United States Patent [19]

Mott

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[45] **Jan. 8, 1974**

[54] **INSIDE DRILLING TOOL BLOWOUT PREVENTER**

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[21] Appl. No.: **201,878**

[52] **U.S. Cl.** ..... **166/244,** 166/315, 166/224 S, 175/318

[51] **Int. Cl.** **E21b 41/00**

[58] **Field of Search** ..... 166/224, 224 S, 244, 166/315; 175/317, 318, 241–243

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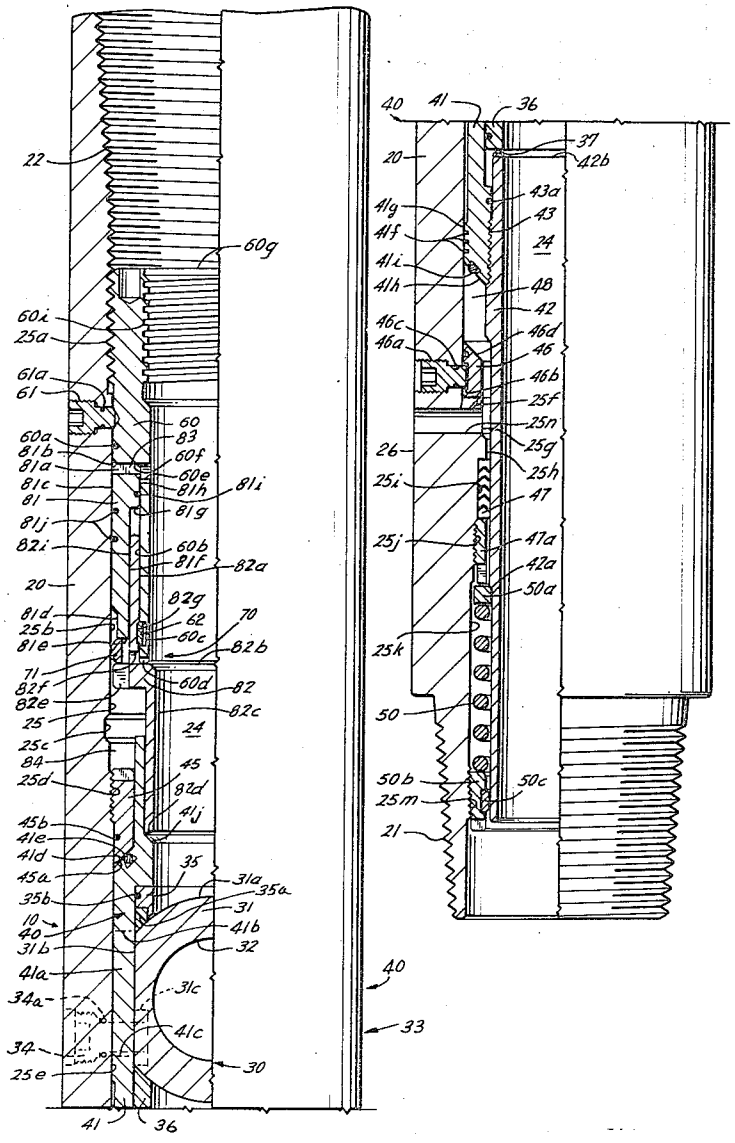
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Primary Examiner—David H. Brown
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[57] **ABSTRACT**

A drilling tool connected in a drilling string includes a pressure responsive rotatable ball valve for enabling drilling fluid flow down the bore of a drill string which automatically rotates closed for blocking flow through the bore of the drill string when incipient pressure conditions indicate the direction of flow through the bore may be reversed. Means for releasably locking the ball in the open position in response to a preselected directional pressure to enable the running of other tools and the like through the bore of the drilling string are provided. The drilling tool may be employed for controlling an undesired flowing stream of fluid from the bore of the drilling string by stabbing the tool to connect with the drilling string utilizing a stabbing member which is removed after connecting to enable the ball valve to rotate closed to control the flowing stream.

13 Claims, 8 Drawing Figures



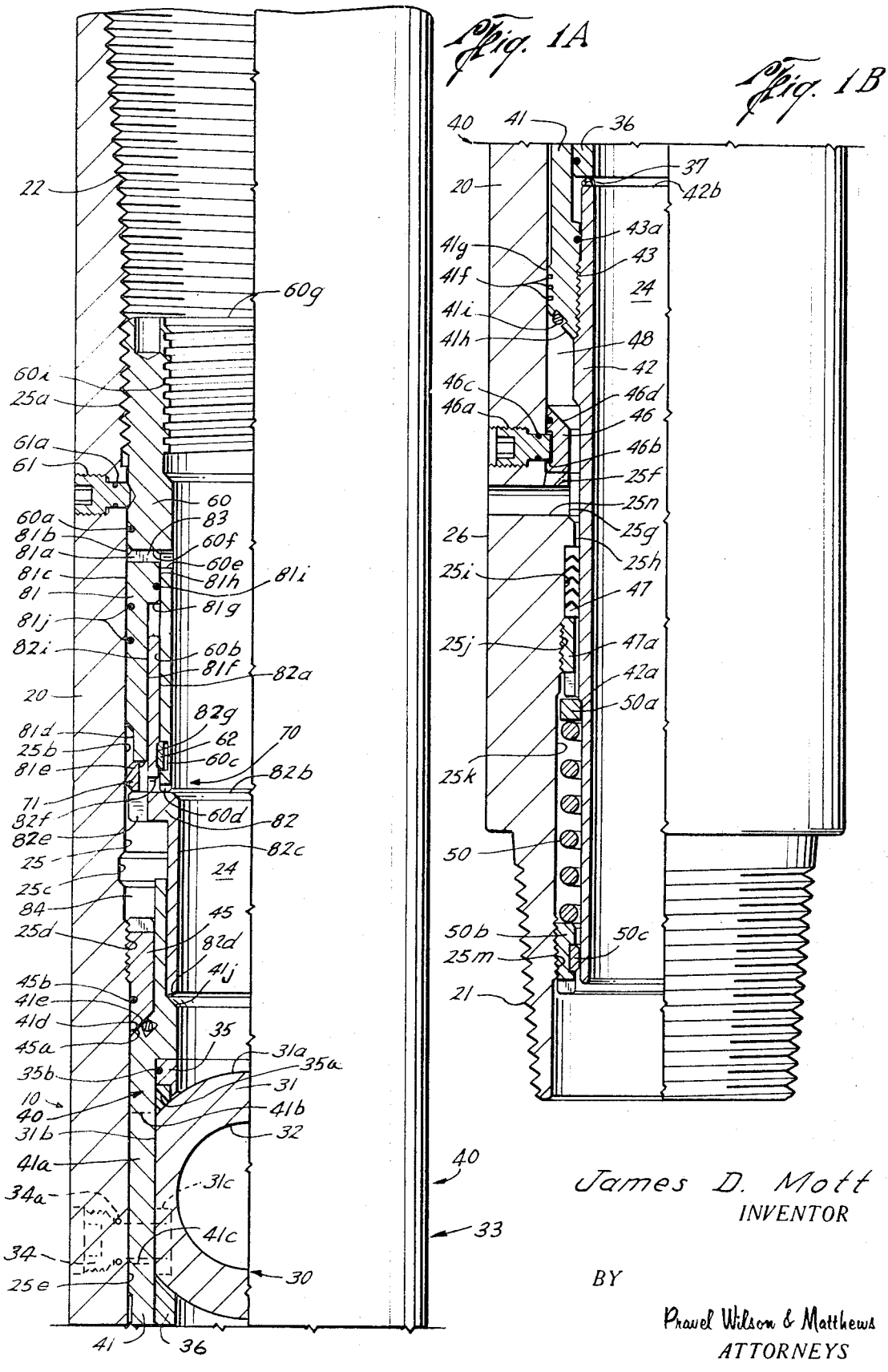
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Fig. 1A

Fig. 1B



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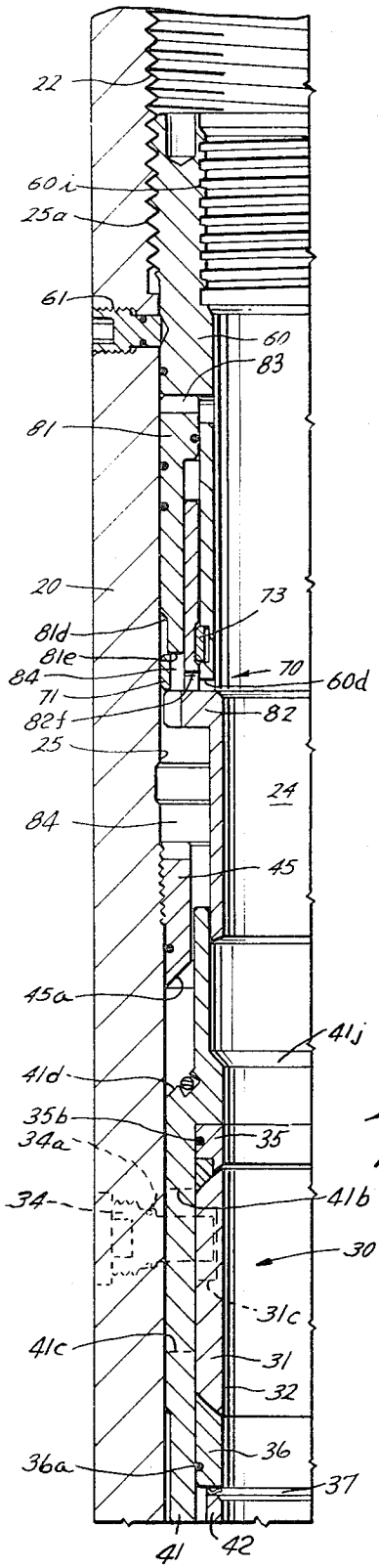


Fig. 2A

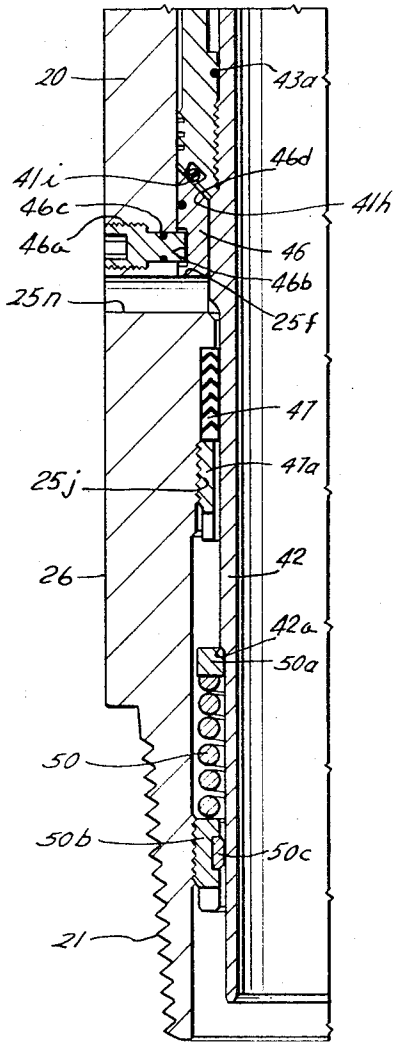


Fig. 2B

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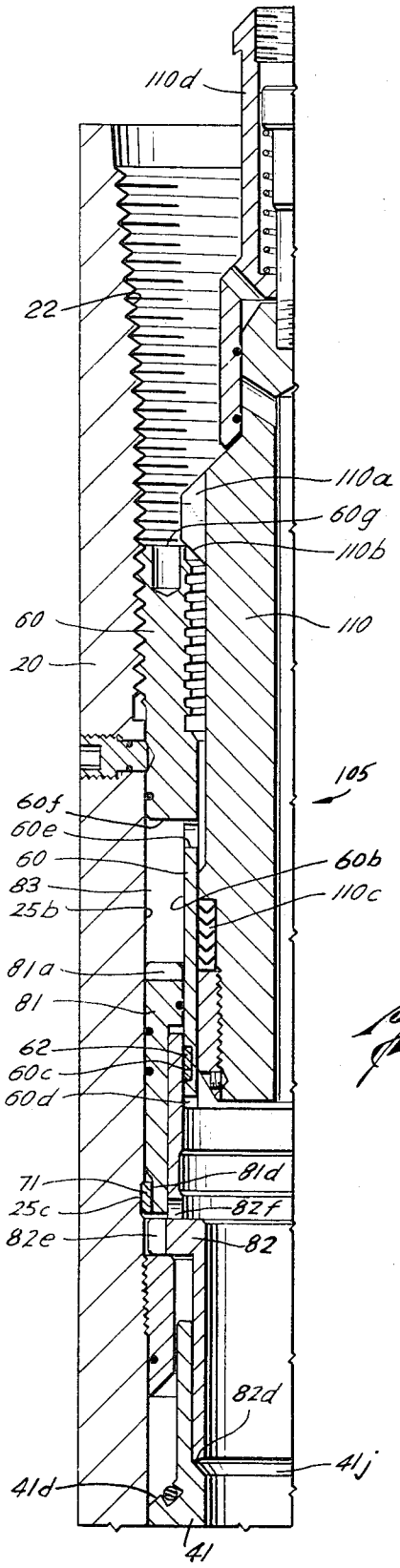


Fig. 3A

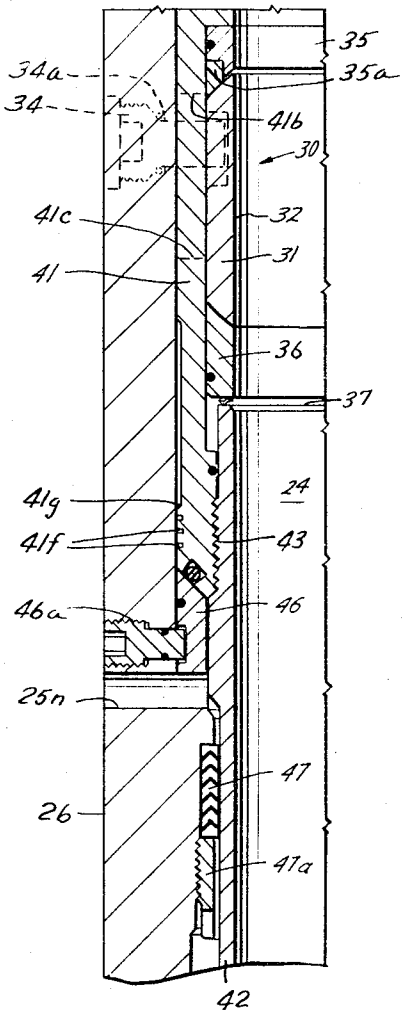


Fig. 3B

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Fig. 4

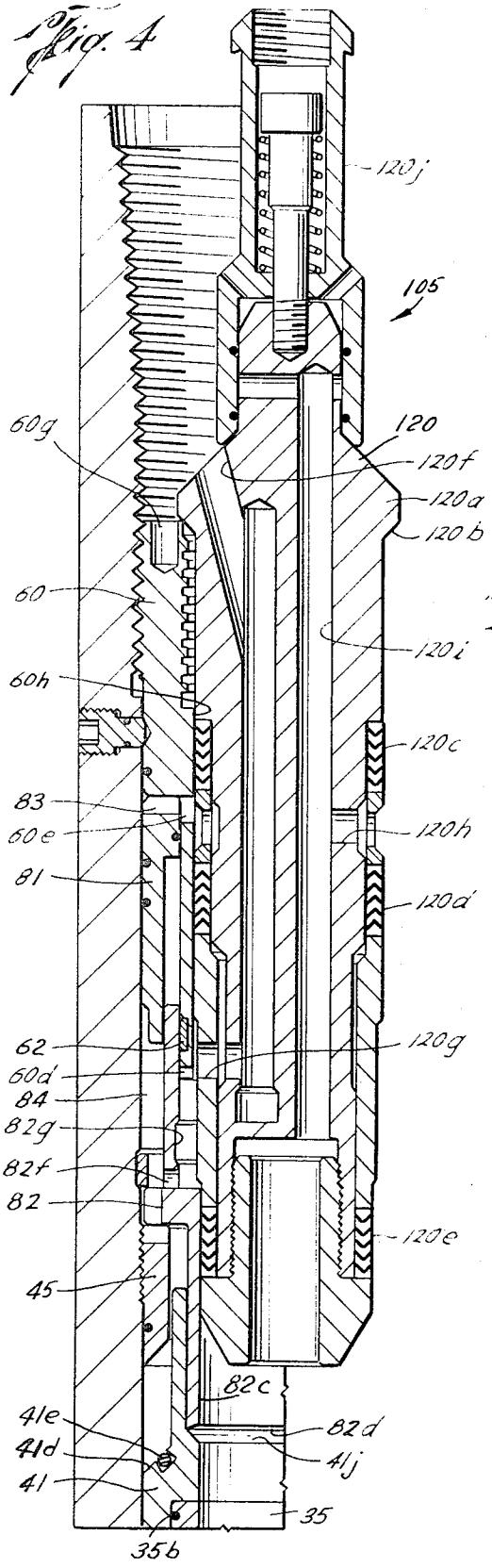
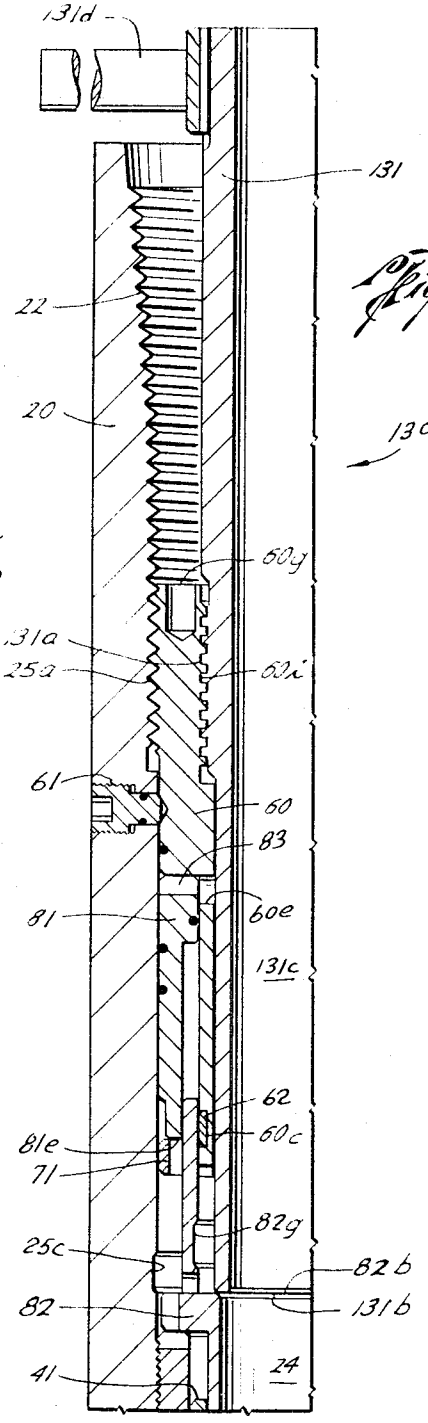


Fig. 5



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INSIDE DRILLING TOOL BLOWOUT PREVENTER

BACKGROUND OF THE INVENTION

This invention relates to the field of a new and improved inside blowout preventor.

Use of back pressure or check valves connected in a drilling string to automatically control well blowouts inside the pipe or drill string has previously been undesirable during drilling operations because of the tendency to restrict the flow of circulating drilling fluid and to interfere with the running of other well tools through the bore of the drill string. These valves operated in response to the pressure in the bore of the drilling string which required that the drilling string be filled with drilling fluid from above the valve as the drill string was lowered into the drill hole increasing nonproductive trip time. When used in continuous drilling operations these valves also tended to be eroded or otherwise worn or damaged by the circulating drilling fluid wherein they were often rendered inoperable to block flow up the bore of the drill string when required to do so. This problem of reliability was especially true of the inside blowout preventers that were initially stabbed into the drill string to control an existing blowout flow and were not removed until after the well pressure was controlled by establishing circulation of denser drilling fluid.

SUMMARY OF THE INVENTION

This invention relates to a new and improved inside blowout preventer.

The drilling tool includes a tubular member adapted for connection in a drilling string having a bore therethrough for communicating with the bore of the drill string. A rotatable ball type valve is movably disposed in the bore of the tubular member for automatically controlling the flow of circulating drilling fluid through the bore of the drill string in response to movement of a pressure responsive piston means. The ball is rotated open when the pressure in the bore of the tool for enabling the desired flow through the bore exceeds the well pressure adjacent the drilling tool by a predetermined value. A means for urging keeps the ball rotated closed until existence of the desired flow pressure conditions. A releasable locking means utilizing preselected directional pressure in the bore of the tubular member locks the ball in the open position to enable the running of other tools through the bore of the drilling tool if desired. The ball may also be releasably locked open by a stabbing member for enabling a stabbing connection of the drilling tool in a drill string having an upwardly flow therethrough for controlling the flow from the drill string.

Another object of the present invention is to provide a new and improved inside blowout preventer.

Yet still another object of the present invention is to provide a new and improved pressure responsive inside blowout preventer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are side views, partially in section, illustrating the drilling tool of the present invention in the closed position;

FIGS. 2A and 2B are views, similar to FIGS. 1A and 1B respectively, illustrating the drilling tool in the open position;

FIGS. 3A and 3B are views, similar to FIGS. 2A and 2B, respectively, illustrating the drilling tool locked open before removal of a locking plug;

FIG. 4 is a view similar to FIG. 3A, illustrating the drilling tool with an unlocking plug positioned therein prior to unlocking; and

FIG. 5 is a view similar to FIG. 3A, illustrating the drilling tool with a stabbing sleeve installed.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Attention is directed to FIGS. 1A and 1B where the drilling tool of the present invention is generally designated **10.** When connected in a drilling string the tool **10** enables desired circulating flow of drilling fluid down the bore of the drill string to a drill bit. When a well blowout occurs which reverses the direction of flow through the bore of the drill string the tool **10** will block flow through the bore of the drill string.

As illustrated in FIGS. 1A and 1B, the drilling tool **10** of the present invention includes a tubular member or flow control housing **20** which is connected in the drilling string (not illustrated) to form a portion thereof. The tubular member **20** has a threaded pin connection **21** at the lower end for connecting the tubular member **20** with a portion of the drilling string below the drilling tool **10** and a threaded box connection **22** at the upper end for connecting with a portion of the drilling string above the drilling tool **10.**

The tubular member **20** has longitudinal bore **24** extending therethrough which is aligned with and communicates with the bore (not illustrated) of the drill string. The bore **24** provides a flow passage for enabling circulation of drilling fluid down the bore of the drill string through the drilling tool **10** to the ports of a drill bit as is well known in the art. The bore **24** is formed by an inner surface **25** of the tubular member **20** which is defined in greater detail, commencing from the box connection **22** by a threaded portion **25***a*, a constant diameter portion **25***b* having a locking recess **25***c* therein, a threaded portion **25***d*, a constant diameter portion **25***e*, a lower annular limit shoulder **25***f*, a vent portion **25***g*, a seal portion **25***h* having a recess **25***i* therein, a threaded portion **25***j* and a constant diameter portion **25***k* having a raised threaded portion **25***m*. The tubular member **20** has a flow channel vent opening **25***n* formed therethrough adjacent the constant diameter vent portion **25***g* to enable communication between the well annulus area adjacent an exterior surface **26** of the tubular member **20** and the bore **24.**

Disposed in the bore **24** adjacent the constant diameter surface **25e** is a movable bore closure means designated **30.** The bore closure means **30** includes a ball member **31** having a bore **32** therethrough for enabling flow when aligned with the bore **24** of the tubular member **20** and a pivot means **33** for imparting rotation to the ball **31** when the ball **31** is moved longitudinally in the bore **24.** The ball **31** is movable from a transverse or closed position (FIG. 1) blocking flow through the bore **24** of the tubular member **20** to an aligned or open position (FIG. 2) enabling flow of fluid through the bore **24** of the tubular member **20.** The ball member **31** includes an outer spherical surface **31***a* having a pair of circular parallel flat portions **31***b* with each of the flat portions **31***b* having an elongated radial extending recess **31c** formed therein for imparting rotational movement to the ball **31.** The pivot means **33** includes a pair

of corresponding pins 34 threadedly secured with the tubular member 20 for ease of assembly, at an eccentric location and extending within the corresponding recess 31*c* to rotate the ball 31 when the ball 31 moves longitudinally in the bore 24. The pins 34 carry an O-ring 34*a* to seal the pin 34 to the tubular member 20 to block leakage of fluid therebetween.

The drilling tool 10 includes a pressure responsive piston means 40 operably connected with the ball 31 for effecting movement of the ball 31 to and from the open and closed positions. The piston means 40 is disposed in the bore 24 for moving longitudinally between an upper position rotating the ball 31 closed, illustrated in FIGS. 1A and 1B, and a lower position rotating the ball 31 open, illustrated in FIGS. 2A and 2B, in response to urgings thereon. The piston means 40 preferably includes an upper sleeve member 41 and a lower sleeve member 42 threadedly secured together at 43 (FIG. 1B) for ease of assembly. The piston sleeve 41 is concentrically positioned between the ball 31 and the tubular member 20 adjacent the constant diameter inner surface portion 25*e* of the tubular member 20. The piston sleeve 41 has a pair of longitudinal slots or windows 41*a* formed through the sleeve 41 to provide longitudinal movement enabling clearance to the piston sleeve 41 about the fixed pivot pins 34 extending into the recesses 31*c* in the ball 31. The slots 41*a* have an upper and lower end surface 41*b* and 41*c*, respectively, defining the length of the slot 41*a*. The piston sleeve 41 mounts thereon a portion of the bore closure means 30 including a seat ring 35 mounted concentrically above the ball 31 and having a replaceable seating element 35*a* which engages the spherical surface 31*a* of the ball 31 for blocking flow of fluid upwardly through the bore 24 about the outer surface 31*a* of the ball 31. The seat ring 35 has an O-ring 35*b* to seal between the annular seat ring 32 and the piston sleeve 41 for blocking the passage of fluid therebetween.

The piston means 40 includes a movement upper limit stop means comprising a stop ring 45 threadedly secured to the tubular member 20 by threads 25*d* for engaging the sleeve 41 in the upper position with a downwardly facing tapered annular shoulder surface 45*a*. The stop ring 45 has an O-ring 45*b* to seal the stop ring 45 to the surface 25*e* of the tubular member 20 to block leakage of fluid therebetween. The sleeve 41 engages the ring 45 with a corresponding upwardly facing tapered annular shoulder surface 41*d* and seals thereto in the upper position with an O-ring 41*e* carried on the surface 41*d* to block passage of fluid between the ring 45 and the piston sleeve 41. The sleeve 41 has a plurality of annular labyrinth sealing openings 41*f* formed in a sleeve guide collar 41*g* for limiting the passage of fluid between the piston 41 and the surface 25*e* of the tubular member 20 when the piston sleeve 41 moves to and from the upper and lower positions.

As illustrated in FIG. 2B, the piston means 40 includes a movement lower limit stop means comprising a stop ring 46 located adjacent the shoulder 25*f* of the tubular member 20. The stop ring 46 is secured in the bore 24 by pin member 46*a* threadedly engaged with the tubular member 20 extending within a recess 46*b* of the ring 46. The pin 46*a* is sealed by an O-ring 46*c* with the tubular member 20 to prevent leakage of fluid therebetween. The stop ring 46 has an upwardly facing tapered annular shoulder 46*d* for engaging the sleeve 41 in the lower position. The sleeve 41 has a corresponding downwardly facing tapered annular shoulder 41*h* for engaging the stop ring 46 and which carries an O-ring 41*i* for blocking passage of fluid between the sleeve 41 and the stop 46 when the sleeve 41 is in the lower position.

The lower piston sleeve 42 is sealed to the upper sleeve 41 by an O-ring 43*a* to prevent leakage of fluid therebetween to provide a straight through flow conduit or wash pipe through the lower portion of the well tool 10. The concentric sleeve 42 is sealed to the tubular member 20 by a Chevron packing 47 to prevent leakage of fluid therebetween. The packing 47 is secured in the recess 25*i* by a ring keeper member 47*a* threadedly engaged with the threaded portion 25*j* of the tubular member 20.

As illustrated in FIG. 2B, the well tool 10 includes a means for urging movement of the ball 31 to the closed position when the pressure in the bore 24 exceeds the pressure adjacent the well tool 10 by less than a predetermined value comprising a spring means 50. The spring means 50 is concentrically positioned about the lower portion of piston sleeve 42 for urging the piston means 40 to move upwardly. Urging of the spring 50 is transmitted through a ring keeper member 50*a* to the piston means 40 by engagement of the concentrically mounted keeper 50*a* with the downwardly facing annular shoulder 42a of the sleeve 42. The lower end of the spring 50 is mounted with the tubular member 20 by engaging a ring keeper member 50*b* threadedly secured to the tubular member 20 at the threads 25*m*. The lower portion of the sleeve 42 engages a ring member 50*c* mounted with the keeper 50*b* for guiding the longitudinal movement of the sleeve 42 to prevent misalignment and binding of the sleeve 42.

The bore closure means 30 includes a means for spacing the ball 31 from the seat ring 35 prior to commencing to rotate the ball 31 which is mounted on an upwardly facing upper annular shoulder surface 42*b* of the sleeve 42 and includes a ring member 36 and an annular shaped longitudinally expanding spring means 37. The ring 36 is positioned above the spring ring 37 to engage the lower spherical surface 31*a* of the ball 31 to impart the upwardly urging of the spring means 37 to the ball 31 to move the ball 31 into sealing engagement with the seat ring 35. When the upwardly urging of the spring 37 is overcome and the spring 37 is compressed the ball 31 is enabled to move downwardly to a spaced position from the seat ring 35.

The concentric arrangement of the piston sleeves 41 and 42 and the tubular member 20 form an annular expansible chamber 48 therebetween for urging the piston means 40 to move upwardly to rotate the ball 31 closed in response to the pressure in the chamber 48. The chamber 48 is located beneath the annular shoulder 41*h* for urging the sleeves 41 and 42 upwardly in response to the pressure adjacent the exterior surface 26 of the tubular member 20 communicated into the chamber 48 through the flow passage 25*n*. The effective surface area of the shoulder surface 41*h* on which the pressure in the chamber 48 urges varies depending upon the position of the piston means. When the piston means is in the upper position (FIG. 1B) the thickness of the annular effective surface area extends from the seal of the chevron packing 47 with the sleeve 42 to the outer edge of the surface 41h. When the piston means 40 moves to the lower position the annular effective surface area is reduced by the O-ring 41i effecting a

seal with the surface 46*d* to block communication of the pressure in the chamber 48 to the outer portion of the surface 41*h*. By increasing the pressure responsive effective surface area for urging the piston means 40 to move upwardly when the piston means 40 commences to move upwardly a snap action movement will be imparted to the piston means 40 to move the ball 31 closed.

The pressure in the bore 24 above the ball 31 for enabling the desired flow down the bore of the drilling string urges downwardly on the piston means 40 on an upwardly facing pressure responsive annular effective surface area formed by the shoulder surface 41*d* of the sleeve 41 extending outwardly from the sealing location of the O-ring 35*b*. When the piston means 40 is in the upper position, the O-ring 41*e* effects a seal with the upper stop ring 45 to block communication to the outer portion of the surface 41*d* which reduces the thickness of the annular effective surface area. The initial downward movement of the piston means 40 breaks the seal and extends the effective surface area to the outer edge of the surface 41*d* to provide an increased urging for imparting an opening snap action to the piston means 40 and the ball 31.

As illustrated in FIG. 1A, the tubular member 20 includes a sleeve member 60 secured therein by the threads 25*a* to form a flow passage through the bore 24. The sleeve 60 is blocked from threadedly disengaging with the tubular member 20 by engagement with a threaded lock pin 61. The lock pin 61 carries an O-ring 61*a* to seal the pin 61 to the tubular member 20 to prevent leakage of fluid therebetween. The sleeve 60 is sealed to the surface 25*b* of the tubular member 20 by an O-ring 60*a* to block passage of fluid therebetween.

A means for releasably locking the bore closure means 30 in the open position in response to a preselected directional pressure in the bore 24 is also included in the drilling tool 10. The means for releasably locking the ball 31 in the open position includes a locking detent means 70, a latch assembly 80, and the annular recess 25*c* in the surface 25*b* of the tubular member 20. The lower portion of the sleeve 60 is stepped by a smaller outer surface constant diameter portion 60*b* to form an annular space between the surface 60*b* and the surface 25*b* of the tubular member 20 for receiving the locking detent means 70 and the latch assembly 80. The sleeve 60 has an annular recess 60*c* formed in the surface 60*b* for carrying an expansible detent ring 62 preventing inadvertant movement of the latch assembly 80. A plurality of downwardly extending flukes 60*d* having openings therebetween are spaced from a port 60*e* for communicating fluid pressure from the bore 24 into the annular space between the surface 60*b* and the surface 25*b* of the tubular member 20.

The detent means 70 includes a movable detent snap ring 71 having a gap therein to enable the ring 71 to expand and contract radially. This enables the ring 71 to move outwardly into the detent receiving annular recess 25*c* when aligned therewith.

The movable latch assembly 80 includes a ring-shaped detent latching member 81 and a latch assembly movement control sleeve 82 concentrically disposed in the bore 24 between the surface 60*b* and the surface 25*b*. The detent latch ring 81 is movable between an upper or released position (FIG. 1) and a lower or locked position (FIG. 3A) in response to a directional pressure in the bore 24 to lock the detent ring 71 in the recess 25*c*. The ring 81 has a plurality of upwardly extending flukes 81*a* for engaging an annular shoulder 60*f* with the sleeve 60 to provide a movement upper limit stop for the ring 81. When the ring 81 is in the upper position the flukes 81*a* are located adjacent port 60*e* in the sleeve 60 for enabling communication of the pressure in the bore 24 to the openings between the flukes 81*a*. The flukes 81*a* are notched at 81*b* for enabling communication among the plurality of fluke openings to communicate the pressure in the bore 24 to the entire upwardly facing annular fluked surface 81*a* for urging the latch member 81 to move downwardly in response to the pressure in the bore 24. The latch member 81 includes a constant diameter outer surface 81*c* having a stepped smaller diameter portion 81*d* adjacent the lower shoulder 81e for locking the detent 71 in the recess 25*c*. The ring 81 has a smaller diameter inner surface portion 81*f* positioned adjacent the sleeve 82 for concentrically mounting the sleeve 82 and the ring 81 while enabling relative movement therebetween. The sleeve 81 forms a downwardly facing annular shoulder 81*g* connecting the lower constant diameter surface portion 81*f* when an upper portion 81*h* for providing a pressure urging surface on the sleeve 81. The ring 81 carries an O-ring 81*i* to seal to the surface 60*b* of the fixed sleeve 60 to prevent leakage of fluid between the ring 81 and the sleeve 60. The ring 81 mounts a pair of O-rings 81*j* to seal the outer surface 80*c* of the ring 80 to the surface 25*b* of the tubular member 20 to block passage of fluid therebetween.

The sealing of O-rings 80*i* and 60*a* forms an expansible or variable capacity chamber 83 communicating with the bore 24 of the tubular member 20 through the port 60*e*. As illustrated in FIG. 3A, the chamber 83 is defined in greater detail by a portion of surface 25*b* of the tubular member 20, the surfaces 60*b* and 60*f* of the fixed sleeve 60 and the upper fluked surface 81*a* of the ring 81. A preselected directional fluid pressure from the bore 24 communicated through the port 60*e* into the expansible chamber 83 will urge on the upper surface 81*a* of the ring 81 to move the ring 81 downwardly.

The sleeve 82 is longitudinally movable relative to the tubular member 20 between the upper or released position and the lower or locked position. The sleeve 82 has an upper inner larger constant diameter surface portion 82*a* which concentrically mounts the sleeve 82 adjacent the surface 60*b* of the fixed sleeve. The sleeve 82 has an upwardly facing annular shoulder 82*b* which engages the downwardly extending flukes 60*d* of the sleeve 60 to provide a movement limit upper stop for the sleeve 82 while enabling communication of the pressure from the bore 24 through the openings between the flukes 60*d* to the surface 82*a*. The lower inner constant diameter surface portion 82*c* of the sleeve 82 is preferably of at least the same diameter as the bore 32 of the ball 31 to provide a full bore opening through the tool 10. The sleeve 82 has a lower annular shoulder 82*d* which engages an inner annular shoulder 41*j* of the piston sleeve 41 when the sleeve 82 moves downwardly as will be explained. The sleeve 82 as a plurality of radially outwardly extending flukes 82*e* to assist in guiding the longitudinal movement of the sleeve 82 while enabling fluid pressure communication through the openings between the flukes 82*e*. The flukes 82*e* also control the movement of the detent ring

71 to align with the recess 25*c* and engage the locked detent 71 to lock the piston means 40 in the lower position. The sleeve 82 has a port 82*f* formed therethrough immediately above the shoulder 82*b* for enabling communication from the bore 24 through the openings between the flukes 60*d* and through the port 82*f* to the concentric area adjacent the exterior of the sleeve 82. The sleeve 82 has an annular recess 82*g* formed in the upper inner surface 82*a* which aligns with an expansible snap ring 62 located in the recess 60*c* of the sleeve 60 when the sleeve 82 is in the upper position. The movement of the snap ring 62 into the recess 82*g* prevents the sleeve 72 from any inadvertent movement from the upper position.

As illustrated in FIG. 2A, fluid pressure in the bore 24 communicated through the opening between the plurality of flukes 60*d* and through the port 82*f* in the sleeve 82 is communicated into a variable capacity or expansible chamber 84. The fluid pressure in the chamber 84 will urge on the downwardly facing surfaces 81*d*, 81*e* and 81*g* of the ring 81 to urge the ring 81 to move upwardly in response to the pressure in the chamber 84. Because the effective surface areas on which the pressure in the chambers 83 and 84 urge on the latch member 81 are the same size, no movement of the latch 81 will be effcted as long as the pressure in the bore 24 is communicated into both the chamber 83 and the chamber 84.

Fluid pressure in the bore 24 communicated through the port 82*f* is also communicated to urge downwardly on the upwardly facing effective surface area of the piston sleeve 41 to urge movement of the piston means 40 downwardly until the shoulder 41h engages the shoulder 46*d* of the lower stop ring 46.

As illustrated in FIGS. 3A and 4A, a bridge plug means 105 is included in the means for releasably locking the bore closure means 30 in the open position and is used to control movement of the latch means 80 by controlling communication of pressure in the bore 24 in the predetermined manner through either the port 82*f* or the port 60*e*. The ports 82*f* and 60*e* are spaced a sufficient distance on an inner surface 60*g* of the sleeve 60 to enable the plug means 105 to establish a seal therebetween.

As illustrated in FIG. 3A, the means for releasably locking the ball 31 in the open position includes a locking bridge plug means 110 for communicating a preselected directional pressure into the chamber 82 to urge on the latch ring 81. The locking plug 110 includes a fluted seating collar 110*a* having a lower shoulder surface 110*b* engaging an upwardly facing shoulder 60*g* of the sleeve 60 for positioning the locking plug 110 in the bore 24 of the tubular member 20. The seating collar 110*a* is fluted to enable communication of the pressure in the bore 24 above and below the seating shoulder 110*a*. The locking plug 110 carries an annular packing ring 110*c* to seal the locking plug 110 to the surface 60*g* of the sleeve 60 between the port 60*e* and the fluted portion 60*d* when the seating shoulder 110*b* engages the shoulder 60h to block communication of the pressure in the bore 24 above the locking plug 110 to the chamber 84. By pumping or lowering the locking bridge plug 110 down the bore of the drill string to seat within the bore 24 of the drilling tool 10, a subsequent increase in the pressure in the bore of the drill string above the plug 110 will be communicated through the port 60*e* and will be blocked from communicating through the port 82*f* to effect a downward pressure urging on the ring 81. A fishing neck 110d secured to the upper portion of the locking plug 110 enables retrieval of the bridge plug 110 from the bore 24 of the drilling tool 10 by a wire line operation after locking the ball 31 open.

The means for releasing the ball 31 from the locked open position includes a cross-over or releasing plug means 120, illustrated in FIG. 4, for communicating a preselected directional pressure to move the latch assembly 80 to release the locking detent 71. The releasing plug 120 is positioned in the bore 24 of the tubular member 20 by lowering the plug 120 down the bore of the drill string. The releasing plug 120 includes an exteriorly extending annular collar 120*a* having a downwardly facing annular seating surface 120*b* for engaging the upwardly facing shoulder 60*g* of the sleeve 60 to block downwardly movement of the plug 120 as well as positioning a plurality of packing or seal rings 120*c*, 120*d* and 120*e* to effect seals in the drilling tool 10. The packing ring 120*c* seals between the releasing plug 120 and the inner surface 60*h* of the sleeve 60 above the port 60*e* while the packing ring 120*d* seals between the locking plug 120 and the sleeve surface 60*h* below the port 60*e* to prevent fluid leakage therebetween. The packing ring 120*e* seals between the plug 120 and the inner surface 82*c* of the sleeve 82 below the port 82f to block communication of the fluid pressure from the chamber 84 with the bore 24 below the plug 120. The plug 120 includes a vertical extending channel 120*f* which communicates the pressure in the bore 24 above the plug 120 to a horizontally disposed port 120*g* in the plug 120 communicative with area between the packing rings 120*d* and 120*e*. The fluid pressure between the packing rings 120*d* and 120*e* is communicated through the openings between the flukes 60*d* and through the port 82*f* into the chamber 84 for urging the latch ring 81 to move upwardly to release the detent 71 from the recess 25*c*. The releasing plug has a horizontal port 120*h* located between the packing rings 120*c* and 120*d* communicating with a vertical extending exit channel 120*i* for communicating the chamber 83 and the bore 24 of the tubular member 20 below the unlocking plug 120. The unlocking plug 120 has a fishing neck 120*j* secured to the upper portion of the plug 120 to enable retrieval of the bore plug 120 from the bore 24 of the tubular member 20 by a wire line fishing operation after releasing the ball 31.

As illustrated in FIG. 5, the tool 10 includes a stabbing means 130 for controlling an undesired flowing stream of fluid from the bore of the drill string by enabling connection of said tubular member with the drill string and thereafter enabling said ball 31 to rotate closed. The stabbing means 130 includes a stabbing sleeve or tubular lock member 131 having a left handed thread 131*a* for engagement with a thread 60*i* on the fixed sleeve 60 to secure the sleeve 131 concentrically in the bore 24 of the tubular member 20. The initial engagement of the threads 60*i* and 131*a* also engages a lower shoulder 131*b* of the tubular member 131 with the annular shoulder 82*b* of the detent sleeve 82 in order that rotation of the sleeve 131 to move the threads 131*a* and 60*f* into complete engagement also moves the sleeve 131 downwardly along with engaged detent sleeve 82 to rotate open the ball 31. The sleeve 131 has a longitudinal bore 131*c* aligned with the bore

24 to enable flow through the bore 131*c* when the sleeve 131 is secured in the tubular member 20.

The use and operation of the present invention provides the driller of a well with flexible protection against inside the drill pipe blowouts during drilling operations previously available only through the use of a plurality of drilling tools. The drilling tool 10 may be connected for automatically controlling the direction of flow in the drill pipe in the drill string at any location, but preferably it is connected a short distance above the drill bit. When lowering the drill string into the well the rotatable ball 31 may be locked open to enable the drilling fluid within the drill hole to flow up the bore of the drill string eliminating the need of filling the bore of the drill string from above the drilling tool 10 to prevent collapse of the drilling string. The rotatable ball valve 31 is then unlocked, as will be explained, prior to commencing drilling operations to enable automatic pressure responsive operation of the drilling tool 10. The driller may, by installing the stabbing sleeve 131, maintain the drilling tool 10 on the rig floor and stab the tool 10 in the drilling string for controlling the flow only after a blowout flow or kick has occurred.

The drilling tool 10 is in the condition illustrated in FIG. 1A, when connected in the drilling string prior to commencing drilling operations. The piston means 40 is urged upwardly by the spring means 50 to rotate the ball 31 to the closed position. The latch 81, the detent ring 71 and the sleeve 82 are all in the upper position and are held there against inadvertent movement by the snap ring 62. The driller, to establish circulation of drilling fluid prior to commencing drilling, will increase the pressure of the drilling fluid supplied to the bore of the drill string by the mud pumps. This pressure will be communicated through the bore of the drill string to the bore 24 of the tubular member 20 above the closed ball 31.

This increased pressure in the bore 24 is communicated through the openings between the flukes 60*d* and the port 82*f* into the expansible chamber 84 and through the port 60*e* into the expansible chamber 83. Because this pressure is urging on equal effective surface areas of the latch member 81 the pressure urgings on the latch member 81 is equal and offsetting and the latch member 81 remains in the position illustrated in FIG. 1A.

As the pressure of the circulating fluid in the bore 24 above the ball 31 is increased to a pressure greater than the pressure in the bore 24 beneath the ball 31, the pressure urging on the upper surface 31a of the ball 31 urges the ball 31 and engages lower ring member 36 to move downwardly when the pressures overcome the upwardly urging of the spring 37. This initial movement spaces the spherical surface 31*a* of the ball 31 from the seating surface 35*a* of the seat ring 35 to prevent scarring or other damage to the ball 31 or seating surface 35*a* when the ball 31 is rotated. This movement also tends to equalize the pressure in the bore 24 urging on the ball 31 before commencing to impart rotation to the ball 31 enabling the longitudinal movement of the ball 31 to be effected by a smaller urging pressure.

The pressure communicated through the port 82*f* is also communicated through the openings between the flukes 82*e* of the sleeve 82 into the lower portion of the expansible chamber 84. This pressure urges downwardly on the piston means 40 on the upwardly facing annular effective surface area of the piston sleeve 41 not sealed by the O-ring 41*e*. The piston sleeve 41 and the detent sleeve 82 are not sealed therebetween, hence there is some communication of fluid pressure where these sleeves adjoin between the expansible chamber 84 and the bore 24.

The pressure in the bore 24 above the ball 31 when increased sufficiently will urge movement of the ball 31 and the piston means 40 downwardly overcoming the upwardly urging on the piston means 40 of the spring 50 and the well pressure in the chamber 48. As the piston means 40 commences to move downwardly the O-ring 41e moves from sealing contact with the shoulder 45*b* to enable the pressure in the bore 24 above the ball 31 to be communicated along the outer surface of the upwardly facing effective surface area of piston means 40 to the labyrinth opening 41*f*. This increases the downwardly urging on the piston means 40 to insure that the piston means 40 moves downwardly and does not flutter or hesitate when moving between the upper and lower positions. As the piston means 40 moves downwardly the expansible chamber 48 below the shoulder 41*h* providing upwardly urging on the piston means 40 by the well annulus pressure is reduced in size. Fluid within the chamber 48 is vented into the well annulus adjacent the exterior surface 26 of the tool 10 through the port 25*n* in the wall of the tubular member 20. The piston means 40 will continue to move downwardly until the shoulder 41*h* engages the shoulder 46*d* of the lower stop 46 which is sealed therebetween by the O-ring 41*i*, This seal reduces the downwardly facing pressure responsive effective surface area of the piston means 40 for urging the piston means 40 upwardly communicating with the well pressure.

The downwardly movement of the piston means 40 by the pressure in the bore 24 above the ball 31 also moves the ball 31 downwardly. The downward longitudinal movement of the ball 31 relative to the fixed eccentric pins 34 imparts a 90° rotation to the ball 31 to rotate the ball 31 from the closed position (FIG. 1A) to the open position (FIG. 2A). Reference is made to my copending application, Ser. No. 72,034, filed Sept. 14, 1970, which illustrates in greater detail the rotational movement of the ball 31 to and from the open and closed positions upon longitudinal movement of the ball 31 relative to the fixed eccentric pins 34.

The downwardly movement of the piston means 40 to rotate ball 31 open compresses the spring 50 which continues to impart a constant upwardly urging to the piston means 40. By sealing the housing 20 to the sleeve 42 with packing 47, a net upwardly facing pressure responsive surface area on the piston means 40 for the pressure in the bore 24 to urge the piston means 40 to move downwardly in response to the pressure in the bore 24 is provided. This arrangement enables the ball 31 to remain in the open position as long as the pressure in the bore 24 downwardly urging on the effective surface area so formed is greater than the combined upwardly urging of the spring 50 and the well annulus pressure adjacent the exterior of the drilling tool 10 communicates through the channel 25n into the expansible chamber 48.

Should the pressure of the drilling fluid circulated down the bore 24 of the drill string be reduced or the pressure in the annulus of the well communicated through the port 25n be increased, such as by a blowout, the ball 31 will be automatically rotated closed to control the flow of fluid through the bore 24. The dif-

ferential pressure urging on the piston means **40** will be reduced by either occurrence which will enable the urging of the spring **50** to move the piston means **40** upwardly to rotate the ball **31** closed. The upwardly movement of the piston means **40** will engage the ring **36** carried by the sleeve **42** with the ball **31** for moving the ball **31** upwardly. The upwardly movement of the ball **31** relative to the fixed pins **34** extending within the recesses **31***c* will rotate the ball **31** 90° from the open position (FIG. **2**) to the closed position (FIG. **1**). By sensing the incipient pressure changes between the bore **24** and the well annulus the ball **31** will be automatically rotated to the closed position to block upwardly flow of fluid through the bore **24** of the tubular member **20.**

When it is desirable to run a well tool through the bore of the drill string or when lowering the drilling string into the well, the ball **31** may be locked open to provide a full bore opening through the tubular member **20.** The locking plug **110** is lowered down the bore of the drill string until the shoulder **110***b* seats upon the shoulder **60***g* to position the plug **110** in the tubular member **20.** The pressure in the bore of the drill string above the plug **110** is then increased and communicated through the openings between the flukes **110***a* of the locking plug **110** to the port **60***e*. The fluid pressure is communicated through the port **60***e* into the expansible chamber **83** to urge downwardly on the upwardly facing surface **81***a* of the latch **81** for moving the latch **81** downwardly. Use of the plug **110** preselects the direction that the increased pressure will act on the latch ring **81** because the increased pressure in the bore **24** above the plug **110** is also blocked from communicating into the expansible chamber **102** by the packing **110** *c* which eliminates the normal offsetting pressure urging on the latch **81.**

The downwardly urging of the pressure in the chamber **83** on the latch ring **81** will move the latch ring **81** downwardly to engage detent **71** with the lower shoulder **81***e* to move the detent **71** and latch **81** downwardly together until the lower shoulder of the detent **71** engages the upper shoulder of the guide flukes **82***e* of the detent sleeve **82.** This urging will then force movement of the snap ring **62** from the recess **82***g* into the recess **60***c* to enable the engaged latch **81,** detent **71** and sleeve **82** to move downwardly. The downwardly movement of the sleeve **82** engages the shoulder **82***d* with an annular shoulder **41***j* of the piston means **40.** The downwardly urging of the pressure in the chamber **83** on the latch **81** will then be used to overcome the upwardly urging of the spring **50** and the well annulus pressure in the chamber **48** to move the latch ring **81,** the detent **71,** the detent sleeve **82,** the piston means **40** and the ball **31** downwardly. The downward movement of the ball **31** relative to the pivot pins **34** will rotate the ball 90° to the open position.

When the ball **31** is rotated open the detent **71** is aligned with the recess **25***c* in the surface **25***b* of the tubular member **20** and will move outwardly into the recess **25***c* enabling the latch ring **81** to move downwardly to the locking position illustrated in FIG. **3A.** With the detent **71** locked outwardly into the recess **25***c* by the shoulder **81**d of the ring **81** a subsequent reduction of the pressure in the chamber **83** will leave the ball **31** locked in the open position. The upper shoulder of the plurality of flukes **82***e* engages the lower shoulder of the detent **71,** latched in the recess **25***c* to block upwardly movement of the sleeve **82.** The engagement of the shoulder **41***j* of the piston sleeve **41** and the shoulder **82***d* of the locked sleeve **82** blocks upwardly movement of the piston means **40** in response to upwardly urgings thereon. The locking plug **110** may be retrieved from the bore **24** of the drilling tool **10** after locking the ball **31** open by connecting a fishing tool with the fishing neck **110***d* for removing the plug **110.** Other well tools may then be run through the bore **24** of the tubular member **20** as desired or the drilling string may be lowered into the well to fill the drilling string with drilling mud in the well.

After completion of the running of the other tools through the bore of the drill string and the tubular member **20,** the driller may desire to return the drilling tool **10** to automatic pressure responsive operation. As illustrated in FIG. **4,** this is accomplished by dropping or lowering the unlocking plug **120** down the bore of the drill string until the shoulder **120***b* of the unlocking plug **120** is seated on the shoulder **60***h* to position the plug **120** in the bore **24** of the well tool **10.** The driller then increases the pressure in the bore of the drill string above the plug **120** which is communicated through the channel **120***f* and the ports **120***g* and **82***f* into the expansible chamber **84.** This increased pressure in the chamber **84** urges upwardly on the downwardly facing portions **81***d*, **81***e* and **81***g* of the latch ring **81** to move the latch **81** upwardly to the position illustrated in FIG. **4.** The plug **120** blocks communications of this increased pressure in the bore **24** to the surface **81***a* in the chamber **83** to provide a preselected directional pressure urging on the latch ring **81.** Fluid within the expansible chamber **83** is vented by the plug **120** through port **120***h* and channel **120***i* into the bore **24** of the tubular member **20** below the plug **120** to enable upwardly movement of the latch **81** from the detent **71.**

The pressure introduced into the expansible chamber **84** by use of the unlocking plug **120** will also urge downwardly on the piston means **40** to maintain the piston means **40** in the lower position and the ball **31** in the open position. When the pressure in the bore of the drill string above the plug **120** is reduced, the spring **50** and the pressure in the chamber **48** will urge the piston means **40** to move upwardly to rotate the ball **31** closed. The engagement of the sleeve **41** of the piston means **40** with the sleeve **82** will force the detent **71** to move out of the recess **25***c* enabling the sleeve **82** and detent **71** to move upwardly until the recess **82**g aligns with the detent **62** which will then expand outwardly into the recess **82***g* to block subsequent inadvertent movement of the sleeve **82.** The unlocking plug **120** is then retrieved from the bore **24** to enable resumption of drilling operations.

Should the driller desire for any reason not to connect the drilling tool **10** in the drill string for automatic operation the tool **10** may still be utilized as an inside blowout preventer. By using the stabbing sleeve **131,** illustrated in FIG. **5,** the drilling tool **10** may be connected or stabbed in the drill string while an upwardly flow or kick is occurring in the bore of the drill string. To prepare the drilling tool **10** for stabbing, the annular shoulder **131***b* of the sleeve **131** is inserted into the bore **24** at the threaded box **22** end. The mating left handed threads **131***a* of the tubular member **131** and the threads **60***i* of the sleeve **60** are brought into engagement and the tubular sleeve **131** is manually rotated using handles **131***d* to move the sleeve **131** fur-

ther into the bore **24** of the tubular member **20.** As the shoulder **131***b* moves toward the threaded pin end **21** of the tubular member **20** it engages the upwardly facing annular shoulder **82***b* of the sleeve **82** for moving the sleeve **82** downwardly. As the sleeve **131** continues to move into the bore **24,** the detent ring **62** is forced inwardly from the recess **82***g* into the recess **60***c* of the sleeve **60** to enable the sleeve **82** to move downwardly. The lower shoulder **82***d* of the sleeve engages the shoulder **41***j* of the piston sleeve **41** to move the ball **31** and the piston means **40** downwardly. As illustrated in FIG. **5,** when the threads **60***i* and **130***a* are fully engaged the sleeve **131** has forced the piston means **40** to the lower position to rotate the ball **31** to the open position. The drilling tool **10** is maintained in this condition on the floor of the drilling rig when the tool **10** is to be stabbed into the drilling string.

When an upwardly flow or kick occurs in the bore of the drill string, the drilling tool **10** is ready for stabbing in the drill string. With the ball **31** in the open position, the threaded pin connection **21** may be stabbed into an upper box connection of the drill string. With the full bore opening of the drilling tool **10** provided by the open ball **31** and the sleeve **131,** only a minimum amount of interference with the stabbing operation will be caused by the upwardly flowing stream of fluid from the bore of the drill string. When the threaded pin connection **21** is stabbed into and the tool **10** rotated to fully engage with the threaded box connection of the drill string, the handles **131**d may be used to rotate the tubular member **131** to remove the sleeve **131** from the bore **24** of the drilling tool **10.** By making the threads **60***i* and **131***a* a left handed engagement, rotating the tubular member **131** to disengage threads **131***a* and threads **60***i*, the sleeve **60** will not inadvertently disengage from threads **25***a*. Because the fluid pressure in the bore **24** exhausting to the atmosphere above the tool **10** urging downwardly on the piston means **40** is less than the combined upwardly urging of the spring **50** and the atmospheric pressure in the chamber **48,** the spring **50** will urge the piston means **40,** the ball **31** and the sleeve **82** to move upwardly as the sleeve **131** is removed from the bore **24.** The upward movement of the ball **31** rotates the ball about the fixed pins **34** back to the closed position to control the undesired flowing stream of fluid in the bore **24** of the tubular member **20.** The ball **31** rotates closed to block the flow prior to disengagement of the threads **60***i* and **130***a* in order that the sleeve **131** will now be blown violently from the bore **24** by the flow. The upwardly movement of the piston means **40** also moves the sleeve **82** upwardly to align the recess **82***g* with the detent **62** to enable the detent **62** to expand outwardly into the recess **82***g* to secure the sleeve **82** against subsequent inadvertent movement.

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

I claims:

1. A method of operating a safety valve connected in a well tubing for controlling flow of fluid in an undesired direction through the bore of a well tubing, including the steps of:

a. sensing the pressure in the bore of the well tubing for enabling flow in the desired direction through the bore;

b. sensing the pressure adjacent the exterior of the safety valve;

c. comparing the pressure in the bore with the pressure adjacent the exterior of the safety valve to determine the pressure differential;

d. opening the safety valve to enable flow of fluid through the bore of the tubing when the pressure in the bore of the tubing exceeds the pressure adjacent the exterior of the safety valve by a predetermined value; and

e. increasing the sensing of the pressure in the bore of the well tubing as the valve commences to open for increasing the urging opening the valve wherein said valve is moved fully open.

2. The method as set forth in claim **1,** including the step of rotating a flow blocking member of the safety valve when opening the safety valve to enable flow of fluid through the bore of the tubing.

3. The method as set forth in claim **2,** including the step of spacing the rotatable flow blocking portion of the safety valve from a safety valve seat prior to rotating open the flow blocking portion of the safety valve.

4. The method as set forth in claim **1,** including the step of locking the opened safety valve to render the safety valve inoperative to control flow of fluid through the bore of a well tubing.

5. The method as set forth in claim **4,** including the step of releasing the locked open safety valve to enable the safety valve to control flow of fluid in the undesired direction through the bore of the well tubing.

6. The method as set forth in claim **1,** including the step of:

closing the safety valve to block flow of fluid through the bore of the tubing when the pressure adjacent the exterior of the safety valve is exceeded by the pressure in the bore of the tubing by less than the predetermined value wherein the safety valve is operated.

7. The method as set forth in claim **6,** including the step of:

rotating a flow blocking member of the safety valve to control flow of fluid through the bore of the tubing.

8. A method of controlling a flowing stream of fluid from a bore of a well tubing by stabbing a pressure responsive safety valve for stopping the stream including the steps of:

a. locking the valve open to enable flow therethrough by securing a lock member with the valve;

b. connecting the valve with the well tubing housing the stream of fluid flowing from the bore;

c. removing the lock member to enable pressure responsive operation of the safety valve; and

d. closing the valve to block the flow from the bore of the tubing when the pressure in the bore of the tubing exceeds the pressure adjacent the exterior of the safety valve by less than a predetermined value.

9. The method as set forth in claim **8,** including the step of rotating flow blocking member of the safety valve to close the valve.

10. The method as set forth in claim **9,** including the step of:

moving the flow blocking member of the safety valve along the bore when rotating to close the valve.

11. The method as set forth in claim **9,** including the step of opening the valve to enable flow through the bore of the well tubing when the pressure in the bore of the tubing exceeds the pressure adjacent the exterior of the safety valve by a preselected pressure.

12. The method as set forth in claim **11,** including the step of rotating the flow blocking member of the safety valve to open the valve.

13. The method as set forth in claim **12,** including the step of:

moving the flow blocking member of the safety valve along the bore when rotating to open the valve.

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