VALVE

This invention pertains to valves and in particular to a dual valve device utilizing a sleeve valve coupled to a ball valve, a pressure differential sensor, and a valve positioner and operator.

When drilling or operating earth wells, it is highly desirable to have apparatus in the well which may operate to maintain pressure control and prevent "blowouts" by closing off well overflow near the producing formation and providing means to introduce heavy fluid into the well to "kill" the well.

One such system is shown on p. 813 of the 34th revision of the "Composite Catalog of Oilfield Equipment and Services" and is described as a "block-kill" system. This system requires numerous downhole devices such as a block-kill actuator, an actuator mandrel, control line, and a block-kill valve which are operated by additional surface pumping equipment pressure required to apply pressure to the well annulus at the surface. A complicated system with fragile parts of this type could not be depended on to remain operable over long periods when used in well drill pipe as drill pipe is subjected to frequent impact, compression, tensile, torquing, and combination loads while drilling.

The valve of the present invention replaces all the numerous devices required in the above described system and operates automatically in close formation outflow and open wall flow passages to allow killing fluid to be pumped in.

According to the invention, a dual valve for use in wells comprises:

a. a tubular housing, connectable to well tubes at both ends, having a longitudinal flow passage therethrough and at least one flow passage through said housing wall intersecting said longitudinal flow passage;

b. coupled flow control means in said housing for controlling flow through said wall and longitudinal flow

passages;

c. unlockable locking means for locking said coupled flow control means in operating position with said longitudinal flow passage open to flow and said wall flow passage closed to flow;

d. sensor means to unlock said locking means when pressure outside the valve exceeds a defined pressure in the valve; and

e. operating means in said housing to operate said coupled flow control means closing said longitudinal flow passage to flow and opening said wall flow passage to flow.

The invention device preferably houses in one rugged unit, which may be included in well tubing or drill pipe, a ball valve coupled to a sleeve valve, an annulus pressure sensor, a lock positioning the sleeve valve closed, closing the wall flow passages above the ball valve to annulus inflow and positioning the coupled ball valve open to flow through the housing. As the valve is positioned in this position, an operating spring is compressed to furnish operating force.

The valve is then run to the desired depth in the well and when annulus pressure outside the valve exceeds housing through flow passage pressure inside the valve by a preset amount, the sensor unlocks the positioning lock releasing the compressed spring to close the ball valve, closing off formation flow, and opening the sleeve valve and wall flow passages to flow pumped in from the well annulus to kill the well.

A main ball valve device of the type shown in U.S. Patent No. 4,140,153 to Deaton, herein incorporated by reference, is utilized in the present invention. The ball valve could be of the type disclosed in U.S. Patent No. 4,289,165 to Fredd or, like the prior art, a flapper type valve could be utilized.

The sensor in one embodiment of the present invention is a spring loaded differential piston which is moved by

greater pressure outside the dual valve to compress a spring and operate a collet type lock positioning device.

The sensor in another embodiment is a number of precharged bellows which react to pressure outside the valve and operate a ratchet type positioning lock.

Both embodiments of the invention valve may be reset to operate repeatedly while in place in the well.

The invention provides an improved block and kill valve which is simple and rugged enough to be used in well drilling pipe. The invention also provides an improved block and kill valve which automatically operates when preset annulus pipe pressure differentials are present. Operating pressures may be preset, and the valve may be reset to operate repeatedly without being retrieved from the well.

Reference is made to the drawings, in which:

Figure 1 (A and B) is an elevational view of an embodiment of the invention dual valve, half sectioned, showing the valves positioned to operate during and after installation in a well;

Figure 2 (A and B) is of the valve of Figure 1 after operation;

Figure 3 (A and B) shows another embodiment of the dual valve of the present invention in elevation, half sectioned, wherein the two valves are positioned to operate;

Figure 4 shows the valve of Figure 3 after operation;

Figure 5 is a fragmentary enlarged view of the lock mechanism of the embodiment of Figure 3 in the locked position; and

Figure 6 is a fragmentary enlarged view of the lock mechanism of the embodiment of Figure 3 in the unlocked position.

Referring now to Figure 1 showing the dual valve 10 locked in position for installation in a well, the valve 10 is provided an appropriate top connection 11 and bottom connection 12 for connecting the valve 10 into a well pipe string to be lowered into a well. An internal profile 13 is

provided in upper connector 14. The upper end of operator tube 15 is slidably received in upper connector bore 16. A downward facing shoulder 15a is provided on operator tube 15 to compress operating spring 17, and a longitudinal bore and flow passage 15b is provided therethrough. Upper connnector 14 is connected to upper housing 18 at thread 19 and sealed thereto with seal 20. Housing 18 is provided with internal shoulder 21 on opposite sides of which press operator spring 17 and piston spring 22. The lower end of piston spring 22 presses through ring 23 on the upper end of sensor piston 24. A seal 25 is provided in internal shoulder 26 in lower housing 27 slidably sealing piston 24 to housing 27. At least one port 27a is provided in housing 27. A seal 28 is also provided for sealing upper housing 18 to lower housing 27 above their connecting threads 29. Another seal 30 in sensor piston 24 slidably seals it to the outside of operator tube 15. An internal bore 31 is provided in the lower end of piston 24 and groove 32 is formed in the outside of operator tube 15. Collet 33 with arm lug portions 34 is installed over the upper end of insert 35 and retained thereon by set screws 36. Seal 37 slidably seals insert 35 to operating tube 15. Lower connector 38 is connected to lower housing 27 at threads 39 and sealed to insert 35 with seal 40. At least one port 41 is provided in operating tube 15. A chamfered shoulder 42 is formed on the lower end of insert 35, engageable by secondary valve surface 43a formed on seat member 43. Seat member 43 is connected to operator tube 15 at threads 44.

The construction and operation of ball valve device 45, housing in lower connection 38, is described in U.S. Patent No. 4,140,153. The ball valve device 45 includes shoulder 42, seat member 43, control arms 46 fitted to ball member 47 in frame 48, seat 43b formed on the lower end of seat member 43, and shoulder 49 in lower connector 38.

Figure 3 shows another embodiment of the invention, in which valve 50 utilizing a pair of bellows 51 with lower ends joined to body connector 52. The upper ends of bellows

51 are joined to ring 53. Ring 53 is secured to latch tube 54 with screws 55 when bellows 51 are in slots 56 provided for the bellows in latch tube 54. Bellows 51 and ring 53 may be gas pressure charged internally by loosening screw seals 57, opening passages 58 to admit pressured gas into bellows 51 and ring passage 53a, and tightening seals 57 to seal the charge in the bellows and passages. Slots 59 are cut near the lower end of latch tube 54 through which pawls 60 may engage teeth 61 on operating tube 65 (see also Figures 5 and 6). Pawls 60 are positioned in opposed slots 62 in the lower end of body connector 52 and are retained by and pivot around pins 63. Camming surfaces 64 and 66 are formed at either end of slots 59 to cam pawls 60 into and out of engagement with teeth 61. The lower end of latch tube 54 is enlarged to extend camming surface 66. A longitudinal flow passage 67 is provided through operating tube 65. An operating spring 68 biases operator tube 65 upwardly. At least one port 69 is provided in tube 65. A seal 70 slidably seals tube 65 in connector 72. At least one port 71 is provided in lower housing 73.

Either embodiment of the present invention may be preferred by a well operator depending on conditions in a particular well.

To utilize the embodiment of this invention shown in Figures 1 and 2, the dual valve 10, if not in the running and operating position shown in Figure 1, is placed in position on the surface by pushing down on the upper end of operating tube 15, to move operating tube 15 downwardly (disengaging valve 43a from shoulder 42), compressing spring 17, rotating ball valve 45 to open flow passage 15b to flow while moving ports 41 below seal 37 to close flow through ports 41. When groove 32 on tube 15 is opposite lugs 34, spring force in the collet arms 33 moves lugs 34 into groove 32 and compressed spring 22 moves ring 23 and piston 24 down and bore 31 over lugs 34 to lock lugs 34 in groove 32 and operator tube 15 and the valve 10 in running and operating position.

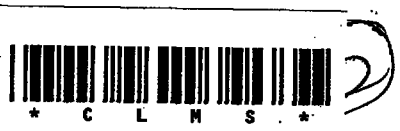
The valve 10 is then connected into a well tube string and lowered to desired depth in the well. As ball valve 45 is open, two-way well flow may occur freely through flow passage 15b, and no flow may occur through ports 41 as they are below seal 37. In the event pressure in the well annulus outside the valve 10 acting through ports 27a on the sealed differential piston area between the inside of seal 30 and the outside of seal 25 produces an upward force on piston 24 sufficient to overcome the combined downward forces of compressed spring 22 and force produced by pressure in flow passage 15b acting down on sealed differential piston area from the outside of seal 25 to the inside of seal 30, piston 24 moves up compressing spring 22. The rate of spring 22 may be preselected to determine a desired pressure difference between well tube pressure in valve flow passage 15b and greater well annulus pressure outside of valve 10 to move piston 24 up. Upward movement of piston 24 continues until bore 31 is above the upper end of lugs 34 unlocking lugs 34 to be moved out of groove 32. Compressed spring 17 maintains an upward bias on operating tube 15 sufficient to cam lugs 34 outward from groove 32 with cam surface 32a, releasing the tube 15 to be moved up until ports 41 are above seal 37 and in pressure communication with ports 27a, and ball valve 45 has rotated to close flow passage 15b and well outflow (Figure 2). If required, fluid may be pumped down the well annulus through ports 27a and 41 into flow passage 15b and up in the well tube to a level sufficient to overcome well pressure on the lower side of the closed ball valve 45, "killing" the well.

To reposition the valve 10 to operating position, reopening ball valve 45 and closing ports 41 to flow, an appropriate tool may be lowered in the well tube to contact the upper end of operator tube 15 and push it down to reposition valve 10 in locked operating position.

To utilize the embodiment shown in Figures 3 and 4, bellows 51 are pressure charged to a predetermined pressure which will automatically operate the dual valve 50 when

pressure outside the valve is slightly greater than pressure in bellows 51. If valve 50 is in the operated position as shown in Figure 4, it must be repositioned to the run and operate position as shown in Figure 3 by pushing down on the upper end to move operator tube 65 down, "ratcheting" teeth 64 by pawls 60, compressing spring 68, moving ports 69 below seal 70, and rotating ball valve 45 open. The pressure charge in bellows 51 maintains the bellows extended and exerting a constant upward pull on latch tube 54. Cam surfaces 66 on tube 54 are constantly urging pawls 60 into engagement with teeth 64 on tube 65. Operator tube 65, therefore, is automatically locked in down position by pawls 60 engaging a tooth 64 (see Figure 5). Ports 69 are now below seal 70 and closed to flow, and ball valve 45 is open for flow through flow passage 67, as shown in Figure 3. The valve 50 is then connected into a well tube and lowered into the well to the desired depth. When well annulus pressure outside the valve 50, acting through ports 71 in housing 73 up through clearances between outside latch tube 54 and inside housing 73 and connector 52, overcomes the pressure charge in bellows 51, the well annulus pressure compresses and shortens the bellows and moves latch tube 54 down. Cam surfaces 66 are moved out of engagement with pawls 60 and cam surfaces 64 contact and cam pawls 60 around pins 63 out of engagement with teeth 61 (Figure 6), unlocking tube 65 to be moved up by compressed spring 68. Upward movement of tube 65 moves ports 69 above seal 70 and rotates ball valve 45. Valve 45 has closed flow passage 67 to upflow and ports 69 are above seals 70 and open to flow through ports 71 into and up flow passage 67 as shown in Figure 4.

An appropriate tool may later be lowered in the well tube to engage the upper end of and move operating tube 65 down repositioning the dual valve 50 for repeated operation.



CLAIMS

1. A dual valve for use in wells comprising:

a. a tubular housing, connectable to well tubes at both ends, having a longitudinal flow passage therethrough and at least one flow passage through said housing wall intersecting said longitudinal flow passage;

b. coupled flow control means in said housing for controlling flow through said wall and longitudinal flow passages;

c. unlockable locking means for locking said coupled flow control means in operating position with said longitudinal flow passage open to flow and said wall flow passage closed to flow;

d. sensor means to unlock said locking means when pressure outside the valve exceeds a defined pressure in the valve; and

e. operating means in said housing to operate said coupled flow control means closing said longitudinal flow passage to flow and opening said wall flow passage to flow.

2. A valve according to Claim 1, wherein said coupled flow control means comprise upper and lower valves movable longitudinally between open and closed positions and coupled such that when said upper valve is closed, said lower valve is open, and when said upper valve is open, said lower valve is closed.

3. A valve according to Claim 1 or 2, wherein said unlockable locking means comprise:

a. a longitudinally movable operator tube having a groove thereon;

b. a collet in said housing having at least one arm with a lug portion, said lug portion engageable in said groove; and

c. means retaining said lug portion engaged in said groove.

4. A valve according to Claim 3, wherein the defined pressure includes the pressure within the longitudinal flow

passage.

5. A valve according to Claim 1 or 2, wherein said unlockable locking means comprise:

a. a longitudinally movable operator tube having teeth thereon;

b. a longitudinally movable latch tube surrounding said operator tube having at least one slot therethrough, said slot having a camming surface in each end;

c. at least one pawl, pivotably anchored in the housing and extending through said latch tube slot, said pawl having at least one tooth thereon and cammable by said cam surface in the lower end of said latch tube slot to pivot and engage said operator tube teeth on upward movement of said latch tube and cammable by said cam surface in the upper end of said latch tube slot to pivot and disengage said operator tube teeth on downward movement of said latch tube.

6. A valve according to Claim 4, wherein the sensor means comprise:

a. a shoulder in the housing;

b. a longitudinally movable piston disposed in said housing around said operator tube and slidably sealed to said housing and said operator tube; and

c. a resilient bias surrounding said tube below said shoulder biasing said piston downwardly.

7. A valve according to Claim 5, wherein the sensor means comprise at least one pressure chargeable bellows in the housing having one end connected to said housing and the other end connected to said latch tube, said defined pressure being the pressure within the bellows.

8. A valve according to Claim 5 or 7, wherein said operating means comprise:

a. a shoulder on the operator tube;

b. a shoulder in said housing; and

c. a resilient bias surrounding said tube between said shoulders biasing said tube upwardly.

9. A valve according to Claim 2, wherein said upper valve is a sleeve type valve and said lower valve is a ball type valve.

10. A valve according to Claim 3, wherein said retaining means is a bore in the sensor means piston.

11. A valve according to Claim 5 or 8, wherein said resilient bias is a coil spring.

12. A valve according to Claim 9, wherein said upper and lower valves are coupled by an extension of the operator tube.

13. A dual valve for use in wells, substantially as described with reference to, or as shown in, Figures 1 and 2 or Figures 3 to 6 of the drawings.