

[54] MUD SAVER VALVE AND METHOD

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Related U.S. Application Data

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[52] U.S. Cl. **175/65, 166/315, 175/218**

[51] Int. Cl. **E21b 7/00**

[58] Field of Search **175/57, 218, 65; 166/315, 106, 75; 137/496, 536, 71, 493.2; 251/149.5**

[56] **References Cited**

UNITED STATES PATENTS

3,331,385	7/1967	Taylor.....	175/218
21,535	9/1858	Hondy et al.	137/493.2
2,749,992	6/1956	Hill.....	166/106

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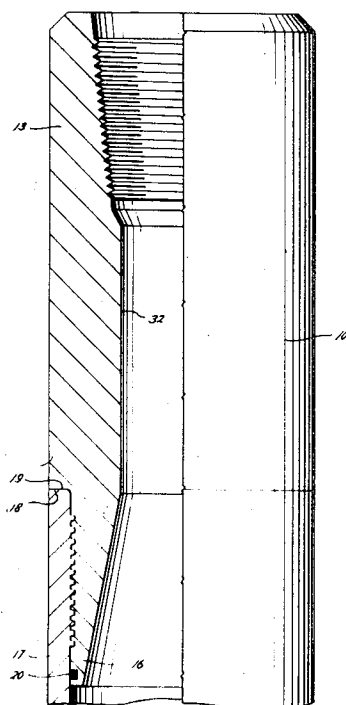
[57] **ABSTRACT**

A mud saver valve assembly is connected between the lower end of the kelly and uppermost joint of drill pipe, the assembly including a downwardly opening spring loaded poppet valve and an upwardly opening ball check valve. The downstream face of the poppet is shielded from line pressure by a sealed air chamber at atmospheric pressure in such a manner that the resul-

tant force of downstream pressure on the poppet tends to open the poppet.

Before adding another joint to the drill string the mud pump is shut down and the pressure gage checked to make sure there is no pressure in the drill string, any pressure in the drill string being transmitted through the ball check valve. If there is pressure it is bled off through a bleed off valve, if possible. With pressure down, the connection between the mud saver valve assembly and drill string is broken and a connection is made between the mud saver valve assembly and a joint of pipe in the mouse hole. No mud escapes from the kelly since the hydrostatic head of mud in the kelly is not sufficient to open the poppet valve in the mud saver valve assembly. The added joint of pipe is connected to the drill string still in the hole and the mud pump is turned on, automatically opening the poppet valve to restore circulation. The new joint is checked for leaks and if okay the drill string is lowered and drilling resumed. Since the downstream side of the poppet is shielded from mud pressure the pressure drop across the valve need not equal the spring force to hold the valve open, whereby pump horsepower is not wasted and whereby rapid valve erosion is eliminated. If on opening the bleeder valve, drill string pressure is not relieved, it is possible to close the blow out preventers and reverse circulate to kill the pressure in the formation, the poppet valve being full open under well pressure thereabove in the kelly transmitted by the ball check valve, the atmospheric chamber below the poppet enabling the poppet to stay open when there is well pressure in the kelly sufficient to overcome the spring bias tending to close the poppet.

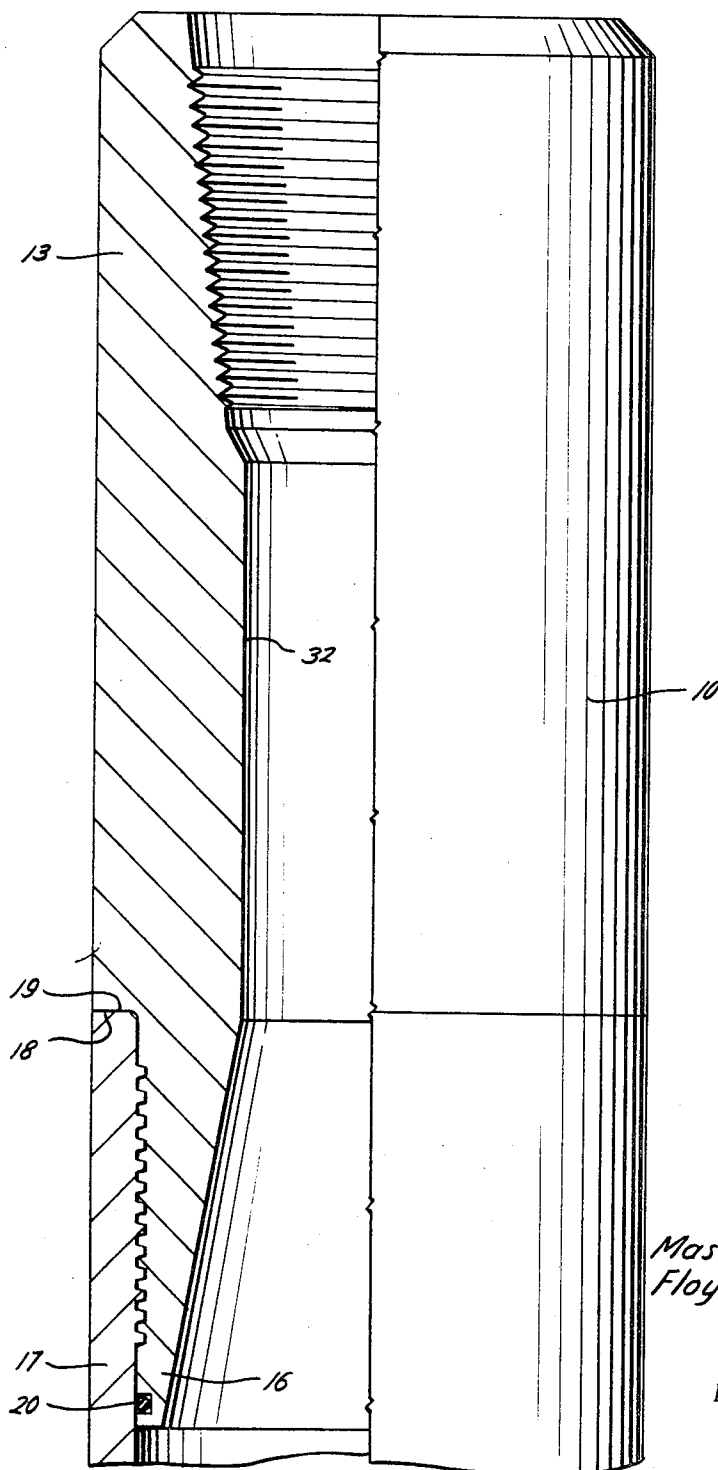
2 Claims, 5 Drawing Figures



PATENTED JUN 12 1973

3,738,436

SHEET 1 OF 4



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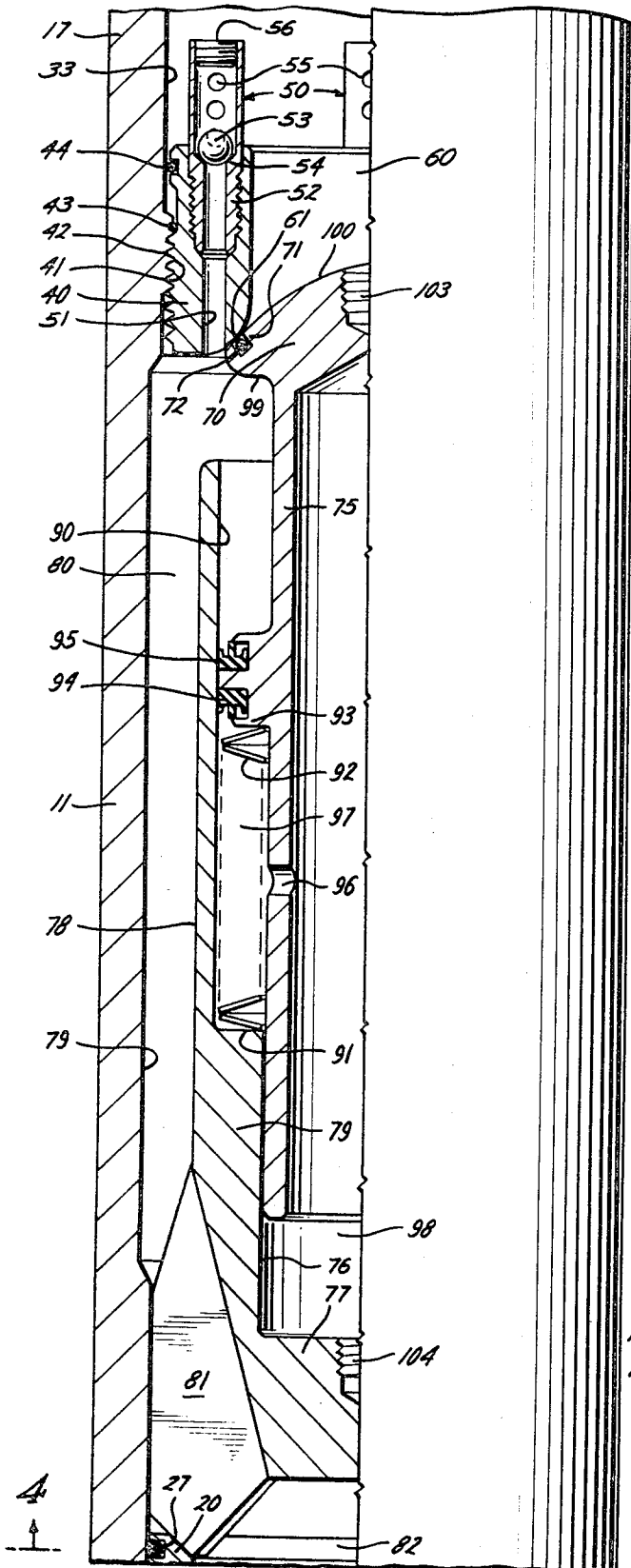


Fig. 2

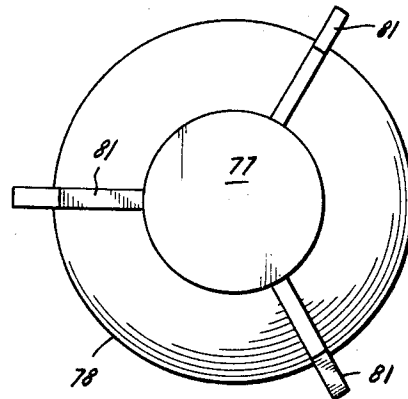


Fig. 4

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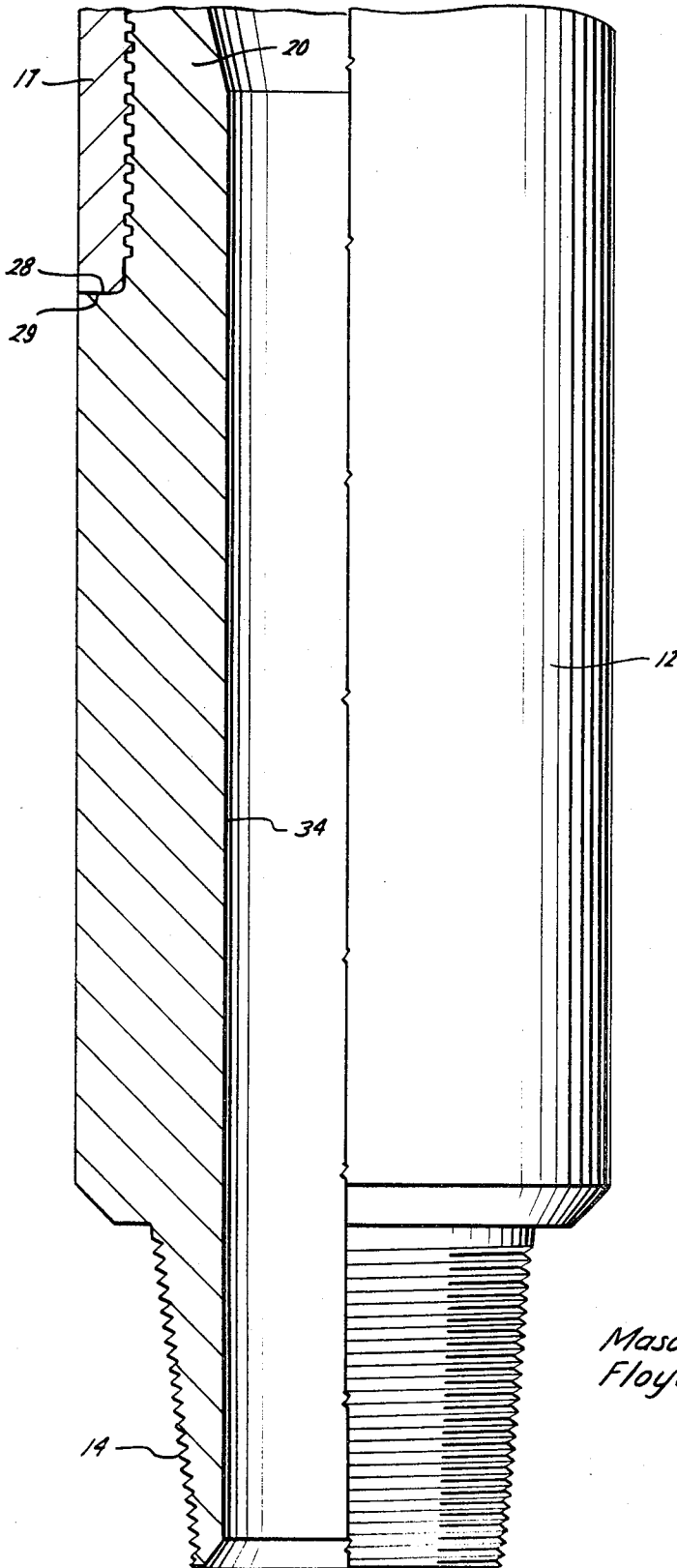
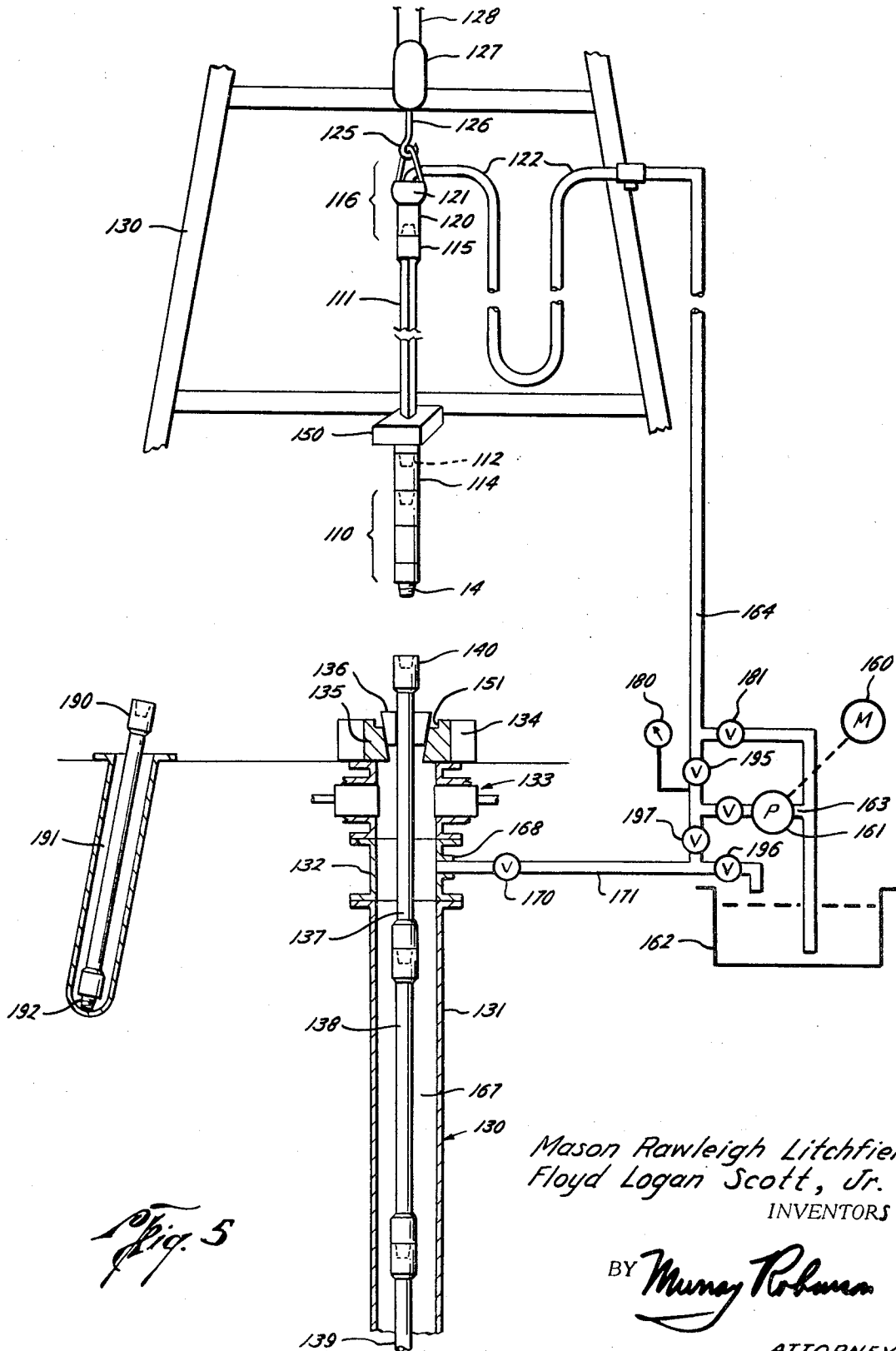


Fig. 3

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MUD SAVER VALVE AND METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of a prior application of the same title, Ser. No. 58,525, filed July 29, 1970 by the same applicants as for the present application. The assignee of the present application and said application Ser. No. 58,825 is also the assignee of application, Ser. No. 58,824 filed July 29, 1970 and Ser. No. 147,484 filed May 27, 1971, both directed to subject matter related to that of the present application.

BACKGROUND OF THE INVENTION:

a. Field of the Invention

This invention pertains to valves and more particularly to a valve assembly of the type known as a kelly foot valve or mud saver valve used in the rotary system of drilling oil wells.

b. Brief Description of the Prior Art

A gravity opened, stinger closed kelly foot valve is shown in U.S. Pat. No. 3,191,905 to Brown. This valve will open when the kelly is connected to the joint of drill pipe in the mouse hole, whereby the mud in the kelly will be lost. The valve is therefore not adapted for mouse hole operation.

A full opening flapper gate type spring loaded pressure release, kelly foot valve is shown in U.S. Pat. No. 3,289,691 to Kennard. However flapper gate valves may not seal tightly to retain mud in the kelly.

A spring loaded poppet type pressure release kelly foot valve is shown in U.S. Pat. No. 3,331,381 to Taylor. However no means is provided to communicate drill pipe pressure to the mud pressure gage after the mud pump is shut down to warn the operator prior to breaking the drill pipe connection to the valve.

A later U.S. Pat. No. 3,433,252 to Kennard shows a kelly foot valve of the pressure and spring actuated rotary plug type. This valve may be rather expensive to manufacture.

The combination of an upwardly opening ball check valve in the seat of a downwardly opening spring loaded poppet type pressure release valve is shown in U.S. Pat. No. 2,749,992 to Hill. However there is no suggestion that such a valve assembly be used as a kelly foot valve to indicate the presence of drill string pressure to warn the operator prior to breaking the connection between the kelly and drill pipe whereby the pressure can be relieved before the connection is broken.

Various means have been used to keep a spring loaded, kelly foot valve open without the necessity of a pressure drop across the valve equal to the force exerted by the bias spring. In the Kennard rotary, ball plug, kelly foot valve construction, an annular piston is geared to the ball and the upper piston head is exposed to upstream pressure and the lower piston head is sealed off from the fluid passage. In the Kennard flapper gate kelly foot valve construction shown in his earlier patent a similar annular piston drive is used, the piston being exposed to upstream pressure on one side and to the pressure in a sealed chamber on the other side. Such arrangements require a more complicated valve structure than the simple poppet valve employed in the present invention. Furthermore, in none of these constructions is there incorporated any means to admit drill string pressure to the kelly when the poppet is

closed, such as to cause the poppet to open and permit reverse circulation.

SUMMARY OF THE INVENTION

According to the invention the difficulties with the foregoing prior art constructions are avoided by providing at the lower end of a kelly a mud saver valve assembly including a downwardly opening spring loaded poppet valve and between the seat of the poppet and the valve body an upwardly opening ball check valve. The lower face of the poppet is shielded from upwardly acting line pressure by being disposed in a sealed gas chamber at atmospheric pressure, the sides of the poppet slidably, sealingly engaging the sides of chamber. The shielding is such that the resultant force on the poppet due to downstream pressure acts to close the poppet; this being accomplished by making the chamber of larger diameter than the poppet seat. This has the further advantage that when the poppet opens it enters the top of the chamber to keep out flowing mud which might deposit cuttings in the chamber.

With such construction a novel method of adding a joint of drill pipe to a drill string becomes possible comprising shutting down the mud pumps, determining from the mud pressure gage the existence of any drill string pressure. If any exists, eliminating it, and thereafter breaking in the connection between the drill pipe and mud saver valve assembly, which is automatically closed against downflow of mud due to hydrostatic pressure in the kelly, making a connection between the mud saver valve assembly and a joint of pipe in the mouse hole while leaving the kelly foot valve closed to prevent loss of the mud, elevating the joint of pipe out of the mouse hole and connecting it to the drill pipe in the hole, starting the mud pump which automatically opens the mud saver valve and starts mud circulation, checking the newly added joint of drill pipe for leaks, and if no leaks are found, lowering the drill string to resume drilling. In eliminating drill string pressure prior to breaking the connection of the drill pipe and mud saver valve, as is desirable to prevent injury to the operator, the bleed off valve in the stand pipe is first opened. If that is not effective, it is then possible to close the blow out preventers and reverse circulate, e.g. with heavy mud, to kill formation pressure, the poppet valve of the mud saver valve assembly being full open due to drill string pressure being transmitted to the kelly above the poppet by the ball check valve and the lower face of the poppet being sealed off from line pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

For a detailed description of a preferred embodiment of the invention reference will now be made to the accompanying drawings wherein:

FIGS. 1-3 are half sections through the upper sub, body, and lower sub of a mud saver valve assembly embodying the invention;

FIG. 4 is a bottom view of the sealed chamber forming part of the assembly shown in FIG. 2, as indicated by line 4-4 of FIG. 3; and

FIG. 5 is a pictorial view of a drill rig and well bore illustrating the method of the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring to FIGS. 1-3, there is shown a mud saver valve assembly comprising an upper sub or short,

length of pipe 10, a tubular valve body 11 and a lower sub 12. The upper sub is provided with a tapered threaded box 13 forming part of a usual rotary shouldered connection by means of which the mud saver valve can be connected on to the pin at the lower end of a kelly or other drill string member. The lower end of sub 12 is provided with a tapered threaded pin 14 forming part of a usual rotary shouldered connection by means of which the mud saver valve assembly can be connected to a box at the upper end of a drill pipe or other drill string member.

The lower end of sub 13 is provided with a cylindrically threaded box 17 at the upper end of the valve body 11, there being shoulders 18, 19 on the box and pin to form a seal as the pin root and box mouth are axially stressed by tight makeup. Also, there is an O-ring seal 20 provided around the small end of the pin 16 seal with the inside of body 11.

The upper end of sub 12 is provided with a cylindrically threaded pin 26 which is screwed into a cylindrically threaded box 27 at the lower end of the valve body 11, there being shoulders 28, 29 on the box and pins to form a seal as the pin root and box mouth are axially stressed by the tight make up. Also, there is an O-ring seal 30 provided around the small end of the pin 26 to seal with the inside of body 11.

There is a fluid passage axially through the mud saver valve assembly including passage 32 through sub 10, passage 33 through body 11, and passage 34 through sub 12.

Referring now particularly to FIG. 2, a seat ring 40 is provided with an external cylindrical thread 41 by means of which it is screwed into a cylindrical thread 42 on the interior of the valve body. An O-ring 43 provides a seal at the upper end of the threads and a further O-ring 44 carried by the seat ring at its upper end provides a further seal between the seat ring and valve body.

Annularly disposed about the seat ring are one or more upwardly opening ball check valves 50 such as shown at 50. Each valve 50 includes an inlet passage 51, a seat tube 52 screwed into the seat ring at the upper end of passage 51, and a ball 53 adapted to rest on and seal with an annular tapered seat 54 in the seat tube. There are a plurality of outlet ports 55 in the seat tube. A plug 56 is screwed in to the upper end of the seat tube to retain the ball.

There is a flow passage 60 through the seat ring 40. At the lower end of the flow passage the flow passage flares downwardly providing a hyperbolically tapered seat 61.

A poppet or valve closure 70 has an elliptically tapered upper face providing a seating surface 71 in which is disposed an O-ring 72 adapted to seal with seat 61 when the valve is closed. Depending from poppet 70 is a tubular skirt 75 which slides telescopically inside the cylindrical interior 76 of a tubular cup 77 (see also FIG. 4). The outer periphery 78 of the side wall 79 of the cup is generally cylindrical and is spaced radially from the enlarged inner periphery 79 of the valve body forming an annular flow passage 80 therebetween. The cut 77 is provided with webs 81 at its lower end which rest on the bevel 82 at the upper end of pin 20 of the lower sub.

There is an enlarged cylindrical bore 90 in the upper part of the side 79 of cup 77, forming a shoulder 91 at the end of the enlarged bore. A Belleville spring 92

bears at its lower end against shoulder 91 and at its upper end against an annular flange 93 around skirt 75. A pair of oppositely facing annular lip seal 94, 95 carried by flange 93 seal between the flange 93 of skirt 75 and the bore 90 of the tubular cup 77.

A port 96 communicates the annular space 97 between cup and skirt occupied by spring 92 with the space 98 inside cup 77 and skirt 75 whereby any mud leaking past seals 94, 95 will pass into the sump space 98 to prevent hydraulic locking of the valve. The chamber defined by the cup and skirt, enclosing spaces 97, 98, contains air at atmospheric pressure when the mud saver valve assembly is initially assembled and it is intended that sliding seal means 94, 95 will keep mud, water, or other drilling fluid out of the cup-skirt chamber whereby the gas pressure in the chamber will remain substantially atmospheric. Since mud is not an elastic fluid, a considerable amount of mud leakage can occur without the gas pressure in the chamber formed by the cup and skirt rising greatly above atmosphere.

The forces beneath poppet 70 tending to close the poppet are the force of spring 92 (prestressed in compression when assembled) plus the force of atmospheric pressure in spaces 97, 98 on the underside of flange 93 and the underside of the poppet skirt and the underface of the poppet inside the skirt.

The downstream line pressure acts upwardly on the annular area 99 of the underside of the poppet outside skirt 75, but this pressure also acts downwardly on the larger annular area of the upper face of flange 93 and the annular area on top of the poppet outside O-ring 72, the net effective area being such as to create a downward force.

Other forces acting down on poppet 70 tending to open the valve are initially the force of gravity on the poppet plus the force of the upstream pressure acting on the exposed area of the upper-face 100 of the poppet plus the force of an indeterminate pressure between upstream and downstream pressure acting on the seating surface 72 of the poppet.

When the valve opens, seating surface 72 will be exposed to upstream line pressure, and the net effective area of the poppet previously exposed to downstream line pressure will be exposed to a pressure equal to upstream line pressure less the pressure drop across the poppet. This will tend to open the valve fully once it starts to open despite the slight increase in the force exerted by long prestressed Belleville spring 92 as it is compressed and despite the slight increase in the air pressure in the cup-skirt chamber as the poppet moves down and compresses the gas. The chamber is large compared to the poppet travel from closed to open position, e.g. a ratio of five to one, so that such gas pressure increase is not great.

The spring 92 is prestressed to exert sufficient force on the poppet to keep it closed under the hydrostatic pressure of a column of drilling mud in the kelly beneath which the mud saver valve assembly is connected. For example, assuming a forty three foot kelly full of 16 pounds per gallon density drilling mud, the mud pressure would be about 40 pounds per square inch. Assuming further, as an approximation, that the net effective area exposed to downstream pressure were zero and that the area of the poppet exposed to mud weight equaled the area of the poppet, skirt and flange exposed to air pressure of the chamber, the spring force would have to exceed that due to the dif-

ference between the mud pressure and air pressure acting over the area exposed to the mud. With a pressure difference of 40 minus 15 or 25 pounds per square inch and an area of three square inches, the spring load would be somewhat in excess of 75 pounds, e.g. 100 pounds to insure tight closure of the poppet valve.

With a mud pump pressure of the order of 1,000 pounds per square inch, the valve will of course open fully when the mud pump is turned on. Since the mud pressure is shielded by the skirt-cup chamber from the underside of the poppet except for a net effective area directed downwardly, and since the seat area of the poppet is exposed to full upstream pressure when the valve opens, once the valve opens it opens fully without the need for a pressure drop across the valve just to keep it open.

When the poppet opens, it can move down until the skirt 75 bottoms in cup 77. The lower part of the cup acts as a guide for the skirt during this motion. The volume reduction of the air or gas in the cup-skirt chamber will be equal to the area circumscribed by bore 90 multiplied by the poppet travel. As previously stated, the initial volume of the chamber is large compared to this volume reduction, e.g. a ratio of five to one. The poppet moves down to the cup preventing drilling mud flowing through the valve from depositing any debris or, especially in the case of reverse circulation, any cuttings, into the cup, and preventing erosion of the cup, skirt, and seals 94, 95 by the turbulent abrasive mud.

The belleville spring 97, which comprises a plurality of alternately oppositely directed conical washers, preferably exerts an initial force not in excess of 100 percent of the weight of a column of drilling mud in the kelly to which the mud saver valve assembly is connected which mud has a specific gravity of three. Since most drilling muds have a density of not over 24 pounds per gallon, this will insure that the spring will hold the poppet shut with only the hydrostatic pressure of mud in the kelly but will open when the mud pump is turned on. It may be noted here that it is uncertain what gas pressure will exist in the kelly above the mud column when the pump is shut down, but if there exists atmospheric pressure at the top of the kelly, e.g. as the result of opening a bleed valve to reduce the drill string pressure, there may be atmospheric pressure in the kelly above the mud column. However the atmospheric pressure above the mud column will be offset by the atmospheric pressure in the cup-skirt chamber acting in opposition. therefore the poppet will stay closed if there is no fluid pressure in the kelly other than that of the mud and the atmosphere.

Since the belleville spring urges the poppet towards its seal and urges the cup 77 down against pin 20 which supports the webs 81, it is apparent that the poppet and the cup-skirt chamber are captured between the seat ring 40 and the pin 20 on the lower sub. The spaces between the azimuthally spaced apart webs 81 provide fluid paths through the cup connecting with the fluid passage 80 formed between the cup and valve body.

When the valve assembly needs to be cleaned it is easily disassembled by unscrewing the lower sub 12. On reassembly, the spacing between shoulder 28 and seat 40 is set so that the belleville spring is properly compressed when the lower sub is made up tight. If for any reason it is desired not to break the connection with the lower sub, the upper sub can be disconnected, the seat

ring unscrewed and the poppet and cup withdrawn by the tools screwed into sockets 103, 104.

In the foregoing description of the mud saver valve assembly reference has been made to the net effective area. By effective area is meant the projection of the area subject to pressure on a plane perpendicular to the direction of the force that is most effective and cause a desired effect, e.g. in the case of the poppet, forces most effective to open and close the valve are directed axially. By net is meant the algebraic sum, e.g. in the case of oppositely directed areas, the difference between such areas, or in the case of like directed areas, the sum thereof. By direction of an area is meant the direction perpendicular to the area going into the surface presenting such area.

In considering the operation of the poppet valve, it is perhaps best to consider the poppet, skirt, and flange 73 as one part, which may be called the valve closure. Reference may be made to such element in the claims appended hereto, especially in connection with the specification of the net effective areas thereof subject to various pressures.

Although the invention is described as relating to a mud saver valve assembly it is clear that it is also useful with other drilling fluids such as water or oil. Therefore the device may also be called a drilling fluid saver assembly. Furthermore, though the assembly has been described as being made as a separate unit, it could be integrated with the kelly saver sub or even with the kelly. For example upper sub 10 could be the usual kelly saver sub, since the upper sub does not serve to retain any of the inner parts of the valve which are captured between the seat ring and lower sub. It is only necessary that enough area on the outer surfaces be provided to accommodate tongs for making and breaking connections where desired. For example, if sub 10 is to be the kelly saver sub, the sub 10 and valve body 11 should have enough length and be soft enough to accommodate tongs.

Referring now to FIG. 5 there is shown the mud saver valve assembly 110 whose details are shown in FIGS. 1-4. The valve assembly 110 is connected to the lower end of a kelly 111, the kelly being a tube of non-circular, e.g. square outer periphery having screw connection means at its opposite ends, e.g. a pin 112 at its lower end connected to the box of a kelly saver sub 114 whose pin is connected to the box 13 (FIG. 1) of the mud saver valve assembly 110 and a pin 115 at its upper end connected to a swivel 116. The combination of the aforescribed mud saver valve assembly and the kelly (and kelly sub) constitutes the heart of the present invention since the purpose of the valve is to prevent loss of mud from the kelly when additional joints of drill pipe are to be added therebelow.

The kelly is connected at its upper end to a swivel 116 which includes a lower part 120 adapted to connect to and rotate with the kelly and an upper part 121 rotatably connected to the lower part and adapted to remain stationary while the lower part rotates. The upper part 121 is connected to hose 122. The swivel provides means to transmit drilling fluid from the hose to the kelly while allowing relative rotary motion therebetween.

The swivel 116 is provided with a bail 125 whereby it is suspended on hook 126 carried by travelling block 127. The travelling block is suspended by cable 128 from the conventional crown block (not shown) at the

upper end of derrick 130. By this means the kelly and mud saver valve assembly can be raised and lowered relative to the earth's surface.

An earth bore 130 is provided with casing 131 and a casing head 132. Above the casing head is mounted blowout preventer 133. On top of the preventer is disposed rotary table 134 adapted to receive a master bushing 135.

As shown, a set of slips 136 is received in the master bushing whereby is suspended a drill string including drill pipes 137, 138, 139. However when it is desired to rotate the drill pipe the kelly is lowered and pin 14 (see also FIG. 3) of the mud saver valve assembly is stabbed and screwed into the box 140 at the upper end of the drill string. The slips are then removed and the string lowered until kelly bushing 150 disposed around the kelly and held up by kelly saver sub 114 is received in the square recess 151 in the top of the master bushing. Thereupon the rotary table can rotate the drill string through the master bushing and kelly bushing and drilling can proceed.

During drilling motor 160 drives mud pump 161 to withdraw mud from pit 162 through pipe 163 and pump it through it and pipe 164 to hose 122. The mud then goes through the swivel and down the kelly, the kelly, saver sub, and the mud saver valve assembly into the drill string. Mud returns from the bottom of the earth bore through annulus 167 and thence out through side port 168 in the casing head; the mud passes through wing valve 170 and pipe 171 back to the mud pit.

When drilling has progressed to the point where the kelly has moved down to the point where the pin is right on top of the kelly bushing, it is necessary to add another joint, i.e., piece of drill pipe. The drill string is lifted with the derrick until the kelly bushing is out of the master bushing and slips are inserted to suspend the drill string as shown. The motor 160 is stopped, thereby shutting down pump 161. At this time the pressure in the drill string, as indicated by gage 180, should drop to substantially zero. If it does not, bleeder valve 181 is opened to bleed off the residual pressure. It will be recalled that at this time ball check valve 50 will communicate drill string pressure upwardly through the mud saver valve assembly into the kelly and thence through the hose 122 to stand pipe 164 and gage 180.

Assuming that the pressure has been reduced to zero, the mud saver valve assembly is unscrewed from the box 140 of the upper joint of pipe 137. The ball check valve 50 closes; the spring 92 keeps the poppet valve closed; no mud leaks out of the kelly. This is the condition shown in FIG. 5.

The lower end of the kelly is then pushed over to one side to align the mud saver valve assembly pin 14 with the box 190 of the joint of pipe 191 disposed in the mouse hole, a hole drilled close to the main bore 130 and slightly inclined relative thereto. The pin 14 is stabbed and screwed into box 190, the joint 191 is lifted out of the mouse hole, and pin 192 on the joint 191 is stabbed and screwed into box 140. The pump motor 160 is then restarted restoring circulation, and the newly added joint 191 and its connections are checked for leaks. If there are no leaks, the joint 191 is lowered into the hole and kelly 111 is lowered until kelly bushing 150 is again in recess 151. Drilling can then resume.

If there should be difficulty in lowering the drill string pressure after shutting down the pump, it may be desirable to reverse circulate the mud. Since there is pressure in the kelly communicated thereto by the ball check valve, the poppet valve will also be open so that mud can flow upwardly through the mud saver valve assembly. The cup-skirt chamber below the poppet largely shields the poppet against the dynamic force of the upwardly flowing mud.

To reverse circulate, the blowout preventer is closed, the pump outlet 195 and return line valve 196 are closed, and by pass valve 197 and bleeder valve 181 are opened. After the pressure has been brought under control the joint 191 can be added as previously described, circulation returned to its normal direction, and drilling resumed.

Although it has been pointed out that the drilling fluid saver assembly of the present invention is such as to allow reverse circulation should that be desirable, the assembly of course is intended for normal circulation during drilling and such normal direction of circulation can be employed in adding heavy mud to reduce drill string pressure. It is only desired to distinguish the present valve assembly from an ordinary upwardly closing check valve which would prevent reverse circulation.

While a preferred embodiment of the invention has been shown and described, modification thereof can be made by one skilled in the art without departing from the spirit of the invention.

We claim:

1. In the method of adding a joint to a rotary drill string suspended in a well bore from a kelly connected by a mud line to a mud pump with gage means indicating the pressure at the pump output,

in which method after the mud pump is shut down, the gage is then read to see if the drill string pressure communicated through the kelly has fallen sufficiently for it to be safe to disconnect the kelly from the drill string preparatory to inserting a new joint of pipe, the improvement comprising:

placing a downwardly opening, upwardly closing spring loaded poppet type mud saver valve in the connection between the kelly and drill string to retain mud in the kelly when the pump has been shut down and the connection between the kelly and drill string broken, and

prior to breaking said connection by-passing said poppet valve to effect immediate full equalization of pressure between the drill string and drill pipe whereby when said gage is read immediately after shutting down the pumps prior to breaking the connection it will indicate true drill string pressure.

2. Method according to claim 1 including after the step of reading the gage and before breaking the kelly to drill string connection the following steps performed, e.g. when the gage reading indicates excessive pressure in the drill string:

closing off the upper end of the annulus between the drill string and the upper end of the well bore, introducing the pressure drilling fluid into said annulus adjacent the upper end thereof but below the point where the annulus is closed off as aforesaid, and

shielding an area of the lower side of the poppet from drill string pressure sufficient for the valve to open due to said equalization of the drill string and kelly pressures when said drilling fluid is introduced into said annulus and flows down the annulus and back up the drill string into and out of the kelly through said poppet.

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