Oct. 20, 1959 J. H. BOSTOCK 2,909,227

WELL TOOLS

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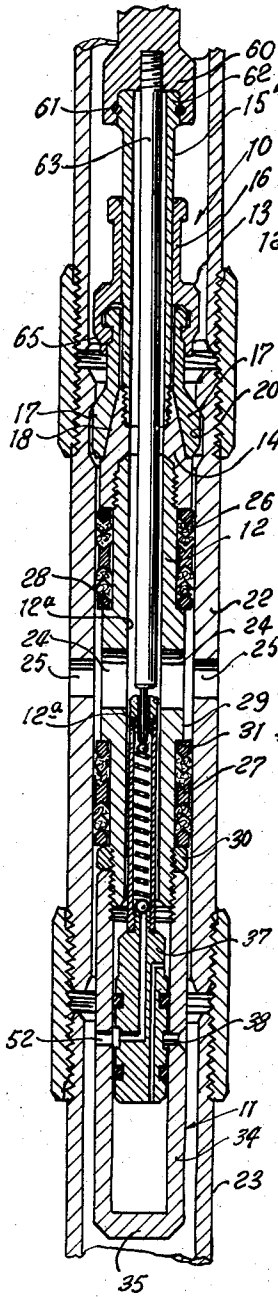


Fig. 1

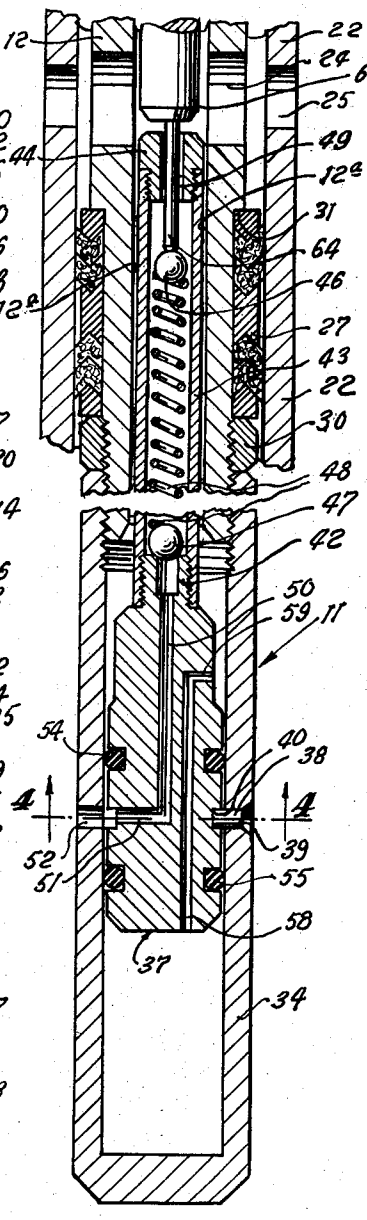


Fig. 2

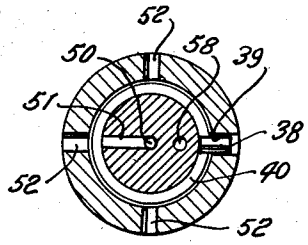


Fig. 4

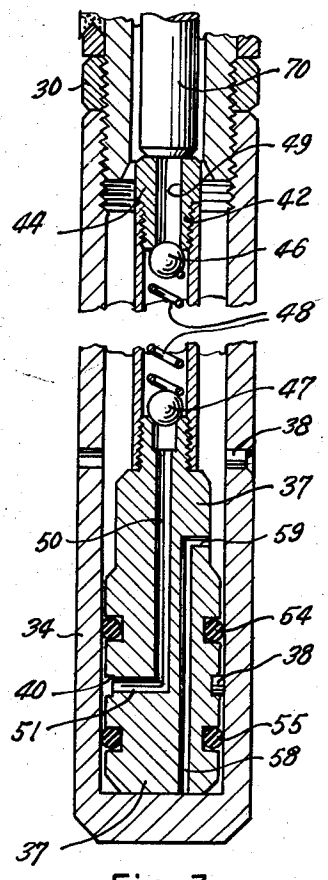


Fig. 3

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WELL TOOLS

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This invention relates to well tools and more particularly to a valve for controlling upward or downward flow of well fluid through such tools.

An object of the invention is to provide a new and improved valve for controlling flow of well fluids through well tools.

Another object is to provide a valve, of the type described, which may be connected to a well tool to prevent upward or downward flow of well fluid through the well tool.

Still another object is to provide a valve, of the type described, which may be opened during downward movement of the well tool in a well to permit equalization of fluid pressure thereacross during such downward movement and thus facilitate such movement.

A further object is to provide a valve, of the type described, which may be moved to an inoperative fully open position prior to removal of the well tool from the well to allow well fluids to flow through the well tool thereby equalizing fluid pressures across the well tool and thus permitting removal thereof from the well.

A still further object is to provide a valve, of the type described, wherein the upward active pressures of fluid below the well tool are utilized to help move the valve to inoperative position.

Another object is to provide a valve, of the type described, which, when in inoperative or fully open position, is not subjected to any pressure differential which might tend to move it to closed or operative position.

Still another object is to provide a valve, of the type described, whose operation is not affected by sand or other foreign matter which may lodge therein.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of a device constructed in accordance with the invention, and reference to the accompanying drawings thereof, wherein:

Figure 1 is a vertical sectional view of a well tool provided with the valve showing the well tool and valve being seated in a well flow conductor;

Figure 2 is an enlarged vertical sectional view of the valve connected to the lower end of the well tool and showing the manner in which the dependent prong of a running tool holds a ball check or equalizing valve of the valve open while the well tool is being lowered into the well to permit equalization of fluid pressure thereacross during such downward movement;

Figure 3 is a view similar to Figure 2 showing the valve in inoperative position to permit flow of well fluid through the well tool and also showing the lower end of a pulling tool prong employed to move the valve to inoperative position; and

Figure 4 is a horizontal cross-sectional view taken on line 4—4 of Figure 2.

Referring now to the drawings, the well tool 10 to which the valve 11 is connected may include a choke mandrel 12 provided at its upper end with a locking assembly 13. The locking assembly includes a locking

mandrel 14 threaded on the upper end of the choke mandrel and a carrier mandrel 15 threaded in the upper end of the locking mandrel. The carrier mandrel has slidingly disposed thereon a dog carrier 16 which carries outwardly movable locking dogs 17. The dogs are movable outwardly to the locking positions shown in Figure 1 by engagement with the downwardly and outwardly extending frusto-conical surface 18 of the locking mandrel when the dogs are moved downwardly thereon.

The dogs 17 engage in an internal annular locking recess 20 of a sealing nipple 22 connected in the well conductor 23 of the well, as shown in Figure 1, to lock the choke mandrel 12 in place in the sealing nipple with the lateral ports 24 thereof aligned with lateral ports 25 formed in the wall of the sealing nipple. The upper and lower packing assemblies 26 and 27, respectively, seal between the choke mandrel and the sealing nipple above and below the lateral port thereof.

The upper packing assembly 26 is held in place on the choke mandrel by the lower end of the locking mandrel and the upwardly facing annular shoulder 28 of the external annular flange 29 formed on the mid-portion of the choke mandrel while the lower packing assembly 27 is held in place by a retainer ring 30 threaded on the lower end of the choke mandrel and the downwardly facing annular shoulder 31 at the lower end of the flange 29 of the choke mandrel.

The packing assembly of the choke mandrel prevents any flow of well fluid upwardly past the choke mandrel, except that which enters into the choke mandrel through the lateral ports 24 and 25, when the valve 11 is in the operative or upper position shown in Figure 1.

The valve 11 includes a hollow cage 34 having its upper end threaded on the lower end of the choke mandrel and having its lower end closed by a bottom 35. A valve body or plunger member 37 is disposed in the cage and held against movement therein by a shear pin 38 which extends through a lateral opening 39 of the cage into a registering external annular groove 40 formed intermediate the ends of the valve body.

The valve body is provided with a reduced threaded upper neck or extension 42 on which is threaded the lower end of an elongate spring housing or stem 43 which extends upwardly into the central longitudinal bore 12a of the choke mandrel. A valve seat or bushing member 44 is threaded into the upper end of the spring housing or stem 43, and a pair of ball check valves 46 and 47 are disposed in the spring housing or stem and are yieldingly biased apart toward closed positions by a spring 48 whose opposite ends bear against the ball check valves. The upper ball check valve 46 seats against the valve seat 44 to close the bore 49 thereof while the lower ball check valve 47 seats against the upper extension 42 to close the flow passage 50 of the valve body.

The flow passage 50 extends downwardly and then laterally as at 51 so that its lower end of opening communicates with the groove 40 of the valve body and with lateral ports or apertures 52 formed in the wall of the cage. External annular seal rings 54 and 55 carried by the valve body above and below the groove 40 seal between the valve body and the cage above and below the lateral ports 52 of said cage, so that fluids entering the ports 52 are directed into the flow passage 50.

A by-pass flow passage 58 extends longitudinally from the lower end of the valve body 37 to a point above the upper seal ring 54 of the valve body, and there communicates with a lateral passage 59 which extends to the exterior of the valve body and communicates with the interior of the cage 34 above the seal ring 54. The lateral passage may be of smaller diameter than the by-pass flow passage for a reason to be hereinafter more fully described.

The well tool 10 and the valve 11 connected to the lower end thereof are lowered into the well by means of a running tool 60 adapted to be connected to and operated by means of the usual flexible line raising and lowering mechanism having a sinker bar and link jars (not shown) incorporated therein. The running tool is connected by pins or rivets 61 extending through suitable apertures in said running tool and in an external annular flange 62 at the upper end of the carrier mandrel 15. The running tool has an elongate dependent prong 63 which extends through the carrier mandrel and locking mandrel 14 into the choke mandrel 12 where its lower reduced portion or tip 64 extends through the bore 49 of the valve seat 44 to displace the upper ball check valve 46 to open position. This permits the well tool 10 and the valve to move easily downwardly even when the packing assemblies 26 and 27 of the choke mandrel enter into the sealing nipple 22 and seal between the nipple and the choke mandrel, because well fluid can continue to flow upwardly to equalize the pressure across the well tool 10 and the valve 11 through the lateral ports 52 of the cage, the flow passages 51 and 50 of the valve, displacing the lower ball check valve 47 to flow into the spring housing or stem 43 and thence through the bore 49 of the valve seat 44 to the bore of the choke mandrel.

The well tool is lowered until the shoulder 65 on the carrier 13 engages the upper end of the landing nipple 22, whereupon the dogs are positioned within the locking recess 20 of the sealing nipple. Jars are then imparted to the running tool to cause the locking mandrel to move upwardly between the dogs to hold the dogs in expanded locking positions wherein they extend into the locking recess and thus lock the well tool in place in the sealing nipple.

The running tool is then disconnected from the well tool by shearing the pins 61 and is withdrawn upwardly allowing the spring 48 to move the upper ball check valve to closed position against its valve seat.

Well fluids thereafter cannot flow upwardly from below the choke mandrel into the central longitudinal bore thereof, and only well fluids entering the choke mandrel through its lateral ports 24 from the ports 25 of the landing nipple can reach the surface. The fluid pressure from below acts equally on the seal rings 54 and 55, entering the cage therebetween through the ports 52, so that it does not tend to shear the pin 38. Similarly, the pressure from above acts on both sides of the valve body due to the provision of the by-pass passages 58 and 59, and therefore does not tend to shear the pin since the pressures to which the valve and the well tool are subjected are balanced across the two seal rings 54 and 55 even though a substantial pressure differential exists between the exterior and interior of the well conductor. The valve 11 must withstand differential pressures ranging up to several thousand pounds per square inch and, when it becomes desirable to remove the well tool 10, the valve must permit equalization of such pressures existing across the well tool since the locking mandrel 14 must be moved downwardly to release the dogs 17 before the well tool can be moved upwardly. This cannot be done easily if an upwardly acting pressure differential of several thousand pounds per square inch exists across the well tool and valve.

The pulling tool which is employed to remove the well tool 10 is provided with a dependent prong 70 which engages the valve seat 49 and drives the valve body 37 downwardly from the position shown in Figures 1 and 2 shearing the shear pin 38 as it does so, and moving the upper seal ring 54 below the lateral port 52 of the cage 34. The high pressure below the well tool now enters the valve cage and creates a downwardly acting pressure differential across the valve body, the pressure in the cage below the valve body being the same low pressure as exists in the bore of the choke mandrel, since the cage is connected to the mandrel through the by-pass passages 58 and 59 of the valve body. This downwardly acting pressure differential across the valve body exists for only a short period of time, since the pressures across the valve body will be quickly equalized by fluid flow downwardly into the cage through the by-pass flow passages 58 and 59. However, this period of downwardly acting pressure differential is of sufficient duration to permit such pressure differential to help positively move the valve body 37 to its lower inoperative position, shown in Figure 3. The duration of the period can be varied by varying the diameter of the lateral by-pass port or flow passage 59; the smaller the diameter of this lateral by-pass port, the longer the duration of the period. By-pass flow passages 58 and 59 also permit any fluids which may be present in the cage below the valve body to escape therethrough as the valve body is moved downwardly in the cage.

Once the valve body is moved to its lower inoperative position, it is not subjected to any upwardly acting pressure differential. The only force which may tend to move it upward is that created by the skin friction between the stem 43 and upwardly flowing well fluids, which is not great enough to move the valve body in the cage.

With the valve body in the inoperative position shown in Figure 3, well fluid from below the choke mandrel may flow into the longitudinal bore of the choke mandrel through the lateral port of the cage and thence into the lower end of the choke mandrel. As a result, the pressure across the well tool is equalized and the pulling tool may then be employed to jar the locking mandrel downwardly to free the dogs 17 from the locking recess 20 and thus permit upward removal of the well tool 10 and valve 11.

It will be noted that the stem 43 extends upwardly well into the longitudinal bore of the choke mandrel so that sand or other foreign material which may accumulate in the lower portion of the bore of the choke mandrel below the lateral ports 24 thereof will not prevent contact of the prong 70 of the pulling tool with the upper end of the valve body.

It is believed readily apparent that other types of locking and sealing means than those illustrated may be employed with the valve structure if desired.

It will now be apparent that a new and improved valve 11 for well tools, such as the locking and sealing assembly 10, has been provided which includes a valve cage connectible to the lower end of the well tool, a valve body 37 slidable longitudinally in the valve cage and having a flow passage 50 which communicates with a lateral port of the cage and also with the longitudinal bore of the well tool through an upward extension having a double acting ball check valve 46 and 47, means 38 for selectively holding the valve body in operative position in the valve cage wherein the flow passage 50 communicates with the lateral ports 52 of the cage, sealing means 54 and 55 between the valve body and the valve cage and disposed above and below the lateral ports 52 of the cage when the valve body is in operative position, and a by-pass flow passage 58 and 59 in the valve body communicating with the interior of the cage below the valve body and the longitudinal bore of the well tool.

It will also be apparent that, by proper dimensioning of the orifice of the by-pass flow passage 59, the upwardly flowing well fluids create a downwardly acting pressure differential across the valve body to force the valve body to inoperative position when the valve body is moved toward its lower inoperative position by a pulling tool prong. It will also be seen that one ball check valve 46 may be held in open position by a running tool while the well tool is being lowered into position in the well, whereby no pressure differentials are permitted to exist across the well tool which might tend to prevent such downward movement of the well tool.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. A valve for well tools comprising: a valve cage having a valve receiving chamber therein with an open upper end for connection to the lower end of a well tool which has a bore; a valve body in the valve cage and movable therein between first and second positions; said valve cage having a lateral aperture intermediate its ends providing fluid communication between the exterior of said cage and the chamber therein; said valve body having a flow passage one of whose ends communicates with said lateral aperture when said valve body is in its first position in said valve cage and the other of whose ends communicates with the open end of the cage; means on said valve body for operably closing said other of said ends of said passage in said valve body against flow in one direction therethrough; means sealing between said cage and said body above and below said lateral aperture in said cage and said one end of said valve body flow passage when said body is in said first position; means for initially releasably positioning said body in said first position; and a by-pass flow passage in said body communicating with the interior of said cage below said body and opening outwardly above said sealing means, said sealing means being ineffective to prevent fluid flow through said lateral aperture in said cage when said body is moved downwardly in said cage to its second position.

2. A valve for well tools comprising: a hollow valve cage having an open upper end for connection to the lower end of a well tool which has a bore; a valve body in the valve cage and movable therein between first and second positions, said valve cage having a lateral aperture intermediate its ends providing fluid communication between the exterior of said cage and the hollow interior thereof; said valve body having an upper portion adapted to extend upwardly in the open end of said valve cage; said valve body having a flow passage communicating at one end with the exterior of the upper end of said upper portion of said body and at its other end with the lateral aperture of the valve cage when said valve body is in its first position in said valve cage; valve means in said upper portion disposed to shut off fluid through the passage in said valve through the upper portion in either direction; means sealing between said cage and said body above and below the lateral aperture in the cage when the body is in its first position; means for initially releasably positioning said body in said first position; and a by-pass flow passage in said body communicating with the interior of said cage below the body and opening outwardly out of the body within the cage above the sealing means; the sealing means being positioned below the lateral aperture of the cage when the body is moved downwardly in said cage to its second position.

3. A valve for well tools comprising: a hollow valve cage having an open upper end for connection to the lower end of a well tool which has a bore; a valve body in the valve cage and movable therein between first and second positions; said valve cage having a lateral aperture providing fluid communication between the exterior of said cage and the interior thereof, said aperture being disposed intermediate the ends of said valve cage; said valve body having an upper portion reduced in diameter and projecting upwardly from said valve body; said valve body having a flow passage communicating with the exterior of the upper end of said upper portion of the valve body and with the lateral aperture of the valve cage when said valve body is in its first position in said cage; valve means in said upper portion comprising a pair of oppositely acting ball check valves, and means interposed between the ball check valves biasing the ball check valves in opposite directions toward closed position; means sealing between said cage and said body above and below the lateral aperture of the valve cage when the body is in its first position; shearable means for initially holding said body in said first position; and a by-pass flow passage in said body communicating with the interior of said cage below the body and opening outwardly of the valve body into the valve cage above the sealing means, the sealing means being ineffective to prevent fluid flow through the lateral aperture of the cage when the body is moved downwardly in said cage to its second position.

4. A valve for well tools comprising: a hollow valve cage having an open upper end for connection to the lower end of a well tool which has a bore; a valve body in the valve cage and movable therein between first and second positions, said valve cage having a lateral aperture providing fluid communication between the exterior of said cage and the interior thereof intermediate the ends of said cage; said valve body having a flow passage one of whose ends communicates with said lateral aperture in said cage when said valve body is in its first position in said valve cage and the other of whose ends communicates with the valve cage above said well body; a pair of oppositely biased ball valves in said flow passage in said valve body for operably closing off flow of fluid through said flow passage in said body; means sealing between said cage and said body above and below said lateral aperture in said valve cage and said one of said ends of said flow passage in said body when body is in its first position in said valve cage; a by-pass passage in said body communicating with the interior of said cage below said body and opening outwardly into said hollow valve cage above said sealing means; said sealing means being ineffective to prevent fluid flow through said lateral port when said body is moved downwardly in said cage to its second position in said cage; one of said ball valves being movable to an open position to permit flow of well fluid upwardly through the flow passage in the valve body; and means for initially releasably positioning said body in said operative position.

5. A valve for well tools comprising: a hollow valve cage having an open upper end for connection to the lower end of a well tool which has a bore; a valve body in the valve cage and movable therein between first and second positions; said valve cage having a lateral aperture formed therein intermediate its ends and providing fluid communication between the exterior of said cage and the interior thereof; said valve body having an upper portion reduced in diameter and extending upwardly from the upper end of said body; said valve body having a flow passage therein providing communication between the exterior of the reduced upper end of the valve body and with the lateral aperture of the valve cage when said valve member is in its first position in said valve cage; a pair of oppositely biased ball valves in said flow passage in said upper portion for preventing flow through the upper portion in either direction; means sealing between said cage and said body above and below the lateral aperture in said valve cage; when the body is in its first position in said valve cage; shearable means holding said body in said first position; a by-pass passage in said body communicating with the interior of said cage below the body and opening outwardly of said valve body into the valve cage above the sealing means, the sealing means being moved below the lateral port of the cage when the body is moved downwardly in said cage to its second position in said valve cage; one of said ball valves being movable to an open position to permit flow of well fluid upwardly through the flow passage in said valve body; and means for nitially releasably positioning said body in said first position.

6. A valve of the character set forth in claim 1 wherein: said means for initially releasably positioning said

body in its first position comprises a shear member extendng through an aperture in said valve cage and in said valve body; and said sealing means also seals between said body and said cage above and below said lateral aperture in said cage when said body is in said first position; said shear member being shearable to permit said body to move downwardly to its second position.

7. A valve for well tools comprising a hollow cylindrical valve cage having a closed lower end and an open upper end for connection to the lower end of a well tool which has a bore; a valve body in the valve cage; said valve body being movable within the valve cage between first and second positions therein; said valve cage having a lateral aperture therein intermediate its ends providing communication between the exterior of said cage and the interior thereof; said valve body having a flow passage one of whose ends communicates with said lateral aperture of said cage when said valve body is in its first position in said valve cage and the other of whose ends communicates with the exterior of the upper end of the valve body; a pair of oppositely acting valve means in said flow passage in said valve body for closing

off flow through said passage, one of said valve means closing off flow through said flow passage when the other of said valve means is in open position; means sealing between said cage and said body above and below said lateral aperture in said cage and said one end of said flow passage in said body when said body is in said first position; means for initially releasably positioning said body in said first position; and a by-pass flow passage in said body communicating with the interior of said cage below said body and opening outwardly of said valve body into the valve cage above said sealing means, said sealing means being moved below said lateral port when said body is moved downwardly in said cage to its second position in said valve cage.

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