CHECK VALVE FOR USE IN A TUBULAR FLOW CONDUCTOR

Norman F. Brown, Dallas, Tex., assignor to Oilz Engineering Corporation, Dallas, Tex., a corporation of Delaware

Filed Sept. 21, 1962, Ser. No. 225,283
17 Claims. (Cl. 137—496)

1. This invention relates to well tools and more particularly to check valves for use in a tubular flow conductor for permitting flow of fluids through the tubular flow conductor.

An object of this invention is to provide a new and improved check valve for use in a tubular flow conductor, such as a string of drill pipe used in the drilling of wells, for preventing flow of fluids, such as the mud used in drilling operation in an undesired direction through the tubular flow conductor.

Another object is to provide a valve for flow conductors responsive to the pressure differential between the longitudinal bore or flow passage of the flow conductor and the exterior thereof which closes the bore or flow passage of the flow conductor when the pressure exteriorly of the flow conductor exceeds the pressure within the longitudinal flow passage of the flow conductor.

Still another object is to provide a valve responsive to the pressure differential between the flow passage or bore of the flow conductor and the exterior thereof for closing the flow passage upon the reversal of such pressure differential between the flow passage and the exterior of the flow conductor to prevent any appreciable reverse flow of fluid from the exterior of the longitudinal flow conductor and through the flow passage thereof.

A further object is to provide a check valve connectable in a string of drill pipe to constitute a section thereof and spaced above the drill bit secured to the lower end of the string of drill pipe which permits downward flow of drilling fluid pumped downwardly through the drill pipe and out its lower end which then circulates back to the surface in the well externally and about the string of drill pipe which closes the longitudinal flow passage of the string of drill pipe upon an increase in pressure in the well exteriorly of the drill pipe which would tend to cause upward flow of the drilling fluid through the flow passage of the drill pipe.

A further object is to provide a check valve which is responsive to the pressure differential between the longitudinal flow passage of the drill pipe and the well exteriorly of the string of drill pipe.

A still further object is to provide a check valve provided with a rotatable ball valve having an axial flow passage therethrough which is in alignment and in communication with the longitudinal flow passage of the string of drill pipe when the pressure within the flow passage at the check valve exceeds the pressure exteriorly thereof and having means for rotating the ball valve to a closed position wherein the axial flow passage of the ball valve is placed out of communication with the flow passage of the string of drill pipe to prevent upward flow of fluids through the string of drill pipe.

A further object is to provide a check valve for a string of drill pipe which will close immediately upon the occurrence of increased pressure in the well to prevent reverse or upward flow of fluids through the longitudinal flow passage of the string of drill pipe to prevent upward movement of any well tool disposed in the drill pipe below the check valve, such as a drill pipe logging tool which is dropped into the longitudinal flow passage of the string of drill pipe and pumped to the bottom thereof and held against movement out of the lower end by the drill bit connected to the lower end of the bit, which, if reverse flow of fluids occurred in the longitudinal flow passage of the string of drill pipe, might cause damage to the well logging tool and could also prevent closing of the check valve due to the lodgement of such well tool in the check valve prior to its closure.

Another object is to provide a check valve of the type described wherein the valve may be locked against movement towards its closed position by immovably positioned in the check valve and which may be pumped down or lowered by a flexible line through the longitudinal flow passage of the string of drill pipe into position in the check valve into locking position and which may be removed therefrom by a suitable fishing or running tool lowerable into the string of drill pipe by a flexible line.

A still further object is to provide a check valve which requires no resilient biasing means to hold it in either closed or open position and which normally rests in open position.

Another object is to provide a check valve having a single piece housing or mandrel connectable with the string of drill pipe to constitute a section thereof which because of its single piece structure has the required strength to withstand the compressional and torsional forces imposed thereon during drilling operation.

Still another object is to provide a check valve wherein the bore of the housing need not be enlarged to receive the operative mechanism of the valve whereby the housing is not weakened and may withstand the forces applied thereto during drilling operation.

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 view, partly in elevation and partly in section, with some parts broken away, of a check valve embodying the invention connected in a string of drill pipe and showing the check valve held in open position by a releasable locking tool;

FIGURE 2 is a sectional view taken on line 2—2 of FIGURE 1;

FIGURE 3 is a sectional view taken on line 3—3 of FIGURE 1;

FIGURE 4 is a view taken on line 4—4 of FIGURE 3;

FIGURE 5 is a fragmentary sectional view taken on line 5—5 of FIGURE 1;

FIGURE 6 is a view partly in elevation and partly in section with some parts broken away showing the check valve in closed position;

FIGURE 7 is a perspective view of the ball valve of the check valve illustrated in FIGURES 1 through 5;

FIGURE 8 is a view, partly in elevation and partly in section, of the releasable locking tool for locking the check valve in its open position; and,

FIGURE 9 is a view partly in elevation and partly in section, with some parts broken away, of a modified form of the check valve.

Referring now particularly to FIGURES 1 through 8 of the drawing, the check valve 10 includes an elongate tubular mandrel or housing 11 internally threaded at its upper end as at 12 and having an externally threaded lower portion 13 by means of which the upper and lower ends of the housing may be connected to the lower and upper ends 14 and 15 of adjacent sections 16 and 17, respectively, of a string of drill pipe whereby the tubular housing of the check valve constitutes a section of the string of drill pipe. The section 16 has the usual downwardly facing annular stop shoulder 18 which engages the upper annular end surface of the housing and the housing in turn has a downwardly facing annular stop shoulder 19 which engages the upper annular end surface.
of the section 17 of the drill string. The tubular housing 11 is spaced above the drill bit connected to the lower end of the string of drill pipe. The operating or valve mechanism 19 of the check valve includes a ball valve 20 rotatably mounted in the enlarged portion 21 of the longitudinal bore or flow passage of the housing 11, an upper valve member 22 and a lower valve member 23 which are provided with annular arcuate seal surfaces 25 and 26, respectively, which engage the outer spherical surface 27 of the ball valve. The ball valve has a flow passage 30. The ball valve has a pair of opposed, substantially circular flat or planar surfaces 32 and 33 past which extend the flat tie bars 36 and 37, respectively, connecting the upper valve member 22 to the retainer member 38 disposed below the valve member 23. The tie bars are disposed to limit movement of the retainer member 38 and the upper valve member away from each other. A plurality of springs 49, whose opposite end portions are retained in aligned recesses in the tie bars 41 and 42 of the lower valve member and its retainer 38 bias the lower valve member upwardly toward the upper valve member. The tie bars extend through suitable aligned longitudinal recesses in the retainer, the lower annular valve member and the external annular flange 43 at the lower end of the valve member. Each of the tie bars has an inwardly extending hook portion 44 at its upper end whose lower outwardly and inwardly inclined shoulder 45 engages a corresponding upwardly and outwardly extending upwardly facing shoulder 46 of the flange 43 of the upper valve member and a similar hook portion 47 at its lower end whose upper and inwardly inclined shoulder 48 engages the similarly inclined shoulder 49 of the retainer 38. Due to this inclination of the hook portions 44 and 47 of the tie bars, and their engagement with the similarly inclined shoulders of the upper valve member and of the retainer, the force exerted by the springs tends to hold the tie bars against outward displacement into contact with the internal surfaces of the tubular housing. The lower valve member 23 has a lower reduced annular flange 50 which telescopes into the enlarged upper portion 58a of the bore of the retainer to maintain the lower valve member and the retainer in alignment with one another. The ball valve is provided with a pair of oppositely facing blind slots 51 and 52 and in which are receivable the inner end portions of the mud passage 56 of the valve and which extend through suitable bores in the housing and are properly secured therein in fluid tight relation in any suitable manner, as by welds or the like. The blind slots of the ball valve are parallel to one another and extend angularly relative to the central longitudinal axis of the ball valve whereby the engagement of the pins 54 and 55 with the surfaces of the ball valve defining the blind slots, as the operating or valve mechanism 19 is moved upwardly from the position illustrated in FIGURE 1 to the position illustrated in FIGURE 1, wherein the axial flow passage 30 is in communication with the bores or passages of the upper and lower valve members and the retainer member permitting flow of fluids through the string of drill pipe, to its closed position wherein its axial passage 30 is placed out of communication with the bore or longitudinal flow passage of the drill string above the ball valve due to the sealing engagement of the arcuate surface 27 of the ball valve with the seat surface 25 of the upper valve member. The lower valve member and the retainer member are provided with longitudinally extending external recesses, such as the recesses 64, 65 and 66, respectively, to permit flow of fluids past these elements as the assembly is moved upwardly or downwardly in the housing. The bore of the valve housing may be enlarged slightly, as by the provision of the internal annular recess 67 to accommodate any possible lateral movement of the ball valve as it moves between its open and closed positions. Downward movement of the valve assembly is limited by the engagement of the lower annular end surface of the retainer with the upwardly facing annular shoulder 69 of the tubular housing defining the lower end of the enlarged portion 21 of the longitudinal bore or flow passage of the housing. A seal assembly 75 is disposed in the enlarged portion 21 of the flow passage of the housing 11 to seat between the upwardly extending tubular extension 76 of the upper valve member and the housing and to close the annular piston chamber 78 between the tubular extension and the housing 11. The seal assembly 75 includes a tubular seal retainer 80 having an external annular recess 81 at its lower end in which is disposed an O-ring 82 or other suitable sealing means for sealing between the seal retainer and the housing. The seal retainer has an internal annular flange which provides an upwardly facing shoulder 83 to limit downward movement on the seal retainer of the seal element assembly 84, which may be of the chevron type, which seals between the tubular extension and the retainer. Upward movement of the seal element assembly on the retainer is limited by the lower annular end surface of the tubular nut 86 screwed into the internally threaded upper portion of the retainer. A plurality of ring segments 88, whose outer portions extend into an annular internal lock recess 90 of the housing and whose inner portions extend into the externally opening annular space between the downwardly facing annular shoulder 91 of an external flange on the upper end of the nut 86 and the upper annular end surface 92 of the seal retainer, lock the seal assembly 75 which includes the seal retainer, the seal element assembly 84 and the nut 86 against longitudinal movement in the valve housing. A latch pin 98 disposed in the lateral bore 99 of the housing has an intermediate reduced portion 100 which is disposed in the lateral aperture or bore 102 of the retainer and a further reduced end portion 103 which extends into the aperture or bore 105 of the nut to prevent rotation of the nut relative to the retainer. The bore 107 is an external threaded portion in which is receivable a suitable plug 107 which closes the port 99 against flow of fluids therethrough and which also limits outward movement of the latch pin. The annular nut is provided with a plurality of upwardly opening slots 110 engageable by a suitable tool for rotating the nut during assembly and installation of the valve as will be explained in greater detail below. The upper end of the tubular extension 76 has an annular external piston 115 which includes the annular seal retainer 116, the seal element assembly 117 which may be of the chevron type, and the annular nut 118. The seal retainer 116 has an internal annular recess in which is disposed an O-ring 120 or other suitable sealing means which seals between the seal retainer and the tubular extension of the upper valve member. The retainer has an external annular flange at its lower end providing the annular upwardly facing shoulder 21 which limits downward movement of the seal assembly 117 on the seal retainer. Upward movement of the seal assembly is stopped or arrested by the downwardly facing end shoulder or surface 122 of the nut 119 which is threaded on the upper end of the retainer. The nut 119 has a pair of upwardly opening slots 124 in which are receivable suitable driver portions of a tool by means of which the annular nut is rotated. The seal element assembly seals between the retainer and the housing.
extension 76 by a plurality of ring segments 125 similar to the ring segments 83 which have inner portions which extend into the external annular recess 126 of the tubular extension and whose outer portions extend into the annular space between the downwardly facing annular shoulder 127 provided by an internal flange at the upper end of the nut 118 and the upwardly facing annular end surface of the portion 125 of the nut is placed adjacent to the ring segments.

The nut is held against rotation on the seal retainer by means of a locking or set screw 129 threaded in a bore formed between two ring segments 125 in adjacent portions of the nut and the tubular extension which extends below the internal flange of the nut so that the lower end portion of the screw may engage the upper end of the seal retainer.

The valve housing has a plurality of ports 130 which communicate the exterior of the housing with the annular piston chamber 78 between the tubular extension 76 of the upper valve member and the internal surfaces of the housing 11 above the seal assembly 75 whereby the downwardly facing surface or area of the piston, defined by the lines of sealing engagement of the O-ring 120 with the tubular extension 76 and of the seal element assembly 117 with the internal surfaces of the housing 11, is exposed to the pressure from the exterior of the tubular housing.

When the pressure exteriorly of the housing 11 exceeds the pressure within the bore or longitudinal flow passage of the housing, the force of the external pressure acting on the downwardly facing surface of the piston is effective to face the piston and the operating assembly or mechanism upwardly in the valve housing, the ball rotating from the open position illustrated in FIGURE 1 to the closed position illustrated in FIGURE 6 upon such upward movement of the upper valve member of the valve assembly.

The various elements of the check valve are installed in the enlarged portion 21 of the bore or longitudinal flow passage of the valve housing 11 by first assembling the operating assembly or mechanism by connecting the upper valve member, the lower valve member and the retainer member 38 by means of the tie bars 36 and 37, the springs 40 permitting telescoping movement of the lower valve member into the retainer member to permit movement of the hooks 44 and 47 of the tie bars into proper position in engagement with the shoulders 46 and 48 of the valve member and the retainer member respectively, and then permitting the springs to move the retainer member downwardly relative to the lower valve member and tie bars to prevent disengagement of the hooks 44 and 49 from the upper valve member and the retainer member, respectively, whereby the operating mechanism may be lowered into the bore or flow passage of the housing as a unit.

The ball valve is rotated to a position wherein the open ends of the slots face substantially downwardly and are in alignment with the pins 54 and 55, respectively, so that the ball valve is lowered into position in the housing, the pins will enter the open ends of the slots. Dowward movement of the operating mechanism is stopped by the engagement of the retainer member 38 with the internal annular shoulder 69 of the valve housing.

The seal member 80 with the O-ring 82 and the seal element assembly 84 assembled therein is then lowered into the annular space between the tubular extension 76 of the upper valve member and the valve housing 11 until its recess 102 is aligned with the lateral bore 99 of the mandrel whereupon a suitable tool, such as the broad outer portion of the pin 98, is placed in the bore 99 to extend into the aperture 102 of the seal retainer 80 to hold it against movement in the tubular housing. The ring segments 83 are then inserted in the internal annular recess 90 of the housing and the nut 86 is telescoped over the tubular extension of the upper valve member and threaded into the upper end of the seal retainer by means of a suitable tool which engages in the upwardly opening slot 110 of the nut, the seal retainer 80 being held against rotation by the pin 98 which extends into its recess 102. When the nut has been properly threaded into the seal retainer, its aperture 105 is aligned with the aperture 102 of the seal retainer and with the bore 99 of the housing. The pin 98 is then removed from the bore 99, reversed and replaced so that its reduced end portion 103 enters into the aperture 105 of the nut 86. About 125 of the intermediate portion 100 enters into the aperture 102 of the seal retainer and thus holds the nut against rotation relative to the seal retainer. The plug 107 is then threaded into the bore 99 to close the bore against flow of fluids therethrough and to hold the pin in place.

The piston seal retainer 116 with the O-ring 120 and the seal assembly 117 assembled thereon is then telescoped on the tubular extension of the upper valve member until one of the downwardly opening recesses 131 thereof is aligned with the lateral bore or aperture 132 of the housing. A suitable pin is then inserted through the bore 132 so that its inner end extends into the recess 131 to engage the seal retainer 116 and hold it against movement in the housing. The ring segments 125 are then inserted into the external annular recess 126 of the tubular extension 76, the nut 118 is lowered into the housing and then rotated by means of a suitable tool which engages in the upwardly opening slot 110 of the nut 86 so that the nut is screwed on the seal retainer. The set screw 129 is then threaded in the bored bore 129a to lock the nut against rotation relative to the tubular extension and to the seal retainer.

The operating mechanism 19 may be removed from the housing by reversing the above installation procedure. If the check valve is now to be employed in a string of drill pipe into which a well logging tool is to be lowered until its downward movement is stopped by the drill bit at the lower end of the drill string with its electrode extending outwardly of the drill bit through the downwardly opening eye or nozzle of the drill bit through which the drilling mud flows in or out of the string of drill pipe, the housing 11 is connected in the string of drill pipe to form a section thereof at a location which will be disposed above the upper end of the logging tool when the logging tool is in position in the string of drill pipe. If the well logging tool is, for example, twenty-two feet long, the check valve is connected in the string of drill pipe more than twenty-two feet from the drill bit. The check valve is now in the open position illustrated in FIGURE 1 and the string of drill pipe is extended into the well. The usual circulation of drilling mud during drilling operations is carried on by pumping the drilling mud down through the string of drill pipe and out through the eye or nozzle of the drill bit and thence upwardly through the well bore about the string of drill pipe to the surface. The pressure within the bore or flow passage of the valve housing is of course higher than the pressure immediately to the exterior thereof so that the ball valve is held in its normal open position by the differential in pressure between the interior and the exterior of the housing, the internal pressure acting on the downwardly facing surface or area of the piston 115 between the external surface of the tubular extension 76 and the line of sealing engagement of the packing assembly 117 with the internal surface of the valve housing and the external pressure acting on the downwardly facing annular area or surface of the piston 115 between the line of sealing engagement of the O-ring 120 with the external surface of the tubular extension and the line of sealing engagement of the packing assembly 117 with the internal wall surfaces of the valve housing. The check valve will therefore remain in its open position as long as the external pressure does not increase to exceed the internal pressure by a predetermined amount needed to overcome the frictional and gravity forces tending to hold the operating mechanism 19 in its lower open position.

If the pressure in the well at the housing now suddenly
increases as when a blow-out condition occurs, so that the pressure exteriorly of the valve housing now becomes greater than the pressure within the valve housing, the force of the pressure from the exterior of the housing acting on the lower surface of the piston 115 moves the operating mechanism upwardly in the housing since the pressure within the housing is now lower than the external pressure because back or reverse flow of fluids into the string of drill pipe through the eye or nozzle of the drill bit at the lower end thereof is restricted by the restricted orifice of the eye or nozzle of the drill pipe. Since this pressure differential is good enough to overcome the forces of friction and gravity, the operating mechanism is moved quickly upwardly in the valve housing from the position illustrated in FIGURE 1 to the position illustrated in FIGURE 6, the ball valve rotating during such movement to cause its axial flow passage 30 to move out of communication with the bore or flow passage of the upper valve member and the reverse or upward flow through the valve is prevented due to the engagement of the accurate surface 27 of the ball valve with the seat surface 25 of the upper valve member. The pressure differential across the ball valve of course urges the ball valve toward the seat surface 25 so that the greater the pressure differential the greater the force with which the ball valve is held in sealing engagement with the seat surface of the upper valve member. Upward movement of the operating mechanism of the check valve is limited by the engagement of the upper annular shoulder 43a of the upper valve member with the annular end surface or shoulder 44c of the seal retainer 9b of the seal assembly 75.

If prior to the occurrence of the abnormal pressure condition within the well bore, a well logging tool has been pumped down into the drill string below the check valve, the valve will close before any appreciable back flow or reverse flow of fluids can take place through the drill string and through the check valve, since the logging tool further restricts the effective orifice of the eye or nozzle of the drill bit and also the effective orifice of the flow passage through the string of drill pipe below the check valve. As a result, when the pressure increases externally of the valve housing, no appreciable flow of drilling mud will take place upwardly through the drill string tending to equalize the pressure differential between the interior and exterior of the valve housing and the valve closes rapidly before any appreciable upward movement of the logging tool can take place. The well logging tool will not hinder or prevent proper operation of the check valve since it will not be moved into engagement therewith upon the occurrence of a sudden increase in the bottom hole pressure of the well. When the longitudinal flow passage of the string of drill pipe is closed by the check valve, the annulus at the surface may be closed by the usual blow-out preventers and thus prevent the blow-out; that is, prevent the expulsion with violence of the contents of the well. Subsequently when proper conditions have been made through the usual surface equipment of the well, the pressure in the string of drill pipe above the check valve can be increased by pumping mud into the upper end of the string of drill pipe and, once the pressure within the valve housing 11 increases above that of the pressure exteriorly of the valve housing, the force of the pressure acting on the area of the upwardly facing surface of the upper valve member and of its piston 115, moves the operating mechanism downwardly to open position to permit circulation of a new flow of drilling mud or fluid down the string of drill pipe, out the eye or nozzle of the drill bit at the lower end of the string of drill pipe and up the annulus between the drill string and the bore of the well to load the well and keep it under control.

It is sometimes desirable to reverse the circulation of drilling fluid through the well; that is, to pump the drilling fluid down the annulus between the string of drill pipe and the bore of the well and then up through the eye or nozzle of the drill bit into the string of drill pipe and thence to the surface. Such reversal of circulation of course will cause the pressure exteriorly of the valve housing to become higher than the pressure within the valve housing and would cause the check valve to close and prevent such reverse circulation. If it is desired to reverse circulation of fluids in the well, the locking tool 150 for locking the check valve in open position is pumped down the longitudinal flow passage of the string of drill pipe into the check valve, or is lowered thereto by the usual flexible line running tools. The locking tool has a substantially tubular elongate body 151 slotted at its lower end portion to provide a plurality of resilient collet fingers 152 whose lower ends have external bosses 153. The locking tool has an external annular flange 154 adjacent its upper end which provides a downwardly facing annular beveled shoulder 155 engageable with the upwardly facing shoulder 156 of the tubular extension 76 of the upper valve member to limit downward movement of the locking tool through the valve housing. A fishing neck 157 is provided on the upper end of the locking tool and has the usual external annular flange 158 at its upper end which provides the undercut shoulder 159 by means of which running or pulling tools may be attached to the locking tool. The longitudinal flow passage 160 of the tubular body 151 communicates with the exterior of the locking tool above the external annular flange 154 thereof through the ports 163. The bosses 153 are provided with upper downwardly outwardly inclined or beveled shoulders 166 whose inclination is more steep than that of the lower upwardly and outwardly beveled shoulders 167 of the bosses. The upper and lower shoulders of the valve housing defining the internal annular locking recess 171, located below the shoulder 69 of the housing, are beveled or inclined at the same angles as the shoulders 165 and 167, respectively.

When the locking tool 150 is pumped, or moved downwardly by means of flexible line tools, through the longitudinal flow passage of the string of drill pipe, its resilient collet fingers flex inwardly whenever the beveled lower shoulders 167 of the bosses 153 thereof engage any upwardly facing obstructions, such as the shoulder 156 at the upper end of the tubular extension of the upper valve member, to permit passage of the locking tool past such obstruction. When the locking tool is moved downwardly to the position in the tubular housing wherein its bosses 153 are aligned with the internal locking recess 171 of the valve housing, the resilient force of the collet fingers moving outwardly the ends of the collet fingers outwardly and the bosses 153 move downwardly into the locking recess. At this time, the downwardly facing shoulder 158 of the locking tool engages the shoulder 156 of the upper valve member to stop further downward movement of the locking tool in the valve housing. The engagement of the upper shoulders 166 with the shoulder 160 of the valve housing now restrains the locking tool in its operative locking position in the check valve so that when reverse circulation is commenced, the valve mechanism will be prevented from moving upwardly in the valve housing and the ball valve 20 will be prevented from rotating to its closed position. The resilience of the collet fingers 152 of the locking tool and the inclination of the shoulders 166 of the bosses and of the shoulder 160 of the mandrel 11 is such that the pressure differential existing across the locking tool 150 during circulation of the drilling fluid down through the annulus and then upwardly through the longitudinal flow passage of the string of drill pipe will not cause upward displacement of the locking tool from its operative locking position in the check valve.
3,200,837

158 on the upper end of the fishing neck 157 of the locking tool so that an upward force then exerted on the upper end of the locking tool through the flexible wire will cause upward movement of the locking tool from the valve housing, the camming engagement of the shoulders 166 of the bosses with the shoulder 169 now camming the lower ends of the collet fingers inwardly to release the locking tool for upward movement and removal from the valve housing.

When the locking tool is removed from the string of drill pipe at the surface, the normal circulation of the drilling fluid may again be initiated and the check valve will again function as described to close the longitudinal flow passage of the string of drill pipe to prevent reverse or upward flow of fluids through the housing.

The check valve 200 illustrated in FIGURE 9 is similar in structure and function to the valve 10 and accordingly corresponding elements of the check valve 200 have been provided with the same reference numerals, to which the subscript "a" has been added, as the corresponding elements of the check valve 10. The seal assembly 75a includes a seal retainer 80a having an internal flange 202 at its upper end which provides a downwardly facing shoulder 203 which limits upward movement of the seal assembly 84a relative to the seal retainer 200a. Downward movement of the seal assembly relative to the seal retainer is limited by the nut 245 threaded into the lower end of the seal retainer and then locked against rotation relative thereto by a suitable pin 206 which extends through suitable aligned apertures in the nut and in the seal retainer. The seal retainer is also provided with a suitable external annular recess in which is disposed an O-ring 82a or other suitable sealing means for sealing between the seal retainer and the internal surfaces of the tubular valve housing 11a.

The seal assembly 75a is held against longitudinal movement in the valve housing by a plurality of screws 203 threaded in suitable lateral bores 209 of the valve housing and having cone shaped inner ends 212 which are received in an external annular recess 214 of the seal retainer 80a. The piston 115a includes a seal retainer 116a whose external flange provides an upwardly facing annular shoulder 121a which limits downward movement of the seal assembly 75a on the seal retainer. The seal retainer also is provided with an internal annular recess in which is disposed an O-ring 120a which seals between the tubular extension 76a of the upper valve member 22a. Upward movement of the seal assembly 117a on the seal retainer is limited by the downwardly facing end surface or shoulder 123a of the nut 118a threaded into the upper end of the seal retainer and secured thereto against rotational movement by means of a pin 212a which extends through suitable aligned apertures in the nut and in the seal retainer. The piston is secured to the upper end of the tubular extension 76a of the upper valve member by a plurality of ring segments 125a whose inner portions are received in the external annular recess 126a of the tubular extension and whose outer portions extend between the downwardly facing shoulder 127a of the internal annular flange of the nut 118a and the upper end surface or shoulder 128a of the seal retainer.

It will be apparent that the assembly 75a and the piston 115a may be assembled on the extension 76a of the upper valve member 22a and the whole assembly then moved downwardly into the enlarged portion 21a of the bore of the mandrel 214 of the seal retainer 80a in alignment with the bores 209 of the mandrel whereupon the screws 208 may be rotated to cause their forward inner end portions to enter into the recess 214 and thus lock the seal assembly 75a against movement in the housing. The screws 208 may be locked in place by the screw plugs 215. The mandrel has a plurality of ports or slots 220 which open from the exterior of the mandrel to the interior of the housing below the lower portion of the seal assembly 117a and above the upper end of the seal retainer 80a of the lower seal assembly whereby the pressure from the exterior of the housing may be communicated to the piston chamber 78a.

The remaining elements of the operating assembly or mechanism 19a are identical in structure to the corresponding elements of the valve 10.

It will be apparent that the check valve 200 will operate in the same manner as the valve 10 to close the longitudinal flow passage of the valve housing, and therefore upon the string of drill pipe when the check valve assembly 11a is connected in the string, whenever the pressure exteriorly of the housing increases to exceed the pressure within the valve housing to a degree sufficient to overcome the forces of gravity and friction acting on the operating mechanism by moving the valve mechanism upwardly and that the locking tool 150 may be used to releasably lock the valve 200 in its open position when it is desired to pump fluid downwardly through the annulus of the well and then up through the string of drill pipe.

It will now be seen that a new and improved check valve has been described and illustrated which includes a single piece valve housing having a longitudinally movable operating assembly or mechanism mounted in the longitudinal flow passage thereof provided with piston means exposed to the pressure from the exterior of the housing whereby the operating mechanism may be moved to closed position upon the occurrence of a predetermined pressure differential between the interior and the exterior of the housing.

It will further be seen that the operating mechanism includes an upper valve member which provides a seat surface engageable with the spherical surface of a ball valve for sealing therewith when the ball valve is rotated to a closed position preventing flow of fluid through the housing upward longitudinal movement of the valve mechanism in the housing.

It will also be seen that the operating mechanism does not restrict the flow passage of the string of drill pipe so that such tool as a logging tool may be passed therethrough.

It will further be seen that a locking means, such as locking tool 150, may be employed to releasably lock the valve in open position and that the valve housing and the locking tool have engageable means for releasably holding the locking tool against displacement from its operative locking position wherein it holds the operating mechanism of the valve against movement in the valve housing towards closed position.

It will further be seen that the illustrated and described check valve operates quickly before any appreciable reverse flow of fluid may take place through the check valve upon the occurrence of an increased pressure exteriorly of the valve housing whereby any well tools located in the flow passage of the string of well pipe will not be moved upwardly in the longitudinal flow passage prior to the closing of the check valve.

It will further be seen that the mandrel or housing of the check valve is formed of a single piece having a longitudinal flow passage whose enlarged upper portion 21a receives the operating mechanism of the check valve and that the operating mechanism is held releasably in the valve housing by such means as the ring segments 88 of the valve 10 or the screws 208 of the valve 200 which hold the lower seal assembly 75 or 75a, as the case may be, against movement in the housing.

It will further be seen that the housing being of single piece construction is of sufficient strength to withstand the compressional and torsional forces to which it is subjected during drilling operations and that while its wall thickness is smaller than that of the drill collar, it may be made of a metal of greater strength need not be changed or modified when the check valve than that of the drill collar whereby drilling operations
It will also be apparent that if desired the annular locking groove or recess 171 of the valve housing may be omitted if the body of the tubular locking tool is of sufficient length that when the locking tool is in position in the valve housing with its annular downwardly facing shoulders 156 in engagement with the upper beveled shoulders 166 thereof engaging the similarly beveled annular shoulder 180 at the lower end of the valve housing. The bosses then extend into the recess 181 formed between the lower end of the valve housing and the upwardly facing annular shoulder 182 of the section 17 of the string of drill pipe.

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

1. A valve including: a tubular housing adapted to be secured in a tubular flow conductor to form a section thereof, said housing having a longitudinal flow passage; valve means mounted in said flow passage for permitting flow in one direction through said passage when in open position and preventing flow in a direction opposite to said one direction when in closed position, said valve means being movable between open and closed positions, said operating means including a pair of longitudinally spaced members and means connecting said members for causing said members to move simultaneously in said flow passage, said valve means being disposed between and being engaged by said valve members whereby said valve means is moved by and with said operating means, said operating means being exposed and responsive to pressure within said flow passage and also to pressure exteriorly of said housing, said operating means means moving said valve means to closed position when the pressure exteriorly of said housing exceeds the pressure within said passage and moving said valve means to open position when the pressure within said longitudinal flow passage exceeds the pressure exteriorly of said housing, said valve means being moveable between said closed and open positions only by the force exerted on said operating means by the pressure within said flow passage and the force exerted thereon by the pressure exteriorly of said housing.

2. A valve including: a tubular housing adapted to be secured in a tubular flow conductor to form a section thereof, said housing having a longitudinal flow passage; valve means mounted in said longitudinal passage of said longitudinal flow passage for permitting flow in one direction through said passage when in open position and preventing flow in a direction opposite to said one direction when in closed position, said valve means having operating means connected to said valve means for moving said valve means to open position when the pressure within said passage and also to the pressure exteriorly of said housing whereby said operating means is movable by such pressure for moving said valve means to closed position when the pressure exteriorly of said housing exceeds the pressure within said passage and for moving said valve means to open position when the pressure within said longitudinal flow passage exceeds the pressure exteriorly of said housing, and locking means removably positionable in said housing and engageable with said valve means for locking said valve means in open position and removing said valve means from said housing by a force exerted thereon in a direction opposite said one direction, said locking means being movable in said housing only when said valve means is in open position, said locking means and said housing having coengageable means for releasably restraining said locking means in position, and said valve means whereby flow of fluid through said flow passage and the tubular flow conductor may take place in a direction opposite to said one direction.

3. A valve including: a tubular housing adapted to be secured in a tubular flow conductor to form a section thereof, said housing having a longitudinal flow passage; valve means mounted in said longitudinal passage of said longitudinal flow passage for permitting flow in one direction through said passage when in open position and preventing flow in a direction opposite to said one direction when in closed position, said valve means having operating means connected to said valve means for moving said valve means to open position when the pressure within said passage and also to the pressure exteriorly of said housing whereby said operating means is movable by such pressure for moving said valve means to closed position when the pressure exteriorly of said housing exceeds the pressure within said passage and for moving said valve means to open position when the pressure within said longitudinal flow passage exceeds the pressure exteriorly of said housing; and locking means removably positionable in said housing and engageable with said valve means for locking said valve means in open position and removing said valve means from said housing by a force exerted thereon in a direction opposite said one direction, said locking means being movable in position locking said valve means by a force exerted thereon in one direction and being movable from said locking position and removable from said housing by a force exerted thereon in a direction opposite said one direction.

4. A valve including: an integral tubular housing adapted to be secured in a tubular flow conductor to form a section thereof, said housing having a longitudinal flow passage; valve means mounted in said longitudinal passage permitting flow in one direction through said passage when in open position and preventing flow in a direction opposite to said one direction when in closed position, said valve means having operating means connected to said valve means for moving said valve means to open position when the pressure within said longitudinal flow passage and the pressure within said passage and also to the pressure exteriorly of said housing whereby said operating means is movable by such pressure for moving said valve means to closed position when the pressure exteriorly of said housing exceeds the pressure within said passage and for moving said valve means to open position when the pressure within said longitudinal flow passage exceeds the pressure exteriorly of said housing; and means in said flow passage releasably secured to said housing and engageable with said operating means for holding said operating means and said valve means against removal from said housing.

5. A valve including: a tubular housing adapted to be secured in a tubular flow conductor to form a section thereof, said housing having a longitudinal flow passage; valve means mounted in said longitudinal flow passage and including a body rotatably disposed in said passage, said body having a flow passage therethrough, said housing and said body having coengageable means for moving said body about an axis perpendicular to the longi-
3,200,887 3

1. A tubular flow conduct for forming a section thereof, said housing having a longitudinal flow passage, said first member having means exposed to the pressure within said longitudinal flow passage of said body in said first open position, said body having a flow passage therethrough, said housing and said body having coengageable means for sealing therebetween when said body is in said second closed position for closing said flow passage of said valve member, said housing having lateral port means communicating the exterior of said housing with said longitudinal flow passage, said first member having means exposed to the pressure within said longitudinal flow passage of said housing and to the pressure exteriorly of said housing through said port means of said housing whereby said first member is moved longitudinally in one direction to one extreme longitudinal position in said housing by the force of the pressure exteriorly of said housing when the pressure exteriorly of said housing exceeds the pressure within said passage of said housing and in a direction opposite to said one direction to a second extreme longitudinal position in said housing when the pressure within said housing exceeds the pressure exteriorly of said housing when said body is in said open position.

2. A valve including: a tubular housing adapted to be secured in a tubular flow conductor to form a section thereof, said housing having a longitudinal flow passage, said first member having means exposed to the pressure within said longitudinal flow passage of said body in said first open position, said body having a flow passage therethrough, said housing and said body having coengageable means for sealing therebetween when said body is in said second closed position for closing said flow passage of said valve member, said housing having lateral port means communicating the exterior of said housing with said longitudinal flow passage, said first member having means exposed to the pressure within said longitudinal flow passage of said body in said first open position, said body having a flow passage therethrough, said housing and said body having coengageable means for sealing therebetween when said body is in said second closed position for closing said flow passage of said valve member, and said body being disposed in said first open position, said locking means having a longitudinal flow passage communicating with said flow passage of said housing above and below said valve means.

7. A valve including: a tubular housing adapted to be secured in a tubular flow conductor to form a section thereof, said housing having a longitudinal flow passage, said valve means exposed to the pressure within said longitudinal flow passage of said housing and having a body rotatably disposed in said housing, said body having a flow passage therethrough, said housing and said body having coengageable means for sealing therebetween when said body is in said first open position, said locking means having a longitudinal flow passage communicating with said flow passage of said housing above and below said valve means.

A valve member mounted in said longitudinal flow passage and having a passage communicatig with said flow passage of said body in said second closed position for closing said flow passage of said valve member, and said body being disposed in said first open position, said locking means having a longitudinal flow passage communicating with said flow passage of said housing above and below said valve means.
3,200,837

with and out of communication with said flow passage of said first member when said operating mechanism is in said upper position in said housing, said body and said first valve member having coengageable seat surfaces for sealing therebetween to prevent flow through said longitudinal flow passage of said housing when said operating mechanism is in said upper position in said housing, said first valve member having external annular piston means engageable with said housing; and annular seal means removably disposed in said housing intermediate the ends thereof and sealing between said valve member and said housing above said body and below said piston means, said housing having lateral port means communicating the exterior thereof with the interior thereof between said seal means and said piston means whereby the force of pressure acting on said piston means moves said operating mechanism upwardly to said upper position when the pressure exteriorly of said housing exceeds the pressure within said housing and the force of the pressure acting on said piston means moves said operating mechanism downwardly to said lower position when the pressure in said flow passage of said housing above said operating mechanism exceeds the pressure exteriorly of said housing; and means releasably locking said seal means in said housing including an exterior annular recess provided in said seal means and an interior annular recess provided in said housing and aligned with said external recess and removable lock means extending into said recesses.

12. A valve including: a tubular housing adapted to be connected in a tubular flow conductor to constitute a section thereof and having a longitudinal flow passage; an operating mechanism mounted in said passage for limited longitudinal movement therein between an upper position and a lower position, said operating mechanism including a tubular valve member extending and movably longitudinally in said longitudinal flow passage of said housing and having a longitudinal flow passage, a body having a flow passage therethrough, said body and said housing having coengageable means for mov- ing said body about an axis perpendicular to the longitudinal axis of said flow passage of said housing upon movement of said body longitudinally relative to said housing, and means connecting said body to said valve member for causing said body to move said valve member upon longitudinal movement of said valve member in said flow passage of said housing, said flow passage of said body being in alignment and in communication with the flow passage of said valve member when said valve member is in said lower position in said housing to permit flow through said housing and being disposed out of alignment with and out of communication with said flow passage of said valve member when said valve member is in said upper position in said housing for holding said operating mechanism in said upper position.

13. The valve of claim 12 wherein said locking means and said housing have coengageable means for releasably restraining said locking means in position holding said operating mechanism in said lower position.

14. The valve of claim 12 wherein said locking means and said housing have coengageable means including a downwardly facing shoulder on said housing and outwardly biased boss means on said locking means engageable with said downwardly facing shoulder of said housing for holding said operating mechanism in said lower position.
15. A valve including a tubular one piece housing having a flow passage therethrough; a rotatable valve body member having a flow passage therethrough rotatably mounted in said housing passage for opening and closing the flow passage of the housing; a valve operating member connected to said rotatable valve body member for moving the body member to cause the same to rotate in said housing between open and closed positions, said valve operating member having external annular piston means removably secured to one end thereof and engageable with said housing in said passage and movable with said member; annular seal means removably disposed in the housing passage intermediate the ends thereof and sealing between the valve operating member and the housing passage between the connection of the body member with the operating member and the piston means; said annular seal means and said valve member having coengageable means limiting movement of said valve member in one longitudinal direction in said housing, said housing having lateral port means communicating the exterior thereof with the interior thereof between the seal means and said piston means for directing fluid pressure into the housing between the piston and seal means for moving said piston means and said operating member in said housing to move said valve; and means engageable with said annular seal means and said housing for releasably locking said annular seal means in said housing, said annular seal means being positioned and locked in said housing after said valve body and valve operating member have been positioned in said housing and said piston means being secured to said valve operating member after said annular seal means have been positioned and locked in said housing.

16. The valve of claim 15 wherein said seal means in said housing includes external recess means provided in said annular seal means and means insertable through a lateral bore of said housing and into said recess means to prevent longitudinal movement of said annular seal means in said housing.

17. A valve of the character set forth in claim 15, wherein said means engageable with said annular seal means and said housing for releasably locking said seal means in said housing comprises an external annular recess provided in said annular seal means and an internal annular recess provided in the flow passage of said housing and aligned with said external recess of said seal means, and removable lock means disposed in said annular recesses engaging said members to hold the same against movement relative to each other longitudinally of said housing.

References Cited by the Examiner

UNITED STATES PATENTS

1,865,121 6/32 Lotton 277—189
1,869,452 8/32 White 92—168 XR
2,162,578 6/39 Hacker 251—89 XR
2,921,601 1/60 Fisher 137—496
2,998,077 8/61 Keithahn 251—62 XR
3,035,808 5/62 Knox 137—496 XR

M. CARY NELSON, Primary Examiner.

MARTIN P. SCHWADRON, Examiner.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,200,837

August 17, 1965

Norman F. Brown

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 10, line 74, strike out "need not be changed or modified when the check wave".

Signed and sealed this 1st day of February 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents