

- [54] **DIAMOND BIT WITH ANNULAR MUD DISTRIBUTING GROOVE**
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- [30] **Foreign Application Priority Data**
May 10, 1971 Great Britain 13,928/71

- [52] U.S. Cl. 175/330, 175/404
- [51] Int. Cl. E21b 9/16, E21c 13/02
- [58] Field of Search 175/329, 330, 404,
175/60

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[57] **ABSTRACT**
In a full hole diamond bit of the type provided with a core ejector an improved mud distribution system includes two sets of mud channels communicating with an annular groove concentric with the central bit axis. Mud is supplied to the groove via conduits communicating with the central mud flow passage of the bit.

8 Claims, 9 Drawing Figures

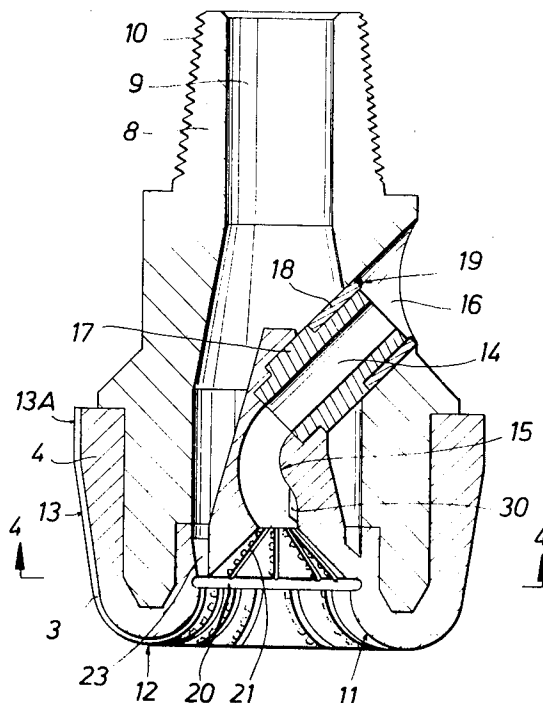


FIG. 1

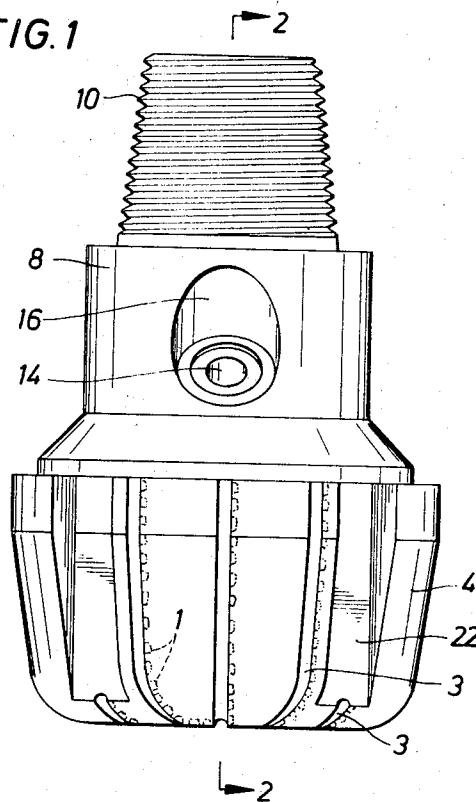
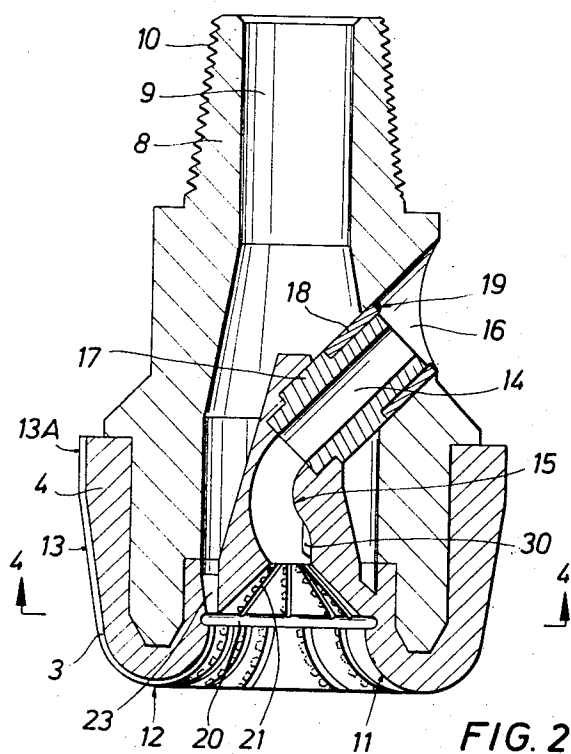


FIG. 2

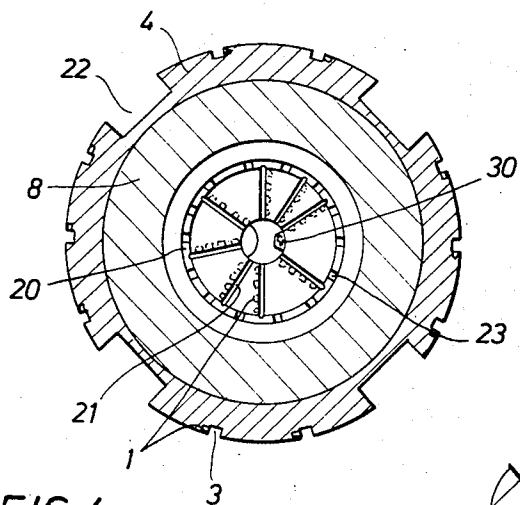


FIG. 4

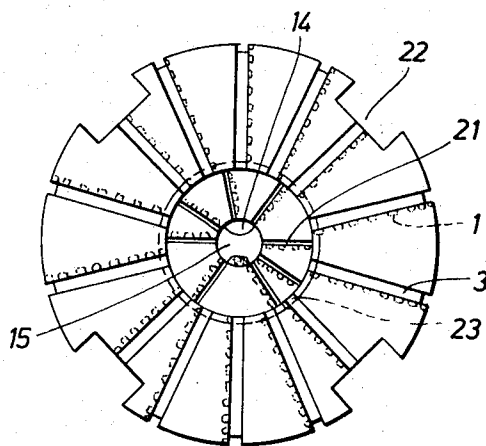


FIG. 3

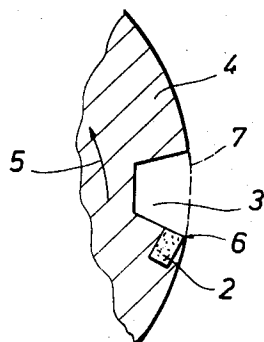
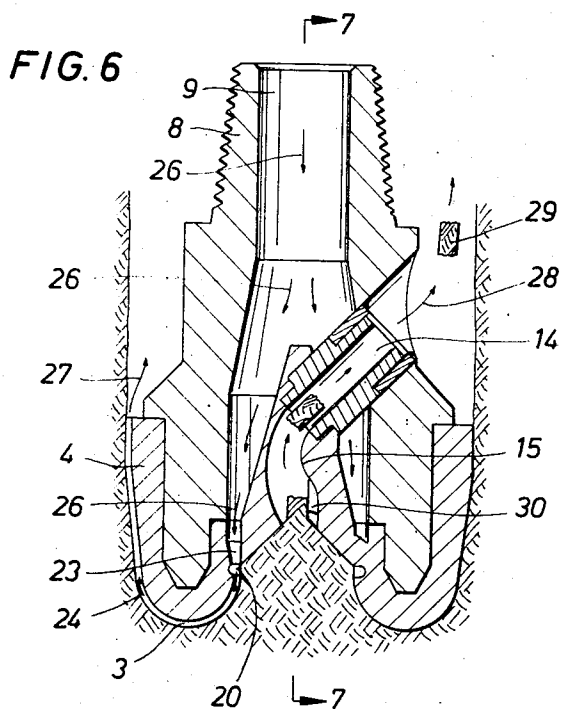
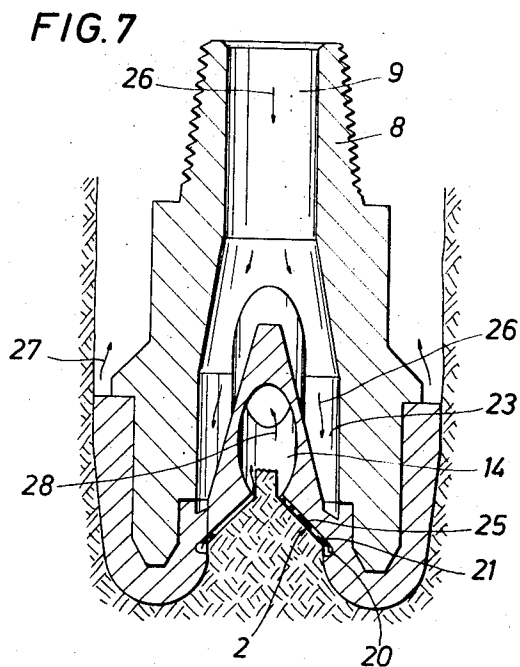
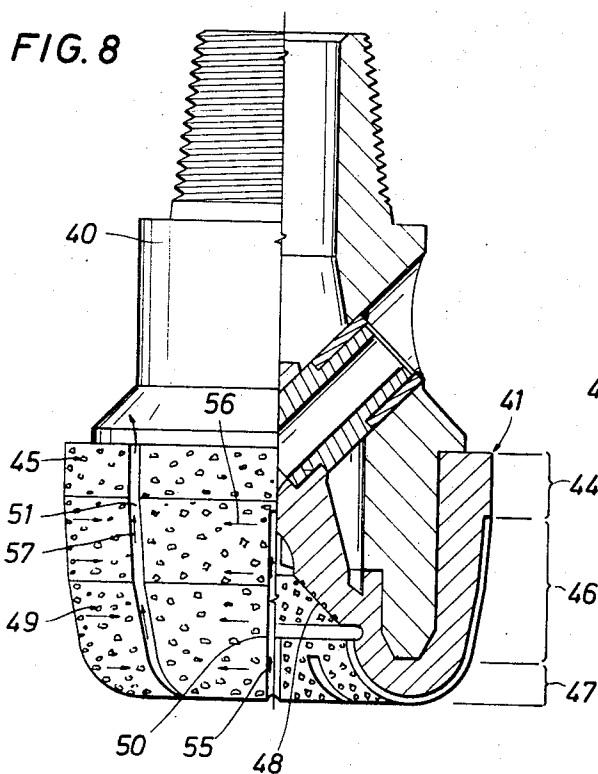
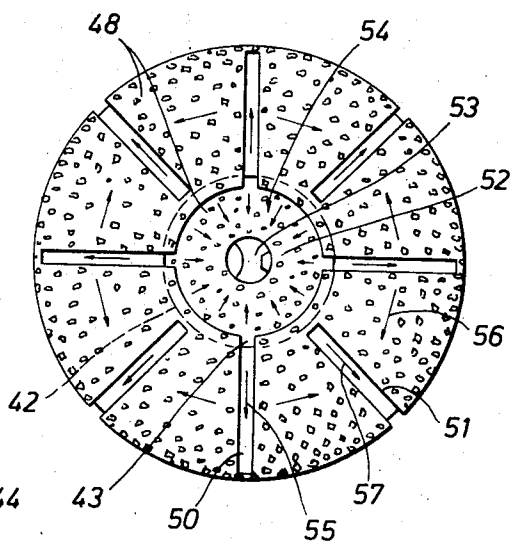


FIG. 5



DIAMOND BIT WITH ANNULAR MUD DISTRIBUTING GROOVE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to diamond bits of the type used in well drilling.

2. Description of the Prior Art

Diamond bits are used for drilling holes through rock material of poor drillability when drilling subsurface formations for the purpose of prospecting for and/or recovering oil or other valuable products. These bits are usually of the rotary type. The diamonds thereof exert a scraping or scratching action on the rock through which a hole is being drilled, the bit being loaded in an axial direction and being rotated around its central axis.

Bits of this type are especially useful for drilling through deep, abrasive, hard formations, since under these operating conditions they have a longer life than other types of rotary rock bit, such as a roller bit. Consequently, a diamond bit has to be replaced less frequently than a bit of another type. The higher material and manufacturing costs of a diamond bit as compared with other types of bits are easily compensated by the advantages obtained as a result of the reduction in time required to replace the worn bits during drilling operations.

The diamonds applied in the diamond bits can have various shapes. They are generally mounted in a bit body consisting of a wear-resistant powder, such as tungsten carbide, which is sintered at an elevated temperature by means of a suitable binder, such as a copper alloy. In manufacturing the bit, the diamonds can be glued on their appropriate locations in a graphite mold of the bit body, which is thereafter filled with the wear-resistant powder and subjected to a sintering operation.

Mud channels are commonly arranged in the surface of the bit body. During the drilling operations, mud is passed through these channels to promote cooling of the bit and to remove drilling flour and scrapings. The diamonds may be grouped between these mud channels according to various patterns. In one pattern the diamonds are uniformly distributed over the areas located between the mud channels. In another pattern the diamonds are preferably located near one side of each mud channel. In still another pattern the diamonds are arranged in a single row along one side of each mud channel.

Drilling of the central part of the hole with a diamond bit has been a major problem. Since the area available for mounting diamonds in the central portion of the diamond bit is rather small, only a limited number of diamonds can be set in this area. This results in a relatively high workload being exerted on each of these centrally located diamonds during drilling. This problem has been solved by leaving the center of the bit free of diamonds, thereby creating a core during drilling which is repeatedly broken off during operation of the bit and removed via a laterally extending core ejector conduit debouching into the annular space between the rotary drill pipe and the walls of the hole above the bit body.

It will be appreciated that such a full hole diamond bit with a core forming part and a core ejector requires a much more complicated mud distribution system than full hole bits without such a core forming part, or

core bits in which the core forms a substantial part of the hole being drilled. (In the latter type bit the core can be removed to the surface in lengths which are sufficient for study of the various formation layers which are being drilled.)

In the more simple mud distribution systems of the aforementioned bit types, the mud required for cooling the diamond bit and removing the scrapings, cuttings and drilling flour from the surface thereof to allow an optimal operation of the diamonds, is passed through channels arranged in the surface of the bit body and extending from a central supply conduit in or near the central part of the bit body towards the side wall of the bit. Thus, in core bits of full hole bits the mud is passed in a single direction over the bit body (i.e. from the inner part towards the outer part thereof).

In contrast, the mud distribution system required for a full hole bit with core forming means has to guide the mud in two flows over the bit surface, one flow being directed towards the center in the direction of the core ejector conduit, and the other flow being directed towards the side wall of the bit. Both flows of mud are eventually combined in the annular space above the bit (and around the drill pipe or drill collars connected thereto). In such a system it has been difficult to obtain an even distribution of mud flow along the diamonds positioned in the bit body.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an improved mud channel system for a full hole diamond bit with core forming part and a core ejector, which mud channel system allows an even distribution of mud along the diamonds carried by the bit body.

Another object of the present invention is to provide a full hole diamond bit with core ejector and mud distribution system, wherein the mud distribution system is of a design allowing flows of mud therethrough at relatively high rates without being liable to excessive erosion.

Still another object of the present invention is to provide a full hole diamond bit with core ejector comprising a mud distribution system allowing an optimal cooling and cleaning of the diamonds mounted in the core forming part of the bit.

According to the invention, an improved full hole diamond bit of the type having a core forming part and a core ejector having a conduit laterally extending from the central axis of the bit, comprises a mud distribution system arranged in the surface of the body of the bit and communicating with mud supply conduits passing through the body of the bit, said system comprising an annular groove into which the mud supply conduits debouch, said groove being arranged in the core forming part and facing the central axis of the bit, and communicating with fluid passageways extending towards the core ejector conduit and towards the side wall of the bit.

The fluid passageways extending towards the side wall of the bit may consist of a group of channels.

If desired, the fluid passageways extending towards the core ejector conduit may also consist of a group of channels.

Each mud channel, or at least some of the mud channels, may be arranged with the longitudinal axis thereof in a flat plane and have a single row of diamonds placed in one of the side walls of the mud channel.

An extremely good distribution over the various mud channels will be obtained by using an annular groove having a cross-sectional area larger than the cross-sectional area of each of the mud channels.

If desired, at least some of the mud channels may border on areas in which diamonds are more or less evenly distributed, one channel bordering on such area communicating with the annular groove only, and the other channel bordering on the area communicating with the core ejector conduit only.

The exits of the mud supply conduits and the entries to the mud channels extending towards the core ejector conduit may be in the same wall of the annular groove, at least one entry to a mud channel extending towards the core ejector conduit being located between the exits of two mud supply conduits.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 of the drawing shows a side view of a full hole diamond bit according to the invention.

FIG. 2 shows a longitudinal section of the bit according to FIG. 1 taken along the central axis thereof in the direction of arrows 2-2.

FIG. 3 is a bottom view of the bit according to FIG. 1.

FIG. 4 is a cross-section of the bit according to FIG. 2 taken over the line 4-4.

FIG. 5 represents detail A of a portion of a mud channel in the view of FIG. 4 on an enlarged scale and shows the setting of a diamond in the wall of the mud channel.

FIG. 6 shows a bit according to the invention in an operative position while drilling a hole in a subsurface formation.

FIG. 7 is a longitudinal section over the central axis of the bit according to FIG. 6 taken in the direction of arrows 7-7.

FIG. 8 is a side view of another embodiment of the invention.

FIG. 9 is a bottom view of the bit according to FIG. 8.

DESCRIPTION OF A PREFERRED EMBODIMENT

The full hole diamond bit shown in FIGS. 1-4 is an embodiment of the diamond bit of this invention in which the diamonds are arranged in single rows along one side of each mud channel. In FIGS. 1, 2 and 3 the location of these diamonds along the mud channels is indicated by crosses 1. The diamonds are not actually visible except along interior walls of the mud channels 3. The position of a diamond 2 in the side wall of a mud channel 3 arranged in the surface of a bit body 4 is shown on an enlarged scale in FIG. 5. Such positioning of diamonds in a diamond bit is more fully described in a copending U.S. Pat. application of Feenstra and Pols, Ser. No. 239,037, filed Mar. 29, 1972.

On rotation of the bit body 4 in the direction of arrow 5, the edge 6 of the cube-shaped diamond 2 will scrape an annular track in the wall of the hole in which the bit body is operating. The flow of mud passing through the channel 3, which at the open side thereof is closed off by the wall of the hole being drilled (vide broken line 7, FIG. 5), will cool the bit body 4 and the diamond 2, and remove the scrapings from the scraping edge 6 of the diamond 2, thereby preventing clogging of the channel 3 by cuttings, scrapings and flour originating from the drilling operation.

The longitudinal axis of each channel 3 is in a flat plane (e.g. the plane of the drawing for the channel 3 as shown in FIG. 2) which ensures a minimum erosion of the walls of the channels by the mud flows passing therethrough.

The bit body 4 consists of a sintered mass of wear-resistant material (such as tungsten carbide powder sintered at an elevated temperature by means of a binder such as a copper alloy). The body 4 is sintered around a steel shank 8 (vide FIG. 2) in a manner known per se. The shank comprises a central bore 9 and an outer screw thread 10 at the upper end.

The surface of the bit body 4 consists of three major parts:

viz. a core forming part 11 for scraping the bottom of the hole during the drilling operation in a manner such that a central core portion is left; a bottom part 12 for scraping the bottom of the hole during the drilling operation so that the hole is deepened, and a side wall 13 for scraping the wall of the hole during drilling.

The side wall 13 lies on the surface of a cone and the diamonds arranged in this side wall are adapted to scrape the wall of the hole being drilled to increase the diameter thereof. Above the side wall 13, the bit body 4 comprises a wall portion 13A having a cylindrical shape. The diamonds located in this wall portion 13A have a blunt setting, which means that they cannot scratch, scrape or cut the wall of the hole being drilled. Thus, the wall portion 13A is suitable for guiding the bit through the hole which is being drilled, without enlarging the diameter of the hole when lateral forces are exerted on the bit.

The lower part of the side wall 13 of the bit body merges into the bottom part 12, which at its other side merges into the central portion 11 which is adapted to scrape the subsurface formation during drilling operations such that a small diameter core is formed.

The upper portion of this core forming part 11 is of frustoconical shape and its top end passes over into a core ejector consisting of a conduit 14 curved at one end thereof to form a core breaking area 15 and being arranged at the other end thereof to pass through an opening 16 in the side wall of the shank 8. The conduit is partly formed in the bit body 4, and partly by a tube 17 consisting of sintered, wear-resistant material held in position by restraining means such as steel tube 18 welded into the opening 16 by a weld 19.

The mud distribution system for guiding the mud flow along the scraping edges of the diamonds is arranged in the outer surface of the bit body 4. The system consists of an annular groove 20 communicating with two groups of channels. One of these groups comprises channels 21 leading towards the core ejector conduit 14. The other group comprises channels 3 passing over the lower section of the core forming part 11 of the bit body, the bottom part 12, the side wall 13 and the cylindrical part 13A, and debouching — when the drill bit is in operation in a hole — into the annular space around the steel shank 8. It will be appreciated that the core ejector conduit 14 debouches into the same space.

Each of the channels 21 being arranged in the frustoconical area of the core forming part 11, has the longitudinal axis thereof located in a flat plane to reduce the erosion of the mud flow passing through each channel 21 to a minimum.

The cross-sectional area of the annular groove 20 is larger than the cross-sectional area of each of the channels 3 and 21. It will be appreciated that an increase in the difference between these cross-sectional areas will promote the uniformity of distribution of the mud flow over the various channels.

The surface of the bit body 4 is further provided with junk slots 22 into which some of the mud channels 3 debouch.

Mud supply conduits 23 are arranged in the bit body 4, which conduits communicate at their upper ends with the inner bore 9 of the steel shank 8, and at their lower ends debouch into the upper wall of the annular groove 20.

As can be seen from FIG. 2, the annular groove 20 is arranged in the core scraping part 11 of the surface of the bit body 4 and faces the central axis (not shown) of the bit. Thus the groove comprises an upper wall into which the mud supply conduits 23 debouch, and in which the entries to the mud channels 21 leading to the core ejector conduit 14 are located. In the lower wall of the groove 20, and facing the outlets of conduits 23, the entries to the mud channels 3 are located. Thus the number of conduits 3 is equal to the number of channels 23.

It will be appreciated that during operation of the bit in a hole penetrating a subsurface formation, the open sides of the channels 3 and 21 and the open side of the groove 20 are closed off by the wall of the hole (and the core) which is being drilled. Thus, any fluid supplied to the groove 20 via the mud supply conduits 23 has to leave the groove 20 either through the group of mud channels 21 leading to the core ejector conduit 14 or through the group of mud channels 3 leading towards the side wall of the bit. The mud flow through the channels 3 is indicated by arrows 24 in FIG. 6, which shows the bit according to FIG. 2 when drilling in a subsurface hole. The mud flow through the channels 21 is indicated by arrows 25 in FIG. 7, which shows a section through the central axis of the bit according to FIG. 6, but now passing over the channels 21.

In FIGS. 6 and 7, the flow of mud supplied to the annular groove 20 and passing through the bore 9 of the steel shank 8 and through the mud supply conduits 23 arranged in the body 4, is indicated by arrows 26. The mud flow discharged from the mud channels 3 into the annular space above the body 4 is indicated by arrows 27. The mud which has passed through the channels 21 is discharged into the same annular space via the core ejector conduit 14 (vide arrows 28) thereby entraining the core parts 29 which have been broken off by the core breaker 15. The diamond 30 placed in the upper part of the core scraping part 11 has very large dimensions and is applied for reducing the diameter of the core to an extent suitable to allow breaking of the core by the bending action of the core breaker part 15, without jamming the core in the upper part of the core scraping part 11.

Attention is drawn to the row of diamonds 2 placed along the right channel 21 in FIG. 7. It will be appreciated that each mud channel 21 has a single row of diamonds set therealong. The diamonds touch the wall of the core with their scraping edges (compare the situation of the diamonds 2 set in the wall of the channel 3 shown in FIG. 5) thereby scraping annular tracks thereon on rotation of the bit. More than one diamond may run in the same track, and adjoining tracks overlap

to prevent the formation of ridges on the formation being drilled.

Tests have shown that the distribution of the mud over the two groups of mud channels 3 and 21 by means of the annular groove 20 prevents erosion of the body 4. Serious erosion was encountered with other mud distribution systems, one such system having mud supply conduits directly feeding the supply of mud into a mud channel leading to the core ejector conduit and into a mud channel leading to the side wall of the bit. The erosion occurring in and around the junction between each set of channels and a mud supply conduit was reduced by the use of an annular groove connecting all the junctions. A further improvement was obtained by applying a groove with relatively large cross-section as compared to the cross-sections of the mud channels. Another improvement resulted from arranging the entries to the mud channels leading to the core ejector tube in planes different from the planes in which the mud supply conduits are located.

It will be appreciated that the invention is not limited to the particular design of a diamond big as shown in FIGS. 1-5 of the drawing. Thus the invention may also be applied to diamond bits having core forming parts, bottom parts and side wall parts of shapes different from those shown in FIGS. 1 and 2. Further, more than one row of diamonds may be placed along each channel, or even, if desired, fields of diamonds may be placed between some or all of the sectors lying between adjoining mud channels 3 or between adjoining mud channels 21.

An arrangement of a mud flow distribution system to be applied in combination with diamond fields is shown in FIGS. 8 and 9.

The bit shown in FIGS. 8 and 9 consists of a steel shank 40 having a bit body 41 connected thereto. The bit is a full hole bit and comprises a core ejector, which being similar to the core ejector shown in FIG. 2 is not described here. An annular groove 42 is arranged in the surface of the core forming portion of the bit this groove being similar to the groove 20 of the bit according to FIGS. 1-4 and having mud supply conduits 43 similar to the mud supply conduits 23 shown in FIGS. 1-4, debouching thereinto.

The body 41 has a gauge side 44 provided with blunt-set (non-cutting) diamonds 45, a side wall 46, a bottom part 47 and a core forming part 48. Parts 46-48 are provided with diamonds 49 scraping annular tracks into the subsurface formation during drilling operations carried out in such formations. A plurality of channels 50, e.g. four channels, communicate with the groove 42 opposite to the locations where the mud supply conduits 43 debouch into the groove 42, these channels 50 extending over the bit surface towards the side wall 46 thereof. Between these channels 50, channels 51 are arranged. These channels do not communicate with the groove 42 and extend over the lower area of the core forming part 48, the bottom part 47, the side wall 46 and the gauge side 44, and communicate, contrary to the channels 50, with the annular space around the upper part of the shank 40.

As can be seen from FIG. 9, which shows a bottom view of the bit according to FIG. 8, the central area of the core forming part 48, which area is within the annular groove 42, is provided with diamonds 52 set in a position to scrape the core portion of the bottom of the hole being drilled in a manner similar to the manner as

described with reference to the bit according to FIGS. 1-4. A small-diameter core is then left which is discharged via the core ejector conduit 53 after being broken off.

The flow of mud over the surface of the bit is indicated by arrows. Mud is supplied to the annular groove 42 via the mud supply conduits 43 which communicate at their upper ends with the central bore (not shown) of the shank 40. Two flows of mud emerge from the groove 42. One flow is directed inwardly towards the center of the core ejector conduit 53 and cools the diamonds 52 located in the upper area of the core-forming part 48. This flow, which further removes the scrapings, cuttings and flour resulting from the action of the diamonds 52 is indicated by arrows 54. The other flow is directed radially outwardly through the channels 50 as indicated by arrows 55, and is subsequently distributed over the bit surface (vide arrows 56) and finally collected in the channels 51 and discharged (vide arrows 57) into the annular spaces around the shank 40. The flows indicated by arrows 56 cool the diamonds and remove the scrapings, cuttings and flour resulting from their action on the formation.

It will be appreciated that, as the diamonds in the gauge side 44 of the bit are set in a blunt position, there is no need for cooling these diamonds.

If desired, a channel arrangement similar to the arrangement of the channels 50 and 51 which distribute and collect the mud, respectively, may also be applied in the central portion of the core-forming part 48 of the bit. Further, the system of radial flow in the remaining portion of this central part may be applied for a portion of the central part in combination with channels arranged in this central part and operating in the manner of channels 50 and 51, or with channels similar to channels 21 shown in the embodiment according to FIGS. 1-4, each of which has a single row of diamonds set in one wall of the channels.

If desired, one or more of the sectors located between the channels 21 shown in FIG. 3 may be provided with diamonds, and the channels bordering on such sectors may be shaped in such a manner that one of the bordering channels is a distribution channel and the other channel is a collecting channel. It will be appreciated that no single rows of diamonds are then applied along these channels. The distribution channel communicates with the annular groove but not with the core ejector conduit, whereas the collecting channel communicates with the core ejector conduit but not with the annular groove. The field of diamonds arranged between such two channels is then flushed by a flow of mud running from the distribution channel to the collecting channel.

It will further be understood that the invention is not limited to the shapes of the diamonds used, the cross-sections of the annular grooves 20 and 42, the cross-sections of the mud channels 3, 21, 50 and 51 or the arrangement of channels belonging to one and the same group either with respect to each other and/or with respect to the central axis of the bit or the core ejector conduit. Further, any type of wear resistant material may be applied in the manufacture of the bit body. The body may be directly sintered to the shank, or the shank may be brazed to the body afterwards.

The profile of the bottom part 47 and/or the core-forming part 48 of the bit described with reference to FIGS. 8 and 9, may be step-shaped, preferably such

that the steps of one sector are slightly displaced with respect to the steps of the adjoining sectors, so that during rotation of the bit flow channels are present along the steps scraped in the bottom of the hole which is being drilled. The flow of mud passing through these channels when flowing from the distribution channels towards the collection channels cools the diamonds placed on the steps and removes the scrapings to prevent clogging of the flow passages.

It will be appreciated that the central axis of the outflow opening of a supply conduit 23 need not coincide with the central axis of the cross-section of the inflow of a channel 3 (as is the case in the arrangement shown in FIG. 2). If desired, the central axis of the outflow opening may be directed towards the central axis of the bit.

The cross-section of the outflow opening of a supply conduit 23 may be larger than the cross-section of the inlet opening of a channel 3 cooperating with this conduit 23 (cf. the arrangement in FIG. 3 where the cross-sections are equal). In another embodiment, the outflow opening may have an oblong shape and even be positioned such that it faces the entries to two or more channels 3. In still another embodiment, the entries to channels 3 may be located between the outlet openings of the supply conduits 23.

The entries to channels 21 are preferably located between the outlet opening of the supply conduits 23.

We claim as our invention:

1. An improved full hole diamond bit of the type which includes a shank having a side wall and a central bore; a cutting surface connected to the shank for cutting a hole during operation of the bit, the cutting surface comprising a side wall portion for scraping the wall of the hole during operation, and also comprising a core-forming portion for scraping a portion of the hole bottom during operation, the core forming portion comprising a diamond-carrying surface tapered upwardly toward the top of the bit when in the operating position; and a core ejector conduit extending from the upper end of the core-forming portion of the cutting surface through the side wall of the shank; wherein, in operation, the full hole diamond bit forms a core which passes up the core ejector conduit and is ejected through the shank side wall, and wherein the improvement comprises a system for distributing mud to the cutting surface which comprises:

an annular groove provided in the core-forming part of the cutting surface;

at least one fluid supply conduit connecting the annular groove with the central bore of the shank; and a plurality of channels formed in the cutting surface, said channels intersecting the annular groove; said channels being divided into at least two groups of at least one channel each, a first group of channels extending away from the annular groove along the cutting surface towards the core ejector conduit and a second group of channels extending away from the annular groove along the cutting surface toward the side wall portion thereof,

whereby, in operation, drilling fluid flows from the central bore of the shank, through the fluid supply conduits, into the annular groove and then in part flows through the first group of channels in the cutting surface toward the core ejection conduit, and in part flows through the second group of channels in the cutting surface towards the side wall portion.

2. The full hole diamond bit of claim 1 wherein each of the plurality of channels has a longitudinal axis which is arranged in a flat plane and wherein the cutting surface comprises a plurality of single rows of diamonds each row comprising a plurality of diamonds placed in one of the side walls of one of the channels. 5

3. The full hole diamond bit of claim 1 wherein the area of the cross-section of the annular groove is larger than the area of the cross-section of each of the plurality of channels.

4. The full hole diamond bit of claim 1 further including a plurality of channels in the core-forming part which intersect the ejector conduit but do not intersect the annular groove; wherein channels in the first group of channels do not intersect the ejector conduit; 15 wherein at least some of the channels in the first group of channels border on sector-shaped areas of the cutting surface, said sectors being defined by adjacent channels; and wherein one of the adjacent channels bordering on each sector-shaped area is a channel 20 which communicates with the annular groove only, and the other of the adjacent channels bordering on the sector-shaped area is a channel which communicates with the core ejector conduit only.

5. The full hole diamond bit of claim 1, wherein the 25

fluid supply conduits intersect the annular groove from above and the channels in the second group of channels intersect the annular groove from below both directions being taken with the bit in its operative position.

6. The full hole diamond bit of claim 5, wherein the intersection of at least one fluid supply conduit with the annular groove is located between but on the opposite side of the annular groove from the respective intersections with the annular groove of two of the second 10 group of channels.

7. The full hole diamond bit of claim 5, wherein the intersection of at least one fluid supply conduit with the annular groove is directly oppositely positioned across the annular groove from the intersection of at least one of the second group of channels with the annular groove.

8. The full hole diamond bit of claim 5, wherein the channels in the first group of channels intersect the annular groove from above when the bit is in its operating position, and wherein the intersection of at least one channel in the first group of channels is located between and on the same side of the annular groove as the intersection of the annular groove with two fluid supply conduits.

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