April 3, 1962 M. R. JONES 3,027,914

CHECK VALVE

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Fig. 1

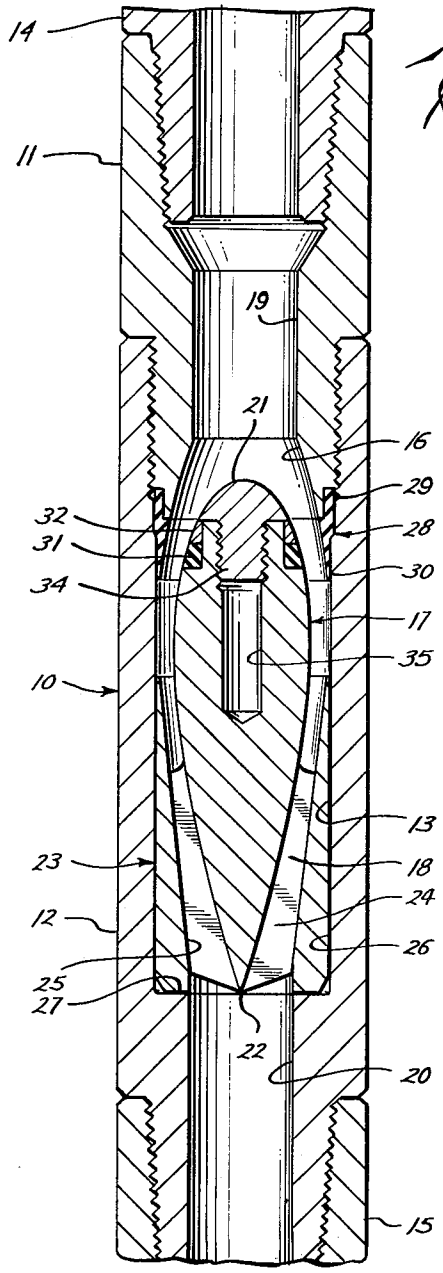
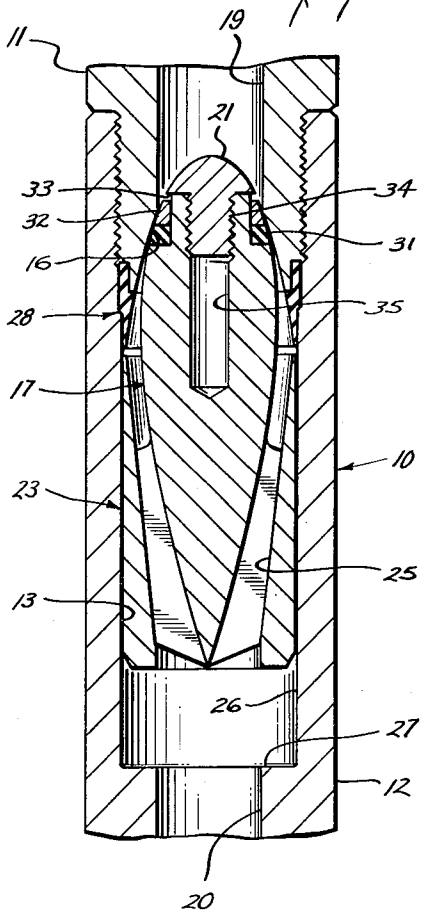


Fig. 2



Marvin R. Jones
INVENTOR.

BY Browning, Simms, Hyer & Eickenroht
ATTORNEYS

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Fig. 3

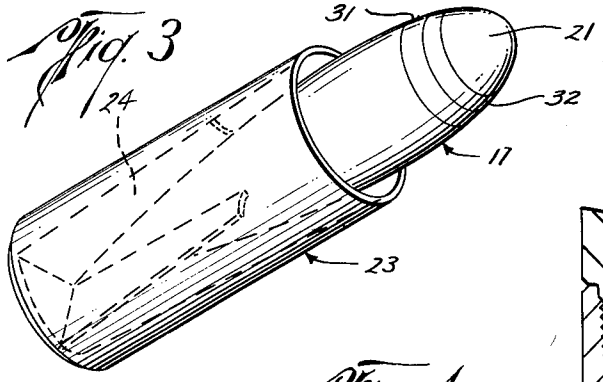


Fig. 4

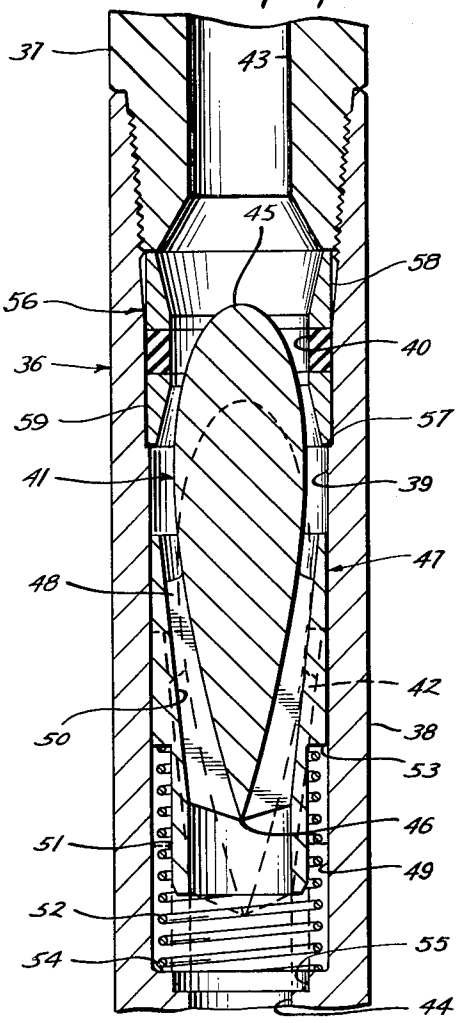
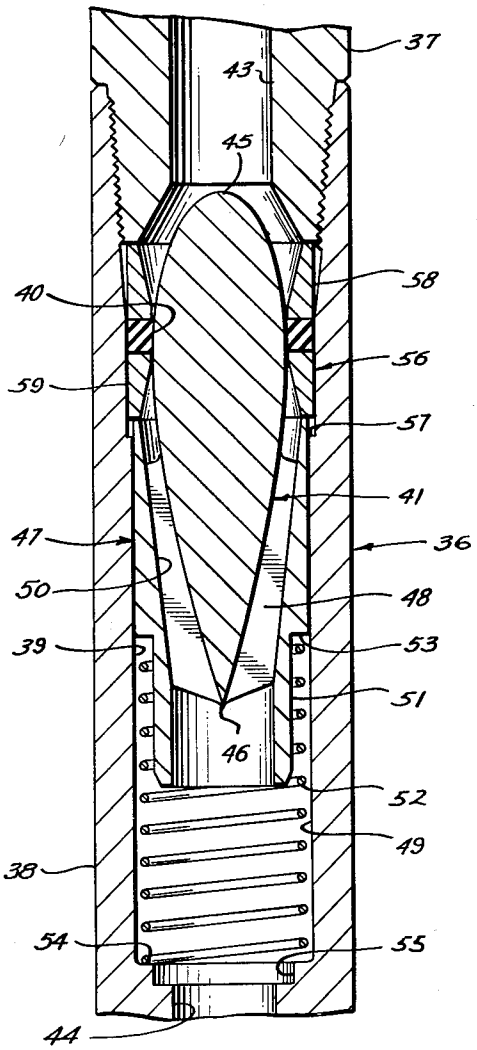


Fig. 5



Marvin R. Jones
INVENTOR.

BY Browning, Simms, Hyer & Eickenroht
ATTORNEYS

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CHECK VALVE

Marvin R. Jones, Houston, Tex., assignor to Cameron Iron Works, Inc., Houston, Tex.

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3 Claims. (Cl. 137—515.7)

This invention relates broadly to improvements in check valves and, more particularly, to an improved check valve especially well suited for use in a drill string.

In the drilling of petroleum wells by the common rotary method, operators circulate "mud" downwardly through a rotary drill string having a bit at its lower end and upwardly through the annular space between the drill string and the well bore. This drilling mud carries bit cuttings out of the bore, stabilizes the walls of the bore, and balances formation pressures. Occasionally, the formation pressure exceeds the hydrostatic pressure of the mud so that unless it is restrained, it blows the mud out of the bore and the drill string.

Operators usually employ plug valves in the drill string just above the Kelly joint and just below the rotary swivel for controlling this reverse flow in the drill string. Workmen usually go aloft by rope slings in order to operate these valves with wrenches. This operation consumes critical time and involves considerable danger to the workmen. Attempts to replace the plug valve with a check valve automatically responsive to significant reverse flow have failed because of rapid erosion to the valve parts which is caused by excessive turbulene within the valve.

An object of this invention is to provide a check valve in which the cutting of the sealing surfaces thereof and the power required to circulate such fluids therethrough are reduced to a minimum.

Another object is to provide a check valve which is automatically responsive to any significant reverse flow and through which fluid may be circulated in a normal direction with a minimum amount of acceleration.

A further object is to provide a check valve for use in a drill string which is adapted to open and close automatically in response to starting and stopping, respectively, of the mud pumps.

A still further object is to provide a check valve of this type which is inexpensive to manufacture and easy to maintain.

In accordance with the present invention, these and other objects are accomplished by means of a check valve which includes a body having an opening therethrough, a seat on the body within the opening, and a valve member longitudinally reciprocable within the opening between a seated position closing the opening and an unseated position providing an annular flow path through the opening which is substantially straight and of an annular cross-sectional area throughout at least approximately equal to the cross-sectional area of the opening at apposite ends of the body. With such a construction, there is a minimum amount of restriction to flow through the valve and thus a minimum cutting of the sealing surfaces. Also, there is only a small pressure drop across the valve so that a minimum of power is required in pumping drilling mud or other fluid therethrough.

The valve member is so constructed that when the valve is used in a drill string, and there is no flow of drilling mud downwardly therethrough, the valve member will be seated due to its buoyancy in the drilling mud in the string. Thus, there is no tendency for the valve member to freeze in an open position. On the other hand, it is contemplated that the valve member will be closed with such a small force that it will open as soon as the mud pumps are started. This novel arrangement

may be provided either by a spring urging the valve member toward seated position or a valve member having a hollow body of light weight metal.

In the preferred form of the check valve of the present invention, the valve member is guided in its movement between seated and unseated positions by means of an annular member secured to the valve member for sliding within the body opening and spaced concentrically therefrom to define at least part of the annular flow path through the opening. The valve body comprises two coaxially connected parts one of which is disconnectable from the other to permit removal of the guide member and valve member from the opening through the valve body. This not only simplifies fabrication and assembly of the valve, but also permits the guide member and valve member to be repaired or replaced, as desired.

Either the seat on the valve body or the surface of the valve member seatable thereon comprises a ring of resilient sealing material which is confined by an expander for radial expansion into engagement with the other of the seat and valve member seating surface. More particularly, the expander is disposed adjacent the sealing ring and is movable longitudinally of the sealing ring, in response to movement of the valve member into seated position, to radially expand the sealing ring. This construction insures an initial contact between the sealing ring and its opposite surface, despite wear or tolerances, and also establishes a pressure within the sealing ring which is a multiple of the pressure sealed against.

Although the check valve of the present invention is particularly well suited for use as a Kelly safety valve or as a drill string float valve, it has many other uses in fluid circulating systems wherein erosion of the parts or excessive pressure drops are a serious problem, and the claims are to be so construed.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a longitudinal sectional view of one embodiment of a check valve constructed in accordance with the present invention, and in an open position to permit fluid to be circulated downwardly therethrough;

FIG. 2 is a similar view of the check valve of FIG. 1, but in a closed position to prevent flow upwardly therepast;

FIG. 3 is a perspective view of the valve member and guide member of the valve of FIGS. 1 and 2 removed from within the valve body thereof;

FIG. 4 is a longitudinal sectional view of another embodiment of the check valve of the present invention, with the valve member thereof shown in solid lines in an intermediate position, in which there is no flow therethrough, and in broken lines in an open position during circulation downwardly therethrough; and

FIG. 5 is a similar view of the valve of FIG. 4 in a closed position.

Referring now specifically to the above-described drawings, the check valve embodiment shown in FIGS. 1 to 3 comprises a valve body **10** which includes a pair of tubular parts **11** and **12** coaxially and threadedly connected together to define an opening **13** therethrough. The outer ends of these tubular parts are similarly connected to other tubular parts **14** and **15**, respectively, with the opening **13** forming a continuation of the flow passage through such parts which, for the purposes of this description, comprise a drill string. An annular seat **16** is formed on the body part **11** within the opening **13** and a valve member **17** is reciprocable within the opening between a seated position (FIG. 2) to close the opening and an unseated position (FIG. 1) to provide an annular flow path **18** through the opening. Thus, as drilling mud or other fluid is pumped downwardly through the string, the valve member will be unseated to permit such

fluid to pass through flow path 18. On the other hand, upon a reversal of flow or an increase in pressure of well fluid within the string beneath the valve, the valve member will automatically be moved upwardly into seated position so as to prevent the flow of such fluid upwardly past the valve.

As previously described, and as can be seen from FIG. 1, this flow path is substantially straight and of an annular cross-sectional area throughout at least approximately equal to the cross-sectional area of the opening 13 at opposite ends of the body as well as that of the flow passage through tubular part 14 thereabove. With reference to FIG. 1, the opposite ends of the opening 13 are indicated at 19 and 20.

As can be seen from FIGS. 1 to 3 the outer surface of the valve member 17 is curved convexly at its head or upper end 21 and is tapered from the head and along its sides to point 22 at its opposite end. This construction still further reduces the resistance to the flow of drilling mud or the like downwardly through the valve body in the position shown in FIG. 1.

An annular member 23 is secured to and spaced concentrically about the valve member 17 by means of thin, radially extending ribs 24 for sliding within a cylindrical portion 26 of the opening through valve body part 12 so as to guide the valve member during its reciprocation within said opening. The inner surface 25 of the guide member is also tapered from its upper to its lower end to form an uninterrupted continuation of the annular flow path 18 beneath the portion thereof formed between the valve member and body opening 13. As shown in FIG. 1, the outer surface of the guide member fits closely within cylindrical portion 26 and is intersected by inner surface 25 so as to maintain a smooth contour for the flow path 18.

The lower end of the guide member 23 is engageable with an upwardly facing shoulder 27 on the valve body so as to locate the valve member in its above-described unseated position. On the other hand, movement of the valve member 17 in a seating direction is limited by the engagement of its seating surface upon seat 16. As can be understood from FIGS. 1 and 2, valve body part 11 is disconnectable from part 12 to permit the guide member and valve member to be moved axially out of the cylindrical portion 26 of the opening through valve body part 12.

As shown in FIGS. 1 and 2, a ring 28 of resilient sealing material is disposed between the valve body parts 11 and 12 at the inner end of the threaded connection therebetween. More particularly, the upper end 29 of the sealing ring is confined between a reduced outer diameter portion of the inner end of valve body part 11 and the inner surface of valve body part 12, and the inner surface of the lower end of the seal member is tapered down to a lip 30 to provide a portion of flow passage 18. It will also be understood from these figures that the seal member 28 is removable from the opening through valve body part 12 along with the guide member and valve member. Obviously, other seal means may be used, if desired.

The valve member 17 comprises a body having a ring 31 of the resilient sealing material disposed thereabout to form the seating surface engageable with the seat 16. An expander ring 32 is also received about the body of the valve member body above and adjacent the sealing ring 31, and is longitudinally slidable with respect thereto from its FIG. 1 to its FIG. 2 position for radially expanding the sealing ring into engagement with the seat 16 as the expander ring engages the valve body upon movement of the valve member into closed position. As previously mentioned, this arrangement is desirable in that it insures an initial engagement between the outer surface of the sealing ring and the seat 16, despite wear of the ring or tolerances. Furthermore, when the sealing ring is sealably engaged with the seat 16, it will be compressed to a unit pressure which is a multiple of the unit pressure being sealed against. Thus, high pressure fluid beneath the closed valve will provide a correspondingly tight seal between the valve member and valve body.

The upper end of the expander ring 32 is retained by an annular shoulder 33 on the head 21 of the valve member when the sealing ring is collapsed. More particularly, the head 21 of the valve member comprises a cap threadedly connected at 34 to the upper end of a hollow space 35 within the valve member body. Obviously, such a space increases the buoyancy of the valve member in a seating direction and the chamber 35 may be formed to any suitable size or filled with any suitable material for further adjusting such buoyancy. As previously mentioned, the reason for increasing the buoyancy of the valve member in this manner is to enable it to be forced upwardly into the seated position of FIG. 2 when there is no flow therepast, but when the drill string is filled with drilling mud, so that there is no tendency for the valve to stick in the open position of FIG. 2 when the mud pumps have been shut down. As previously mentioned, the buoyancy of the valve member may also be increased by forming it of a light weight material, such as aluminum or its alloys.

On the other hand, while this buoyancy will desirably close the valve member in the conditions above described, it is contemplated that the closing force will be so small that when the mud pumps are again started, the valve member will automatically open. Obviously, this balancing effect could be accomplished by one skilled in the art in the light of this disclosure.

Similarly to the above-described embodiment, the check valve of FIGS. 4 and 5 comprises a valve body 36 which includes a pair of tubular parts 37 and 38 coaxially and threadedly connected together to define an opening 39 therethrough. As in the case of the embodiment of FIGS. 1 to 3, these parts forming the valve body may be connected within a drill string or other conduit. An annular seat 40 is formed on the body within the opening 39, in a manner to be described hereinafter, and a valve member 41 is reciprocable within the opening between a seated position (FIG. 5) to close the opening and an unseated position (see broken lines in FIG. 4) to provide an annular flow path 42 through the opening.

As in the case of the embodiment shown in FIGS. 1 to 3, the valve member 41 will assume the unseated position when drilling mud or other fluid is pumped downwardly through the drill string. On the other hand, the valve member 41 is automatically responsive to a reversal of flow or an increase of pressure of the fluid within the string beneath the valve for movement into the seated position of FIG. 5 so as to prevent such fluid from movement upwardly therepast. The solid lines of FIG. 4 illustrate the valve member 41 in a position it will assume when there is neither the circulation of mud downwardly therethrough nor a rush of fluid upwardly therepast, and furthermore when the drill string is not filled with drilling mud or other fluid.

As can be seen from FIG. 4, and as previously described, the flow path 42 is substantially straight and of an annular cross-sectional area throughout at least approximately equal to the cross-sectional area of the opening 39 at the opposite ends of the body, as indicated at 43 and 44. Also, similarly to the valve member 17 of FIGS. 1 to 3, the outer surface of the head 45 of the valve member 41 is curved convexly and the opposite sides of such valve member are tapered from the head to a point 46 at the opposite end of the valve member.

An annular guide member 47 is secured to and spaced concentrically about the valve member 41 by means of thin, radially extending ribs 48 for sliding within a cylindrical portion 49 of the opening 39 through the valve body. Also, the inner surface 50 of the guide member 47 is tapered to form an uninterrupted continuation of

the annular flow path 42 beneath that portion thereof formed between the valve member and the body opening 39. As in the case of the guide member of the FIG. 1 to 3 embodiment, the outer surface of guide member 47 fits closely within the cylindrical portion 49 of the valve body opening so as to maintain a substantially smooth contour on the outside of the flow path 42.

The lower end of the outer surface of guide member 47 is reduced at 51 to receive the upper end of a compression coil spring 52 acting between a downwardly facing shoulder 53 on the guide member 47 and an upwardly facing shoulder 54 on the valve body. This coil spring 52 urges the valve member 41 upwardly toward its seated position so that when the drill string is filled with drilling mud or other fluid, the buoyancy of the valve member will be such as to raise it to its seated position of FIG. 5. Obviously, the buoyancy may be adjusted as desired by means of springs of different rates. On the other hand, when drilling mud or other fluid is pumped downwardly through the drill string, the valve member 41 will be urged to an unseated position to compress the coil spring 52 between oppositely facing shoulders 53 and 54 on the guide member 47 and the valve body, respectively. Generally, this downward flow will fully compress the spring and urge the valve member into the unseated position shown by broken lines in FIG. 4. As previously indicated, however, when the drill string is not filled with drilling mud, the spring will not have sufficient effect to urge the valve member 41 to its fully seated position, but only to a position somewhere intermediate its seated and unseated positions, such as shown in solid lines in FIG. 4.

The tubular part 38 of the valve body is counterbored at 55 beneath cylindrical portion 49 thereof so as to receive the lower end of reduced portion 51 of guide member 47 in the unseated position of the valve member. In this manner, the spring 52 will be enclosed within a chamber formed between cylindrical portion 49 and reduced portion 51 intermediate shoulders 53 and 54 and thereby protected from the drilling fluid passing downwardly through the valve.

As in the case of the FIGS. 1 to 3 embodiment, the tubular part 37 of the valve body is disconnectable from tubular part 38 to permit the valve member and guide member to be removed from the opening 39 through the valve body. Furthermore, in this embodiment of the present invention, the seating surface of the valve member is located about its thickest or maximum diameter portion, as shown in FIG. 5, so that the valve has a flow path therethrough of maximum area.

Also, in this particular embodiment of the invention, the seat 40 is provided on an annular ring of resilient sealing material which is carried by a third body part 56 held between the inner end of tubular body part 37 and an upwardly facing annular shoulder 57 on tubular valve body part 38. More particularly, this valve body part 56 includes an upper ring 58 and a lower ring 59 confining the opposite ends of the sealing ring and is removable with the guide member and valve member upon disconnection of valve body part 37 from part 38.

The lower ring 59 is engaged by the upper end of guide member 47, as the valve member moves into the seated position of FIG. 5, so as to expand the sealing ring forming the seat 40 radially into engagement with the aforementioned seating surface about the thickest portion of the valve member 41. As previously described in connection with the seal ring 31 of the FIGS. 1 to 3 embodiment, this arrangement not only insures an initial engagement of the sealing ring with its opposite surface, but also provides the sealing ring with a pressure which is a multiple of the pressure being sealed against.

It will be noted that in each of the above-described embodiments, the wall of the valve body is relatively thick, even about the portion thereof within which the valve member is reciprocable. Thus, there is little danger of failure of the valve body even under the highest of well pressures. Furthermore, it will be seen that the outer diameter of the valve body is not enlarged and, as indicated in FIG. 1, is substantially the same as the outer diameter of the drill string. This construction also makes the check valve of the present invention particularly well suited for use as a drill string valve inasmuch as it will not choke the annular space through which the drilling mud returns.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advatnages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. A check valve, comprising a body having an opening therethrough, a ring of resilient sealing material on the body within said opening, a valve member longitudinally reciprocable within the opening between a seated position in which its thickest cross-sectional portion is movable into the ring to close the opening and an unseated position providing an annular flow path between the valve member and body opening, an annular guide member secured to the valve member for sliding within the body opening and spaced therefrom to provide an annular flow path which forms a continuation of the annular flow path between the valve member and the valve body opening, an expander ring adjacent and longitudinally slidable with respect to the sealing ring, means for locating the expander in position to be engaged by the guide member as the valve member moves toward closed position to expand said sealing ring into engagement with said thickest cross-sectional portion of the valve member, and cooperable parts on said guide member and valve body for locating the valve member in its unseated position.

2. A check valve of the character defined in claim 1, including a spring acting between the valve body and guide member for urging the valve member toward its closed position.

3. A check valve of the character defined in claim 1, wherein the valve body comprises two axially connected parts, and said sealing ring and expander are removable from the body opening to permit removal of the valve member and guide member upon disconnection of one of said parts from the other.

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