United States Patent [15] 3,667,557
Todd et al. [45] June 6, 1972

[54] **MUD DIVERTER AND INSIDE BLOWOUT PREVENTER DRILLING TOOL**

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[22] Filed: **Jan. 20, 1971**

[21] Appl. No.: **107,951**

[52] **U.S. Cl.** **175/242,** 175/38, 175/243, 175/318, 175/320

[51] **Int. Cl.** **E21b 27/00,** E21b 41/00, E21b 17/04, E21b 21/00

[58] **Field of Search**...........175/38, 320, 232, 324, 241–243, 175/316–318; 166/224, 224 S

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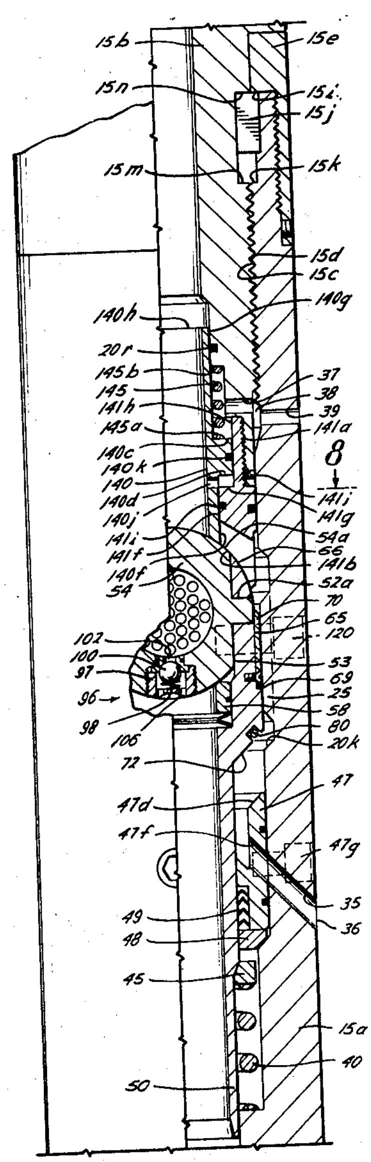
[57] **ABSTRACT**

A tubular member positioned in the drill string above a drill bit includes a rotatable ball valve to divert drilling fluid and the like in the well bore if the drill bit nozzles become clogged thus permitting continued circulation of the drilling fluid. The member also includes a movable sleeve to automatically prevent flow of the drilling fluid or the like up the drill string from the drill bit. The rotatable ball valve tends to prevent clogging of the drill bit nozzles by maintaining smaller channeled openings in the rotatable ball valve unclogged by wiping the ball valve surface and flushing the wiped clogging particles into the well bore.

22 Claims, 9 Drawing Figures



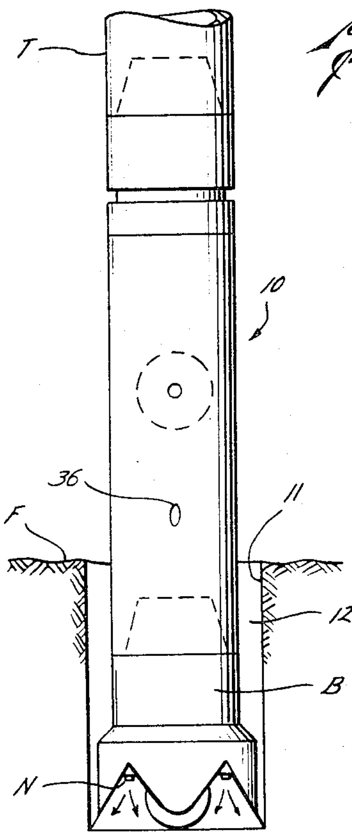
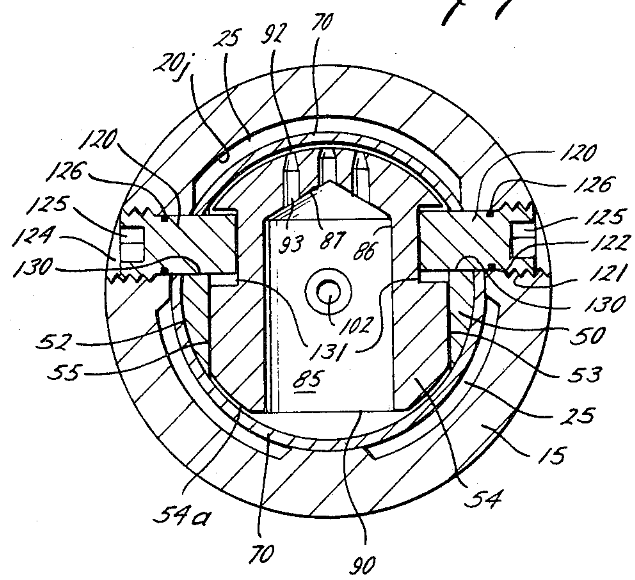


Fig. 1

Fig. 7



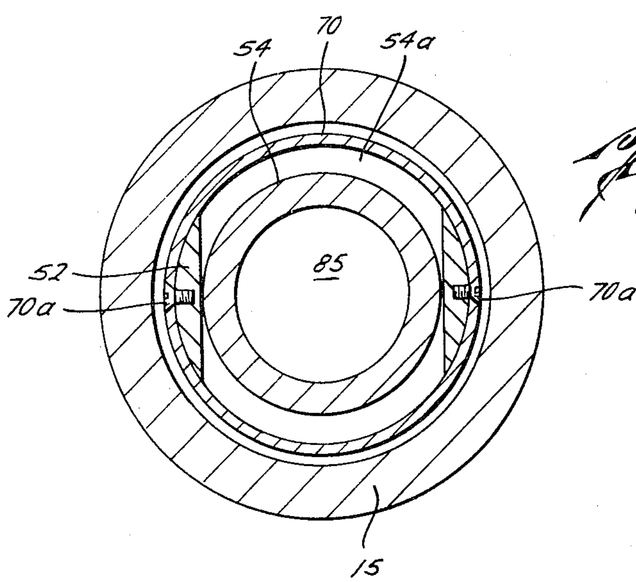


Fig. 8

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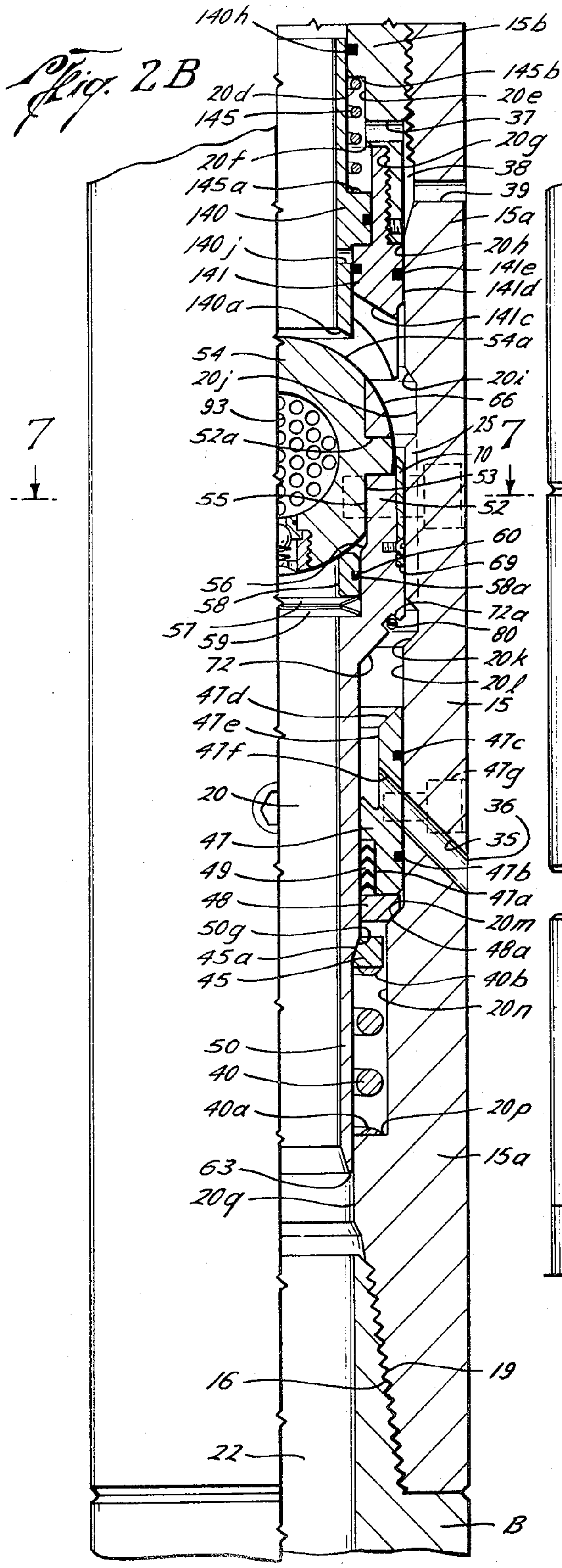

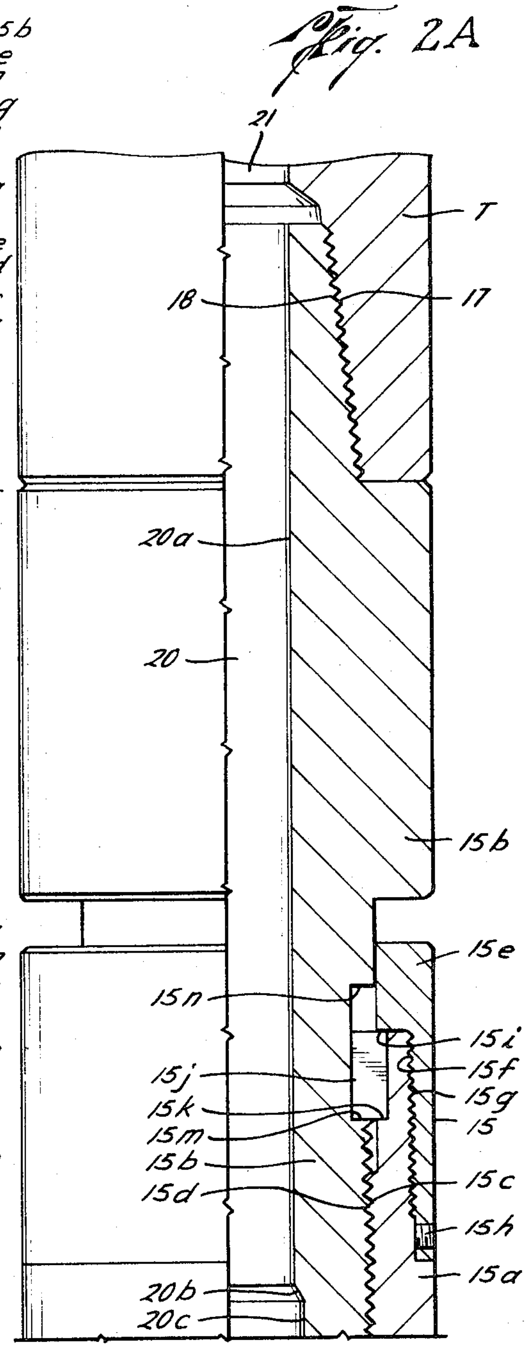

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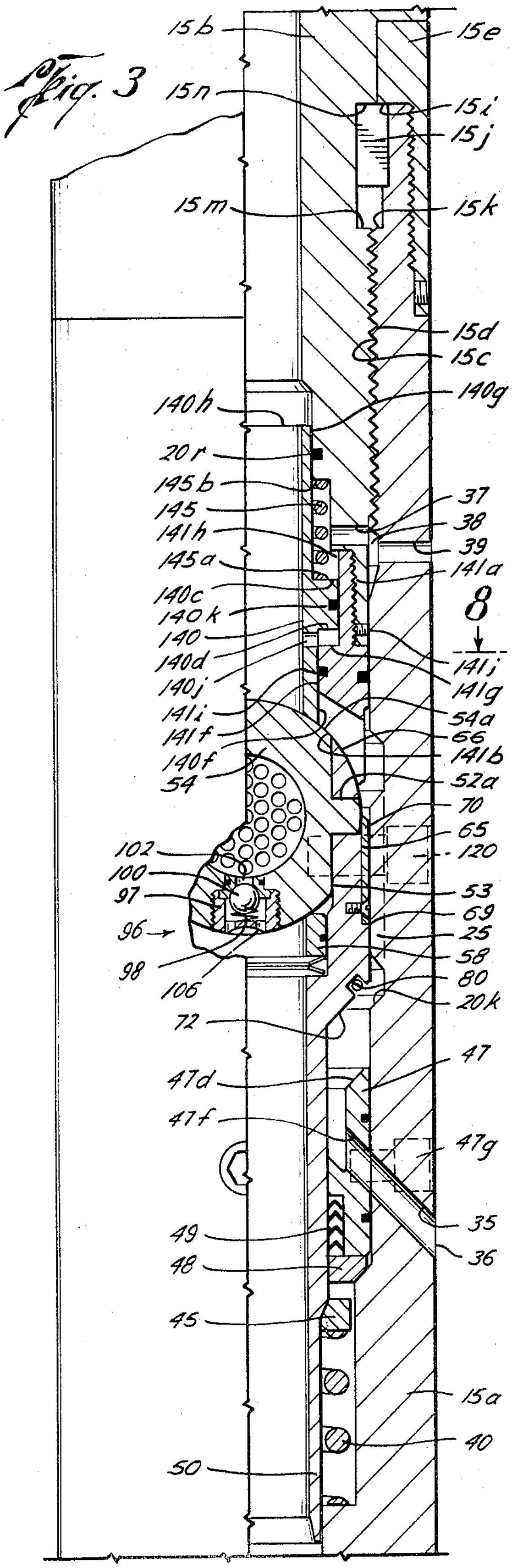

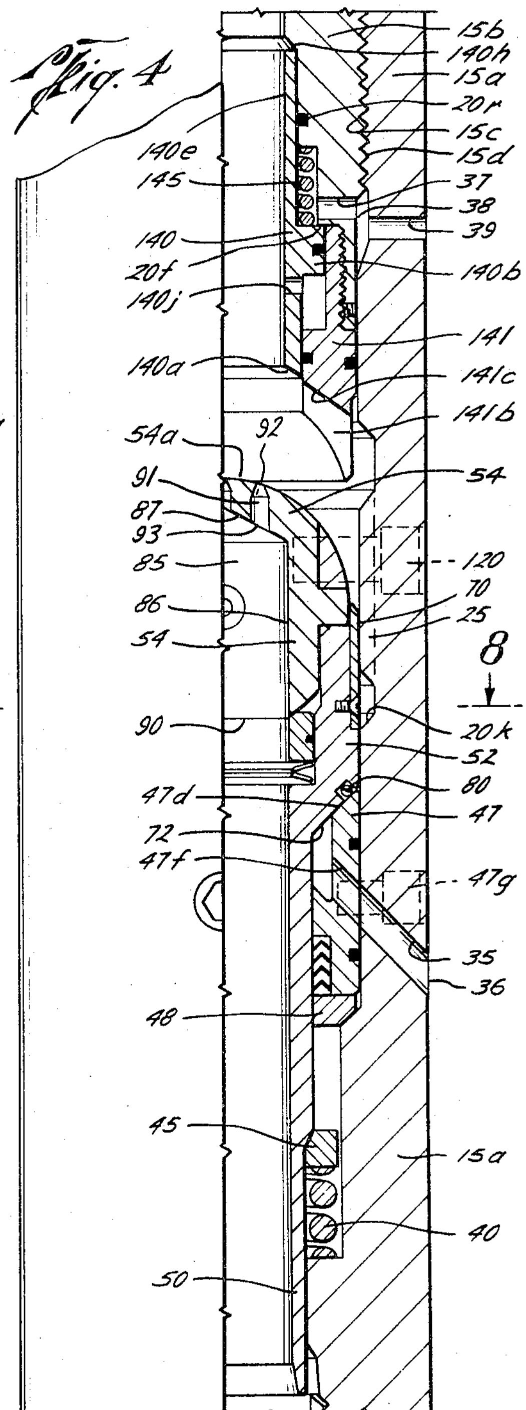

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Fig. 5

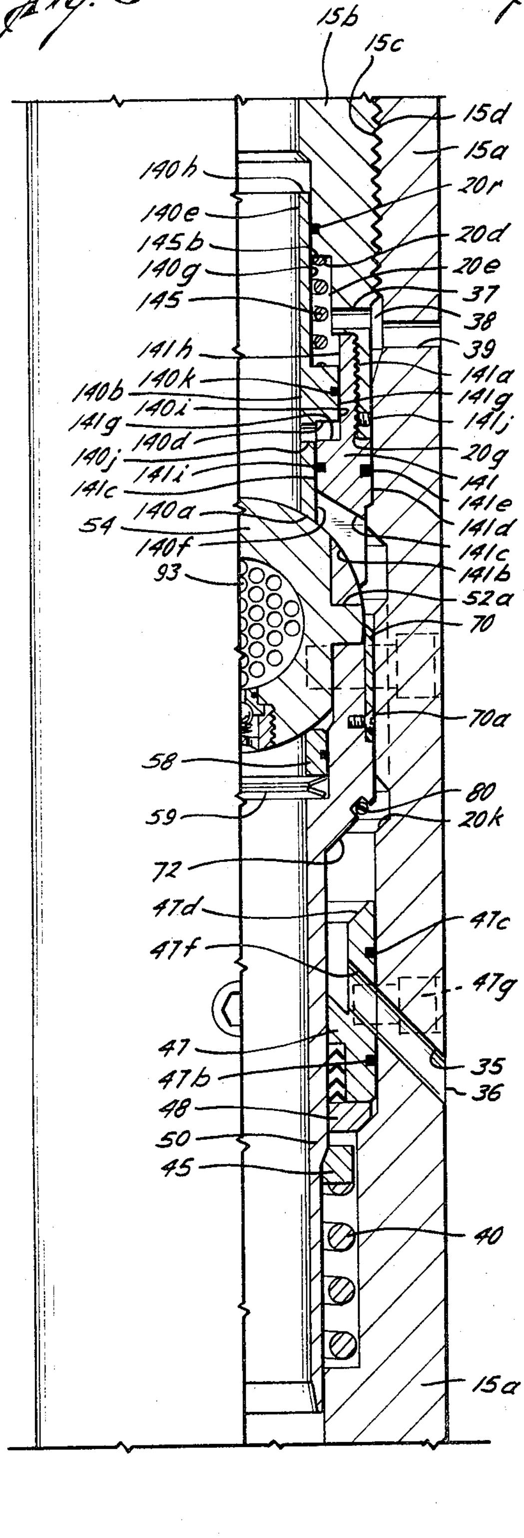
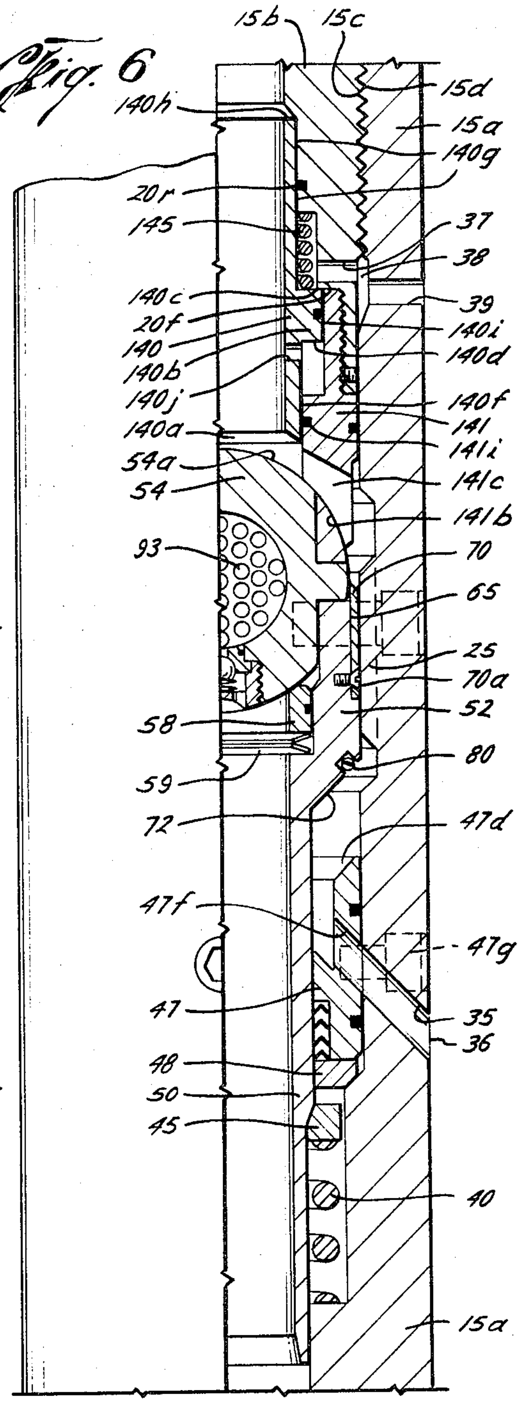


Fig. 6



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MUD DIVERTER AND INSIDE BLOWOUT PREVENTER DRILLING TOOL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of mud diverter and inside blowout preventer drilling tools and more particularly to a new and improved mud diverter and inside blowout preventer drilling tool.

2. Description of the Prior Art

Previously, if the nozzles of a drill bit became clogged by matters suspended in the drilling fluid, the entire drilling string was pulled with the drilling fluid in the string. Pulling a "wet" string subjected the drilling crew to having drilling fluid spilled all over them and the rig floor. Also, pulling the string "wet" required more costly down time as well as wasting expensive drilling fluid. Further, once the drilling bit was unclogged, and the drilling string run back into the well bore, the drilling string had to be filled from the surface supply of drilling fluid, since suspended particles, such as cuttings, in the drilling fluid remaining in the well bore tended to again clog the drill bit nozzles.

Other devices have used screens and the like in the drill string for screening the drilling fluid before it reached the nozzles of the drill bit and thus tended to prevent clogging of the drill bit nozzles. Such screens did not provide a means for flushing such screened particles into the annulus between the well bore and the drilling string and thus left the particles in the screen. In addition, these devices did not include provisions for full circulation of the drilling fluid into the annulus between the well bore and the drill string without circulating through the drill bit nozzles. Prior devices also have not provided for maintaining the fluid in the drilling string to assist in control of blowout conditions.

SUMMARY OF THE INVENTION

This invention relates to a new and improved mud diverter and inside blowout preventer drilling tool including a tubular member for positioning above a drilling bit in a drill string and having an inner bore communicating with the bore of the drill string and the drill bit, such tubular member having a circulation channel therein for permitting communication between the inner bore of the tubular member and the annulus between the well bore and the tubular member when the circulation channel is open, a first movable member positioned in said inner bore and mounted with said tubular member for selectively permitting the flow of drilling fluid through the inner bore of the tubular member or through the circulation channel as desired, said first movable member controlling flow of fluid therein through channels in said member, said channels being movable from transverse to aligned position relative to the well bore to permit communication between the inner bore and the drilling bit. The invention also includes a second movable member positioned in said inner bore and mounted with the tubular member for blocking the permitted flow passage of the first movable member in response to the pressure difference between the pressure of the fluid in the annulus and the pressure of the fluid in the tubular member inner bore.

It is an object of the present invention to provide a new and improved mud diverter and inside blowout preventer drilling tool.

Yet another object of the present invention is to provide a new and improved mud diverter and inside blowout preventer drilling tool wherein circulation of the drilling fluid may be accomplished without utilizing the drill bit nozzles.

Still yet another object of the present invention is to provide a new and improved mud diverter and inside blowout preventer for filtering the drilling fluid of drill bit nozzle clogging material prior to flowing the drilling fluid through the drill bit.

Still yet another object of the present invention is to provide a new and improved mud diverter and inside blowout preventer drilling tool wherein channel members in a movable member of such valve are wiped to remove clogged material therefrom to thus attempt to prevent clogging of the channel members.

Still yet another object of the present invention is to provide a new and improved mud diverter and inside blowout preventer drilling tool to eliminate the pulling of wet drilling string if the nozzles of the drill bit become clogged.

Yet another object of the present invention is to provide a new and improved mud diverter and inside blowout preventer drilling tool wherein the drilling string above the tool may be filled with drilling fluid which enters the drilling string from the well bore as the string is lowered into a well bore.

Yet still another object of the present invention is to provide a new and improved mud diverter and inside blowout preventer drilling tool where all flow through the tool is blocked when the annulus pressure is greater or substantially equal to the tubular member inner bore pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the mud diverter and inside blowout preventer drilling tool of the present invention in use in a well bore with a drill bit and drill string;

FIG. 2A is a partial cross-sectional view of the mud diverter and inside blowout preventer drilling tool of the present invention partially assembled.

FIG. 2B is a partial cross-sectional view of the mud diverter and inside blowout preventer drilling tool of the present invention;

FIG. 3 is a partial cross-sectional view of the mud diverter and inside blowout preventer drilling tool completely assembled;

FIG. 4 is a view similar to FIG. 2 but illustrating the tool of the present invention in the drilling position;

FIG. 5 is a view similar to FIG. 2 illustrating the tool of the present invention in the blocked-in position;

FIG. 6 is a view similar to FIG. 2, illustrating the tool of the present invention in the condition for draining the drill string;

FIG. 7 is a view taken along line 7—7 of FIG. 2B, illustrating the relationship of a first movable member of the present invention relative to the tubular member of the present invention; and

FIG. 8 is a view taken along line 8—8 of FIG. 4, illustrating the position of the first movable member when such valve is opened.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As illustrated in FIG. 1, the mud diverter and inside blowout preventer drilling tool of the present invention is generally illustrated by the numeral 10 and is connected with a tubular drilling string T and a drilling bit B having jet nozzles N as is well known in the art. As is further illustrated in FIG. 1, the drill string is positioned in a well bore 11 of a subsurface formation F to enable the drill bit B to move deeper into the formation as is well known in the art. The nozzles N permit jetting of fluid under high pressure from the drill string T, the drilling tool 10 and out through the nozzle N for drilling operations as is well known in the art. The drilling fluid, as is also well known in the art, circulates around the drill bit B and up the annulus 12 between the formation and the drill string T to the well surface (not shown) to float the drill bit cuttings and the like to the surface of the well site.

As illustrated in FIGS. 2A and 2B, the mud diverter and inside blowout preventer drilling tool 10 includes a tubular member 15 which is connected through the usual box and pin threading connection 16 and 17, respectively, to the box and pin threaded connections 18 and 19, respectively, of an upper tubular drill string member T and the drill bit B, respectively. Different means may be used for placing the tool in the string, but the box down connection is preferred for it allows the tool to be placed adjacent the drill bit.

The tubular member 15 includes a lower portion 15*a* having a threaded portion 15*c* engaging a threaded portion 15*d* of an upper member 15*b*. A concentric threaded cap member 15*e* is secured to the member 15*a* by threads 15*f* engaging threads 15*g* of the member 15*a*. A fastener means, such as a counter sunk bolt 15*h* secures the member 15*e* in position by preventing disengagement of threaded portions 15*g* and 15*f* when the tubular member 15 is rotated in a manner to be discussed more fully hereinafter. As illustrated in the partially assembled condition of FIG. 2A, a shoulder 15*i* of the cap member 15*e* bears against a split ring 15*j* at one side while the other side of the split ring 15*j* is held in position by shoulder 15*k* of the member 15*a*. As illustrated in FIG. 2A, the split ring 15*j* also bears against a shoulder 15*m* of member 15*b* when the tool is in the partially assembled condition and as illustrated in FIG. 3 against shoulder 15*n* of the member 15*b* when in the fully assembled position.

The tubular member 15 is provided with an inner bore or channel 20 which communicates with the inner bore or channel 21 of the tubular member T and the inner bore or channel 22 of the drill bit B. The inner bore 20 of the member 15 is defined as the inner wall 20*a*, tapered shoulder 20*b*, first step wall 20*c*, spring shoulder 20*d*, second step wall 20*e*, port shoulder 20*f* and threaded step 20*g* of member 15*b*, and a chamber wall 20*h*, an inner wall 20*j*, a pair of shoulder portions 20*i* and 20*k* at each end of said inner wall 20*j*, a third step wall 20*l*, a tapered shoulder 20*m*, a fourth step shoulder 20*n*, the exit shoulder 20*p*, and an exit wall 20*q*.

A circulation channel 35 is formed in the wall of tubular member 15 for permitting communication from the inner bore 20 of the member 15 and out of opening 36 into the annulus 12 between formation 11 and the drill string T.

The first movable member in this embodiment includes a piston means 50 and a rotatable ball 54 positioned in the bore 20, but of course may include some other type of rotatable or movable member for selectively permitting the flow of drilling fluid through the tubular member inner bore 20 or the circulation channel 35. The ball 54 includes an outer milled flat surface area 53 to enable the ball to be positioned immediately adjacent the inner surface 55 of the upper sleeve member portion 52, and an outer spherical surface 54a for seating on the seating and sealing member 58.

As illustrated in FIGS. 2B,3, 4, 5 and 6, a spring means or means for urging 40 is positioned adjacent the threaded box end 16 inside the inner bore 20 and is retained in such position by the fourth step shoulder 20*p* which abuts the end 40*a* of the spring means 40. The other end 40*b* of spring 40 abuts block member 45 mounted with the piston means 50. The slidable piston means 50 generally in the form of a cylindrical sleeve, located concentrically within the spring 40 and extends from an area adjacent the inner wall 20*j* to immediately adjacent the exit wall portion 20*q*, at a location 63. The block member 45 abutting the spring 40 is mounted with the slidable piston member 50 by a tapered mating surface 45*a* engaging a corresponding tapered mating surface 50*a* of the slidable piston member 50.

A retainer ring 48 having a beveled surface 48*a* for engaging the beveled shoulder 20*m* of the inner bore 20 retains a circulation bypass valve seat member 47 in the bore 20 and also retains a chevron packing seal 49 in position to prevent leakage of fluid between the slidable piston 50 and the circulation bypass valve seat member 47. The circulation bypass valve seat member 47 is also cylindrical having a stepped inner portion 47a partially retaining the chevron packing 49 in position to prevent leakage of fluid between the slidable piston 50 and the circulation bypass valve seat member 47. The circulation bypass valve seat member 47 is cylindrical having a stepped inner portion 47*a* partially retaining the chevron packing 49 and two outer surface grooves 47*b* and 47*c* containing "O" rings for sealing flow between the third step surface 20*c* and circulation bypass valve seat member 47. The circulation bypass valve seat member 47 also includes a tapered valve seating surface 47*d*, to be described more fully hereinafter, a passageway surface 47*e* and an outlet channel 47*f* aligned with the circulation channel 35 and communicating with circulation channel 35 for permitting flow through the circulation channel 35 into the bore 20. The channel 47*f* and the channel 35 are maintained in alignment for communication therethrough by a suitable fastening means, for example, the countersunk machine bolt 47*g*.

The movable piston sleeve 50 includes an enlarged diameter mounting or connection portion 52 which abuts a machine cutaway or mill surface 53 of a movable member or rotatable ball 54 adjacent an inner side wall 55 of the sleeve 50. The remaining unmachined circular portions of the ball are received in a machined circular opening 52*a* in the enlarged portion 52 of the sleeve. An inner machined shoulder 56 is further machined at 57 to receive a seating member 58 contacting the ball 54 such that movement of the movable member 54 or rotation of the ball 54, as will be set forth hereinafter, enables an outer spherical surface 54a of the ball 54 to seat on the seating means 58. As illustrated in FIGS. 2B, 3, 4, 5 and 6, an O-ring seal 60 in a groove 58a, is provided for preventing leakage between the sealing member 58 and the machined area 57. A spring member 59 fits within the machined area 57 for biasing seating means 58 in contact with the movable member 54. An outer wall 65 of the upper enlarged portion 52 of the sleeve 50 is curved at 66 to complement and match the spherical curved surface 54*a* of the ball 54. Below such curved surface 66 a shoulder 69 receives one end of the wiper or scraper member 70 secured to the sleeve 50 by a suitable fastening means, such as the counter sunk machine screw 70a.

Below the wiper or scraper 70, an outer tapered shoulder 72 of the sleeve 50 is shaped to complementarily seat on and seal against the surface 47*d* of the valve seat member 47 as illustrated in FIG. 4. A grooved opening 72a on the surface 72 of the sleeve 50 contains an O-ring 80 for enhancing the sealing between the surface 72 of the sleeve 50 and the valve seat member surface 47*d*.

As also illustrated in FIG. 4, the rotatable ball valve 54 includes a cavity 85 defined by the side wall 86 and an end wall 87. An opening 90 permits communication of the cavity with inner bore 20 of the member 15. A plurality of channel members 91 are machined in the ball 54 and extend from a restricted nozzle area 92 immediately adjacent the outer spherical surface 54 to opening 93 which communicates with the cavity 85. The restricted nozzle openings 92 are designed smaller in cross-sectional area than the cross-sectional area of the nozzles for the drill bit B and the channels 91 to screen and maintain the plugging size particles on the surface 54*a* of the ball 54 for a purpose to be described more fully hereinafter.

As illustrated in FIG. 3, a spring loaded valve generally designated 96 is machined and positioned in the ball 54 and includes a threaded plug member 97 which retains and houses a spring member 98 which continuously urges a ball member 100 upwardly to obstruct an opening 102 to prevent communication between the cavity 85 and a channel or passageway 106 which communicates with the bore 20.

As illustrated in FIG. 7 a pair of a pin members 120 are threadedly engaged at 121 with the inner walls 122 of a machined opening 124 in the tubular member 15. A milled or cut away area 125 is provided for loosening or tightening the pins 120. O-ring seals 126 are positioned in O-ring grooves (not numbered) in the pins 120 for sealing between the pins 120 and the member 15 to prevent loss of fluid from the bore 20 of such member 15. Pins 120 extend inwardly through the inner wall 20*j* of the member 15 and through holes 130 in the upper portion 52 of the sleeve member 50 for retaining such sleeve member 50 relative to the ball 54.

The pins 120 extend through the slots 130 in the piston into large milled eccentrically positioned slots 131 in the rotatable ball 54. As illustrated in FIG. 7, the diameter of the slots 131 are slightly greater than the diameter of the pins 120. Upward or downward movement of the ball 54 relative to the pins 120 causes rotation of the ball 54 about the eccentrically positioned pins 120 and about the portions of the ball 54 received in sleeve opening 52a.

An enlarged circulation bypass channel 25 is machined in the inner wall of the tubular member 15. The enlarged circulation bypass channel 25 is defined by the channel 141c of channel member 141, a portion of chamber wall 20h, a shoulder portion 20i, inner wall 20j, shoulder portion 20k, a third step wall 201 of inner bore 20, the tapered valve seating surface 47d, passageway surface 47e and outlet channel 47f. The circulation bypass channel allows circulation of the drilling fluid around the first movable member and through the circulation channel into the annulus when the channels 92 in the rotatable ball 54 of the first movable member are in the traverse position.

A second movable member 140 is positioned in the tubular member 15 inner bore adjacent the port shoulder 20f and mounted with the tubular member 15 for blocking the circulation bypass channel 25 in response to the pressure adjacent the tubular member being greater or substantially equal to the pressure in the inner bore. The second movable member also includes a biasing means, a means for urging closed in response to pressure adjacent the tubular member, a means urging open in response to inner bore pressure and means for regulating the means for urging. As illustrated in FIGS. 3 and 5, the movable member 140 is a cylindrical sleeve having one end portion 140a contacting and sealing against the first movable ball member 54 in the closed position and movable to an open position, illustrated in FIGS. 2, 4 and 6. The sleeve includes an enlarged outer portion 140b having a first shoulder surface 140c and a second shoulder surface 140d. The outside surface includes a constant outer diameter portion 140f of the sleeve 140 which extends from the end portion 140a to the second shoulder 140d. Another outer surface portion 140g extends from the shoulder 140c to a location adjacent the end 140h of the sleeve 140. The raised portion 140b also has a uniform diameter surface 140i. The inner surface 140e of the sleeve member 140 has a constant diameter giving a smooth inner bore. A port 140j extends through the sleeve member 140 for permitting communication from the inner bore 20 through the port 140j to the outside of sleeve member 140 for a purpose to be described more fully hereinafter.

A chamber member 141 has threads 141a engaging threaded surface 20g of the tubular member 15b for securing the chamber member thereto and in the inner bore of tubular member 15. The chamber member 141 also includes spacing fingers 141b bearing against the curved portion 66 of the sleeve 50 and the spherical portion 54a of the ball 54, as illustrated in FIGS. 3 and 5. Channels 141c between the spacing ears or fingers 141b permit communication from the bore 20 around the first movable piston 50 when the sleeve 140 is in the open position, as illustrated in FIG. 6.

The chamber member 141 has a uniform diameter outer surface portion 141d having a groove 141e containing an O-ring for sealing the chamber member 141 to the tubular member 15. The chamber member 141 further includes an inner surface 141f, an inner shoulder 141g and a larger uniform diameter inner surface 141h. A suitable fastening means 141j blocks the rotation of engaged threads 141a and 20g to prevent disengagement whenever the tool is rotated as will be more fully described hereinafter. An O-ring in groove 141k seals the chamber member 141 to the outer surface 140f of the slidable sleeve member 140. An O-ring in groove 140k seals the outer surface 140i to inner surface 141h. The surfaces 140f and 141h and shoulder 141g and inner bore pressure urging second shoulder 140d form a chamber communicating through port 140j with the inner bore 20.

The second movable member biasing means is a spring 145 for continuously urging the sleeve to a closed position and has an end 145a bearing against the first shoulder 140c and the and the other end 145b against spring shoulder 20d of the tubular member 15. The spring 145 is located in the chamber defined by the outer surface 140g and exterior pressure urging first shoulder 140c of the movable sleeve 140 and the surface 141h of the chamber member 141 and the shoulder 20f, second wall 20e and shoulder 20d of tubular member 15. The portion 140g of the sleeve 140 is sealed to the wall 20c by an O-ring contained in the groove 20r. The O-ring in groove 140k seals surface 140i to the surface 141h. The chamber thus formed communicates with the exterior of the tool through ports 37 and 39 and manifold 38.

The inner port 37 extends through the tubular member 15b for communicating the chamber to the exterior of the member 15b. The manifold 38 is an annulus shaped opening machined in the inner surface of tubular member 15a for allowing communication between the inner port 37 and the outer port 39 without respect to alignment of the ports 37 and 39. Outer port 39 extends through the tubular member 15a for communicating with the area adjacent the exterior of the tool.

In the use or operation of the present invention, tubular member 15 is connected in the drill string T preferably immediately above the drill bit B as illustrated in FIG. 1. As is well known in the art, the drill string is then lowered into the well bore. The condition of the tool as it is lowered into the well bore depends upon whether the driller desires to fill the drill string T with drilling fluid from an above ground supply of fluid or use the drilling fluid within the well bore. Should the driller desire to use drilling fluid from the above ground supply, the upper tubular member 15b is rotated to tighten threads 15c and 15d until the shoulder 15n of upper member 15b engages the split ring 15j preventing further tightening rotation of the member 15b, as illustrated in FIG. 3. The tool, now fully assembled, is then lowered in the well bore as is well known in the art.

A means for permitting drilling fluid to enter the drilling string from the annulus through the circulation channel and circulation bypass channel is provided should the driller desire to fill the drill string from the annulus. The upper tubular member 15b is rotated to unscrew threads 15c and 15d until the split ring 15j engages the shoulder 15m of tubular member 15b preventing further loosening rotation of member 15b. In this condition, illustrated in FIG.2A, the chamber member 141 secured to the member 15b moves the sleeve 140 to an open position away from the ball 54. Drilling fluid in the well bore is allowed to enter through channel 35 and the circulation bypass channel 25 into the bore 20 and on into the bore opening 21 of the drill string T.

When the drill bit reaches the bottom of the well bore and the drilling operation is to be resumed, the operator first rotates the drill string T tightening threads 15c and 15d until the split ring 15j engages shoulder 15n. At the same time shoulder 15n engages the split ring 15j, the spacing fingers 141b engage spherical surface 54a of the ball 54 and the complementary surface 66 of the piston member 50. The member 141 acts as an upper stop for the rotatable ball 54 and piston 50. The sealing edge 140a of the sleeve 140 first engages the spherical surface 54a of ball 54 moving shoulders 141g and 140d apart to form the chamber communicating with the inner bore 20. The pressure within the bore 20 is transmitted through the port 140j into the chamber where it bears against the second shoulder surface 140d for urging the sleeve member 140 to an open position.

With the drill string T now full of drilling fluid, the operator may then wish to circulate the drilling fluid in the drill string T without circulating through the drill bit B nozzles N. This is done by increasing the inner bore 20 pressure only a certain amount but less than the amount needed to move the spring means 40 downward. The increasing pressure is communicated through port 140j to the chamber where it urges against the second shoulder 140d of the sleeve 140 until the pressure is great enough to overcome the biasing of spring 145 and urging of exterior pressure on first shoulder 140c and the sleeve moves to the open position as illustrated in FIG. 6. With sleeve 140 in the open position, the greater inner pressure of the bore 20 will cause the drilling fluid to flow through the bypass channel 25 and the circulation channel 35 into the annulus 12 of the well. In this manner, the drilling fluid may be circulated without passing through the drill bit nozzles.

While circulating through the tool of the present invention, any large cuttings or the like in the drilling fluid will be flushed out into the well bore without flowing through the drill bit nozzles. As constructed and illustrated in FIG. 6, the cross-sectional flow area of the circulation bypass channel **25** is greater than the cross-sectional flow area of the circulation channel **35**. With this arrangement, the drilling fluid pressure drop is less through the area of the circulation bypass channel than at the circulation channel **35** which therefore enables the fluid to flow into the channel **35** and into the annulus **12**.

When it is desired to begin drilling, the circulation pumping pressure at the well site surface is substantially increased into the area of many thousands of pounds per square inch. This downward pressure thrust is sufficient to overcome the upward thrust of the spring means **40** and compresses the spring **40**, as illustrated in FIG. 4. This allows the sleeve **50** and the rotatable ball **54** to move downward, rotating the ball valve **54** from the transverse position blocking flow through the bore **20**, illustrated in FIG. 6 to the aligned position, illustrated in FIG. 4, permitting drilling fluid communication between the drill string T, bore **21** and the drill bit B. As the piston **50** moves toward the drill bit B, tapered shoulder **72** is brought into engagement with tapered shoulder valve seat **47*d*** for blocking flow of drilling fluid through the circulation bypass **25**, as illustrated in FIG. 4. An O-ring **80** in the groove **72*a*** enhances the sealing of the circulation bypass channel **25**.

With the ball **54** in the aligned position as illustrated in FIG. 4, the drilling fluid flows through the nozzles **92**, channels **91** and cavity **85** of the ball member **54** downwardly into the bore **20** and out through the nozzles in the drill bit B. Any particles which are larger in diameter than nozzle openings **92** will not pass through such openings and will thus remain on the surface **54*a*** of he rotatable ball **54** to clog the openings **92**. As the nozzles **92** become clogged, the circulation pressure thus increases and is indicated by suitable means at the rig site surface and the drilling operations are therefore terminated.

The circulation pressure is then lowered until the spring means **40** returns the piston **50** and the ball **54** back to the position illustrated in FIG. 5. The upward movement of the piston **50** opens the circulation bypass channel **25** and circulation through the drilling tool of the present invention is resumed in the same manner as set out above.

When the ball **54** is being rotated to the position illustrated in FIG. 6, some of the nozzles **92** rotate by the scraper and wiper member **70** to wipe the channel nozzle clogging matter off the nozzles **92**. This enables some of the channels **91** to remain unclogged for further drilling. The removed clogging matter particles are flushed out of the inner bore **20** through the circulation bypass channel **25** and circulation channel **35** into the annulus **12** of the well.

When the ball **54** is being rotated to the transverse position, the ball **54** at some rotational point in time will rotate to a position such that the opening **90** is covered or closed by the seal or seating member **58**. Yet such ball **54** will not have rotated to its fully closed position as illustrated in FIGS. 2B, 3, 5 and 6. It is estimated that the arcuate travel by the ball **54** from a point when the opening **90** is first covered by inner surface area **55** of the sleeve member **50** until such ball member has fully rotated to its fully closed position may be 20°. With the ball **54** in a position where it is not fully seated, there may still exist a pressure differential between the inner bore **21** of drilling string T and the inner bore **20** of the tubular member **15** below the drill. To insure that the pressure remains equal on each side of the ball to permit the ball **54** to rotate to its fully closed position, the ball and spring member designated **96** has been provided to enable the pressure above the ball **100** to force the spring means **98** downwardly thus permitting communication through the passageways **106** between the inner bore **21**, cavity **85**, the opening **102** and the inner bore **20** of the tubular member **15** such that the pressure on each side of the ball **54** is equalized to permit the ball to rotate to its closed position. When the pressure is equalized on each side of the ball and spring valve **96**, the spring means **98** forces the ball **100** upwardly to once again block the opening **102**.

After the wiper member **70** has wiped off the surface area of some of the nozzles **92**, circulation pressure may then be increased again to overcome the spring **40** returning the ball **54** to the aligned position allowing drilling to continue. This operation may be repeated sequentially as often as necessary to unclog the channels **92**.

If, during the drilling operation, a formation pressure should be encountered substantially equal or greater than the pressure within the inner bore, the urging means **40** will move the ball into the transverse position, illustrated in FIG. 5, blocking the drill string T bore **21** from any flow from the drill bit nozzles N. The formation pressure will also be communicated through port **39**, manifold **38** and port **37** into the chamber. Pressure in this chamber against shoulder **140*c*** urges movement of sleeve **140** to the closed position in response to the pressure.

A means for regulating the urging of the shoulder **140*c*** and shoulder **140*d*** in response to the pressure acting on the shoulders is provided by making the effective area upon which each of these pressures urge the sleeve substantially equal in size. Therefore, substantially equal pressures impart substantially equal urging on the sleeve **140** permitting the biasing means spring **145** to continuously urge the sleeve to the closed position, because of the offsetting or balanced urging of the two pressure sensing shoulders **140*c*** and **140*d***. Preferably, these two shoulders have an effective surface area ratio of ONE. Effective surface is defined, for purposes of this invention, as the actual net area upon which the pressure acts. One skilled in the art may vary the ratio of effective area to adjust for different strength springs.

With the formation pressure substantially equal or greater than inner bore pressure, the shoulders **140*d*** and **140*c*** will provide at least equal and offsetting urging to the sleeve **140**. This allows the spring **145** to urge the sleeve **140** to the closed position blocking any flow trough the circulation bypass. Since the ball **54** is in the transverse position, all flow through the tubular member is blocked or prevented allowing the drilling fluid in the inner bore **21** of the drilling string T to remain in the drilling string.

While the invention generally designated at **10** has been designed to prevent clogging of the nozzles N of the drill bit B, it should be understood that on some occasions such clogging cannot be prevented. The clogging of nozzles N of the drill bit B allows the drilling tool to automatically circulate the drilling fluid into the annulus **12** through the channel **35** for so long as the inner bore **20** pressure is sufficient to maintain the sleeve **140** in the open position. The non-compressible drilling fluid trapped within the inner bore **20** between the ball **54** and the clogged nozzles N prevents the downward movement of the sleeve **50** and ball **54** thereby permitting flow from the inner bore **20** through the circulation bypass channel **25** and out of the tool through the circulation channel **35**. The trapped drilling fluid prevents movement of the ball **54** from the transverse position no matter how great the inner bore **20** pressure above the ball **54**, hence circulation may be done at the higher drilling pressure rapidly flushing cuttings and the like in the drilling fluid from the annulus **12**. The ball **54** is automatically forced to the transverse position by spring **40** in conjunction with the seating and sealing member **58** and spring **59** serving as a check valve permitting flow into the inner bore **20** below the ball **54** and preventing escape of the trapped drilling fluid. The drilling pressure above the ball **54** acting on the seat ring **58** depresses spring **59** permitting flow into and filling the inner bore **20** below the ball **54** as the spring **40** urges the sleeve **50** upward. The spring **59** seats the sealing ring **58** against the ball **54**, trapping the drilling fluid below the ball **54** whenever the inner bore **20** pressure below the ball **54** approaches the inner bore **20** pressure above the ball **54**.

If clogging of the nozzles N does occur or for any reason it is necessary to pull the drill string T, the drilling tool of the present invention allows the drill string to be pulled dry, diverting the drilling fluid contained in the drill string into the annulus **12** of the well bore. As the drilling string is elevated, the column of drilling fluid in the bore **21** of the drilling string above the port **140*j*** is greater than the column of drilling fluid above the port **39** providing a greater pressure to the shoulder **140*d*** to urge the sleeve open overcoming the urging of the shoulder **140*c*** and the spring **145** moving the sleeve **140** to the open position, illustrated in FIG. **6**. With sleeve **140** in the open position, drilling fluid flows from the bore **20** through the circulation bypass channel **25** and circulation channel **35** into the annulus **12** of the well. Flow continues in this manner until the inner bore pressure is unable to keep the sleeve open. The operation is repeated sequentially each time the drill string is elevated to disconnect a portion of the drill string.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape, materials as well as in the details of the illustrated construction may be made without departing from the spirit of the invention.

We claim

1. An apparatus for positioning in a drilling string above a drill bit comprising:

a. a tubular member having an inner bore, said tubular member mounted at one end above the drill bit and at the other end to the drilling string for enabling drilling fluid to flow from the drill string through said inner bore of said tubular member;

b. said tubular member having a circulation channel therein for permitting communication through said tubular member between said inner bore and the exterior of said tubular member;

c. a first movable member positioned in said inner bore and mounted with said tubular member for selectively permitting the flow of drilling fluid through said inner bore or through said circulation channel, said first movable member moving in response to said inner bore fluid pressure; and

d. a second movable member positioned in said inner bore and mounted with said tubular member for blocking the circulation channel in said tubular member, said second movable member moving in response to pressure exteriorly of said tubular member when the exterior pressure is greater or substantially equal to the pressure in said inner bore wherein drilling operations are controlled by pressure exteriorly of said tubular member and in said inner bore of said tubular member.

2. The structure as set forth in claim **1**, wherein said circulation channel communicates between said inner bore and the annulus of a well bore and wherein the drilling fluid is permitted to circulate through said circulation channel from said inner bore into the annulus.

3. The structure as set forth in claim **1**, wherein said first movable member includes:

a. a movable member having channels therethrough and adapted to be positioned in a transverse position wherein said channels are transverse with said inner bore and an aligned position with said inner bore wherein said channels are aligned with said inner bore of said tubular member; and

b. piston means positioned in said inner bore and mounted with said tubular member said piston means being connected to said movable member for moving said first movable member from said transverse position for permitting the flow of drilling fluid through said circulation channel to said aligned position for permitting the flow of drilling fluid flow to the drill bit through said inner bore and said aligned channels in said first movable member.

4. The structure as set forth in claim **3**, wherein said tubular member includes a circulation bypass channel therein for allowing circulation of drilling fluid around said first movable member and through said circulation channel into the annulus when said channels in said movable member are not aligned with said inner bore and wherein an increase in circulation pressure above said movable member moves said piston member and thus prevents communication between said circulation bypass channel and said circulation channel and moves said movable member to align said channels in said movable member with said inner bore thus permitting circulation through said bore and out the drill bit.

5. The structure as set forth in claim **4** including means for permitting drilling fluid to enter the drilling string from the annulus through said circulation channel and said circulation bypass channel in said tubular member to fill the drill string when lowering the drill string in the well bore.

6. The structure as set forth in claim **4** wherein said second movable member includes a sleeve movable between a closed position and an open position for blocking flow through said circulation bypass channel in said closed position and permitting flow through said circulation bypass channel in said open position and wherein said first movable member in said transverse position and said movable sleeve in said closed position block all flow of fluid through said tubular member.

7. The structure as set forth in claim **6** wherein said second movable member further includes:

a. biasing means for continuously urging said sleeve to said closed position;

b. means for urging said sleeve to said closed position in response to the annulus pressure adjacent said tubular member;

c. means for urging said sleeve to said open position in response to said inner bore pressure; and

d. means for regulating said means for urging said sleeve to said closed position and said means for urging said sleeve to an open position wherein said regulating means produces an annular pressure greater or substantially equal to the pressure in said inner bore to provide substantially equal pressures on said sleeve by each of said means for urging wherein said biasing means urges said sleeve to said closed position and wherein said sleeve is urged to said open position by greater pressure in said inner bore thereby forcing said means for urging said sleeve to said open position to overcome the forces of said biasing means and said means for urging said sleeve to a closed position.

8. The structure as set forth in claim **7**, wherein:

a. said sleeve includes a raised outer portion having a first shoulder effective surface and a second shoulder effective surface;

b. said first shoulder effective surface communicating with the annulus for urging movement of said sleeve to said closed position in response to the annulus pressure;

c. said second shoulder effective surface communicating with said inner bore for urging movement of said sleeve to said open position in response to said inner bore pressure;

d. said biasing means includes a spring; and

e. said means for regulating said means for urging said sleeve to open and closed positions includes the ratio of the area of said first shoulder effective surface for closing to the area of said second shoulder effective surface for opening wherein an annulus pressure greater or substantially equal to the pressure in said inner bore effectively balances the pressure on said sleeve from said first shoulder and said second shoulder wherein said biasing spring urges said sleeve to said closed position and wherein said sleeve is urged to said open position by greater pressure in said inner bore thereby forcing said means for urging said sleeve to the open position to overcome the pressure forces caused by said first shoulder and said spring.

9. The structure as set forth in claim **4**, including a means for continuously urging said piston means upwardly and wherein an increase in circulation pressure above said piston member overcomes said means for urging, to move said piston means downwardly to prevent communication between said circulation channel and said circulation bypass channel, and to move said first movable member such that said channels in said movable member are aligned with the inner bore of said tubular member.

10. The structure as set forth in claim 9 wherein said first movable member includes a rotatable ball having a plurality of channels extending therethrough in one direction.

11. The structure as set forth in claim 10, wherein said channels have restricted openings to maintain the cuttings or other particles on the surface of the rotatable ball where they may be removed and flushed into the annulus.

12. The structure as set forth in claim 10, including a pair of pins mounted with said tubular member, said piston means and said rotatable ball, said rotatable ball rotating about said pins as said piston means is moved downwardly by increased circulation pressure or upwardly by said means for urging as the circulation pressure decreases.

13. The structure as set forth in claim 10, including a wiper member for wiping at least some of the exposed openings of said channels to remove clogged particles therefrom as said movable member is moved to a position where said channels are not aligned with said inner bore.

14. The structure as set forth in claim 10 wherein said channels in said rotatable ball are smaller than the openings in the drill bit nozzles to thus prevent cuttings or other particles in the drilling fluid from passing through said channels and clogging the drill bit nozzles.

15. The structure as set forth in claim 14, wherein:

a. said sleeve includes a raised outer portion having a first shoulder effective surface and a second shoulder effective surface;

b. said first shoulder effective surface communicating with the annulus for urging movement of said sleeve to said closed position in response to the annulus pressure;

c. said second shoulder effective surface communicating with said tubular member inner bore for urging movement of said sleeve to said open position in response to said inner bore pressure;

d. said biasing means includes a spring; and

e. said means for regulating the urging on the sleeve includes the ratio of the area of said first shoulder effective surface for closing and the area of said second shoulder effective surface for opening wherein an annulus pressure greater or substantially equal to the pressure in said tubular member to provide said sleeve with substantially equal urging from said first shoulder and said second shoulder wherein said biasing spring urges said sleeve to said closed position and where said sleeve is urged to the open position by a greater pressure in the inner bore causing said second shoulder urging to overcome the urging of said first shoulder and said spring.

16. The structure as set forth in claim 15 wherein increasing the circulation pressure within said inner bore first urges said sleeve to the open position permitting the drilling fluid to circulate through said circulation bypass channel and out said circulation channel into the annulus to remove unwanted particles and cuttings in the drilling fluid within drilling string until the pressure is increased sufficiently to overcome said means for urging rotating the ball valve to permit flow through the drill bit.

17. The structure as set forth in claim 15 wherein clogging of said channels in said rotatable ball or said jetting nozzles in the drill bit, is indicated by an increase in pressure at the surface of the well bore wherein the pressure is reduced sufficiently to permit the means for urging to move said piston means upwardly to rotate said ball such that said channels are not aligned with said inner bore and maintain said sleeve urged open wherein circulation of the drilling fluid occurs through said circulation bypass channel around said rotatable ball and out through said circulation channel into the annulus.

18. The structure as set forth in claim 15, wherein pressure in the annulus substantially equal to or greater than pressure in said inner bore permits the urging means to rotate the ball valve to said transverse position blocking flow through the drill bit and permits the pressure on said first shoulder to substantially equal the pressure on said second shoulder wherein said biasing spring urges said sleeve to said closed position thereby blocking all flow through said tubular member.

19. The structure as set forth in claim 15, including a wiper member mounted adjacent said circulation bypass channel and positioned such that rotation of said rotatable ball to the position where said channels in said ball are not aligned with said inner bore wipes the exposed surface area of at least some of said channels to thus scrape and wipe off clogged particles positioned in said channels.

20. The structure as set forth in claim 19, including a spring loaded ball valve mounted with said rotatable ball, said ball having a channel opening therein blocked by said spring loaded ball, said spring loaded ball being positioned in said rotatable ball to insure that said rotatable ball and piston will be moved upwardly and seated by said means for urging to thus maintain said circulation bypass channel open by permitting drilling fluid to flow from above said rotatable ball and through said spring loaded ball into the lower portion of the tubular member when there is a pressure differential between said inner bore of the tubular member above said rotatable ball and below said rotatable ball which thus equalizes the pressure in said inner bore above and below said rotatable ball to fully seat said rotatable ball.

21. The structure as set forth in claim 15, including means for permitting drilling fluid to enter the drilling string from the annulus through said circulation channel and said circulation bypass channel in said tubular member to fill the drill string when lowering the drill string in the well bore.

22. The structure as set forth in claim 21, wherein said means for permitting drilling fluid to enter the drilling string comprises a means or keeping the sleeve in an open position when lowering the drill string.

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