FLUID CONDUIT VALVE

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7 Claims

ABSTRACT OF THE DISCLOSURE

A valve for inclusion in a fluid conduit for controlling fluids flow therethrough. The valve is responsive to changes of fluid pressure in the conduit for moving the body member having means for attaching in the fluid conduit and from the closed position. The valve is particularly useful for inclusion in a drill string below the Kelly to prevent loss of drilling fluid while making connections during make-up and break-out while performing downhole drilling operations. In such use, the valve is designed to close upon termination of the pumping of fluid through the Kelly, and in the closed position supports a column of drilling fluid thereabove to prevent its being lost onto the drilling platform.

This application is a continuation-in-part of co-pending application SN 409,648 filed Nov. 9, 1964, entitled, "Valve Sub," now Patent No. 3,289,691.

This invention relates to a valve for inclusion in a fluid conduit for controlling fluid flow therethrough. More particularly, it relates to a valve which is responsive to fluid pressure to thereby open or close in response to changes in the pressure above or below a predetermined level. The valve of this invention has particular utility for inclusion in a drill string below the Kelly to prevent loss of drilling fluid while making connections during make-up and break-out operations in downhole drilling.

One of the problems encountered during make-up and break-out of drill string during downhole drilling operations is that drilling fluid contained in the Kelly will be lost onto the drilling platform whenever the Kelly and the Kelly saver sub is broken from the balance of the drill string. The result is that the lost mud creates dangerous working conditions on the drilling platform. Moreover, many muds or drilling fluids are extremely expensive thereby causing great economic loss.

Certain prior art valves had been developed for the purpose of preventing this loss. However, they have for the most part been hand operated such that it was difficult to open and close the valves at the desired times because of the inaccessibility of the valve at a point high in a derrick during certain phases of the operation. Moreover, they required the use of a separate wrench which created the hazard of the wrench being dropped into the bore hole.

Other prior art devices have been developed which are responsive to fluid pressure applied by the pumps pumping the drilling fluid, but certain of these valves have not been full opening or have otherwise diverted the drilling fluid such that the sub which contained the valve was subjected to erosion caused by the abrasive action of the drilling fluid with the result that quite often the valve sub would quickly break and thereby drop the drill string into the bore hole necessitating a fishing operation.

It is therefore an object of this invention to provide an improved conduit closure valve which is particularly useful for inclusion in a drilling string to overcome the aforesaid problems.

Briefly stated, the invention herein comprises a body member having means for attaching in the fluid conduit and having an axial bore therethrough. Piston means are mounted for axial movement in the body member, with the piston means including a generally tubular member having an axial bore therethrough of a diameter substantially as large as the diameter of the bore through the drill string. Resilient biasing means are provided for urging the piston means generally upwardly. Full opening bore closing means are provided which are connected to the piston means and adapted to be placed in the closed position by movement of the piston means upwardly. Means are also provided for applying a pressurized fluid to the piston means to thereby drive the piston means downwardly and to move the bore closing means to the open position. In certain embodiments of the invention the bore closure means may be in the form of a pair of flap gates.

In another embodiment of this invention, and which is the presently preferred embodiment, the bore closure means is in the form of a generally annular rotatable bore closure member mounted for rotation to and from the closed position in the body member by movement of the piston means. It is to be understood that the term "annular rotatable bore closure means" is intended to include not only ball type valve closure members, but also plug type valve closure members which may be cylindrical in shape, conical in shape or the like. In this embodiment, rotation means are provided and connected between the closure member and the piston means for rotating the closure member to and from the closed position in response to relative movement of the piston means.

Further reference to the drawings will further explain the invention wherein like numerals refer to like parts and in which:

FIG. 1 is a central vertical section of the presently preferred embodiment of the invention showing the closure member in the closed position.

FIG. 2 is a partial central sectional view of the valve closure member shown in FIG. 1 and taken at an angle transverse to that shown in FIG. 1.

FIG. 3 is a view of the valve closure member taken generally along line 3—3 of FIG. 1, but showing the valve closure member in the open position.

FIG. 4 is a central vertical sectional view of another embodiment of the invention.

Referring now to the FIGS. 1, 2 and 3 generally, the presently preferred embodiment of the invention will be described in detail. The valve is comprised of a body member generally indicated by the numeral 11 which is comprised of a top connector 12 having an axial bore therethrough and upper box thread end for connection to the pin end of an adjacent section of the drilling string, as for example, the lower end of a Kelly. Top connector 12 has supported thereabout a sub protector 13 for protecting wear therein. The lower end of top connector 12 is provided with a reduced end portion 17 having external threads which are connected to and support tubular portion 14 of body member 11 which deep ends thereof. The lower end of tubular portion 14 is provided with pin end 15 for connection to an adjacent section of the conduit, for example, a section of drill pipe. Tubular portion 14 likewise has an axial bore therethrough which is generally of the same diameter as the bore through the drill string and is additionally provided with an enlarged bore thereby forming shoulder 35 in the lower portion thereof for supporting compression spring 34 therein.

Reduced end portion 17 of top connector 12 is provided with internal threads which engage and support upper inner sleeve 18 in a fixed relationship. Sleeve 18 has a conduit means therethrough which provide fluid communication between the bore of top connector 12 and
the annular space between sleeve 18 and tubular portion 14, which space may sometimes be referred to as the piston chamber. Inner sleeve 16 is locked in position by means of lock ring 19 which is threaded thereafter into abutting engagement with the lower end of reduced end portion 17. Sleeve 18 has an externally enlarged lower portion which supports upper Teflon seal 40, which abuts against the valve closure means in the form of ball valve 50.

The piston chamber formed between inner sleeve 18 and tubular portion 14 has mounted therein piston means: including an annular piston head 24 having internal and external O-ring seals 25 thereabouts and is connected to a tubular member in the form of piston sleeve 28, which is adapted for relative axial movement up and down in the piston chamber.

The lower end of piston sleeve 28 has connected thereto, as by threads, lower annular piston head 31 which likewise is provided with internal and external annular O-ring seals 32 for sealing engagement with the adjacent walls.

The lower side of ball valve 50 is additionally supported by a fixed lower sleeve 37, which abuts against the lower end of tubular portion 14 and is provided with O-ring seal 38 thereabout for sealing engagement therewith. The sleeve of internal sleeve 30 is locked in an externally enlarged portion which supports lower Teflon seal 39 which abuts in sealing engagement with the lower side of ball valve 50. There is also supported between ball valve 50 and piston sleeve 28 an annular upper Teflon filler seal 43 and a lower Teflon filler seal 44 for sealing engagement therewith.

Ball valve 50 is provided with an opening 53 therethrough which is generally the same inside diameter as the bore through body member 11, such that the closure member may be described as being full opening.

Ball valve 50 is adapted for rotation upwardly and the closure member 11 is adapted to passageway through bore 53 of valve 50 in the tool and secures it from axial movement therein.

Means are provided for rotating ball valve 50 to and from the closed position, which means conveniently take the form of rack and pinion gear means including rack gears 55 connected to or attached to sleeve 28 for engagement with and rotation of pinion gears 56.

In operation, the valve is installed in a conduit such as being attached in a drill string below the Kelly in the manner shown in FIG. 1. Ball valve 50 would be in the closed position by virtue of the fact that compression spring 34 is urging piston sleeve 28 in a first direction, i.e., upwardly, which thereby causes rack gears 55 to rotate pinion gears 56 such that ball valve 50 is rotated to the closed position. In this position, ball valve 50 is adapted to support a column of drilling fluid thereabout. When the piston move downward through the Kelly starts up, the pressure of the fluid is applied through ports 20 to the upper end of the piston chamber and to the upper end of piston head 24. When this pressure exceeds the predetermined pressure exerted by compression spring 34, piston sleeve 28 is driven downwardly, thereby rotating ball valve 50 to the open position as shown in FIG. 3, whereby ball valve 50 is moved to the full open position to permit the passage of the drilling fluid downwardly through bore 53 of valve 50. When the lower portion of piston sleeve 28 is driven downwardly, thereby rotating ball valve 50 to the closed position again, thereby supporting the column of drilling fluid thereabout.

The foregoing description described the presently preferred embodiment of the invention. Because of its particular construction, the working parts are substantially isolated from the corrosive effects of the drilling fluid. Moreover, a valve constructed in accordance with the embodiments shown in FIGS. 1, 2 and 3 can withstand great tensile forces. For example, a valve sub made in accordance with the invention shown therein and provided with a 6 1/2" O.D. and a 3" I.D. has been shown to have no yield strength of 653 tons, which is adequate to support most drill strings without danger of dropping the drill string. Moreover, because of the full opening nature of the tool, there is little likelihood of the drilling fluid abrading away or weakening the structure to thereby cause breaking of the tool, which might result in dropping the drill string. In addition, it is also possible to withstand a differential pressure of 10,000 lbs, in the closed position from the bottom direction and therefore acts as a blow-out preventor in the closed position. In the preferred embodiment, spring 34 might be provided as a predetermined force of 200 p.s.i. for example. The externally enlarged lower portion of upper sleeve 28 also acts as a stop point for the downward movement of piston head 24 and lock ring 19 acts as a stop for upward movement thereof in the piston chamber.

Not only may the foregoing tool be used as a valve closure means, but it also substitutes for the normal Kelly saver sub which is usually attached immediately below the Kelly. It is to be understood that the various metal parts of the tool may be chrome plated to further reduce the corrosive effects of any drilling fluid passed therethrough.

Referring now to FIG. 4 an alternate embodiment of the invention is shown. The tool is comprised of tubular portion 72 which corresponds with tubular portion 14 shown in FIG. 1 and has means (not shown) for connecting the lower end thereof to an adjacent section of drill pipe. Tubular portion 72 is connected to a top connector (not shown) such as top connector 12 shown in FIG. 1, which has a reduced end portion 71 which corresponds with reduced end portion 17 shown in FIG. 1 with seal ring 93 therebetween.

Reduced end portion 71 has internal threads which threadedly engage and support upper inner sleeve 70 with a seal ring 94 therebetween and which has a plurality of ports 75 which communicate with the annular piston chamber formed between inner sleeve 70 and tubular portion 72. Inner sleeve 70 is locked in position by means of lock ring 76 which abuts against the lower end of reduced end portion 71 in the same manner as lock ring 19 shown in FIG. 1.

In this embodiment the lower end of inner sleeve 70 has pivotally connected thereto a pair of flapper gates 87 which are generally semicircular in plan view and adapted to seal off flow of drilling fluid downwardly through the bore of the tool in the closed position. It is to be understood that flapper gates 87 are pivotally connected by means of hinges 88 in which the lower side of flapper gates 87 are provided with lugs 89 which are pivotally connected by hinge pins 92 to arms 90, the lower ends of which are connected for pivotal movement with the lower end of piston sleeve 82 by means of hinge pins 91. Piston sleeve 82 is generally tubular in shape and is adapted for up and down movement in the piston chamber described above. In addition, piston sleeve 82 has
connected to the upper end thereof piston head 80 which is provided with internal and external O-ring seals 81 for sealing engagement with adjacent walls.

The lower end of piston sleeve 82 is adapted to abut against and engage the upper end of sleeve head 85 which is in the form of an external flange attached to the upper end of moveable lower internal sleeve 74. Internal sleeve 74 is provided with a sleeve bore 86 which is generally of the same size as the bore through the tool and permits fluid flow therethrough. Internal sleeve 74 is adapted for up and down movement in intermediate bore 84 provided in tubular portion 72 as shown. Biasing means in the form of compression spring 73 is provided in the annular space between sleeve 74 and tubular portion 72 and is arranged to abut at its lower end on shoulder 83 and at its upper end to the lower side of sleeve head 85.

As with the compression spring 34 shown in FIG. 1, compression spring 73 is selected to provide a predetermined upper biasing force to sleeve head 85, which thereby forces piston sleeve 82 and piston head 80 upwardly, thereby carrying spacers 85 and flapper gates 87 to the closed position. In the closed position flapper gates 87 are arranged to support a column of drilling fluid thereabove. When the drilling fluid pressure is applied downwardly through the tool, the drilling fluid pressure is applied through ports 75 to the piston chamber to thereby drive piston head 80 and hence piston sleeve 82 downwardly when the pressure exceeds the force exerted by compression spring 73.

The operation of this embodiment of the tool is similar to that described with respect to FIGS. 1, 2 and 3. The closure means are full opening and are adapted to be placed in a closed position by movement of the piston means upwardly as described. The closure means are adapted for movement to the open position by downward movement of the piston means. It is to be understood that spring 73 is provided with a predetermined force sufficient to move flapper gates 87 to the open position and support a column of fluid thereabove which can be overcome by the application of pressure to the drilling fluid in excess of hydrostatic pressure, whereby the flapper gates 87 may be moved to the open position by the application of pressure to the drilling fluid.

Modifications may be made in the invention as particularly described without departing from the scope of the invention. Accordingly, the foregoing description is to be construed as illustrative only and is not to be construed as a limitation upon the invention as defined in the following claims.

What is claimed is:

1. A valve sub for including in a drill string below the Kelly to prevent loss of drilling fluid while making connections during down hole drilling comprising:
   - a body member having means for attaching in said drill string and having an axial bore therethrough and a piston chamber therein;
   - piston means mounted for axial movement in said piston chamber in said body member, said piston means including a tubular member having an axial bore therethrough of a diameter substantially as large as the diameter of the bore through the drill string;
   - resilient biasing means for urging said piston means upwardly when pressure on said drilling fluid is below a predetermined level;
   - full opening bore closing means connected to said piston means and adapted to be placed in the closed position by movement of said piston means upwardly and to support a column of drilling fluid thereabove in the closed position; and
   - means for applying a pressurized fluid to said piston means including a plurality of ports communicating said piston chamber and the bore of said body member for applying drilling fluid under pressure to said chamber to thereby drive said piston means downwardly and to move said bore closing means to the open position.

2. The apparatus as claimed in claim 1 wherein:
   - said bore closing means includes a pair of flapper gates which are cammed to the closed position when said piston means moves upwardly, and are adapted to move to the open position when said piston means moves downwardly in response to drilling fluid pressure above said predetermined amount.

3. A valve sub for including in a drill string below the Kelly to prevent loss of drilling fluid while making connections during down hole drilling comprising:
   - a body member having means for attaching in said drill string and having an axial bore therethrough;
   - piston means mounted for axial movement in said body member, said piston means including a generally tubular member having an axial bore therethrough of a diameter substantially as large as the diameter of the bore through the drill string;
   - resilient biasing means for urging said piston means upwardly;
   - full opening bore closing means connected to said piston means and adapted to be placed in the closed position by movement of said piston means upwardly, and are adapted to move to the open position when said piston means moves downwardly in response to drilling fluid pressure above said predetermined amount.

4. A valve sub for including in a drill string below the Kelly to prevent loss of drilling fluid while making connections during down hole drilling comprising:
   - a body member having means for attaching in said drill string and having an axial bore therethrough;
   - piston means mounted for axial movement in said body member, said piston means including a generally tubular member having an axial bore therethrough of a diameter substantially as large as the diameter of the bore through the drill string;
   - resilient biasing means for urging said piston means upwardly;

5. A valve for inclusion in a fluid conduit for controlling fluid flow therethrough, said valve comprising in combination:
   - a body member having means for attaching in said conduit and a bore therethrough communicating with said conduit;
   - piston means mounted for relative movement in said body member;
   - biasing means for urging said piston means in a first direction;
a generally annular rotatable bore closure member mounted for rotation to and from the closed position in said body member about an axis which is generally transverse to the central axis of said bore; rotation means connected between said closure member and said piston means for rotating said closure member to and from the closed position in response to relative movement of said piston means; and conduit means communicating the upstream side of said conduit and one end of said piston means for applying a pressurized fluid to said piston means to thereby drive said piston means in a direction counter to said biasing means; whereby said closure member is rotated to and from the closed position by relative movement of said piston means.

6. A valve sub for including in a drill string to prevent loss of drilling fluid while making connections during down hole drilling, comprising in combination:
   a body member adapted for attaching in said drill string and having an axial bore therethrough for passage of drilling fluid downwardly therethrough, said body member having an annular piston chamber surrounding and being generally co-axial with said bore; piston means including a tubular member mounted for axial movement in said chamber in said body member and having an axial bore therethrough which is generally co-axial with said bore through said body member;
   resilient biasing means for urging said tubular member in a first axial direction;
a generally annular rotatable bore closure member mounted for rotation to and from the closed position in said body member about an axis which is generally transverse to the central axis of said bore through said body member, and for supporting a column of drilling fluid thereabove in the closed position;
   rotation means connected between said closure member and said tubular member for rotating said closure member to and from the closed position in response to relative axial movement of said tubular member; and conduit means communicating between said piston chamber and the bore of said body member above said closure member for applying said drilling fluid under pressure to said piston means to drive said piston means in a direction counter to said biasing means;
   whereby said closure member is rotated to and from the closed position by relative movement of said piston means.

7. The apparatus as claimed in claim 6 wherein:
said biasing means includes a compression spring selected to apply a predetermined direction in an axial upward force to said piston means.

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