

[54] **FOCUS NOZZLE DIRECTIONAL BIT**
[76] Inventor: **Gary E. Hall**, 300 Tamarack St.,
Gretna, La. 70053
[22] Filed: **Feb. 25, 1971**
[21] Appl. No.: **118,853**

3,563,324 2/1971 Lauber..... 175/393

Primary Examiner—Marvin A. Champion
Assistant Examiner—Richard E. Favreau
Attorney—Arnold, White & Durkee, James L. Jackson,
Tom Arnold, Frank S. Vaden, III and Robert A. White

[52] U.S. Cl..... **175/61, 175/67, 175/339,**
175/393, 175/422
[51] Int. Cl..... **E21b 7/04, E21b 7/18**
[58] Field of Search..... 175/400, 422, 67,
175/231, 61, 339, 340, 393; 299/81

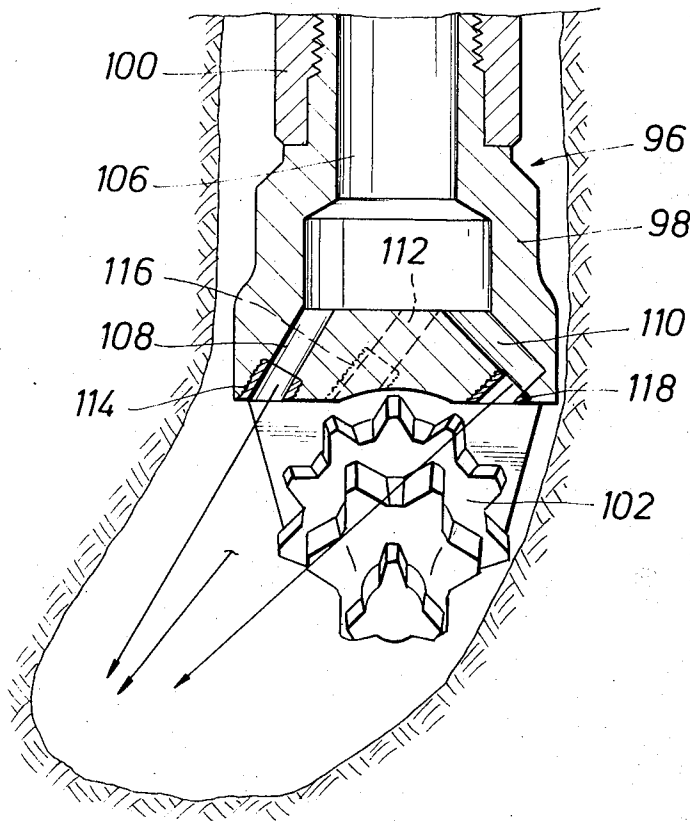
[56] **References Cited**
UNITED STATES PATENTS

3,207,241	9/1965	Neilson	175/340
3,542,142	11/1970	Hasiba	175/67
2,783,972	3/1957	Fehlmann	175/422
1,784,476	12/1930	Zublin et al.	175/340
2,785,875	3/1957	Hayes	175/67 X
3,020,965	2/1962	Keller	175/422
3,144,087	8/1964	Williams	175/339
3,211,244	10/1965	Cordary	175/231 X
3,360,057	12/1967	Anderson	175/340 X

[57] **ABSTRACT**

A focus nozzle directional bit according to the present invention includes a body having a central fluid conducting passage adapted to be disposed in communication with the bore of a drill string used for the drilling of a well. A plurality of branch fluid passages are formed in the body each being disposed in communication with the central fluid passage. A plurality of jet apertures are defined in the body in communication with the branch passages and are orientated to converge jets of pressurized drilling fluid outwardly and downwardly from the bit adjacent a lateral wall of the well bore for the purpose of directionally eroding the same to allow the drill bit to deviate downwardly and outwardly from the original well bore.

6 Claims, 6 Drawing Figures



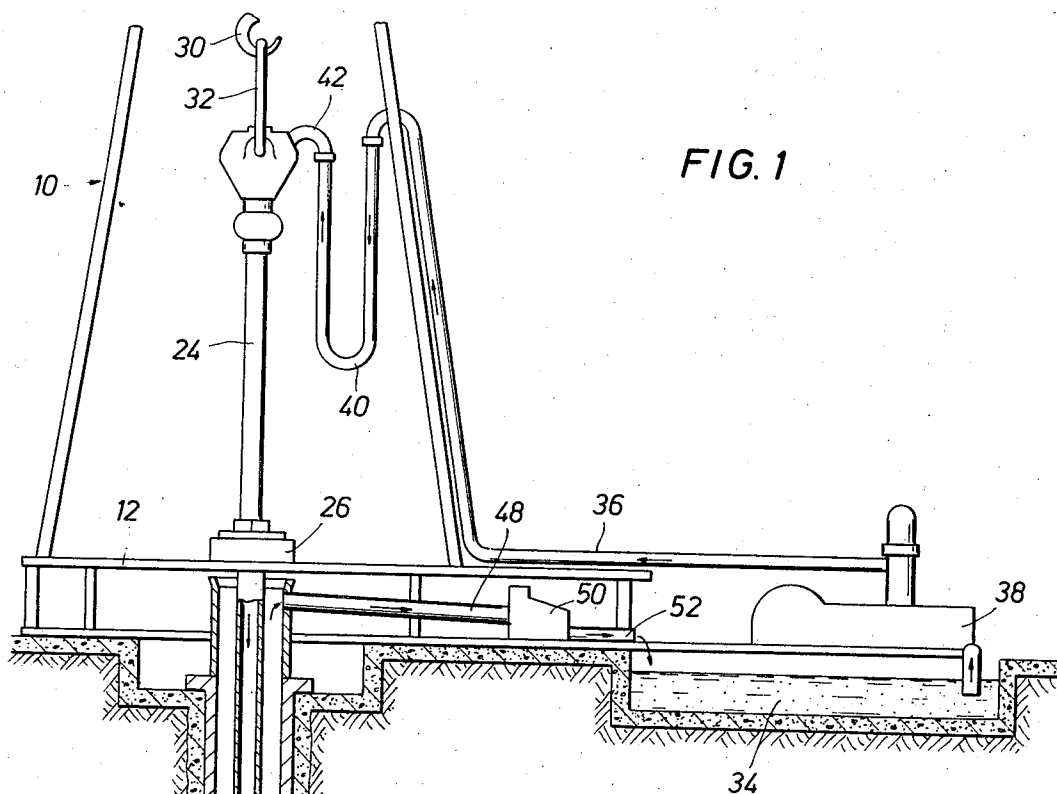


FIG. 1

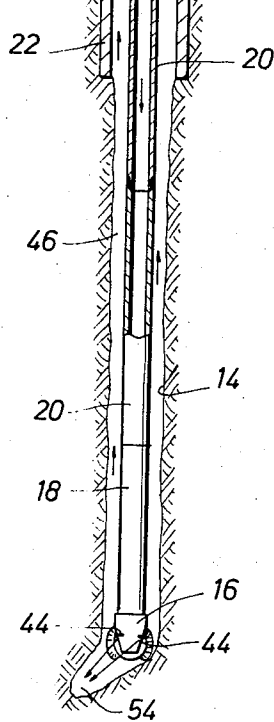
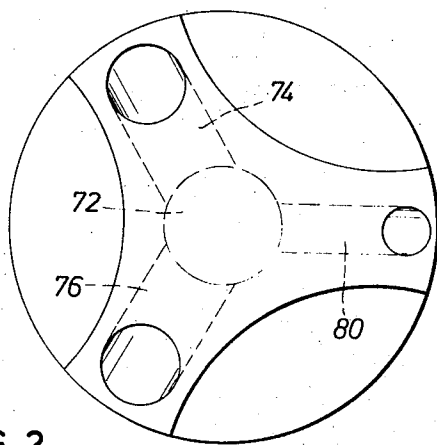


FIG. 2



Gary E. Hall
INVENTOR

BY

Arnold, White & Durkee
ATTORNEYS

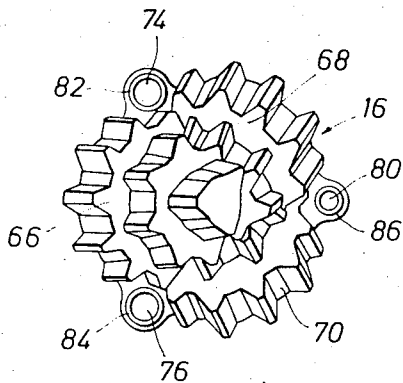


FIG. 3

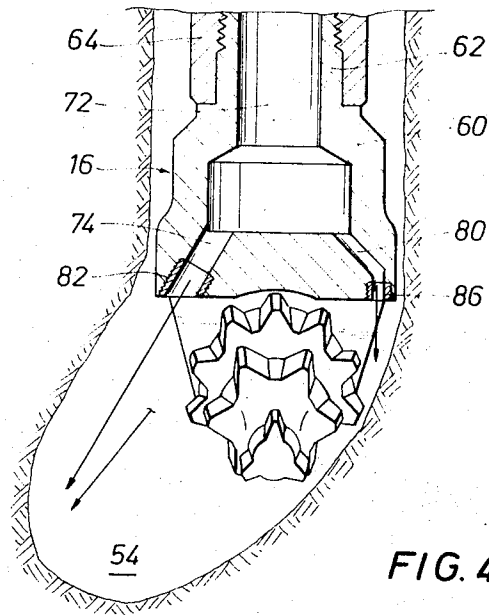


FIG. 4

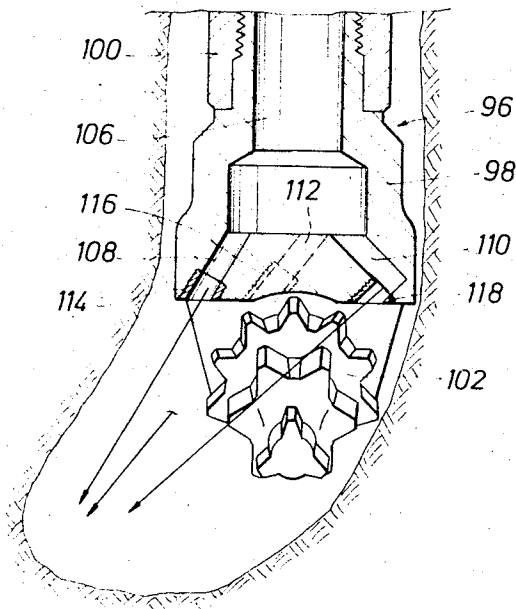


FIG. 5

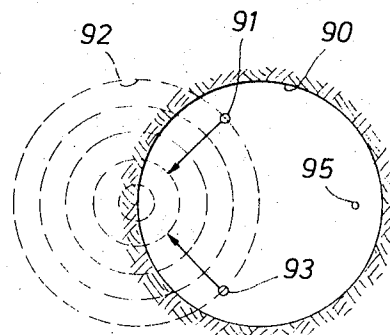


FIG. 6

Gary E. Hall
INVENTOR

BY

Arnold, White & Durkee
ATTORNEYS

FOCUS NOZZLE DIRECTIONAL BIT

BACKGROUND OF THE INVENTION

The present invention relates generally to an improved apparatus for the directional drilling of wells and more specifically to improved apparatus for achieving deflection of a well bore by controlled jet erosion thereof.

In modern oil and gas well drilling, it is increasingly important to be able to drill to increased depths in order to gain access to the decreasing petroleum supply. In conducting drilling operations, especially at extreme depths, it is as well important to be able to control the direction taken by the drilling apparatus. It is frequently necessary to deviate the borehole from a straight vertical path to a path laterally therefrom to obtain production of petroleum products from a particular deposit. It may also be important to utilize deflection techniques to correct the path of a borehole that might have become inadvertently deviated during the drilling process. The technique of directional drilling is particularly important in off-shore drilling where it is frequently desirable to drill a large number of wells from a single drilling platform and yet retain the capability of providing efficient drilling coverage in a designated drilling area.

The art of directional drilling consists of controlling the horizontal angle (direction) and the vertical angle (deviation) to control the three dimensional path of the drill well bore. While deviation is readily controlled through proper stabilizer placement and correct application of bit weight and rotary speed, the control of bore direction or horizontal angle is a frequent problem of concern in directional drilling because the hole direction will not respond nearly so well to variation of stabilizer placement bit weight and rotary speed. When it is necessary to accomplish deviation of a borehole, the new or deviated hole must be drilled with its axis shifted laterally from the original axis of the borehole. There exists several methods for achieving correction or deflection of well bores.

THE PRIOR ART

One method of achieving bore hole deviation concerns utilization of a directional drilling device, referred to as a "whipstock" that is capable of guiding a conventional rotary bit against the side wall of a borehole to cause the bore to be deflected away from the original path thereof. Using this directional drilling technique, it is required that the borehole be opened from the surface down 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. A major disadvantage of this technique is the requirement of numerous trips with the drill string in order to complete the technique. Additionally, whipstock operations are time consuming and expensive. Utilization of whipstocks to achieve deflection of boreholes is considered generally to be the most expensive method of borehole deflection and for the most part such use is limited to extreme depths where other methods of deflection would be generally unacceptable.

Down hole motors are also used for achieving deviation of well bores but such devices are infrequently so

used because of the expensive nature and difficulty of use thereof.

The most prevalent method of achieving borehole deflection is through utilization of a bit or other device capable of deflecting a jet of pressurized drilling fluid laterally against the wall structure of the well bore in such a manner that the well bore is eroded laterally and downwardly thereby allowing the drill bit to deviate from its original course to the path defined by erosion of the well bore. Jet deflection is presently accomplished by drilling bits having a single deflection jet nozzle or orifice that is substantially larger than the cleaning and lubricating orifices of the bit which jet orifice is capable of causing greater flow of drilling fluid in that portion of the well bore that is intended to be eroded for deflection purposes. Erosion will be localized at that portion of the well bore adjacent the larger jet deflection nozzle since this nozzle will allow a majority of the pumped fluid to pass therethrough for selective erosion of a portion of the well bore. As pumping and the resultant well fluid erosion continues, the bottom portion of the hole will be shifted laterally as penetration of erosion progresses. After the eroded deviated bore has penetrated to such degree that the drill bit itself will shift laterally and downwardly, the bit can be rotated in this newly orientated direction and conventional rotary drilling can continue in the direction established by jet deflection. If the jet deflected hole is not eroded to sufficient depth, the drill bit, when rotated, can revert back to the previous axis of the hole instead of deflecting as desired. Experience gained in the field has generally established that a deflected hole in the order of 3 to 5 feet of penetration depending upon the degree of consolidation of the formation is sufficient to prevent reversion of the drill back to the previous axis of the borehole.

Conventional roller cone cutter type drilling bits generally referred to as roller bits or rock bits are frequently utilized for drilling in consolidated formations. Roller bits are generally provided with three jet orifices or apertures communicating with the drill string which direct jets of drilling fluid against the bottom of the well bore immediately adjacent the cutters to wash away eroded formation particles and to provide the drilling bit with proper cooling and lubrication. The three apertures direct drilling fluid in evenly distributed manner within the borehole and therefore will not cause deflection of the well bore if allowed to erode the same without rotation of the bit.

Jet deflection bits may be of generally the same construction as conventional bits but are usually provided with a jet deflection orifice or aperture that is substantially larger than the remaining apertures of the drill bit. For example, the conventional lubrication, cleaning and cooling orifices may be in the order of $\frac{1}{4}$ inch in diameter while the directional jet orifice may be in the order of $\frac{3}{4}$ inch diameter. This design allows a substantially larger volume of drilling fluid to emerge from the directional jet orifice and results in uneven or selective erosion of the well bore along that portion thereof intended to be deflected. Inefficiency of jet deflection is frequently extremely pronounced at extreme depths and it is believed that such inefficiency results due to the extremely high hydrostatic pressure created by the heavy drilling fluid and due to attenuation of jet nozzle velocity in the region of drilling fluid high pressure intensity, in the distance the jet stream must travel from

the nozzle face to the bottom of the well bore. Well bore erosion from single jet deflection drills is frequently substantially attenuated or damped because the jet deflection nozzle is located a substantial distance (usually in the order of 6 inches) above the bottom of the well bore and effectiveness of the jet stream to erode the bottom of the hole is substantially reduced.

A method of overcoming the problem of jet attenuation or damping has resulted in the provision of a modified jet deflection bit having the usual cleaning, cooling and lubrication passages and incorporating, in place of the conventional third roller, an extended deflection jet that extends downwardly near the hole bottom adjacent one side thereof. This jet is substantially larger than the remaining three cleaning, cooling and lubrication jets thereby resulting in the creation of a substantially larger jet flow in the direction of intended hole deflection. The extended jet orifice structure places the deflection orifice much closer to the bottom of the well bore than conventional jet deflection devices and overcomes to a degree the problem of jet attenuation. While jet attenuation is substantially reduced by the extended jet nozzle type deflection bit, it is obvious that the rotary drilling capability of the bit is also substantially reduced by replacement of the usual third roller cutter with the offset extended jet nozzle.

With increasing borehole depth, however, the amount of time necessary to perform a conventional jet deflection operation and accordingly the cost thereof is substantially affected by consolidation of the formation. For example, it has been found at depths greater than 1500 feet the time required for sufficient jet deflection to achieve a deflected borehole will increase directly with the depth involved. For depths of approximately 12,000 feet and greater, it has been found to be virtually impossible to economically utilize jet deflection with the conventional equipment and techniques presently available. It is now believed that the primary cause of the increased drilling expense associated with the increased borehole depth in directional drilling, using mud as the drilling fluid, is the effect of hydrostatic pressure of the drilling fluid acting against the formation being drilled. 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 damped or attenuated in the short interval of distance (6 to 8 inches) from the nozzle to the face of the formation being eroded as indicated above. At substantial well depths, the jetting fluid is emitted into a fluid environment of extremely high pressure simply because hydrostatic pressure is a direct function of the depth of the fluid environment. At shallow borehole depths, hydrostatic pressure will have an insignificant effect from the standpoint of attenuation. The high pressure fluid environment of greater borehole depth reduces or substantially attenuates the velocity of the jetted drilling fluid and therefore substantially reduces the effectiveness of the jetting stream before it strikes the formation being eroded.

It is therefore a primary object of the present invention to provide novel jet deflection apparatus capable of achieving sufficient controlled jet flow that attenuation will not interfere to a substantial degree with controlled deflective erosion of the well bore.

It is a further object of the present invention to provide novel jet deflection apparatus capable of converging jets of flowing pressurized drill fluid to cause elective impingement of such jets upon a lateral portion of the well bore to result in efficient erosion of the same.

It is an even further object of the present invention to provide novel jet deflection apparatus that is capable of achieving efficient jet deflection at substantial well depths without decreasing the rotary drilling effectiveness of a roller bit structure in which such apparatus may be incorporated.

Among the several objects of the present invention is noted the contemplation of novel jet deflection apparatus providing an efficient jet nozzle erosional pattern for exceptional efficient jet erosion in dense formations.

It is also an object of the present invention to provide novel jet deflection apparatus providing the capability of focusing all of the nozzles thereof at a single point and retaining a capability of efficient rotary drilling subsequent to completion of a jet deflection operation.

It is another important feature of the present invention to provide a novel jet deflecting bit structure that is simple in nature, reliable in use and low in cost.

Other improvements of the function and of facility of design will be apparent from the following description taken in conjunction with the drawings in which:

FIG. 1 is a diagrammatic illustration of a preferred embodiment of a drilling apparatus utilizing a jet deflection bit constructed in accordance with the principles of the present invention.

FIG. 2 is a sectional view of a jet deflection bit constructed in accordance with the present invention and illustrating branch fluid passages being connected with a central fluid passage defined in the structure thereof.

FIG. 3 is a bottom view of a jet deflection drilling bit constructed according to the principles of the present invention.

FIG. 4 is an elevational view of a jet deflection bit constructed to carry out the present invention and illustrating focusing of the deflection jets during operation thereof.

FIG. 5 is an elevational view of a jet deflection bit structure defining a modified embodiment of the present invention and illustrating focusing of all of the nozzles during the deflection operation.

FIG. 6 is a diagrammatic plan view illustrating shifting of a deflected bore from the path defined by the original well bore.

BRIEF DESCRIPTION OF THE INVENTION

The present invention accomplishes efficient jet deflection by directing a plurality of deflection nozzles in such manner as to produce converging jets of high velocity drilling fluid that impinge in deviated manner upon the wall structure of the stratum defined by the well bore. A rotary roller bit structure incorporating the present invention may be provided with enlarged jet deflection nozzles, as compared to the cleaning and lubricating nozzle or nozzles thereof, which are connected through appropriately sized passages to a central flow passage that is in turn communicated with a drill string through which pressurized drilling fluid passes during the drilling operation. The jet deflection nozzles are oriented to converge jets of flowing drilling fluid laterally and downwardly of the bit structure in order to impinge upon the adjacent formation during

the jet deflection operation. The impinging action created by the converging jets of drilling fluid function effectively to prevent substantial attenuation of the jetting fluid and thereby result in efficient fluid erosion.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings for a more detailed understanding of the present invention, in FIG. 1 there is illustrated generally at 10 a conventional drilling rig structure including a drilling platform 12 that supports the entire drilling apparatus. A borehole 14 is formed in the earth by rotation of a bit 16 connected to the lower extremity of a drill string 18 having a plurality of pipe joints 20 threadedly secured one to the other in conventional manner. The connection between the rotary bit 16 and the drill string 18 may be accomplished by direct threaded connection of the bit with the lowermost section of drill stem as shown or, if desired, may be accomplished by any one of a number of commercially available connection devices, such as drill collars, bumper subs and the like, without departing from the spirit or scope of the present invention. The drill string 18 extends through a casing 22 that is cemented into the upper portion of the formation to provide optimum sealing at the upper portion of the well bore and to provide for supporting hangers and the like from which production tubing is supported after completion of the well.

The drill string is connected at the upper extremity thereof to a kelly bar 24 of noncircular cross section, that extends in vertically movable but nonrotatable rotation through a rotary table 26 driven in any desirable manner to impart rotation to the drill string and to the drill bit 16 connected thereto. The upper extremity of the kelly bar 24 is rotatably fixed or secured in sealed manner to a swivel 28 that is in turn supported by the hook 30 of a traveling block by a connecting link 32. The Traveling block is connected by a cable that extends in conventional manner through a crown block secured to upper portion of the rig 10. For purposes of simplicity, neither the traveling block nor crown block is illustrated herewith, it being obvious to employ such structures in the drilling of well bores.

For the purpose of supplying pressurized drilling fluid, to the bit 16 during the drilling operation, a supply of drilling fluid, generally referred to as drilling mud, is maintained within a reservoir or slush pit 34 and is transported from the slush pit to a conduit 36 by one or more mud pumps 38. a flexible hose 40 is secured between the conduit 36 and the inlet pipe 42 of the swivel 28 thereby maintaining fluid communication between conduit 36 and the swivel as the kelly is raised and lowered. The drilling fluid follows a path designated by flow arrows through the swivel 28, kelly 24 and through the drill pipe 20 to the bit 16 where it exits from the bit through a plurality of orifices 44. The purpose of the drilling fluid is to wash drill cuttings from the vicinity of the rotary drill and to provide for cooling and lubricating the drill as it is rotated to form the well bore. Drilling fluid flows from the bit upwardly through the annulus 46, defined between the drill string and the well bore, and carries drill cuttings upwardly to a conduit 48 that conducts the drill fluid to a shale shaker 50 where the drill cuttings are removed by passing the drill fluid through one or more screening devices. Drill fluid exiting the shale shaker 50 flows through a conduit 52

back to slush pit 34 where fine particles of drill cuttings are allowed to settle out by gravity and where the drill fluid is further treated to prepare the same for recirculation through the drill string and bit. During the drilling operation, the rotary table 26 is driven and through its nonrotatable relation with kelly bar 24 induces rotation to the drill string 18 which in turn rotates the bit 16 with continuous circulation of drilling fluid from the mud pump 38 through the swivel, kelly and drill string to the drill bit with return of the drilling fluid to the slush pit through the shale shaker.

To carry out borehole deviation in a manner according to the present invention, a conventional rotary drilling bit is replaced with a bit constructed in accordance with the present invention and which conveniently may take the form of the bit illustrated generally at 16 in FIGS. 3 and 4 having a plurality of nozzles or orifices orientated to converge flowing jets of drilling fluid downwardly and outwardly to produce an eroded deflection well bore 54 which may be followed by the bit and drill string as the same are lowered for further rotary drilling operations.

In accordance with the present invention, a jet deflection operation may be carried out by placing, adjacent the formation to be drilled in deflected manner, a plurality of jets of pressurized drilling fluid that are directed to converge downwardly of the drill bit and outwardly with respect to the axis of the original borehole. A drill bit capable of achieving jet deflection in this manner may conveniently take the form illustrated in FIGS. 3 and 4 which illustrate a bit generally at 16 having a body member 60 provided with a threaded extremity 62 adapted for threaded engagement with the internal threads of a drill collar, drill stem or the like 64. As indicated above, the drill bit may also be supported by a bumper sub or by any one of a number of other commercially available devices for use in conjunction with a rotary drilling bit. A plurality of rollers or rotary cutters 66, 68 and 70 are rotatably secured to the lower extremity of the body 60 which rotary cutters engage the formation as the bit is rotated to cause cutting or chipping away of the formation.

The body 60 is provided with a central fluid passage 72 to conduct drilling fluid into the bit structure for distribution to a plurality of lateral fluid passages 74, 76 and 80. Each of the lateral passages may be provided with enlarged internally threaded apertures which receive externally threaded nozzles 82, 84 and 86 respectively therein. Of course, other nozzle structures including nozzles defined by bores in the body structure of the bit may be provided as desired.

As indicated above, jet deflection according to the present invention is accomplished by directing jets of pressurized drilling fluid in such a manner that the jets converge downwardly and outwardly with respect to the bit structure to cause deflective erosion of the well bore immediately below the drill bit. As illustrated in FIGS. 3 and 4, apparatus for such jet deflection may conveniently take the form of a pair of jet nozzles 82 and 84 that are substantially larger in dimension than the remaining cleaning and lubricating nozzle 86. Nozzles 82 and 84 being of larger dimension than the cleaning and lubricating nozzle will logically conduct a substantially larger volume of pressurized drilling fluid as compared with the cleaning and lubricating nozzle 86 thereby resulting in pronounced fluid erosion of a lateral portion of the well bore.

After the deflective borehole has been extended by jetting to such an extent that rotation of the drill bit will not cause the bit to return to the direction established by the original bore (usually 3 to 5 feet) the bit 16 will then be lowered into contact with the bottom of the deflective bore and then will be rotated in conventional manner to drill a substantially straight bore along the direction established by the deflected bore. As the bit is rotated, the converging jets of drilling fluid emerging from nozzles 82 and 84 will function along with the cleaning and lubricating nozzle 86 to circulate drilling fluid in evenly distributed manner only for lubricating and cleaning purposes. The jet deflection capability of drill bit 16 will not detract from the efficient drilling capability of the bit because proper cleaning, cooling and lubrication of the cone cutters will be effectively achieved.

With reference now to FIG. b, jet erosion of a well bore to achieve jet deflection in accordance with this invention is diagrammatically illustrated. The original well bore is shown in solid line at 90 while the deflected bore 92 is illustrated in broken lines with its center disposed at the wall of the original bore. Jet deflection nozzles 91 and 93 direct fluid in converging manner adjacent the bore 90 to erode the bore 92 while cleaning, cooling and lubricating nozzle 95 directs drilling fluid downwardly in conventional manner. Obviously as penetration of the eroded bore continues, the center of the eroded bore will have downwardly and outwardly in angular relation with the original bore. The focus nozzle directional bit of the present invention incorporates a more efficient jetting pattern by incorporating a plurality of orientated nozzles so positioned on the bit that the jet streams emerging will focus at a point a few inches ahead and laterally orientated with respect to the bit. The focusing point can be selectively orientated by altering the nozzle structure in such a manner as to achieve optimum erosion due to the impingement of a plurality of jet streams tending to erode the deflection bore from a plurality of points at the bottom of the well bore. The larger flow of drilling fluid emitting from the focused nozzles and direction of the jets of drill fluid toward a focused point effectively overcomes the problem of attenuation that frequently becomes prevalent when deflection is attempted at substantial depths.

After the jet deflection operation has been completed and the drill is rotated to achieve further rotary penetration along the newly defined deflected bore, it is found that the jet deflection characteristics of the present invention will not adversely affect rotary drilling operations. In the case of single angulated nozzle directional bits, it has been determined that the bit will be subjected to exceptional wear because two of the three rotary cutters will be insufficiently lubricated and cleaned because a major portion of the drilling fluid is concentrated at the deflection nozzle thereby allowing an insufficient flow of drilling fluid to the remaining cleaning and lubricating nozzles. It has been found that the converging jetting nozzles of the present invention creates sufficient fluid distribution at the bit to cooperate with the lubrication and cleaning nozzle 86 to sufficiently remove drill cuttings and to achieve effective cooling and lubrication. The bit, therefore, will not be subjected to exceptional wear after a rotary drilling operation is commenced subsequent to a jet deflection operation.

With reference now to FIG. 5 of the drawings, a modified embodiment of the present invention is illustrated which comprises a bit illustrated generally at 96 having a body structure 98 adapted to be threadably secured to an internally threaded drill stem, collar or drill sub 100 in conventional manner. A plurality of rotary cutter cones, one being illustrated at 102, are rotatably carried by the body 98 for cutting away the formation as the bit is lowered within the well bore in similar manner as discussed above. A central fluid passage 106 is formed in the body 98 and is disposed in communication with a plurality of branch passages 108, 110 and 112 conducting drilling fluid from the central fluid passage to a plurality of jet deflection nozzles 114, 116 and 118 through which drilling fluid emerges adjacent the rotary cutters. Each of the nozzles is orientated to direct drilling fluid to converge downwardly and outwardly with respect to the bit thereby causing jet erosion of the formation to produce a deflective well bore in similar manner as the bit structure illustrated in FIG. 4. The branch passages 108, 110 and 112 and the associated nozzles 114, 116 and 118, if desired, may be of the same physical dimensions thereby concentrating a plurality equal jets of flowing drilling fluid at a single focus point to cause even more efficient jet deflection by eroding the formation at three or more points.

After the deflected bore has been jetted to a sufficient depth to prevent the bit from returning to the path of the original well bore, the bit 96 may be rotated to cause substantially straight drilling from the bore deflection downward along the path defined by the deflected bore. The nozzles 114, 116 and 118 will, during the rotary drilling operation, conduct evenly distributed jets of drilling fluid to all of the rotary cutter cones for effective cleaning, cooling and lubrication thereof. The jet deflection capability of bit 96 will not detract in any manner from the rotary drilling capability thereof.

If desired, the lateral passages 108, 110 and 112 and the associated jet deflection nozzles 114, 116 and 118 may be of different size if desired to produce optimum jet deflection erosion characteristics. It is only necessary, according to the present invention, that the converging jets of drilling fluid be capable of eroding the well bore from more than one point and also be capable of efficiently distributing drilling fluid during a subsequent rotary drilling operation.

In view of the foregoing, it is apparent that I have provided a novel focus nozzle jet deflection bit that effectively offsets the problem of jet attenuation by defining a more efficient jetting pattern that facilitates jet erosion of the formation at a plurality of points to achieve more efficient jet penetration. My invention therefore will achieve efficient jet deflection at substantial depths even when the formations are consolidated to the point that jet deflection would ordinarily be considered in an inefficient operation. My invention is also capable of accomplishing efficient jet deflection without sacrificing the rotary drilling effectiveness of the drilling bit. A jet deflection operation may be accomplished within the spirit and scope of the present application by utilizing at least two, and perhaps several converging jets of pressurized drilling fluid, orientated in any suitable manner, to achieve optimum jet deflection without sacrificing rotary drilling capability. Other variations of the invention will be apparent to those skilled in the art.

Accordingly, without burdening this description will all such possible variations, the foregoing description is to be understood as illustrative only and not as any limitation upon the scope of the invention as defined in the following claims.

What is claimed is:

1. A drill bit for use in borehole deviation by jet deflection comprising:

a body adapted for connection to a drill string;
means defining a central fluid passage in said body adapted to receive drilling fluid from the interior of the drill string;

a plurality of outlet orifices being disposed adjacent the lateral wall of a borehole into which said drill bit is to proceed;

at least two of said plurality of outlet orifices being substantially larger than the remaining ones of said outlet orifices, thereby allowing a substantially larger volume of drilling fluid to flow from said two outlet orifices than the remaining ones of said outlet orifice, said two orifices being oriented to direct fluid flowing therefrom to converge at a point below said bit and laterally of the vertical axis of said bore; and

a plurality of branch conduits placing said orifices in communication with said central fluid passage.

2. A drill bit as recited in claim 1;

said branch conduits communicating said two of said plurality of outlet orifices with said central fluid passage being of substantially larger dimension than the dimension of the remaining ones of said branch passages.

3. A method of forming a directionally deviated well bore in an earth formation comprising the steps of:

conducting a rotary drilling operation to define a well bore extending substantially straight to a depth in the formation where deviation of the well bore is desired;

bringing a plurality of jets of pressurized drilling fluid to bear upon said formation causing fluid erosion of the formation, at least two of said jets being substantially larger than the remainder of said jets and being oriented to converge at a point downwardly and outwardly with respect to said drilled bore to form an eroded bore inclined downwardly and outwardly from the path of the drilled bore;

lowering a rotary drilling bit into said eroded downwardly and outwardly inclining well bore; and rotating the rotary drilling bit and drilling a substantially straight deviated bore following the path defined by the eroded bore.

4. The method of claim 3:

wherein all of said plurality of jets of pressurized drilling fluid are oriented to converge at a point downwardly and outwardly with respect to said drilled bore.

5. Apparatus for producing a deviated well bore by jet erosion comprising:

means for conducting pressurized drilling fluid into a well bore that has been drilled to a depth where deviation thereof is desired;

means defining a plurality of jets of pressurized drilling fluid at least two of which are substantially larger than the remaining ones of said jets;

means converging said two of said plurality of jets of pressurized drilling fluid downwardly and outwardly with respect to the original well bore to cause jet erosion of the formation substantially along the resultant direction defined by said two converging jets of drilling fluid.

6. The apparatus recited in claim 5;

wherein said last mentioned means converges all of said plurality of jets of pressurized drilling fluid downwardly and outwardly with respect to said second mentioned means.

* * * * *

40

45

50

55

60

65

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,746,108

Dated July 17, 1973

Inventor(s) Gary E. Hall

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 7, line 18, "Fig. b" should read --Fig. 6--;
Col. 7, line 29, "have" should read --move--.

Signed and sealed this 27th day of November 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents