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(54) IMPROVEMENTS IN BORE HOLE DRILLS

(71) We, CHRISTENSEN INC., a corporation organised and existing under the laws of the State of Utah, United States of America of 1937 South 300 West, Salt Lake City, Utah 84115, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to bore hole drills or bits, or similar cutter heads.

As is well known in this art, the drilling fluid which is introduced through passageways in the bit is designed to cool the bit, wash the cutting elements so that they present a clean cutting face, move the cuttings to the gage of the bit and lift them up the annulus between the drill string and the wall of the hole.

In order that the drilling fluid have this function, it must have a desirably high mass velocity through the drill bit nozzles without requiring an undesirable high back pressure.

These various requirements have been particularly difficult to meet where the bit is destined for operation in relatively soft formations where clogging of the bit is appreciable. It is also a problem in harder formations.

The present invention provides a bit for drilling wells or bore holes comprising a central bore and a face formed about said bore, fluid channels extending from adjacent the centre of the bit to the gage of said bit and separating said face into blades, cutting elements positioned in the leading edge of said blades, a plurality of passageways positioned in said face and having openings for discharging fluid into said fluid channels, arranged in a longitudinal array in each of said fluid channels and positioned adjacent the leading edges of said blades, and said cutting elements being preformed shaped cutting elements positioned in said face at leading ends of said blades with a portion of the cutting face of the cutting element exposed and the remainder of said cutting element mounted in said face.

Preferably also, the bit includes spaced ribs positioned in said blades and extending across said blades, said openings in each fluid channel being positioned adjacent said cutting elements.

Conveniently, the cutting elements are positioned in slots formed in the face of the bit at the leading ends of said ribs.

Additional cutting elements may be provided positioned in the central portion of the bit and adjacent the gage of the bit.

The arrangement of the openings ensures that the emitted fluid jets sweep across the array of cutters and on rotation cover the entire surface of the cut.

The cutting elements are positioned on the face of the bit in spaced longitudinal arrays about the face of the bit from adjacent the centre of the face to adjacent the gage of the bit with the cutting faces of the cutting elements in the same angular direction as the rotation of the bit. The cutting elements are arranged in each array in close relation so that on rotation of the bit the cutting elements traverse substantially the entire face of the bore hole end surface to be cut by the bit.

In use of a bit in accordance with the present invention, drilling fluid is introduced through an axial bore of the bit and is discharged into the fluid channels through said openings.

The longitudinal arrays of cutters are separated by the fluid channels which may act also as junk slots.

The discharge of drilling fluid passing through the passageways into the junk slots scours the cutters and carries the cuttings to the gage of the bit and up the annulus.

The fluid discharge washes over the cutters and substantially the entire surface of

the formation being cut by the bit when the bit is rotated.

This is accomplished inasfar as the fluid discharge openings are in spiral array and in substantially longitudinal array in each fluid channel or junk slot. In each fluid channel or junk slot the array of discharge openings is more closely positioned to the edge of the junk slot where the cutters are positioned than to the trailing edge of the next preceding blade portion.

Specific embodiments of the present invention will now be described by way of example, and not by way of limitation, with reference to the accompanying drawings in which:-

Figure 1 shows a side view of a bit according to the invention;

Figure 2 is an end view of Figure 1;

Figure 3 is a side view of another embodiment of the invention;

Figure 4 is an end view of Figure 3;

Figure 5 is a schematic view of the arrangement of the nozzles;

Figure 6 is an enlarged and fragmentary sectional view on line 6-6 of Figure 2;

Figure 7 is a fragmentary section showing the position of one form of cutter in the face of the bit;

Figure 7a is a section taken on line 7*a*-7*a* of Figure 7;

Figure 8 is a view of another form of cutter positioned in the face of the bit;

Figure 8a is a section taken on line 8*a*-8*a* of Figure 8;

Figure 9 is another form of cutter positioned in the face of the bit; and

Figure 9a is a section taken on line 9*a*-9*a* of Figure 9.

With reference to the accompanying drawings, the bit shown in the Figures may be formed as described in our co-pending Applications Nos. 28257/77 (Serial No. 1556562) and 34675/77 (Serial No. 1557380) and our patents therein referred to. We may employ the preforms and other cutter elements as described in said applications and patents. Said applications and patents are herein incorporated by this reference.

Instead of employing the spirally arranged stepped configuration as shown in the above applications, we may employ ridges and arrange them spirally as described in said applications or concentrically with suitable arrangement of cutters as described herein.

As described in said referenced applications and patents, the bit may be formed by the techniques usually employed in producing diamond bits whereby a hollow tubular steel mandrel, suitably formed, is coated in a carbon mold with metal bonded hard material such as tungsten carbide. The carbon mold is of a configuration such as to give a bit of the desired form. These procedures are well known to those skilled in the art.

As shown in Figure 1 and 2, the face of the bit is formed on the closed end of a hollow steel mandrel 1. The face of the bit is formed with spaced ribs 2 which may extend either concentrically or spirally from adjacent the central portion of the bit 3 to adjacent the gage of the bit 4. In the forms of Figure 1 and 2, the ribs are in the form of steps 5 each composed of a land 6 and a rise 7. The central portion of the bit is formed by an end surface 8 (see Figure 6) and a conical surface 9 with its apex at 10 at the central axis 11 of the bit. The end surface 8 is substantially flat and substantially perpendicular to the central axis 11 and connects to the stepped portion 5 and to a conical portion 9 at the center of the bit.

The face of the bit is interrupted by fluid channels 12 which also act as junk slots and which separate the face of the bit into blades 13. At the leading edge 14 of the blades cutting elements 15 are positioned in longitudinal arrays so that the cutting elements in one longitudinal array overlap the cutting elements in the trailing blade so that the cutting elements will traverse the portion of the cut not covered by the cutting elements of a preceding leading blade, to assure that all portions of the surface to be cut are traversed by the cutting elements.

The junk slots in both the forms shown in Figure 1 and 3 extend from the center of the bit to the gage 4 of the bit. The junk slots at the gate connect with passageways 16 positioned in the stabilizer section 18 of the bit. Referring to Figures 1 and 2, the blades are formed with steps spaced from each other from a position at an area adjacent to the gage of the bit to the flat portion 8. The steps extend from the leading edge 14 of the blades to the trailing end 19 of the blades.

While the ribs may be arranged on concentric circles about the axis of the bit, we prefer to arrange them in a spiral formation starting adjacent the flat portion 8 of the bit to adjacent the gage of the bit as shown on Figures 1 and 2.

An alternative embodiment is shown in Figures 3 and 4. This bit is formed as is described for the form shown in Figures 1 and 2.

The difference is in the form of the ribs and the shape of the face. Instead of lands and rises, the ribs are in the form of arcuate ribs 102 of cross section which may be semi-circular or segmental. The face of the bit extending from the ribs is convex of an egg shaped form curving to a cuspidal central portion. The ribs extend from adjacent the gage to the central portion 136. All other parts are constructed similarly to those of Figures 1 and 2 and are similarly numbered.

The ribs, as in the case of steps of Figures 1 and 2, may be concentric circles or form a spiral which extends from adjacent the central portion of the face to adjacent the gage of the bit as shown on Figures 3 and 4.

The ribs are interrupted by junk slots which form wedge shaped blades similar to those shown in Figures 1 and 2 and which extend beyond the ribs into the central portion.

The ribs in the blades are spaced so as to form channels 20 which extend across the blades and interconnect the junk slots at the leading and trailing edges of the blades.

In the forms shown in Figures 1 and 3, the shaped cutting elements are mounted in the leading end of the ribs of the blades in sockets provided in the face of the bit at the appropriate location as described below.

The cutting elements to be more fully described below are positioned in sockets formed in the face of the bit at the leading edge of the blades. They are positioned in the leading edges of the ribs of the blades in longitudinal arrays. They are also held in like manner in equally spaced array in the flat portion 8 and the conical portion 9 as may be seen in Figures 1 and 2. As stated previously, the spacing of the cutting elements in each of the longitudinal arrays is such that together they traverse the entire surface of the cut when the bit is rotated. The cutting elements are each of suitable shape and size to accomplish this purpose as will be more fully described below.

The hydraulics, that is the distribution of the drilling fluid across the face of the bit, is provided by suitably arranged nozzles 21 positioned in passageways 22 in the face of the bit which passageways commence at the central bore 23 of the bit and terminate in the nozzle openings, in the junk slots.

The individual nozzles, see Figure 6, are positioned, in the form of Figures 1 and 3, in each junk slot with their openings in a longitudinal array but not necessarily a linear array with the nozzle openings in the array spaced more closely to the leading edge of the blades where the cutters are positioned than they are to the trailing edge of the next leading blade.

Due to the wedge shape of the blade which provides that the edges of the blade are not radially positioned, and the conical shape of the envelope of the face, see Figure 1 or the egg-shaped form of the face of Figure 3, the nozzle openings in each longitudinal array may be displaced from a linear array in order to provide for substantially equal distances between the axis of each of the nozzles and the adjacent leading edge of the adjacent blade in each nozzle opening array.

The nozzle openings are arranged in Figures 3 and 4 in longitudinal arrays which are separated from each other at substantially equi-angular distances. A preferred embodiment is as illustrated in Figure 5 where the longitudinal arrays of nozzle openings are as shown separated by approximately 60° and the nozzle openings are positioned in longitudinal arrays extending from adjacent the center to adjacent the gage of the bit. The several nozzles are positioned in a spiral arrangement extending from adjacent the center of the bit to the gage of the bit as appears from Figure 5.

In the forms of Figures 1 and 3, the separation of the ribs from each other in each blade forms a communication between adjacent junk slots across the blades. The force of the fluid ejected from the nozzles and the rotation of the bit will cause fluid to wash across the face of the blades between the ribs and over the ribs to remove detritus which forms between the ribs.

The purpose of this arrangement as described above is to cause the several streams ejected through the nozzles in each array to wash over the cutters in the adjacent cutter array and to impinge on and cover substantially the entire surface of the area to be cut on rotation of the bit. The arrangement also provides space in the junk slots for a returning stream of drilling fluid carrying the cuttings. Room is thus provided for the return stream along the junk slot in the face of the bit and up the water passages 16 in the stabilizer.

The cutters referred to above may be natural abrasives such as diamonds including black diamonds known as carbonados.

Instead, we may use shaped ceramic bodies such as boron nitride, silicon carbide, titanium carbide, tungsten carbide or alumina.

We prefer, however, to employ a preform cutter formed under high pressure and temperatures known as Compax ("Compax" is a Registered Trade Mark) sold by General Electric Company. It is a shaped cutter of diamonds bonded by a suitable matrix material. It is understood that this preform is manufactured by a process described in U. S. Patent 3,745,623.

The cutters which may be employed may be of various designs. Several are illustrated in Figures 7, 8 and 9.

In Figure 7, and 7*a*, the cutter is a parallelepiped 24 of lengths so that they will extend substantially the width of the lands and along substantially the entire surface of the flat and conical section, in suitably spaced sockets 25 formed in the face of the bit as shown in Figures 1 and 2.

In Figure 8 and 8*a*, the cutter 26 is a quarter sector of a right cylinder with the central external face 27 at the radius and a peripheral arc sitting in suitably formed sockets 28 in the face of the bit at the rise in

each step.

An alternative and preferred form of cutter is the cylindrical cutter 29 shown in Figure 9 and 9*a*. The diameter of the cylinder is substantially greater than the height of the cylinder. The cylindrical cutter fits into a socket 30 formed in the face of the bit at the leading edge of the ribs.

In each of the forms of cutters, the cutting faces are all oriented in the same angular direction in the direction of rotation of the bit and extend from the surface of the face of the bit as is illustrated in Figures 7, 8, and 9. In the form of Figures 1 and 2, the cutters in the conical and flat portion may be in the shape of the cutters as above and are of length and are spaced from each other so that on rotation of the bit the entire surface of the cut is traversed by the cutters.

We prefer to mount the cutters in sockets so that the thrust imposed by the cutting action upon the cutter is transmitted to the body of the bit. As shown in Figure 3, 4, 9 and 9*a*, we prefer to mount the cutters in sockets so that about less than half, and prefeably about 20-40%, e.g. 30% of the exterior surface of the cutter is exposed and the cutter is backed by the body of the bit.

We also prefer to mount the cutter so that they have a backward rake for example, 15° as is illustrated in Figures 7*a*, 8*a* and 9*a*.

The use of shaped discrete cutting elements such as employed herein presents problems in assuring the presence of cutting elements at the center and at the gage of the bit. In the forms of Figures 1 and 3, the presence of the cutting elements at the center is provided by arranging the blades so that they extend to various radial distances from the center of the bit. (See Figures 2 and 4). The terminal ends of the ribs of Figure 2 and the terminal ends of the ribs of Figure 4 are arranged in a staggered formation to assure the presence of cutting elements to cover the entire surface of the cut. With reference to Figure 2, the spiral arrangement will be seen by reference to terminal end 31, which crosses the center, and then terminal ends 32, 33, 34, 35 and 36, and in Figure 4 with reference to terminal ends 131, 132, 133, 134, 135 and 136 taken in that order.

The provision of cutters in the blades extending to the terminal ends of the blades will ensure that the entire surface, including the central surface is traversed by cutters. If desired, the area at the center and between the terminal ends of the cutters of Figure 2 may be supplemented by including diamonds at the central portion. These may be positioned during the casting of the bit in the conventional manner.

In the form of Figures 3 and 4 since the central portion of the bit is not covered by preforms, the bit would, unless additional cutters are provided, leave an uncut portion at the center. To avoid such a result, we position in the return portion of the blades a number of diamonds, carbonados or preforms in the face of the bit at the central portion. They are illustrated by the carbonados shown in Figures 3 and 4 at 135.

In both of the forms of Figures 1 and 3, the spacing of the ribs will provide an area adjacent the gage where cutters will not be placed. In both the forms of Figures 1 and 3, diamonds 37 or other suitable abrasive elements may be positioned at and adjacent the gate to supplement and complete the cutting action of the bit. These may be inserted by the conventional manner.

Additionally, as is conventional, in this art, the stabilizer section may be hard faced as for example, by diamond particles distributed along the face of the stabilizer as shown in 37. The above configuration of the bit will provide that the entire surface of the cut will be traversed by cutting elements and that the drilling fluid passing through from the nozzles will wash at high velocity over the cutters and cover the entire surface of the cut returning the detritus along the junk slots to the passageways in the stabilizer to be returned to the annulus.

WHAT WE CLAIM IS:-

1. A bit for drilling wells or bore holes comprising a central bore and a face formed about said bore, fluid channels extending from adjacent the centre of the bit to the gage of said bit and separating said face into blades, cutting elemets positioned in the leading edge of said blades, a plurality of passageways positioned in said face and having openings for discharging fluid into said fluid channels, arranged in a longitudinal array in each of said fluid channels and positioned adjacent the leading edges of said blades, and said cutting elements being preformed shaped cutting elements positioned in said face at leading ends of said blades with a portion of the cutting face of the cutting element exposed and the remainder of said cutting element mounted in said face.

2. A bit as claimed in claim 1, including spaced ribs positioned in said blades and extending across said blades, said openings in each fluid channel being positioned adjacent said cutting elements.

3. A bit as claimed in any preceding claim, in which the cutting elements are positioned in slots formed in the face of the bit at the leading ends of said ribs.

4. A bit as claimed in any preceding claim, in which additional cutting elements are positioned in the central portion of the bit and adjacent the gage of the bit.

5. A bit as claimed in any preceding claim, in which said openings are arranged in a spiral array extending from adjacent the

central portion of the bit to adjacent the gage of the bit.

6. A bit for drilling wells or bore holes substantially as any one of the specific embodiments hereinbefore described with reference to, and as shown in, the accompanying drawings.

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1596609 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG. 1.

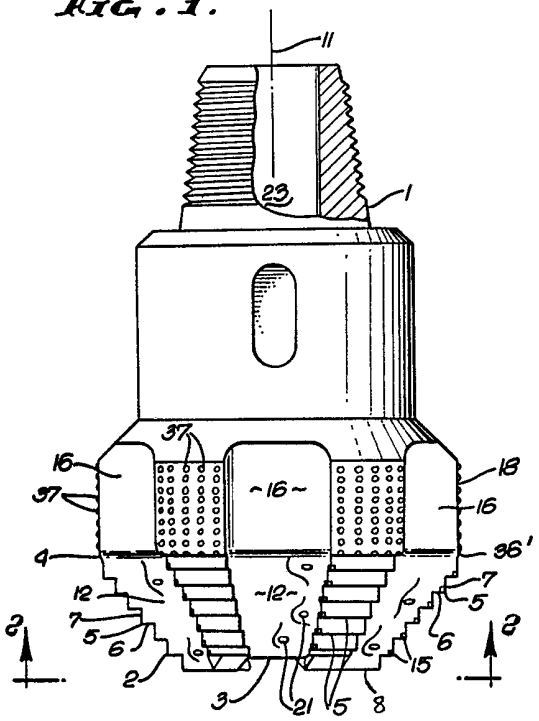


FIG. 2.

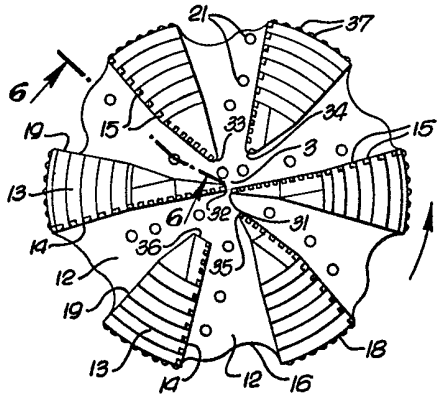


FIG. 7.

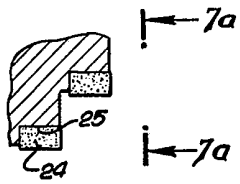


FIG. 7a

FIG. 8.

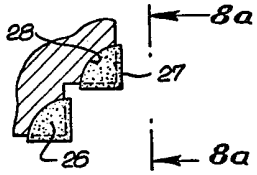
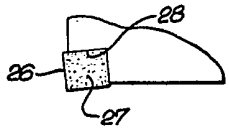
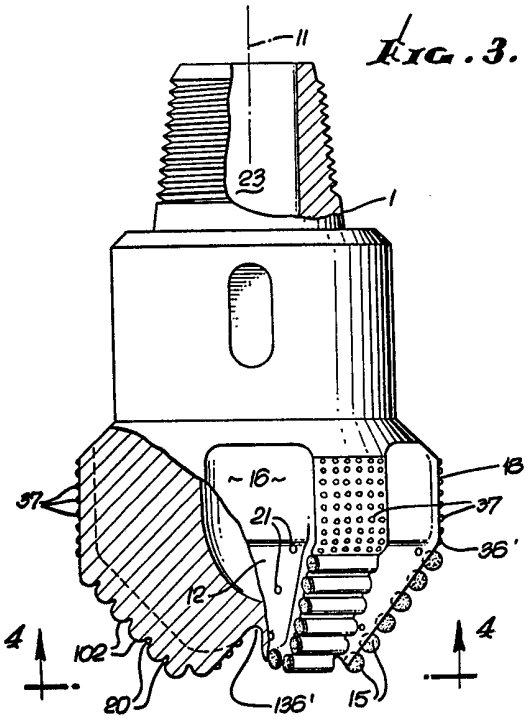


FIG. 8a.




11
23
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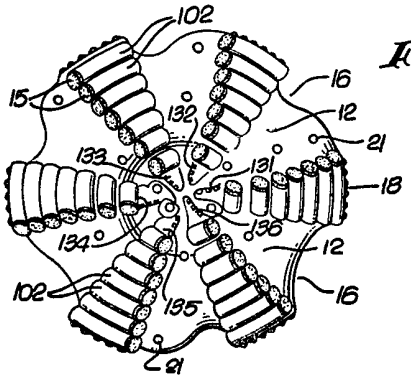
18
16
37
21
37
36'
12
4
102
4
20
136'
15

FIG. 3.


102
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21
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131
18
136
134
12
102
16
135
21

FIG. 4.

FIG. 9.

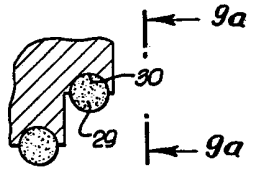


FIG. 9a.

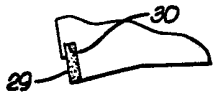
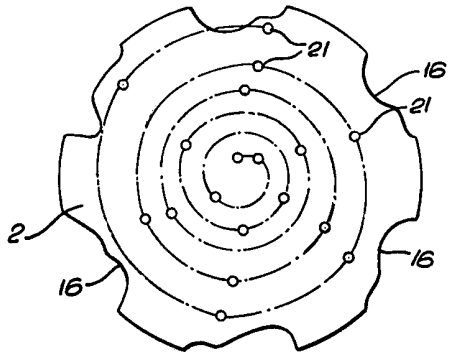


FIG. 5.



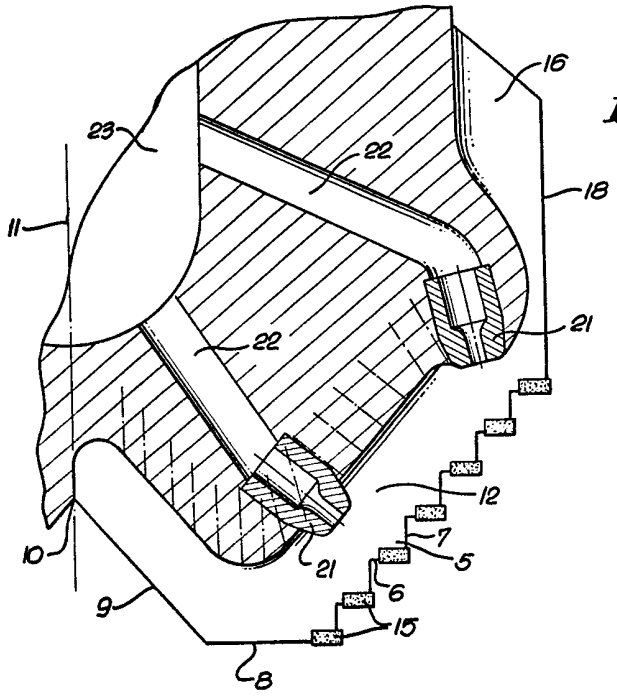


FIG. 6.