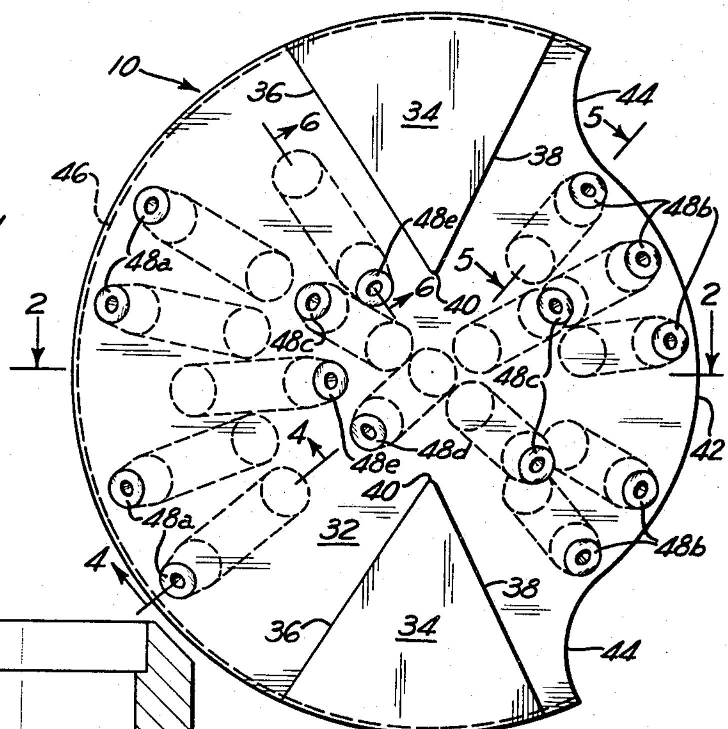
JET DRILLING BIT

Filed Oct. 19, 1966 3 Sheets-Sheet 1

Fig. 1



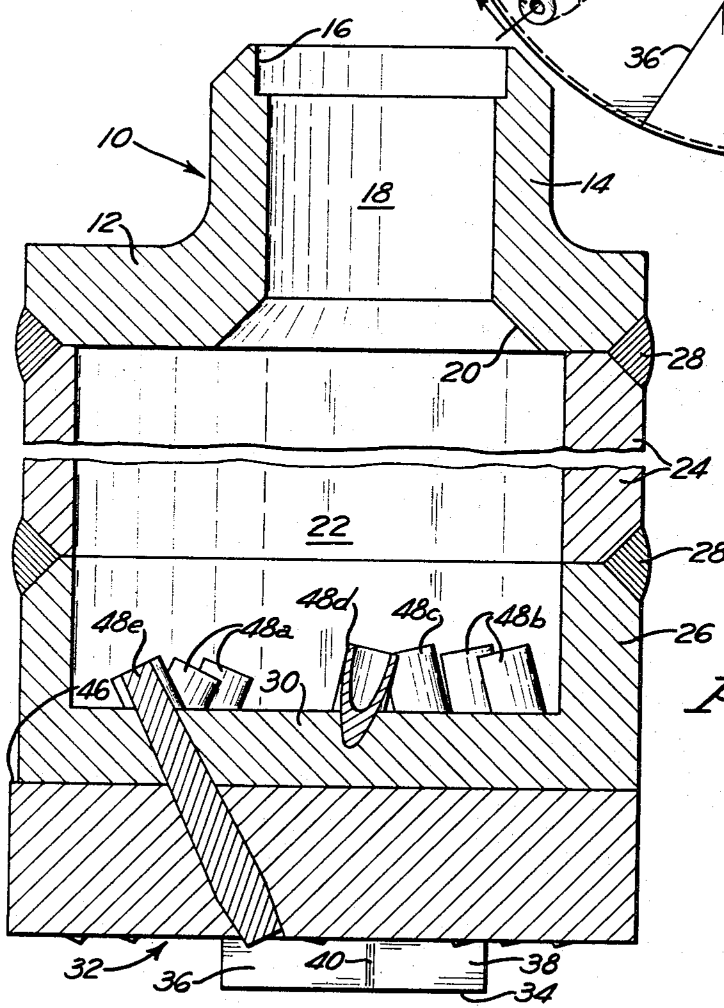


Fig. 2

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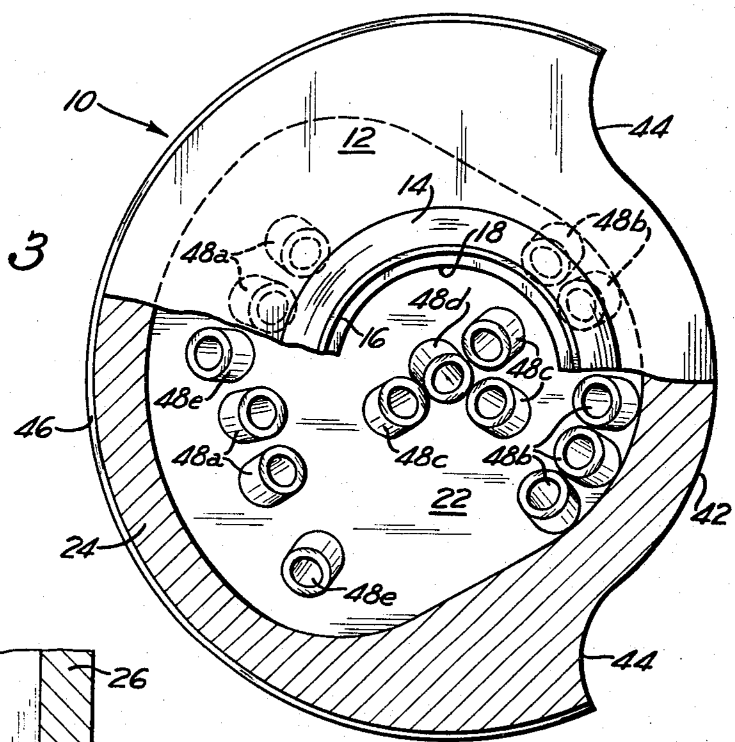
Fig. 3



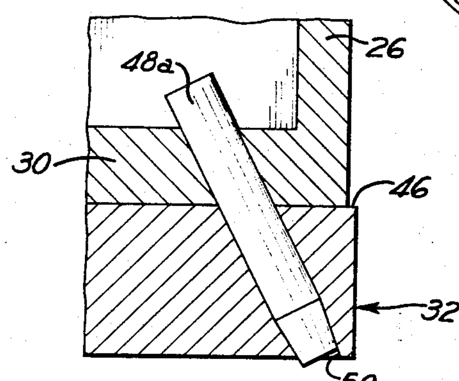


Fig. 4

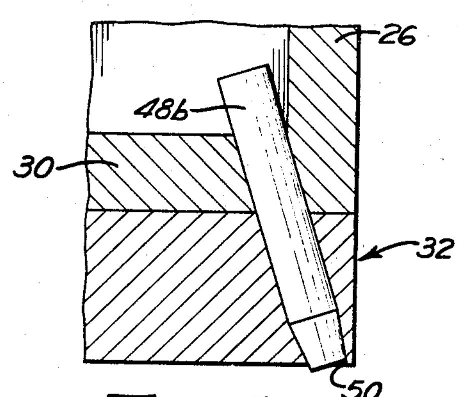


Fig. 5

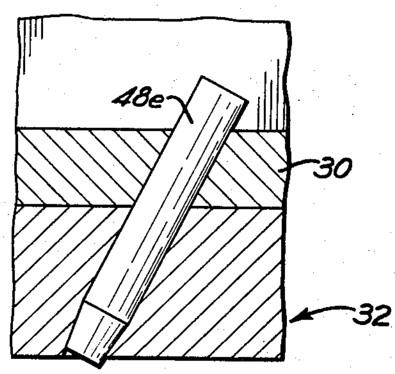


Fig. 6

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Dec. 3, 1968 J. L. PEKAREK 3,414,070

JET DRILLING BIT

Filed Oct. 19, 1966 3 Sheets-Sheet 3

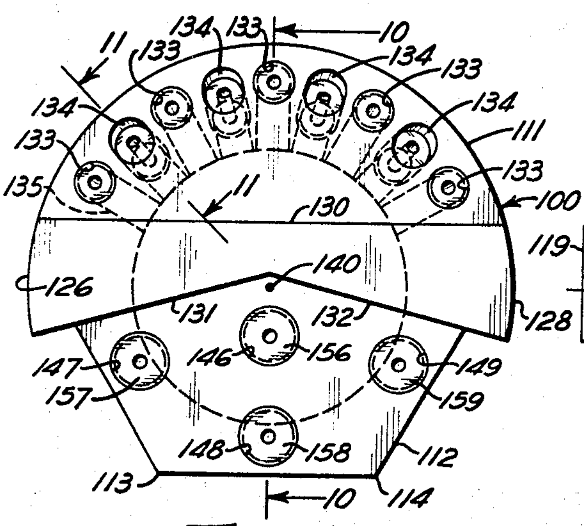

Fig. 7

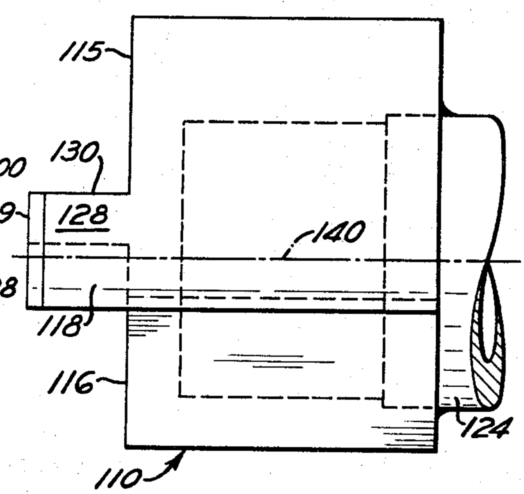

Fig. 8

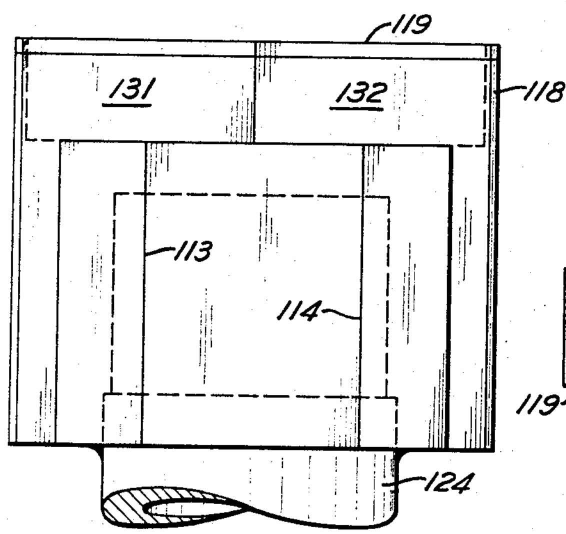

Fig. 9

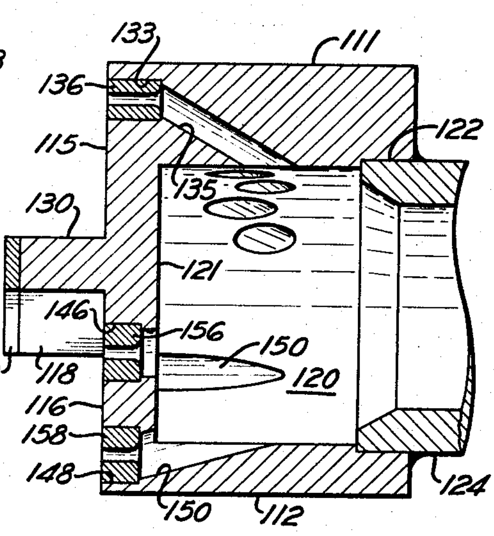

Fig. 10

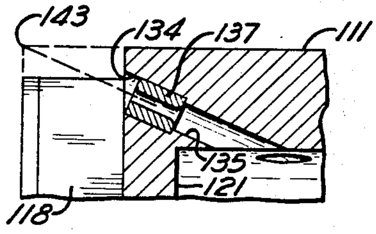

Fig. 11

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3,414,070

JET DRILLING BIT

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Continuation-in-part of abandoned application Ser. No. 311,088, Sept. 24, 1963. This application Oct. 19, 1966, Ser. No. 587,910
12 Claims. (Cl. 175—393)

ABSTRACT OF THE DISCLOSURE

A drill bit for use in hydraulic jet drilling in which a portion of the periphery of the drill bit is at a first radial distance from the center of rotation of the bit and a second portion of the periphery of the bit is at a lesser radial distance from the center of rotation of the bit. Nozzles extend downwardly through the bottom of the bit adjacent each of the portions of the periphery to allow flow of the abrasive-laden drilling fluid and cuttings from nozzles adjacent both portions directly into space surrounding the drill bit without crossing the flow from other nozzles.

This application is a continuation-in-part of copending application Ser. No. 311,088, filed Sept. 24, 1963, entitled "Method and Apparatus," by Robert J. Goodwin, Ernest A. Mori, Joseph L. Pekarek, Paul W. Schaub, and Robert E. Zinkham and now abandoned.

This invention relates to improved bits for use in drilling wells by means of high-velocity jets of abrasive-laden slurries. In the present invention, substantially all of the cutting of the formation is accomplished hydraulically by the use of these high-velocity jets of an abrasive-laden slurry.

Prior methods of drilling deep wells in hard formations comprise various different kinds of mechancial bits which are characterized by a physical removal of the formation by contact of cutting elements of the bit with the formation. One disadvantage of such prior mechanical methods is that a relatively heavy weight, on the order of 3,000 pounds and up per inch of bit diameter, is applied to the bit to assist in the mechanical cutting action. This weight is applied by the use of drill collars, which comprise sections of the drill pipe having large wall thicknesses.

In the jet drilling process utilizing the improved bits of the present invention, the weight applied is substantially less than that required for mechanical cutting bits, because the cutting is accomplished substantially entirely hydraulically by means of high-velocity jets of abrasive-laden slurry. The reduction in weight of the drill string resulting from the elimination of the heavy drill collars results in great economies for the jet drilling method over conventional mechanical drilling methods. These economies are realized because of the saving in cost of the drill collars, reduced power requirements to turn and lift the drill string, increased life of the bit, thus requiring fewer bit changes, and because the drilling rates when using the jet drilling process and the improved bits of the present invention are at least twice as fast as the drilling rates when using conventional bits. The reduced number of bit changes is itself an important advantage, in that the total amount of field time not spent in drilling is reduced, thus reducing the cost per well substantially.

Another important disadvantage of such prior mechanical methods is that they are very much slower in drilling the borehole than the jet drilling process utilizing the bits of the present invention. Speed in drilling is very important, because of the high cost of maintaining a drilling rig and crew in the field.

Certain conventional mechanical bits also incorporate nozzles, but these nozzles produce a stream of conventional drilling mud and not a high-velocity jet of abrasive-laden slurry. The purpose of these streams of mud is to clean the cuttings from the bottom of the borehole to thereby prevent their being further ground up by the cutters. These streams of mud also serve to wash the cutters. In fact, in conventional drilling, steps are taken to remove all particles from the stream, whereas in jet drilling, it is the abrasive particles in the stream which do the cutting. In very soft formations, these streams of mud will penetrate the formation to a certain extent, but their primary purpose remains aiding the mechanical cutting action and not replacing the mechanical cutting action.

The jet bit embodying the invention comprises an elongated hollow bit body which is closed at its lower end. A plurality of nozzles extend through the bottom of the bit, with their outlet faces substantially in the plane of the bottom surface of the bit. The jet bits embodying the invention have a cross-sectional shape which comprises two segments of two different extents outwardly towards the borehole wall. The space around the smaller segment out to the radius of the larger segment will be called the relief area hereinafter. This relief area extends for the entire axial length of the bit. The outlets of the nozzle positioned on the side of the bit adjacent the relief area are at the bit side wall, and yet at a substantial distance from the borehole wall. The nozzles on the opposite side of the bit are also positioned at the side wall of the bit, but are at a larger radial distance from the center of rotation of the bit, and since they are inclined outwardly with respect to the bit axis, will cut a groove of a diameter larger than the bit diameter. These nozzles at the two bit sidewalls are thus positioned so that their flow streams out of the borehole do not interfere with each other.

The single relatively large relief area imports additional important advantages to bits embodying the invention, including the provision of a relatively large, smooth, and completely un-obstructed space within the bit for the flow of abrasive-laden slurry to the entrances of the nozzles. The provision of un-obstructed access to the nozzles without any interference from any re-entrant portions of the bit yields the advantage of uniform flow through all of the nozzles which results in more uniform nozzle wear. The single relatively large relief area permits passage of larger cuttings, causes less back pressure under the bit, and allows the bit to run more smoothly by tending to prevent the wedging or cuttings between the bit and the borehole.

In the accompanying drawing forming a part of this disclosure:

FIG. 1 is a bottom plan view of a first embodiment of a bit embodying the invention; FIG. 2 is a longitudinal, cross-sectional view taken on line **2**—**2** of FIG. 1; FIG. 3 is a top plan view partially in cross-section showing the internal, un-obstructed access space for flow to the nozzle entrances; FIGS. 4, 5 and 6 are cross-sectional views taken on lines **4**—**4**, **5**—**5**, and **6**—**6** respectively of FIG. 1 and show the positioning of the nozzles in this bit; FIG. 7 is a view similar to FIG. 1 of a second embodiment; FIG. 8 is a side elevational view looking from the right side of FIG. 7; FIG. 9 is a front elevational view looking from the lower side of FIG. 7; and FIGS. 10 and 11 are cross-sectional views taken on lines **10**—**10** and **11**—**11** respectively of FIG. 7, and show the positioning of the nozzles in this bit.

Referring now in detail to the drawing, **10** designates a first embodiment of a bit embodying the invention. Bit **10** comprises a top section **12** comprising a neck portion

14 provided with any suitable means 16, such as a welding guide or a threaded section, to attach the bit to the drill string. A longitudinal opening 18 extends through neck 14 and top portion 12, and is provided with an outwardly flaring bottom opening 20 which communicates with a main chamber 22 in the remainder of the body of the bit.

Fixed to the lower end of top portion 12 is the upper end of a central bit portion 24. Fixed to the lower end of central bit portion 24 is the upper end of lower bit portion 26. The joints between portions 12 and 24, and portions 24 and 26, may be made by any suitable means, such as welds 28. Bit portions 24 and 26 could be fabricated in one piece rather than in sections; if desired.

Lower bit portion 26 comprises a flat bottom wall 30, which serves to close off the bottom of the bit. Joined to the bottom, outer surface of bottom wall 30 is a backsplash plate 32, of hard abrasion resistant material, such as sintered tungsten carbide. Backsplash plate 32 should have a hardness of at least 85 on the Rockwell A scale, and should have a substantial thickness, at least 1 inch, and preferably about 1½ to about 2 inches to prevent erosion of the bottom and side walls of the bit by abrasive particles rebounding off of the borehole walls. Abrasives and cuttings carried upwardly by the circulating slurry do not cause serious erosion, and hence making plate 32 of a thickness more than about 2 inches does not result in any increased advantage which would justify the additional cost. Backsplash plate 32 may be secured to bottom wall 30 by any suitable means such as bolts or a suitable abrasion resistant silver solder.

Means are provided to maintain a predetermined standoff between the outlet faces of the nozzles and the bottom of the borehole, and to break off the intervening ridges formed between the grooves cut by the nozzles as the drill bit rotates. To this end a pair of stand-off bars 34 are provided on the lower surface of backsplash plate 32. Stand-off bars 34 have a thickness in the axial direction of about ¼ inch to about 1¼ inches, and preferably a thickness in the range of about ⅜ inch to about 1 inch. At smaller thicknesses of the stand-off bars 34, erosion of the bit is severe because of backsplash from the bottom of the hole, and at thicknesses greater than the above, cutting rate is reduced because the nozzle exits are too far from the borehole bottom. Standoff bars 34 are of substantially circular sector or "pie-like" configuration in plan view, to provide increasing mass at increasing radial distances from the center of rotation. Referring to FIG. 2, stand-off bars 34 are similar and symmetrically disposed, each having a radial extent of about 60°, but are positioned so that the left edges 36 (in FIG. 1), define a smaller angle between them than the angle between the right edges 38, to provide increased space, radially, for the relief area, as will appear more clearly below. The apices 40 of bars 34 are in spaced relation to each other to prevent interference with the high-velocity streams issuing from the nozzles, as will appear more clearly below. Bars 34 may be secured to the backsplash plate in any suitable manner, but are preferably formed integrally therewith.

Between the right surfaces 38 of the stand-off bars 34, bit 10 is formed with a relief area defined by a circumferential edge 42 defined by a radius smaller than the radius defining the remainder of the bit, and by a pair of fillets 44 which join the ends of edge 42 with the ends of the larger radius forming the remainder of the bit. The relief area defined by edge 42 and fillets 44 extends through the entire axial length of the bit including top section 12, center section 24, lower section 26 and backsplash plate 32. Backsplash plate 32 is flush with the sides of the bit in the relief area, but is provided with an overhang 46 throughout the remaining circumference of the bit. Overhang 46 serves to strengthen the backsplash plate in the vicinity of the outermost nozzles 48a, described below, to prevent the formation of a knife edge between the mounting hole for the nozzle and the outer surface of the backsplash plate, which edge could be easily broken off by contact against the borehole wall. No thickened portion or overhang is provided around radius 42 or fillets 44 since these portions are spaced from and do not come in contact with the borehole wall, and therefore a thin edge in the relief area is not objectionable. The relief area is of relatively small extent radially, and of relatively large extent circumferentially, for example, in a 7⅛ inch bit, the relief area measures one inch radially, and 130° circumferentially, which is approximately 7 sq. inches for the relief area. The relief area is about 17% of the total cross-sectional area of the bit including the relief area.

The provision of this radially small but circumferentially wide relief area permits the large unobstructed main chamber 22 shown in FIG. 3, which yields the advantage that the flow paths of the abrasive-laden slurry to each of the nozzles are un-obstructed and uniform to cause uniform nozzle life. This radially small but circumferentially large relief area reduces wedging of particles between the bit and the borehole while at the same time permitting a faster flow of larger cuttings up out of the hole.

Extending through suitably formed openings in bottom wall 30 and backsplash plate 32 are a plurality of nozzles 48. It will of course be understood that different size bits will carry varying number of nozzles, but for the sake of example, bit 10 shown comprises a total of fifteen nozzles 48, and represents a 7⅛ inch bit.

Each nozzle 48 comprises an elongated cylindrical member formed with a longitudinal axial opening, not shown, to produce a high-velocity jet of the abrasive-laden slurry. The inlet end of each nozzle 48 is positioned within main chamber 22 and above the inside or top surface of bottom wall 30 so as to reduce plugging of the nozzles with abrasive. Means are provided to hold each nozzle in the opening formed in the backsplash plate and the bottom wall, and these means may comprise a tapered opening 50, FIGS. 4 and 5, cooperating with a suitable mating taper on the outlet end of the nozzle, and additionally may comprise a suitable sealant such as epoxy cement, silver solder or the like, not shown. The nozzles are fabricated of a hard, abrasion resistant material such as sintered tungsten carbide.

All the nozzles are the same, but in the following description a letter is added to reference numeral 48 to indicate those nozzles having their outlet faces at the same radial distance from the center of rotation of the bit and inclined at the same angle to the longitudinal axis of the bit.

Bit 10 comprises four nozzles 48a positioned with their outlet faces close to the outside circumference of the bit on the side thereof opposite the arcuate relief area. Nozzles 48a are positioned at a substantial angle, on the order of 27°, to the longitudinal axis of the bit to cut a groove in the borehole bottom having a radius about ¼ to ½ inch larger than the bit.

Opposite nozzle 48a bit 10 carries five nozzles 48b positioned closely adjacent to and spaced along radius 42. As shown in FIG. 5, nozzles 48b are positioned at a smaller angle with respect to the longitudinal axis of the bit, on the order of 17°, to cut a groove spaced inwardly of the groove cut by nozzles 48a. The ridge formed between the grooves cut by nozzles 48a and 48b will be in the path of stand-off bars 34.

Bit 10 also carries three nozzles 48c, two of which are positioned inwardly of nozzles 48b, and one of which is positioned inwardly of nozzles 48a. Nozzles 48c will cut a groove spaced inwardly of the groove cut by nozzles 48b, and will produce a ridge therebetween in the path of the stand-off bars. Nozzles 48c, as well as nozzle 48d, are inclined at an angle substantially equal to the angle at which nozzles 48b are inclined, as shown in FIG. 5.

Single nozzle **48***d* is positioned with its outlet still closer to the center of rotation of the bit to cut a groove spaced inwardly from the groove cut by nozzles **48***c*. The ridge produced between nozzles **48***c* and nozzle **48***d* is in the path of the stand-off bars and will be removed by them.

The two remaining nozzles **48***e* are positioned to direct their streams toward the axis of rotation of the bit rather than outwardly from said axis as are the other nozzles, and hence will cut a conical hole rather than a groove. Nozzles **48***e* are positioned at a relatively steep angle, on the order of 27° to the axis of the bit, and the two nozzles **48***e* are positioned with their longitudinal axes spread apart at about an angle of 60° along the circumference of the bit, see FIG. 1. The diameter of the conical hole cut by nozzles **48***e* will be slightly larger than the space between the apices **40** of the stand-off bars **35**. Only one nozzle **48***e* is required to remove the material between the stand-off bars. The second nozzle is a safety to prevent the necessity of a round trip of the bit for cleaning should one nozzle **48***e* become plugged.

All the nozzles in bit **10** are inclined, as described above. Thus, all the ridges formed have a face inclined from the centerline of the borehole. Such inclined ridges are desirable because they are more easily broken by the standoff bars than are vertical ridges.

In operation, bit **10** is caused to rotate in the borehole by means of the drill string attached to attaching means **16**. Bit **10** is rotated at speeds between 20 and 100 r.p.m. with a speed of 50 r.p.m. being preferred. Drilling slurry is supplied under pressure through the drill string into chamber **22**, and from there the slurry is uniformly fed through all of the nozzles, as described above.

An important advantage obtainable with the single large relief area of the invention is that the bulk of the slurry can flow out of the borehole without crossing the flow path from any other nozzle. In bit **10**, the four nozzles **48***a* and the five nozzles **48***b* account for 60% of the slurry, and the flows from these two groups of nozzles do not interfere wtih each other. That is, the flows from nozzles **48***a* will flow outwardly and up the annulus between that side of the bit and the borehole, and the flows from nozzles **48***b* will flow outwardly or directly upwardly to get to the relief area.

Another advantage from the single large relief area, particularly in bit **10**, is that the smooth external cross-sectional shape reduces the possibility of abrasive particles and/or cuttings jamming between the bit and the borehole wall, and therefore permits the bit to run smoothly. This smooth external cross-sectional shape causes the bit to run centered in the hole because more than 180° of the bit cross-section is of the largest diameter of the bit. Also, the single large relief area permits a faster flow of cuttings upwardly, permits passage of larger cuttings to further speed drilling rate, and prevents pressure buildup under the bit if the borehole should be tight.

Bit **100** is a $4\frac{11}{16}$ inch bit, and the relief area is ap- **110** comprising a substantially cylindrical sector **111** and an adjoining prismatic portion **112** whose outer corners **113** and **114** lie on a radius smaller than the radius defining sector **111**. Thus, all points on portion **112** are closer to the center of rotation of bit **100** than any point on sector **111**, to form a single large relief area between portion **112** and the borehole side wall. The bottom surface **115** of the cylindircal sector **111** and the bottom surface **116** of portion **112** are substantially coplanar to form a flat-ended bit body.

Bit **100** is a $4\frac{11}{16}$ inch bit, and the relief area is approximately 17% of the total cross-sectional area of the bit including the relief area, as in bit **10**.

A tongue **118** extends downwardly from the bottom surface **115** and extends completely transversely across the end of the body portion **110**. Side faces **126** and **128** of tongue **118** are curved to form extensions of the cylindrical outer surface of body portion **111**. The length of tongue **118** in the axial direction determines the stand-off of the nozzles from the bottom of the hole being drilled. The bottom surface of tongue **118** is provided with a hard facing **119**, such as sintered tungsten carbide, to resist wear.

The inner portion of the body **110** is formed with a relatively large chamber **120** which is provided with a substantially flat inner bottom surface **121**. The upper end of chamber **120** may be enlarged in diameter slightly as shown at **122**, and after fabrication the bit is fastened to a conventional drill pipe or drill collar **124** by any suitable means such as welding.

Bottom **115** of segment **111** is formed with a plurality of holes **133** and **134**. Holes **133** are drilled perpendicularly to the surface **115**, i.e. parallel to the axis of the bit. Alternate holes **134** are drilled at an angle, as or example 25°, outwardly to the axis of the bit. All of the holes **133** and **134** intersect the end surface **115** at substantially the same radius, see FIG. 7.

While a place for nine nozzles in segment **111** is shown in FIG. 7, this is by way of illustration only and the number will vary depending on the size of the bit. Furthermore, the holes **133** may be located on the same or a different radius as the radius on which holes **134** are located. The inner end of each hole **133** and **134** meets with a communicating hole **135**. The holes **135** are drilled from the inside of the body of the bit at an appropriate angle to meet the respective holes **133** and **134**. Drilling slurry pumped down the inside of the drill string into chamber **120** thus flows uniformly through the holes **135** and out nozzles mounted in holes **133** and **134**, as well as other nozzles described below.

In each hole **133** and **134** there is a nozzle **136** and **137**, respectively, of hard wear-resistant material such as tungsten carbide. The nozzles are held in place by any suitable means, such as silver solder.

Bottom **116** of portion **112** is formed with holes **146**, **147**, **148**, and **149** that communicate with chamber **120** via communicating passages **150**. Holes **146**, **147**, **148**, and **149** are substantially parallel to the axis of the bit, and each is provided with a nozzle **156**, **157**, **158**, and **159** of hard wear-resistant material fastened by any suitable means such as silver solder.

The arrangement, number, and angular orientation of nozzles **136**, **137**, **156**, **157**, **158**, and **159** is such as to effect a uniform penetration rate over the entire borehole bottom. There is no overlap of the annular grooves cut by the bit, because a deeper groove cut in the overlap region would impair the drilling efficiency of the bit, and because a flow stream aimed at a ridge would be a waste of power since the ridges will be removed by the stand-off bars. Maximum penetration rate is obtained with nozzles arranged to cut with a substantially uniform downward penetration of all grooves and the central hole.

In bit **100**, nozzle **156** is located at the smallest radius from the rotation axis **140**. The penetration rate of this jet at this diameter under operating conditions will be known as well as the approximate width of the groove cut thereby. At substantially one groove width farther out from axis **140**, a second radius is provided with nozzles **157**, **158**, and **159**. Inasmuch as the radius is substantially three times as large as the operating radius of nozzle **156**, three nozzles **157**, **158**, and **159** are employed at this radius in order to attain the same penetration rate as nozzle **156**. A further groove-width step outward from the axis of rotation is a radius on which nozzles **136** are located. This radius is substantially five times the radius of nozzle **156**, and therefore five nozzles **136** are employed at this radius. Note that the radii are those on which the respective jets strike the bottom of the hole being drilled, hence nozzles **157** and **136** being parallel to the axis **140** are located on these respective radii.

It is apparent that structural considerations limit the maximum radius at which a nozzle can be mounted in the body of the bit **100**. Hence, in order to cut the outer circumference of the hole, the nozzles **137** are mounted at an outwardly directed angle. As indicated in FIG. 11, nozzles **137** are directed to the intersection **143** of the cylindrical surface of the cylindrical portion of the body of the bit and the lower end of tongue **118**. The jets issuing from nozzles **137** will have some thickness, and therefore the hole drilled by bit **100** will be larger than the cylindrical portion **111** of the bit. Hard facing **119** on the bottom of the tongue **118** serves to break off ridges that remain between grooves as well as to control the standoff of the nozzles

While the invention has been described in some detail above, it it to be understood that this detailed description is by way of example only, and the protection granted is to be limited only within the spirit of the invention and the scope of the following claims.

I claim:

1. A drill bit for drilling earth boreholes by means of a plurality of hydraulic jets of abrasive-laden slurry, said bit comprising a hollow body of substantially constant cross-sectional configuration throughout its length, said body being open at its upper end, means to connect said open upper end of said bit to the open lower end of a drill string for fluid communication therewith, bottom wall means closing the lower end of said body, a plurality of nozzles passing through said bottom wall means, said constant bit cross-sectional configuration comprising a first bit side wall portion and a second bit side wall portion, the ends of said first bit side wall portion being connected to the ends of said second bit side wall portion, respectively, along the length of said bit to form said hollow body, all points on the periphery of said first bit side wall portion being spaced further from the axis of rotation of said bit than any point on the periphery of said second bit side wall portion, whereby, all points on the periphery of said second bit side wall portion are spaced further from the side wall of the borehole formed by said bit than any point on said first bit side wall portion to form a relief area between the periphery of said second bit side wall portion and the borehole side wall for passage of cuttings and said abrasive-laden slurry therethrough, said plurality of nozzles comprising a first group of nozzles positioned along the periphery of said first bit side wall portion and a second group of nozzles positioned along the periphery of said second bit side wall portion, the nozzles of said first group of nozzles being inclined downwardly and outwardly with respect to the axis of rotation of the bit, whereby said first group of nozzles will cut an annular groove in the bottom of the borehole spaced outwardly from said first bit side wall portion.

2. The combination of claim **1**, the nozzles of said second group of nozzles being inclined downwardly and outwardly with respect to the axis of rotation of said bit at an angle smaller than the angle at which said nozzles of said first group of nozzles are inclined.

3. The combination of claim **1**, said bottom wall means comprising a backsplash plate of abrasion resistant material and a bottom member of said bit, means to attach said backsplash plate to the bottom surface of said bottom member of said bit, said plurality of nozzles being mounted with their outlet faces substantially flush with the bottom surface of said backsplash plate, and said backsplash plate comprising stand-off means adapted to position the outlet faces of all of said plurality of nozzles at a predetermined distance from the bottom of the borehole.

4. The combination of claim **1**, the periphery of said first bit side wall portion being defined by an arc of a circle, the major part of the periphery of said second bit side wall portion being defined by an arc of a circle having a radius smaller than the radius defining said first bit side wall portion, and the periphery of said first bit side

wall portion being of larger circumferential extent than the periphery of said second bit side wall portion.

5. The combination of claim **1**, the periphery of said first bit side wall portion being defined by a segment of a circle, the periphery of said second bit side wall portion being defined by a plurality of flat surfaces extending parallel to the axis of the bit, whereby said second bit side wall portion is of prismatic configuration, and the periphery of said first bit side wall portion defining a larger included angle between the ends thereof than the angle include between the ends of said second bit side wall portion.

6. The combination of claim **1**, the cross-sectional area of said relief area in said bit comprising about 17 percent of the total cross-sectional area of said bit including said relief area.

7. A drill bit for drilling earth boreholes by means of a plurality of hydraulic jets of abrasive-laden slurry, said bit comprising a hollow body open at its upper end, means to connect said open upper end of said body to the lower open end of a drill string for fluid communication between said drill string and said body, said bit comprising bottom wall means closing the lower end of said body, a plurality of nozzles passing through said bottom wall means, said plurality of nozzles comprising a first group of nozzles having their outlet faces spaced along a portion of a circle having its center at the axis of rotation of said bit and a second group of nozzles spaced along a portion of a second circle concentric to said first circle and having a radius smaller than that of said first circle, the second group of nozzles being located at a position azimuthally displaced from the first group of nozzles, the radial distance from the center of rotation of the drill bit to that portion of the circumference adjacent the second group of nozzles being less than the radial distance from the center of rotation to that portion of the circumference of the drill bit adjacent the first group of nozzles, said nozzles having their outlets substantially flush with the lower surface of the bottom wall means, abrasion-resistant standoff bars extending downwardly from the lower surface of the bottom wall means, and said nozzles of said first group of nozzles being inclined downwardly and outwardly with respect to the axis of rotation of said bit.

8. The combination of claim **7**, said plurality of nozzles further comprising a pair of nozzles inclined downwardly and inwardly with respect to the axis of rotation of said bit and adapted to cut a hole in the center of the borehole bottom.

9. The combination of claim **7**, said second group of nozzles being inclined downwardly and outwardly with respect to the axis of rotation of said bit, and said first group of nozzles being inclined at an angle larger than the angle at which the nozzles of said second group of nozzles are inclined.

10. The combination of claim **7**, the nozzles of said second group of nozzles being parallel to the axis of rotation of said bit.

11. A drill bit for drilling earth boreholes by means of a plurality of hydraulic jets of abrasive-laden slurry, said bit comprising a hollow body of substantially constant cross-sectional configuration throughout its length, said body being open at its upper end, means to connect said open upper end of said bit to the open lower end of a drill string for fluid communication therewith, bottom wall means closing the lower end of said body, a plurality of nozzles passing through said bottom wall means, said constant bit cross-sectional configuration comprising a first bit side wall portion and a second bit side wall portion, the ends of said first bit side wall portion being connected to the ends of said second bit side wall portion, respectively, along the length of said bit to form said hollow body, all points on the periphery of said first bit side wall portion being spaced further from the axis of rotation of said bit than any point on the periphery of said second bit side wall portion, whereby all points on the periphery of said second bit side wall portion are spaced further from the side wall of the borehole formed by said bit than any point on said first bit side wall portion to form a relief area between the periphery of said second bit side wall portion and the borehole side wall for passage of cuttings and said abrasive-laden slurry therethrough, said bottom wall means comprising a backsplash plate of abrasion-resistant material and a bottom member of said bit, means to attach said backsplash plate to the bottom surface of said bottom member of said bit, said plurality of nozzles being mounted with their outlet faces substantially flush with the bottom surface of said backsplash plate, and said backsplash plate comprising stand-off means adapted to position the outlet faces of all of said plurality of nozzles at a predetermined distance from the bottom of the borehole.

12. The combination of claim **11**, said plurality of nozzles further comprising a pair of nozzles inclined downwardly and inwardly with respect to the axis of rotation of said bit and adapted to cut a hole in the borehole bottom having a diameter at least equal to the space between said stand-off means.

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