United States Patent

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[54] **METHOD FOR DIRECTIONAL DRILLING WITH A JETTING BIT**
8 Claims, 3 Drawing Figs.

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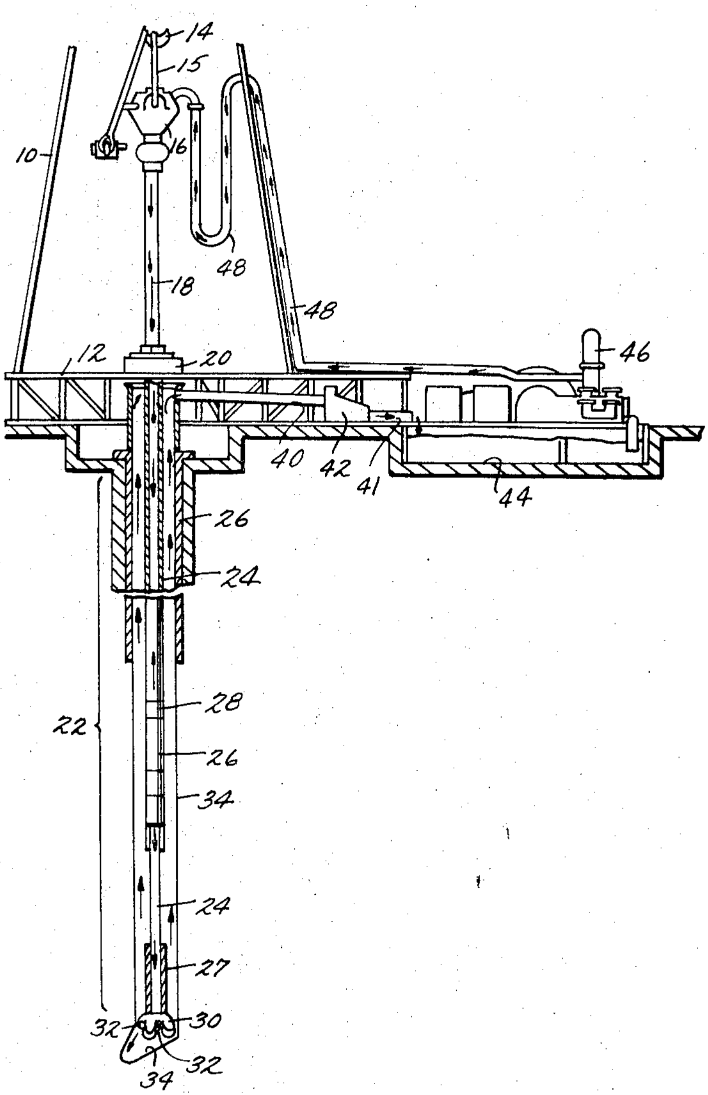
ABSTRACT: Method and apparatus are described for changing the direction taken by a bore hole. A drill bit having at least one outlet orifice or nozzle for drilling fluid e,g, mud, is oriented so that the orifice is adjacent the portion of the interior lateral surface of the bore hole into which it is desired for the drill bit to proceed. The drilling fluid is pumped into the interior of a hollow drill string in the bore hole and out through the orifice in the drill bit. A portion of the drill string adjacent the bit is adapted to be closed in a fluidtight manner by means of a back pressure ball valve, and the portion of the drill string between the valve and the outlet orifice includes a slip joint adapted to be decreased in volume by an inward telescoping motion with vertical reciprocation of the drill string. Decreasing the volume of the drill beneath the abovementioned valve will serve to compress the fluid therein forcing it out of the outlet orifice at an increased velocity. When the drill string is moved vertically upwardly, the valve opens allowing more drilling fluid to flow therethrough. Repetitive vertical reciprocation of the drill string to open and close the slip joint will result in highly accelerated jetting velocities through the outlet orifices in the drill bit.



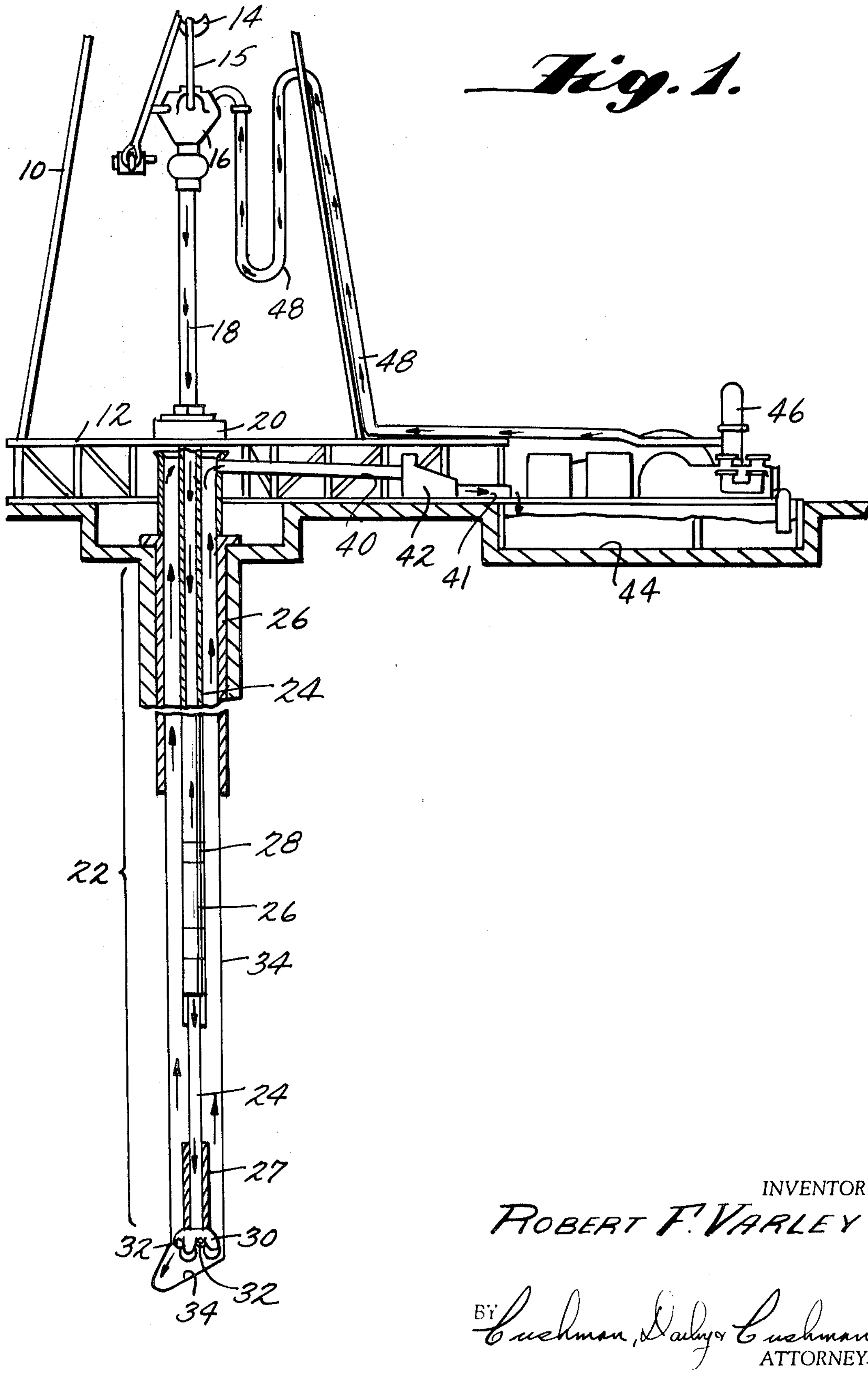


Fig. 1.

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Fig. 2.

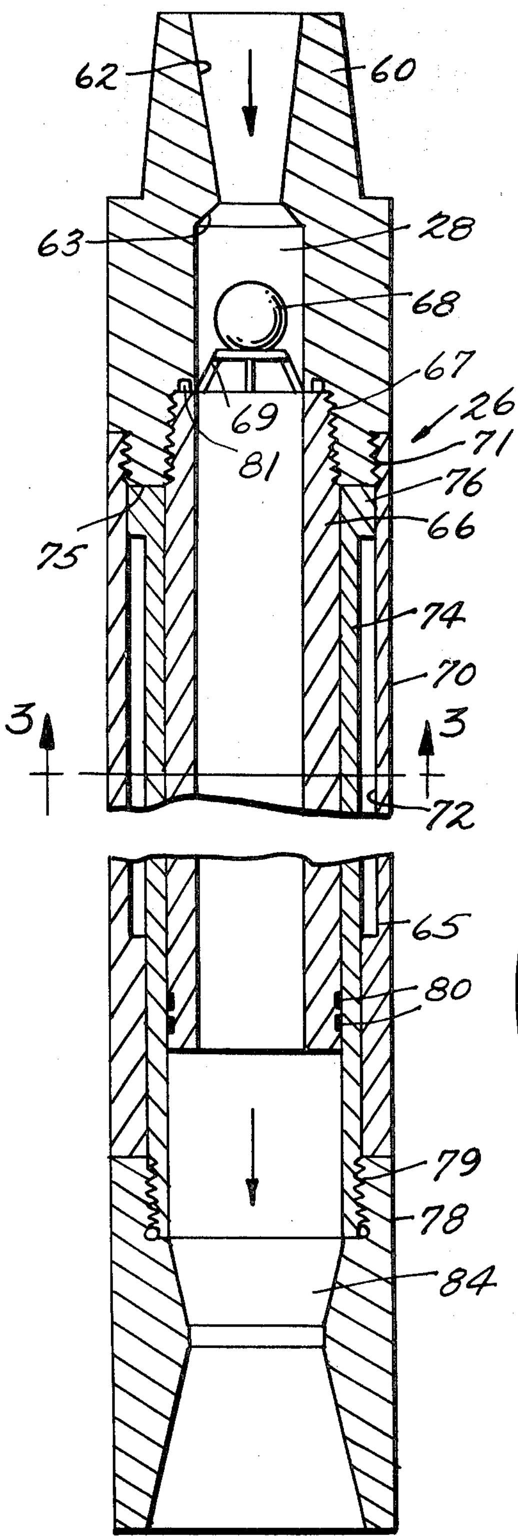
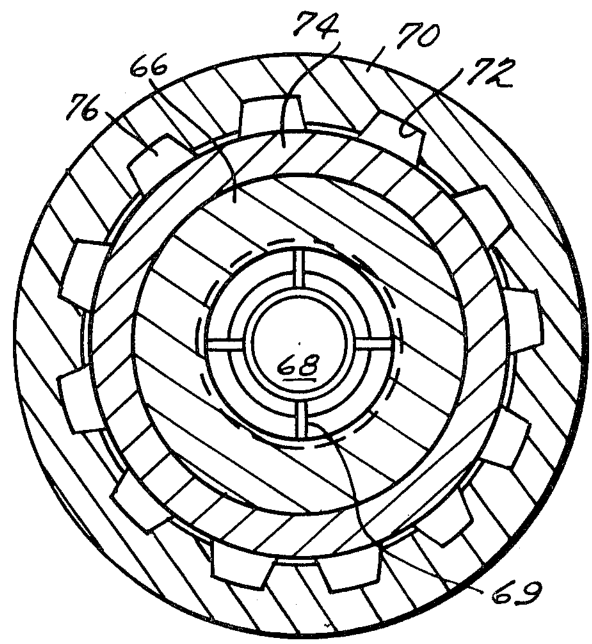


Fig. 3.



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METHOD FOR DIRECTIONAL DRILLING WITH A JETTING BIT

This invention relates to an improved method for directional drilling, and in particular, a method of directional drilling in which increased fluid velocities are achieved and an apparatus placed in a drill string for increasing the fluid pressure and thereby the velocity.

In modern oil and gas well drilling it is increasingly important to be able to drill to increased depths to have access to the decreasing petroleum supply. In working at these greater depths it is, as well, important to be able to control the direction taken by the drilling apparatus. That is, it is often necessary to deviate the bore hole from a straight vertical path laterally therefrom to get to a particular deposit. This technique is particularly important in off-shore drilling where it is desirable to place as few rigs as possible but to have the ability to drill throughout as wide an area as possible.

One of the more commonly used prior art devices for directional drilling was the whipstock. The whipstock would be used to guide a conventional rotary bit against the sidewall of a bore hole and to cause the bore to be deflected away from the original bore hole path. Using this directional drilling technique it is required that the bore hole be opened from the surface downward to an earth formation that is sufficiently consolidated to accept the whipstock which then must be set, using orienting and directional survey equipment, to assure the driller that the whipstock is properly aligned in the hole. Another major disadvantage of this technique is the fact that the bore hole itself must be drilled to a sufficiently large diameter to be able to accept the whipstock body.

The disadvantages of the foregoing directional drilling device were overcome with the advent of a technique for directional drilling known as "jet deflection." The jet deflection method combines hydraulic washing and mechanical cutting to direct the path of the bore hole in the desired direction away from the true vertical. In this method, a drill bit carries a hydraulic nozzle which is oriented in the direction of or adjacent the lateral surface of the bore hole through which the desired deviation is to take place. The drilling fluid, e.g., mud, which is normally circulated through the drill string and bit is circulated to a greater degree against the aforementioned lateral wall to erode that surface so that the drill bit is deviated in the direction that it is desired for the bore hole to take. In many cases, after sufficient penetration in the desired direction has taken place, vertical movement of the drill string is permitted, and the drill bit is reciprocated up and down to achieve a cutting effect, for example by increasing and decreasing the weight applied thereto by the drill string and the collars. The bore hole will then be deviated in the desired direction, i.e. the direction in which the jet is oriented. During this operation no rotation of the drill bit and drill string takes place until the desired deviation is achieved, but a cylindrical hole will still be obtained by the vertical reciprocation of the drill string.

With increasing bore hole depth, however, the amount of time necessary to perform the jet deflection operation and accordingly the cost thereof will be substantially increased. For example, it has been found that at depths greater than 1,500 feet the time required will increase directly with the depth involved. For depths of approximately 12,000 feet and greater it has been found that it is virtually impossible to economically utilize jet deflection with the presently available equipment and using conventional techniques. The foregoing is particularly true where the circulating fluid in the drill string is mud. If the circulating medium is air or a similar gas, it has been found that the rate of penetration is substantially uneffected. Because mud is the more widely used drilling fluid in that it is more economical, it is, however, necessary to arrive at a means for obtaining greater penetration with mud as the drilling fluid at the greater depths.

It is now believed that the primary cause of the increased drilling expense associated with increased bore hole depth in directional drilling using mud as the drilling fluid is the effect of hydrostatic pressure acting against the formations being drilled. Hydrostatic pressure is the pressure exerted due to the depth and weight of the drilling mud column. Hydrostatic pressure increases as a direct function of either the depth of the mud or the weight of the mud column. As drilled depth is increased, the velocity of the drilling fluid being emitted from the jet nozzle is dampened or reduced in the short interval of distance (6 to 8 inches) from the nozzle to the face of the formation being eroded. At these greater depths, the jetting fluid (e.g. mud) is being emitted into a fluid environment of high pressure intensity. Because hydrostatic pressure is a direct function of depth, the fluid environment at shallow bore hole depth will be such that the pressure will be significantly decreased. The high-pressure fluid environment at greater bore hole depths reduces the velocity, and therefore the effectiveness, of the jetting stream before it strikes the formation being eroded.

It is therefore an object of this invention to provide a method which will significantly increase the velocity of the drilling fluid being emitted from a bit when the jet deflection technique is being used for bore hole deviation.

It is another object of this invention to provide a method for using the jet deflection technique of bore hole deviation which may be used economically at increased bore hole depths, particularly where mud is being used as the drilling fluid.

The aforementioned and other objects may be obtained by using the invention described herein which may be best understood by reference to the description given hereinbelow of a preferred embodiment constructed and operating according to the principles of this invention in conjunction with the drawings in which:

FIG. 1 is a diagrammatic illustration of a preferred embodiment of a drilling apparatus modified according to the principles of this invention to carry out the method of this invention;

FIG. 2 is a side cross-sectional view of a preferred embodiment of a slip joint having a back pressure valve included therein constructed according to the principles of this invention and adapted to be placed in a drill string to carry out the method of this invention; and

FIG. 3 is a cross-sectional view of the embodiment of FIG. 2 taken along the line 3—3.

Referring to the drawings and in particular FIG. 1, it will be seen that a bore hole 34 has been started into the earth, and the deviation of the bore hole has been partially carried out by means of the jet deflection technique described herein. The direction to be taken by the bore hole 34 is shown by the arrow in the lower portion thereof.

A conventional drilling rig, generally indicated by the numeral 10, along with a drilling platform 12 supports the entire drilling apparatus. The bore hole 34 has been drilled vertically by means of rotary operation of a drill string 22. The drill string 22 comprises an axially adjacent series of drill pipes 24 and drill collars 27 as needed. As shown in FIG. 1, a drill collar 27 is placed at the lower end of the pipe string 24 with a rotary drill bit being attached thereto. A drill bit 30 shown in FIG. 1 as being attached at the lower end of collar 27 is particularly adapted for use with the jet deflection technique of this invention to be described hereinbelow. The drill pipes 24 and drill collars 27 allow the flow of a circulating medium downwardly therethrough, and in this preferred embodiment this circulating medium is mud. An annular pipe 26 is placed around the drill pipe 24 at the upper portion thereof in bore hole 34 to guide the drilling mud which is flowing upwardly in the bore hole, and a conduit 40 communicates with the pipe 26 to conduct the drilling mud away from the bore hole. The conduit 40 passes through a conventional shale shaker 42 which acts to remove solid particles from the drilling mud, and the drilling mud is then allowed to flow by means of conduit 41 into a reservoir 44.

In order to cause the drilling mud to flow downwardly through the drill pipe 24 a conventional mud pump 46 draws the mud out of reservoir 44 and sends it under pressure through a conduit 48. The conduit 48 extends through a swivel 16 and communicates with a kelly bar 18. The kelly bar 18 couples the circulating drilling mud to the drill pipe 24. During the normal operation of the drilling apparatus a rotary table 20 enclosing kelly bar 18 and the drill pipe 24 causes these elements to rotate to carry out normal drilling action.

In order to carry out bore hole deviation in a manner according to this invention, the conventional rotary bit is replaced by a bit 30 which includes at least one nozzle or orifice 32 through which a greater amount of drilling mud can be caused to flow than through any remaining orifice in the bit. Further, a slip joint 26 is interposed in drill string 22 in a portion thereof near the bit 30. The drill string has included therein a back pressure valve 28 which will prevent the pressurized drilling mud from flowing upwardly through the drill pipe 24. The structural details of this slip joint and back pressure valve will be more completely described hereinbelow with reference to FIGS. 2 and 3.

The bore hole deviation technique described herein requires vertical reciprocation of the drill string. A link 15 extends upwardly from swivel 16 and is coupled to a hook 14. A vertical drive by any well-known means (not shown) acts on hook 14 to cause vertical reciprocation of the drill string.

In order to deviate the bore hole 34 from its vertical path using the technique of jet deflection described herein the drill bit 30 is oriented so that the nozzle or nozzles 32 will direct flow of drilling mud therefrom against the lateral wall of the bore hole in the direction it is desired for the bore hole to take. With pump 46 operating to send drilling mud under pressure down through the drill pipe 24 in the manner described above the drill string 22 is lifted by means of hook 14 a distance equal to the length of travel of the telescoping slip joint 26 as it telescopes outwardly. After the drill string has traveled upwardly the aforementioned distance, it is lowered as rapidly as possible back down into the bore hole 34. At this time, the back pressure valve 28 in the top portion of slip joint 26 closes trapping the drilling mud contained in the slip joint 26 and the drill pipe therebelow. The weight of the lowering drill string 22 causes the slip joint 26 to telescope inwardly on itself reducing the total volume of the area closed by valve 28. The mud contained in the enclosed volume is compressed by the closure of slip joint 26 and is thereby accelerated out of the orifices 32 in bit 30. The above-described operation of vertically reciprocating the drill string 22 to open and close the slip joint 26 is carried out repetitively. The increased jetting velocities die to closure of the slip joint will erode the earth formation adjacent the orifices 32 of nozzle 30 in the desired direction of deviation, and the vertical reciprocation of the drill string will cause drill bit 30 to cut into the aforementioned earth formation.

It has been found by using the technique and equipment described herein jetting velocities may be achieved which are two to four times greater than the velocities of conventional jetting equipment using pumps on the earth surface. That is, conventional equipment relies only on the pumping action of a pump similar to pump 46 described in FIG. 1 to obtain the needed jetting velocities at the orifices in the drill bit. As pointed out hereinabove, the hydrostatic pressure at increased depths will resist this pumping action to an extent that the jetting velocities are significantly reduced thereby reducing the efficiency of the orifices as a means for eroding the earth formation in the bore hole. By using the slip joint 26 to obtain a pressure pulse on a downward stroke of the drill string 22, this problem is overcome, and the jetting velocities are increased by the orders of magnitude set forth above.

FIGS. 2 and 3 illustrate the structural details of the slip joint 26 and the back pressure valve 28. As will be seen from the description hereinbelow, the back pressure valve 28 is actually an integral part of the slip joint 26 and is placed directly above the telescoping portion of the slip joint.

Slip joint 26 includes an upper stepped cylindrical member 60 which mates with the drill pipe 24 thereabove. The interior surface 62 of cylinder 60 converges from a diameter substantially equivalent to the inner diameter of the drill pipe and then abruptly diverges outwardly to form an angular shoulder 63. From that point downwardly the interior surface of member 60 is of a diameter substantially equivalent to the inner diameter at the very upper portion of interior surface 62. An inner cylindrical member 66 is threadably engaged with the lower portion of the interior of end member 60 and extends downwardly therefrom. The inner member 66 is coaxial with end member 60 and is of an inner diameter substantially equivalent to the inner diameter of the lower portion of end member 60 thereby forming a conduit for the drilling mud to flow through.

An outer cylindrical member 70 is threadably engaged at 71 with the outer surface of end member 60 at the lower end thereof. Outer cylindrical member 70 includes a series of trapezoidal splines 72 (see FIG. 3) spaced circumferentially therearound. The splines 72 do not extend the full length of member 70 and abruptly end therein to form shoulders 65. The length of splines 72 are made to be equal the desired distance of travel of the telescoping slip joint. A sliding cylindrical member 74 is placed between members 66 and 70 and is concentric therewith. The sliding member 74 has formed integrally thereon around its upper edge a series of trapezoidal teeth 76 which mate with the splines 72. The teeth 76 extend axially along the outer surface of member 70 a distance only a fraction of the entire length of the sliding member 74. The sliding member 74, throughout the entire distance of travel of the slip joint 26, extends below the lowermost end of inner member 66 abruptly increasing the width of the fluid conduit through the slip joint. A cylindrical bottom end member 78 is threadably engaged at 79 with the lowermost end of the sliding member 74. The outer diameter of end member 78 is substantially equal to the outer diameter of outer cylindrical member 70, but the inner diameter of member 78 is of a configuration such that a connection area 84 is formed for effectively mating with bit 30 or with some short section of drill string connected thereto as will be apparent to those in the art. A pair of closely placed O-ring seals 80 are embedded in the lower portion of the outer surface of inner cylindrical member 70 and form a seal between said member and the inner surface of sliding member 74.

The back pressure valve is formed in the slip joint 26 by a ball member 68 which is of a diameter such that it will fit within the shoulder 63 forming a fluid seal therewith when back pressure is acting thereon. When the valve is not operated to close slip joint 26, the ball 68 rests on a frame support 69 which is attached to and extends upwardly from the upper end surface of cylindrical inner member 66.

During the upward stroke of the drill string 22, as described above, drilling mud is pumped by a pump 46 downwardly through the drill pipe 24, the slip joint 26 and the drill pipe 24 and drill collar 27 placed below the slip joint 26. During this upward stroke the ball 68 will rest on support 69 and will, at least partially, be held thereon by the force of the drilling mud being pumped downwardly in the direction of the arrows through slip joint 26. Further, during this upward stroke the teeth 76 will slide downwardly through splines 72 until at the apex of the upward stroke of the drill string the teeth 76 will rest on shoulders 65 of the outer cylindrical member 70.

As the drill string 22 begins its rapid downward stroke, the weight of the drill string will cause slip joint 26 to begin to close, i.e. the teeth 76 will begin to travel upwardly in the splines 72. By commencing the closure of the slip joint 26, a significant back pressure will be created therein, and this back pressure will cause ball 68 to rise and be wedged in the area formed by shoulder 63. The fluid back pressure acting against ball 68 will hold it in a sealed relationship with shoulder 63. The slip joint will continue its closing motion until teeth 76 come to rest against the lowermost end surface 75 of cylindrical end member 60. Because valve 28 is now closed, the drilling fluid within slip joint **26** and the drill **24** therebelow will be compressed and forced out of the orifices **32** in bit **30** at an increased velocity in the manner described hereinabove. The formation of a conduit of increased diameter by the lower portion of sliding member **74** better enables the slip joint **26** to withstand the higher forces found therein during the closure portion of the operation.

While slip joints are known to those skilled in the drilling art, they are only used to telescope the drill string rapidly in order to transmit shock loads to lower string members in order to free them from a stuck condition in the well bore. The slip joint **26** constructed as described hereinabove differs from the presently available equipment in that its above-described structure is particularly designed to compress substantial volumes of drilling fluid under very high pressures and be structurally competent to withstand the axial loading applied by the weight of the drill string during its downward stroke.

It will be apparent to those skilled in the art that the preferred embodiment and the mode of operation of same described hereinabove are only exemplary and that modifications may be made within the scope of the appended claims.

What I claim is:

1. A method for deviating the direction taken by a bore hole towards a particular direction, said method comprising the steps of:

orienting a jetting drill bit having at least one fluid outlet orifice through which a relatively greater amount of drilling mud can be caused to flow than through other bit orifices so that said at least one orifice is generally directed towards said particular direction and is adjacent the portion of the interior surface of the bore hole into which said drill bit is to proceed to deviate the direction taken by the bore hole,

pumping a drilling fluid into the interior of a hollow drill pipe placed in said bore hole, said drill bit being attached to the lower end of said drill pipe,

closing in a fluidtight manner a portion of said drill pipe adjacent said drill bit, the lower end of said closed portion being in fluid communication with said at least one outlet orifice, and

exerting a pressure on the volume of drilling fluid enclosed within said closed portion of said drill pipe thereby forcing said drilling fluid from said at least one outlet orifice of said drill pipe at an increased velocity.

2. The method defined in claim **1** comprising the additional step of vertically reciprocating an upper part of the drill pipe after said orienting step,

said pumping step occurring during the upward stroke of said upper part

said closing step occurring substantially at the commencement of the downward stroke of said upper part and said exerting step occurring simultaneously with said downward stroke.

3. The method defined in claim **1** wherein said orienting step comprises placing at least one of a plurality of outlet orifices placed around the periphery of said drill bit adjacent the portion of the interior surface of the bore hole into which said drill bit is to be deviated.

4. The method defined in claim **1** wherein said exerting step comprises decreasing the volume of said closed portion of said drill pipe thereby increasing the pressure on the volume of drilling fluid enclosed therein.

5. The method defined in claim **4** wherein said volume of said closed portion of said drill pipe is decreased by decreasing the length of said closed portion of said drill pipe.

6. The method defined in claim **5** wherein said drill pipe comprises at least two sections in axial alignment jointed at adjacent ends thereof by a slip joint having a telescoping portion therein,

said closing step taking place at a point along the length of said drill pipe above said slip joint,

the length of said closed portion of said drill pipe being decreased by closure of said slip joint.

7. The method defined in claim **6** comprising the additional step of vertically reciprocating the structure comprised of said drill pipe and the upper part of said slip joint after said orienting step, said structure being lifted on the upward stroke thereof a distance equivalent the length of travel of said telescoping portion of said slip joint,

said pumping step occurring during the upward stroke of said structure,

said closing step occurring substantially at the commencement of the downward stroke of said structure and

said closure of said slip joint occurring simultaneously with said downward stroke.

8. A process for jet directional drilling using a slip joint and back pressure valve assembly in jet deflection drilling wherein the direction of a bore hole is deviated towards a predetermined direction by jetting substantial quantities of high pressure fluid in the preferred direction of bore hole deviation, said process substantially increasing the jet deflection drilling speed and the possible operating depth of jet deflection drilling and comprising the steps of:

disposing said slip joint and back pressure valve assembly in the lower end of a hollow drill string above a jet deflection bit having at least one outlet orifice through which a relatively greater amount of drilling mud can be caused to flow than through other bit orifices,

orienting said at least one outlet orifice towards an interior portion of said bore hole which is generally oriented in said particular direction,

pumping a drilling fluid into the interior of said hollow drill string,

extending said slip joint by exerting a lifting force on said drill string,

admitting a substantial quantity of said drilling fluid past said back pressure valve into the central interior portion of said slip joint during said extending step, and

rapidly closing said slip joint by releasing at least some of the lifting force on said drill string, and

trapping said substantial quantity of drilling fluid behind said back pressure valve to force said substantial quantity of drilling fluid through said at least one outlet orifice during said closing step to thereby substantially increase the pressure and velocity of the jet-deflecting fluid thus increasing the jet deflection drilling speed and the possible depth of effective jet deflection drilling.