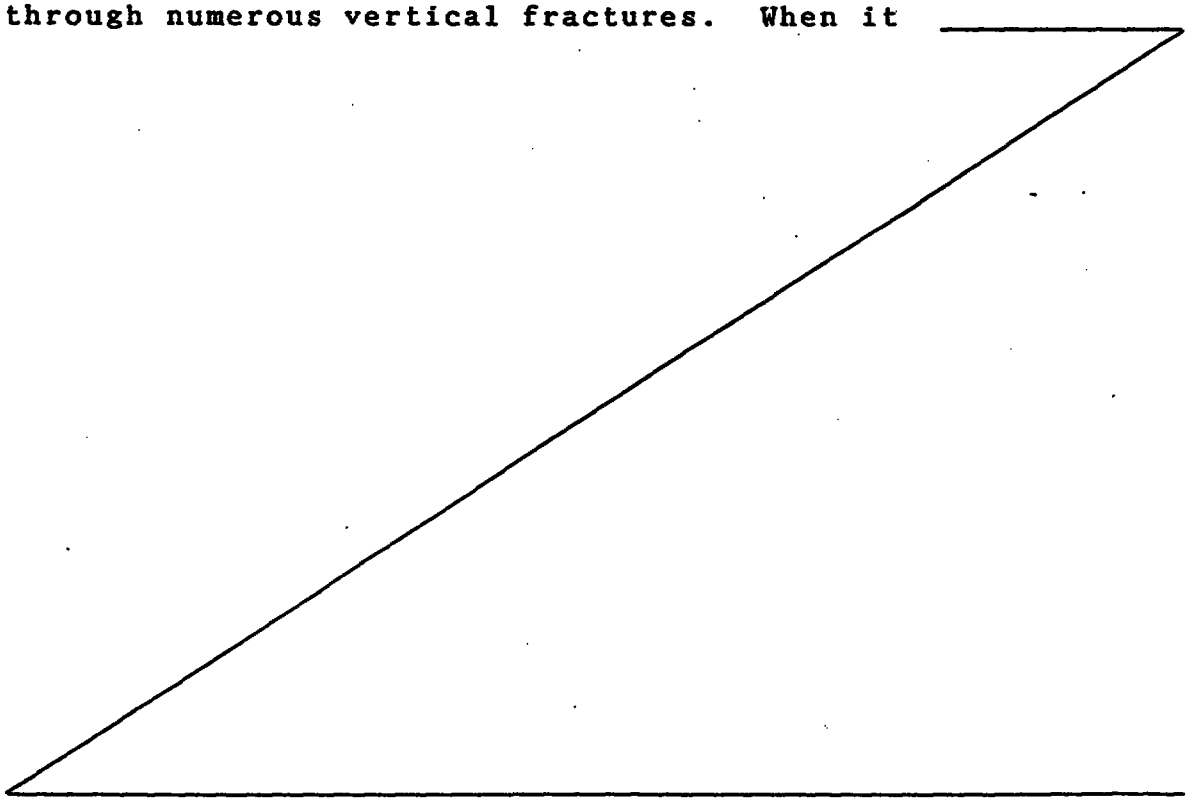
# CASING SHUT-IN VALVE SYSTEM

This invention relates to a valve and to a valve assembly for use within a conduit in a subterranean well.

During well drilling operations, the drill string is frequently tripped from the well for bit or motor replacement. Problems can arise during tripping if hydrocarbon fluids from downhole formations overpressure the drilling fluid in the well bore. Such problems are particularly likely to occur in highly deviated wells, including but not limited to so-called "horizontal drilling" operations in which the well bore descends vertically to a desired kick-off point, and then veers off horizontally through numerous vertical fractures. When it



becomes necessary to come out of the hole and the bottom hole assembly is drawn up into the vertical casing, the well may begin to produce.

One technique previously used to control the upward flow of hydrocarbon fluids when wells become underbalanced during tripping has been to seal off the well bore at the wellhead and to condition the drilling mud by increasing its weight sufficiently to overpressure the hydrocarbon flow. As the drill string is withdrawn to shallower depths, this mud conditioning procedure may have to be repeated several times, progressively increasing the weight of the mud and also increasing costs. To avoid the need for repeatedly reconditioning the drilling fluid during tripping, a valve assembly can be installed downhole to serve as a check valve on the upward flow of hydrocarbon fluids.

The use of flapper valves as check valves or safety valves in subterranean wells has previously been disclosed, for example, in United States Patents Nos. 2,447,842; 4,531,587; 4,706,933; 4,926,945 and 4,977,957.

The flapper valves in each of the prior art patents disclosed above opens and closes by rotating through an angle of 90°. The large differential pressures and high fluid velocities sometimes encountered during use of such valves in downhole applications can cause stress

concentrations leading to valve failure due to broken springs, hinges, or the like. Others have previously sought to reduce the likelihood of such failures by using control pistons in combination with compression strings or hydraulic cylinders to dampen the forces exerted against flappers and their hinge points, or by constructing valve parts from lighter weight materials.

Flapper valves as such which rotate through an angle of less than 90° are known. In U.S. 1,871,536 such a valve is used to provide an arrangement in which a biasing spring which normally holds a closure member of the valve in sealing contact with a valve seat, has its biasing effect neutralised when the valve is opened. In a different field, U.S. 3,672,630 shows a flapper valve for a suction conduit in which the closure member meets an inclined engagement surface to offer decreased resistance in opening.

According to one aspect of the present invention, there is provided a valve for use within a conduit in a subterranean well, the valve comprising a valve seat, a valve closure member rotatable about a hinge point between open and closed positions through an included angle of less than 90°, and control means for movement of the valve closure member reversibly between the open and closed positions, the control means comprising means for biasing the valve closure member to a closed position and said biasing means comprising a plurality of spring strut assemblies rotatably connected to the valve closure member, with at least one strut assembly being rotatable connected to the valve closure member on each side of the hinge point of the valve closure member.

The invention also provides a valve system for use within a conduit in a subterranean well, the valve system comprising a valve including a valve closure member, and means for displacing the valve closure member; the valve comprising a substantially cylindrical body, a valve seat, said valve closure member being rotatable in the body about

a hinge between open and closed positions through an included angle of less than 90°, means for biasing the valve closure member towards the closed position, said biasing means comprising a plurality of strut assemblies rotatably connected to the valve closure member at circumferentially spaced points, with at least one strut assembly being disposed on each side of the hinge of the valve closure member; a sleeve member being adapted to slide reversibly between first and second positions inside the body corresponding respectively to the open and closed positions of the valve closure member; and the means for displacing the valve closure member comprising a shift head assembly having means for releasably engaging the sleeve member for selectively moving the sleeve member between the first and second positions.

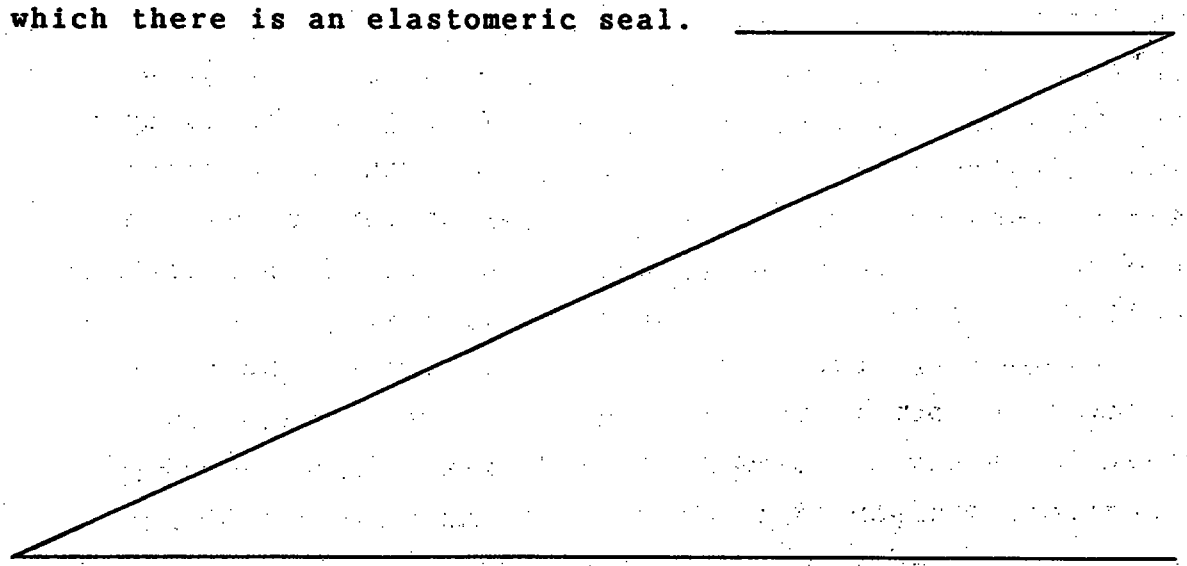
The valve assembly of the invention preferably comprises a curved flapper valve member, a tubular valve seat with a curved seating surface, and an elastomeric seal on the curved flapper to engage the curved seating surface of the valve seat. It may also comprise a longitudinally slidable flow sleeve assembly adapted for use in selectively opening or closing the valve.

The casing shut-in valve system of the invention comprises a shift head assembly adapted to releasably engage the flow sleeve to selectively open or close the valve. The shift head assembly preferably comprises a key housing having a plurality of circumferentially spaced, spring-loaded shift keys that are biased radially outwardly to engage annular recesses in the interior wall of the flow sleeve for use in opening and closing the valve. The shift head assembly preferably further comprises a load equalizer plate and large cross-section O-ring at each end of the key housing to distribute the mechanical load substantially equally to each circumferentially spaced key. A bit sub, rotatably mounted in a Cutless® (registered trademark) bearing, provides a flow channel for drilling fluid through

the shift head assembly. The load equalizer plates are particularly useful where the hole is drilled using a bent sub having, for example, a 3/4° offset.

In the valve system of the invention, the strut assemblies are preferably connected to the valve closure member at points that are longitudinally spaced apart from the hinge of the valve closure member. Each strut assembly preferably comprises a guide member and a hinge support member that are slidably engaged, the guide member being rotatably connected to the body of the valve assembly and the hinge support member being rotatably connected to the valve closure member, and means for biasing the hinge support member away from the guide member. In this arrangement, the hinge support member of at least one strut assembly is preferably rotatably connected to the valve closure member at a position that is radially inward of the hinge of the valve closure member, or it is rotatably connected to the valve closure member at a position that is radially inward of the position where the guide member is rotatably connected to the body. The means for biasing the hinge support member away from the guide is preferably a spring.

In the valve system of the invention, the valve closure member preferably has an arcuate sealing surface on which there is an elastomeric seal.



The apparatus of the invention is further described and explained in relation to the following figures of the drawings in which:

Figure 1 is a schematic elevation view, partially in section, depicting a drilling rig installed over a well bore in which the casing shut-in valve system of the invention is deployed downhole, and in which the drill string is directed horizontally into a subterranean stratum from a kick-off point below the subject valve;

Figure 2 is an elevation view, partially in section and partially broken away, of the flapper valve assembly of the invention, showing the flow sleeve in its upper position and the flapper valve closed, the condition that exists whenever the drill string is drawn upwardly to a point where the bottom hole assembly is above the flapper valve assembly;

Figure 3 is an enlarged elevation view, partially in section, of the casing shut-in valve system of the invention in which the shift head has engaged the flow sleeve and driven it downwardly to open the flapper during insertion of the drill string through the flapper valve assembly;

Figure 4 is an enlarged elevation view, partially in section, of the casing shut-in valve system of the invention in which the shift head has engaged the flow sleeve while being withdrawn upwardly through the flapper valve assembly, just prior to overpressuring the detent member out of the upper detent groove to permit the flow sleeve to be drawn upwardly by the shift head so that the flapper can close;

Figure 4A is an enlarged elevation view, partially in section, showing the flapper valve assembly of the invention after the flow sleeve has been pulled upwardly a sufficient distance that the bow spring detent member has engaged the lower detent groove and the flapper has

closed, thereby blocking the flow of fluids toward the surface;

Figure 5 is a cross-sectional view taken along line 5--5 of Figure 4 through the flapper valve assembly of the invention;

Figure 6 is an enlarged elevation view, partially broken away, of the shift head assembly of the invention;

Figure 7 is a cross-sectional view taken along line 7--7 of Figure 6 through the shift head assembly of the invention; and

Figure 8 is an enlarged detail view, partially in section, depicting the engagement of a shift key with the lower annular recess of the locking sleeve as shown in Figure 3.

Like reference numerals are used to indicate like parts in all figures of the drawings.

Referring to Figure 1, drilling rig 10 is positioned at ground surface 12 over well bore 14. Casing 16 is fixed by cement 18 inside well bore 14, and normally extends 300 to 400 feet below kick-off point 21, where the inclination of well bore 14 begins to deviate from substantially vertical, as might occur during horizontal drilling or in a highly deviated well. Drill string 20 extends downwardly through casing 16 from drilling rig 10, beyond casing end 23, and into the section of well bore 14 that lies horizontally in stratum 32. At the distal end of drill string 20 is a bottom hole assembly that typically comprises MWD (measuring while drilling) equipment 22, stabilizer 24, mud motor 26, shift head 28 and drill bit 30. Flapper valve assembly 34 of the invention is preferably cemented into well bore 14 together with casing 16, and drill string 20 passes through flapper valve assembly 34 as it enters or leaves the hole. According to a particularly preferred embodiment of the invention, flapper valve assembly 34 is installed in casing 34 about 100 hundred feet above kick-off point 21.

Referring to Figures 2 and 3, flapper valve assembly 34 preferably comprises as its primary structural elements upper body member 36, lower body member 38, flow sleeve 40, valve seat sleeve member 42, flapper 54, flapper hinge assembly 56, and spring strut assemblies 58. Upper body member 36 and lower body member 38 are preferably made of tubular steel, and are connected to each other by weld 44, although it is understood that a threaded connection can be used instead of the weld if desired. As shown in Figure 2, upper body member 36 is threaded onto casing section 70, and casing section 72 is threaded onto lower body member 38. For ease of illustration, the well bore and cement are not shown except in Figure 1.

Flapper valve assembly 34 is preferably run into a well in its fully open position, with flow sleeve 40 and flapper 54 in the positions shown in Figure 3 so that cement will not contaminate, foul or otherwise restrict operation of the valve. Lower and upper O-rings 86, 88, respectively, prevent cement from penetrating into the annular space between flow sleeve 40 and upper and lower body members 36, 38 as cement is pumped down casing 16 so that it can circulate back up the annulus between the outside wall of casing 16 and well bore 14. After casing 16 is cemented, it is desirable to wash out the casing, or if necessary, run a scratcher or scraper down through the casing and flow sleeve 40 to insure that upper and lower annular recesses 66, 68, respectively, are clear and available for engagement with shift keys 80 of shift head assembly 76 as described below in relation to Figures 3 and 4.

Flow sleeve 40 is substantially cylindrical, and has an outside diameter slightly less than the inside diameter of upper body section 36 to facilitate longitudinal sliding engagement therebetween. Inside surface 64 of flow sleeve 40 preferably comprises upper and lower annular recesses 66, 68, respectively. Upper annular recess 66 is visible in Figures 2 and 3, and lower annular recess 68 is visible in Figures 3 and 4. The outside surface of flow sleeve 40 preferably comprises annular lower detent groove 50 and upper detent groove 52, which are adapted to receive detent members 45 of bow spring 46 disposed in annular recess 48 on the inside wall of upper body member 36. As shown in Figure 2, flow sleeve 40 is maintained in its uppermost position in flapper valve assembly 34 whenever detent member 45 of bow spring 46 is engaged in lower detent groove 50. Flow sleeve 40 is inserted into flapper valve assembly 34 prior to connecting upper body member 36 to lower body member 38.

Valve seat sleeve member 42 is likewise preferably inserted concentrically into flapper valve assembly 34 prior to assembling upper body member 36 and lower body member 38. Valve seat sleeve member 42 preferably comprises outwardly extending flange 94 that engages and is supported by annular shoulder 92 of lower body member 38. When upper and lower body members 36, 38 are joined by weld 44, valve seat sleeve member 42 is locked into position between annular shoulder 92 and abutting annular shoulder 95 at the lower end of upper body member 36. Although the inside surface of valve seat sleeve member 42 is generally cylindrical, its lower edge presents a constant radius arcuate seating surface 116 generated at an angle less than 90 degrees, and preferably at an angle of about 45 degrees, with the center line of flapper valve assembly 34. Flow sleeve 40 is adapted to slide longitudinally inside valve seat sleeve member 42. The inside diameter of flow sleeve 40 is slightly greater than the outside diameter of drill string 20, including any element of the bottom hole assembly, so that drill string 20 can pass through flapper valve assembly 34.

Flapper 54, the valve closure member, is a section of a cylinder that has an inside radius identical to that of valve seat sleeve member 42 and an arcuate sealing edge 124 that is adapted to engage and seal against seating surface 116. According to a preferred embodiment of the present invention, valve seat sleeve member 42 and flapper 54 are designed and constructed so that sealing edge 124 fully engages seating surface 116 after flapper 54 has rotated about 45 degrees from its fully open position, as is discussed in more detail in relation to Figure 4A below. Because flapper 54 is a cylindrical section, it can be hidden behind flow sleeve 40 when in the open position as shown in Figure 3, but can be rotated to the fully closed position shown in Figures 2 and 4A without interfering with the inside wall of lower body member 38.

Flapper 54 is preferably installed inside flapper valve assembly 34 through a window in lower body member 38 that is defined by vertical edges 96 (one of which is not visible in the longitudinal section shown in Figures 2 and 4A), arcuate bottom edge 97, and arcuate top edge 99 (visible in Figure 5 and shown as a hidden line in Figure 4A). Arcuate window cover 98 is preferably attached to lower body member 38 by means such as peripherally extending weld 100 after flapper 54 is inserted through the window, and after and flapper hinge assembly 56 and spring strut assemblies 58 are connected to lower body member 38. Although only one spring strut assembly 58 is visible in Figure 2, flapper valve assembly 34 of the invention preferably comprises a plurality of spring strut assemblies 58, with at least one spring strut assembly 58 being disposed on each side of hinge assembly 56.

The structure and installation of flapper 54, flapper hinge assembly 56 and spring strut assemblies 58 are further described and explained in relation to Figures 3, 4, 4A and 5, enlarged views in which they are more clearly visible. Flapper hinge assembly 56 preferably further comprises hinge member 110 and hinge pin 112. Hinge member 110 is preferably secured in fixed relation to the upper, outwardly facing surface of flapper 54 at the midpoint of the circumferentially extending arc defined by flapper 54, as seen in Figure 5. Hinge member 110 is preferably rotatably mounted on transversely extending hinge pin 112, and hinge pin 112 is connected in fixed relation to lower body member 38 at a point offset radially outward from the longitudinal axis through the longest section of flapper 54 as shown in Figure 3. According to a particularly preferred embodiment of the invention, best seen in Figure 5, hinge pin 112 is welded into a semi-circular saddle in the face of arcuate top edge 99 of the window in lower body member 38. Elastomeric seal 114 is preferably molded around

sealing edge 124 of flapper 54 to promote a fluid-tight sealing between flapper 54 and valve seat sleeve member 42 whenever flapper valve assembly 34 is rotated to the closed position.

Spring strut assemblies 58 each preferably comprise upper hinge 60, lower hinge 62, guide member 104, strut spring 106 and hinge support member 122. Each upper hinge 60 rotatably connects a spring strut assembly 58 to flapper 54 at a point that is spaced downwardly from hinge member 110. Strut spring 106 biases flapper 54 toward the closed position. By distancing the upper hinge 60 longitudinally from hinge pin 112, the spring force required to start moving a closure member such as flapper 54 from the open to closed position is reduced. The use of a plurality of spring strut assemblies 58, preferably two, circumferentially spaced an equal distance on each side of hinge member 110, also reduces the stress on flapper hinge assembly 56. Arcuate recess 108 is preferably provided on the outwardly facing side of flapper 54 to facilitate the rotation of flapper 54 relative to upper hinge 60 between the open position of Figures 3 and 4 and the closed position shown in Figure 4A. Hinge support member 122 is preferably angled so that upper hinge 60 is disposed radially inward relative to both hinge pin 112 and lower hinge 62. This spacing provides a positive moment that enables strut spring 106 to act through hinge support member 122 on upper hinge 60 to begin forcing flapper 54 radially inward once flow sleeve 40 is retracted upwardly above hinge point 112. This spacing also allows guide member 104 to rotate into the annular space between flapper 54 and window cover 98 when flapper 54 is forced open by the downward motion of flow sleeve 40 as described below in relation to Figure 3, compressing strut spring 106. Recess 102 is preferably provided in lower body portion 38 to accommodate the rotational motion of guide member 104 around lower hinge 62.

Referring to Figure 3, casing shut-in valve system 74 of the invention preferably comprises flapper valve assembly 34 and means such as shift head assembly 76 for controlling the movement of flow sleeve 40 between the upper position shown in Figure 2 and the lower position shown in Figure 3. As shift head assembly 76 is run into the well, shift keys 80, which are biased radially outward, first engage upper annular recess 66 of flow sleeve 40 while flow sleeve 40 is locked in the upper position as shown in Figure 2. When beveled surface 164 of shift keys 80 engages beveled surface 166 of upper annular recess 66, outwardly biased shift keys 80 are cammed out of upper annular recess 66 and pushed back into windows 136, and shift head assembly 76 continues traveling downwardly through flow sleeve 40. When shift head assembly 76 reaches the bottom of part of flow sleeve 40, shift keys 80 engage lower annular recess 68. As shown in more detail in Figure 8, square shoulder 168 of shift keys 80 engages and abuts against square shoulder 170 of lower annular recess 68, stopping the downward travel of shift head assembly 76 through flapper valve assembly 34.

Once shift keys 80 are engaged in lower annular recess 68 of flow sleeve 40, sufficient downward force is exerted on shift head assembly 76 through drill string 20 that bow spring 46 is overpressured, causing detent member 45 to disengage from lower detent groove 50. According to a preferred embodiment of the invention, the restraining load on detent members 45 and bow spring 46 is at least about 10,000 pounds. Because of the heavy weight of drill string 20 hanging from the hook of drilling rig 10, a high order detent is required so that personnel at the surface can recognize when shift head assembly 76 has engaged flow sleeve 40.

Once detent members 45 have disengaged from lower detent groove 50, flow sleeve is pushed downwardly by shift head assembly 76 until detent members 45 again

engage upper detent groove 52 as shown in Figure 3. When flow sleeve 40 reaches this position, bottom edge 82 is spaced slightly apart from beveled annular shoulder 84 of lower body member 38, but beveled shoulder 164 of shift keys 80 contacts and slides against beveled shoulder 84 of lower body member 38 to cam outwardly biased shift keys 80 out of lower annular recess 68 and back into windows 136.

As drill bit 30 precedes shift head assembly 76 downward through flapper valve assembly 34, drill bit 30 contacts flapper 54, rotating flapper 54 from the position shown in Figure 2 toward the position in which it is shown in Figure 3. As flow sleeve 40 is pushed far enough down through valve seat sleeve member that bottom edge 82 contacts flapper 54, flapper 54 is rotated downwardly about 45 degrees into substantially parallel alignment with flow sleeve 40 in the annular space between flow sleeve 40 and window cover 98. As flapper 54 rotates from its closed position into its open position, strut spring 106 is compressed, preparing spring strut assemblies 58 to rotate flapper 54 inwardly again when flow sleeve 40 is returned to its upper position.

The closing of flapper valve assembly 34, as is desirable during tripping to prevent hydrocarbon fluids downhole from overpressuring the drilling mud when the well is underbalanced, is described in relation to Figures 4 and 4A. As the bottom hole assembly of drill string 20 is withdrawn upwardly through flapper valve assembly 34, shift keys 80 of shift head assembly first engage lower annular recess 68 of flow sleeve 40. As beveled surface 172 of shift keys 80 contacts and slides against beveled surface 174 of lower annular recess 68, outwardly biased shift keys 80 are cammed out of lower annular recess 68 and pushed back into windows 136. Shift head assembly 76 then travels upwardly through flow sleeve 40 until shift keys 80 engage upper annular recess

66 as shown in Figure 4. When square shoulder 176 of shift keys 80 engages square shoulder 178 of upper annular recess 66, the upward movement of shift head assembly 76 is stopped until the upward force exerted on shift head assembly 76 through drill string 20 overpressures bow spring 46, causing detent members 45 to snap out of upper detent groove 52.

Once detent members 45 disengage from upper detent groove 52, shift head assembly 76 forces flow sleeve 40 upwardly to the point where detent members 45 of bow spring 46 engage lower detent groove 50 of flow sleeve 40 as shown in Figure 4A. Referring to Figure 4A, as flow sleeve 40 moves up, flapper 54 is rotated through a preferred angle 128 of about 45 degrees from the fully open position to the fully closed position. This rotation is initiated by the action of strut spring 106 on hinge support member 122, which causes hinge 60 to rotate away from window cover 98. Once flapper 54 begins to traverse the bore of lower body member 38, the fluid pressure differential across flapper valve assembly 34 causes sealing edge 124 of flapper 54 to fully seat itself against seating surface 116 of valve seat sleeve member 42. Shut-in pressure exerted on flapper 54 from downhole squeezes elastomeric seal 114 against seating surface 116, thereby improving the seal.

Because the preferred angle of rotation is only about 45 degrees, as compared to the 90 degrees of rotation experienced with conventional flapper valve assemblies, flapper 54 gathers less momentum and less stress is exerted on hinge member 110 and hinge pin 112 when flapper 54 closes. Because of the high pressures that may be exerted on flapper 54 from downhole once flapper 54 begins to close, the smaller angle of rotation and the shorter distance of travel for flapper 54 achieved through use of the invention disclosed herein should minimize the slamming effect on flapper 54 and valve seat sleeve member 42. This will in turn result in

fewer instances of flapper valve failure, and will prolong the life of elastomeric seal 114.

The structure and operation of shift head assembly 76 is further described and explained in relation to Figures 6 and 7. Shift head assembly 76 preferably comprises key housing 134 having a plurality of circumferentially spaced windows 136 containing shift keys 80 that are biased radially outward by key springs 156. According to a preferred embodiment of the invention, three shift keys 80 are provided at an angular spacing of 120 degrees around key housing 134, although it will be appreciated that four or more shift keys can be used within the scope of the invention. Fewer than three shift keys can also be used, but in such instances shift keys having a greater arcuate span and circumferentially spaced key springs are desirable to better distribute the mechanical load and avoid hang-ups.

The maximum diameter of key housing 134 is preferably slightly less than the inside diameter of flow sleeve 40. Windows 136 and shift keys 80 are preferably designed so that shift keys 80 are biased radially outward through windows 136 by key springs 156 a sufficient distance to engage upper and lower annular recesses 66, 68 of flow sleeve 40 when passing therethrough. Shift keys 80 are also adapted to be forced radially inward to a point flush with or slightly inside the outside diameter of key housing 134 to reduce wear and avoid hang-up that might otherwise occur. Key springs 156 are preferably retained inside radially extending cylindrical recesses 158 in keys 80 by sleeve 160. Although not visible in Figures 6 and 7, each shift key 80 preferably comprises two key springs 156 disposed in cylindrical recesses 158 that are parallel and vertically spaced. The use of a plurality of vertically spaced key springs 156 for each shift key 80 enables the key to "float" to some extent, and facilitates engagement with and disengagement from flow sleeve 40.

Key housing 134 is typically mounted on bit sub 144 having externally and internally threaded ends 148, 150, respectively, using a rubber Cutless® (trademark) bearing 152 of the type manufactured by Uniroyal/Goodrich and well known to those of ordinary skill in the art. The use of a bearing such as a Cutless® bearing is desirable to prevent key housing 134 from rotating with the drill string or with the mud motor output shaft. If permitted, such rotation would quickly cause undesirable wear to shift keys 80 and key housing 134. As shown in Figure 7, Cutless® bearing 152 is lubricated by drilling fluid that flows radially outward from flow channel 146 through bleed orifice 154.

When shift head assembly 76 is used with a bent sub, as is frequently the case in the "steered drilling" of a horizontal well, key housing 134 is likely to be canted slightly, such as from about ½ to about 1 degree, when it passes through flow sleeve 40 of flapper valve assembly 34. To help ensure that the mechanical load on shift keys 80 is evenly distributed, load equalizer plates 138 are preferably provided at each end of key housing 134. Each load equalizer plate 138 preferably comprises an annular boss 139 that bears on a relatively soft O-ring 140 disposed in annular groove 142. As shift head assembly 76 engages flow sleeve 40, load equalizer plates 138 remain normal to the bit centerline, but O-rings 140 allow key housing 134 to cant slightly (such as from about ½ to about 1 degree) to allow shift keys 80 to align longitudinally with flow sleeve 40. This distributes the load more evenly to circumferentially spaced shift keys 80.

While the apparatus of the invention is described herein in relation to its preferred embodiment, it will be appreciated that the flapper valve assembly disclosed herein is applicable to downhole uses other than as a casing shut-in valve, such as for example, in a surface controlled, subsurface safety valve where the flapper is closed by a piston actuated by hydraulic pressure.

CLAIMS:

1. A valve for use within a conduit in a subterranean well, the valve comprising a valve seat, a valve closure member rotatable about a hinge point between open and closed positions through an included angle of less than 90°, and control means for movement of the valve closure member reversibly between the open and closed positions, the control means comprising means for biasing the valve closure member to a closed position and said biasing means comprising a plurality of spring strut assemblies rotatably connected to the valve closure member, with at least one strut assembly being rotatable connected to the valve closure member on each side of the hinge point of the valve closure member.

2. A valve system for use within a conduit in a subterranean well, the valve system comprising a valve including a valve closure member, and means for displacing the valve closure member; the valve comprising a substantially cylindrical body, a valve seat, said valve closure member being rotatable in the body about a hinge between open and closed positions through an included angle of less than 90°, means for biasing the valve closure member towards the closed position, said biasing means comprising a plurality of strut assemblies rotatably connected to the valve closure member at circumferentially spaced points, with at least one strut assembly being disposed on each side of the hinge of the valve closure member; a sleeve member being adapted to slide reversibly between first and second positions inside the body corresponding respectively to the open and closed positions of the valve closure member; and the means for displacing the valve closure member comprising a shift head assembly having means for releasably engaging the sleeve member for selectively moving the sleeve member between the first and second positions.

3. A valve system according to claim 2, wherein the strut assemblies are connected to the valve closure member at points that are longitudinally spaced apart from the hinge of the valve closure member.

4. A valve system according to claim 2, wherein each strut assembly comprises a guide member and a hinge support member that are slidably engaged, the guide member being rotatably connected to the body of the valve assembly and the hinge support member being rotatably connected to the valve closure member, and means for biasing the hinge support member away from the guide member.

5. A valve system according to claim 4, wherein the hinge support member of at least one strut assembly is rotatably connected to the valve closure member at a position that is radially inward of the hinge of the valve closure member.

6. A valve system according to claim 4, wherein the hinge support member of at least one strut assembly is rotatably connected to the valve closure member at a position that is radially inward of the position where the guide member is rotatably connected to the body.

7. A valve system according to any one of claims 4 to 6, wherein the means for biasing the hinge support member away from the guide is a spring.

8. A valve system according to any one of claims 2 to 7, wherein the valve closure member has an arcuate sealing surface on which there is an elastomeric seal.

9. A valve for use within a conduit in a subterranean well, constructed and arranged for use and operation substantially as described herein with reference to the

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accompanying drawings.

10. A valve system for use within a conduit in a subterranean well, constructed and arranged for use and operation substantially as described herein with reference to the accompanying drawings.