July 2, 1963 A. B. HILDEBRANDT ETAL 3,095,935

CORING BIT

Filed Sept. 25, 1958

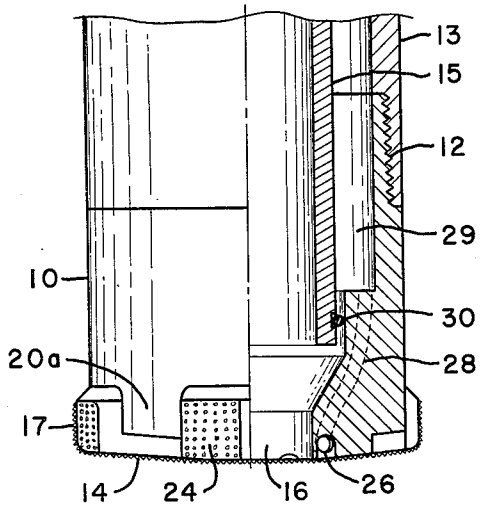


FIG. 1

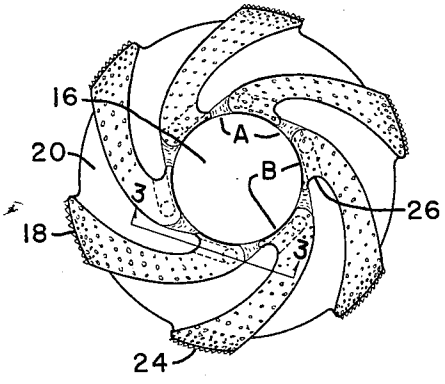


FIG. 2

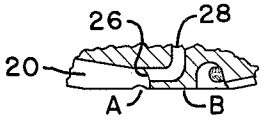


FIG. 3

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CORING BIT

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The present invention relates to rotary drill bits and more particularly to bits for cutting cores. It relates especially to core bits for coring relatively unconsolidated formations with gummy shale sections interdisposed between the sand sections.

In rotary core bits it is desirable to maintain the cutting faces of the bits in a clean and cool state. It is also desirable that the core be undisturbed. Heretofore circulating fluid such as drilling mud has been pumped through the bit for discharge into the hole being drilled to flush the cuttings to the top or entrance of the hole, to clean the cutting face of the bit, and to cool such face.

The aforementioned intended purposes have not been accomplished efficiently. The cutting faces have not been cleaned properly, thus reducing the penetration rate of the bit in the formation. This reduction of penetration rate can be traced in part to the packing of cuttings between the cutting elements on the cutting face which prevent the cutting elements from contacting the bottom of the hole. The cuttings then pack on the bit and skid or slide along the bottom of the hole which generates a great deal of heat which may be sufficient to damage the cutting face. Reduction of penetration rate of the bit may also be traced to the operation of the cutting face upon previously made cuttings remaining between the cutting face and the undisturbed formation in the bottom of the hole.

Attempts have been made to clean and cool the bit by providing grooves in the cutting faces of the bit through which circulation fluid will flow while the bit is rotated. However, the drilling fluid that flows through these grooves has been directed at least in part upon the core being cut, thus contaminating the core such that the true original content and character of the core cannot be determined upon examination at the surface. In unconsolidated formations the drilling fluid very frequently washes away a part of the core, thus making it impossible to obtain a true representative core of the formation of interest. Bits having spiral grooves in the cutting face for the flow of drilling fluids are manufactured by Christensen Diamond Products Company in Salt Lake City, Utah.

In most coring operations the formations encountered are not homogeneous. A part of a formation may be a loose unconsolidated sand, another portion a hard formation, and still another portion a gummy shale. Heretofore bits that were designed for drilling in one of these sections of the formation would be totally ineffective for drilling in the other sections. For example, a bit designed to cut through gummy shale would wash away the core in unconsolidated sections. A bit adapted to drill in unconsolidated sections would gum up in shale due to insufficient cleaning action and the penetration rate would drop to nearly zero. Bits designed to drill through hard sections have poor recovery through unconsolidated sections. The need, then, is quite apparent for a bit that will penetrate effectively in all various sections encountered in coring with the ability to preserve the core. The bit disclosed herein satisfies this need.

Accordingly, it is an object of the present invention to provide an improved rotary coring bit which can be maintained in a clean and cool state by the circulating fluid during the drilling of a hole in the formation and in which the circulating fluid does not contaminate or wash away the core being cut.

Briefly, this invention includes a rotary coring bit having a drilling face to engage the bottom of the borehole and a central core passage extending longitudinally therethrough. The drilling face contains a plurality of substantially uniformly spaced and preferably spiral waterways and uniformly spaced lands between the waterways. Cutting elements are secured to the lands for operation upon the bottom of the hole. A fluid nozzle is provided in each of the lands adjacent the core passage with the nozzle being located such and of a character as to discharge fluid in a path into said waterways which is in a plane substantially tangential to the periphery of the core passage. The discharge path is also preferably substantially horizontal, or parallel to the cutting face. However the discharge path, if desired, may be deviated downwardly but not more than about 30° from a horizontal plane. The bit face contour is designed to give maximum cutting and cleaning action. The fluid nozzles are located and directed to give maximum cleaning of the cuttings without washing the core.

Other objects and a better understanding of the invention may be had from the following description and claims taken in conjunction with the drawings in which:

FIG. 1 is a longitudinal section and side elevation of a rotary core drill bit of this invention;

FIG. 2 is a bottom plane view of the drill bit disclosed in FIG. 1; and

FIG. 3 is a sectional view taken along the line III—III of FIG. 2.

Reference is now made to the drawing in which the best mode contemplated for carrying out the invention is illustrated. The bit body **10** has a suitable connection **12** in its upper portion for securing the bit to the lower end of a core barrel **13** having an inner barrel **15**. A core barrel is not illustrated in complete detail here as core barrels are well known in the art. A particularly suitable core barrel for use with this coring bit is the rubber sleeve barrel disclosed in co-pending application Serial No. 701,840 filed December 10, 1957, now Patent No. 2,927,775, in the name of Alexander B. Hildebrandt.

A lower cutting portion or face **14** is provided at the lower end of body **10**. Core passage **16** is located axially of the body and extends longitudinally therethrough. For the purpose of cleaning and cooling the cutting surfaces of the bit, a plurality of waterways or grooves **20** is formed in the face **14**. The waterways **20** are relatively shallow and are preferably substantially equally spaced from one another around the cutting faces of the bit so as to provide spans or lands **18** between the grooves. The grooves begin at a point at or closely adjacent the periphery of the core passage **16** and preferably curve outwardly and spirally toward the outer periphery of the cutting portion of the bit.

The main cutting portion of the tool is disposed at the lower bottom hole contacting face **14**. Cutting portions may also be provided on the generally cylindrical outer surface **17** of the bit body. If so, waterways **20** and lands **18** will extend upwardly about cylindrical outer surface **17**. The groove portions **20***a* in outer face **17** are substantially parallel to the axis of the bit. Face **14** is normally convex in shape.

Lands **18** are preferably made up of matrix **22** of a hard material of any suitable type. Secured to the bottom of the matrix **22** are hard cutting substances such as diamonds **24** of the proper size which are secured therein in a known manner. The diamonds are arranged in any desired pattern on exposed faces of the lands of the matrix which operates upon the bottom of the hole being drilled. Each land **18** is provided with a fluid nozzle **26** opening into waterway **20**. This nozzle is especially clearly shown in FIG. 3 and is of a character to direct fluid into waterway **20** in a direction which is substan-

tially tangential to the periphery of the coring passage and also preferably substantially horizontal. As the drilling fluid is directed away from the core, the fluid cannot flush and wash the walls of the core. When a convex cutting face is used, it may be desirable to construct the nozzles such that the fluid is directed substantially parallel to the cutting face.

A substantially vertical passageway **28** extends through the body **10** from nozzle **26** to the top of the bit body. Passageway **28** fluidly communicates with passage **29** in the core barrel, and all the drilling fluid which comes down the drill string passes through passage **29**, passageway **28**, and out through nozzle **26**. A suitable seal **30** is provided between inner barrel **15** and the body of the bit below the upper end of conduit **28**. Therefore no drilling fluid comes down through the core passage. Complete control of the flow path of fluid is thus obtained. The flow path directs the drilling fluid such that cleaning and cooling of the cutting face of the drill bit is assured.

It is also important to note that the fluid is directed tangentially and away from the core as it is cut and does not come into high velocity or high pressure contact therewith. The core then is not contaminated by the drilling fluid nor is it washed away. Also any amount of fluid can be jetted through nozzle **26** without washing the core or contaminating the same; this cannot be done with conventional equipment. It is clear then that waterways **20** can be jetted clean at all times and that there will be a source of water at the leading edge of the lands which will be available for cleaning and cooling the lands from the core passage to the periphery of the bit. The "balling up" of cuttings on the face of bits is especially bad in drilling through shale. This "balling up" greatly reduces the rate of penetration. However, the bit disclosed herein, with its novel drilling fluid flow pattern, prevents this "balling up." Therefore a maximum penetration rate may be maintained.

Jetting the fluid parallel to the cutting face and tangentially to the core being cut also aids in drilling straight holes. It is known that in drilling unconsolidated formations quite frequently one side of the borehole is less consolidated than the other side. The jetting action of the drilling fluid removes a portion of the bottom of the borehole from that side which is less consolidated, thus causing the hole to deviate from the vertical. This cannot happen with the present invention as the drilling fluid is discharged substantially parallel to the bottom of the borehole.

The size of the waterways **20** in relation to the size of the land will vary depending upon the various type rock formations which are being drilled. It is contemplated that normally the waterways **20** and the lands **18** will occupy approximately equal area. If the land is too wide, it may "burn" in certain type rock formations. On the other hand, if the total land area is too small, maximum pentration rates may not be obtained. As an example, it has been found that for drilling certain hard type rock formations the waterways should be approximately one-half the area of the land area. For certain soft type rock formations the area of the waterways should be approximately two times the area of the lands.

The exact shape of the waterways is not critical. However, the contour of the waterways should approximate the path which fluid directed from nozzles **26** would assume if unobstructed. Waterways **20** may take the shape of a groove the same width as the diameter of the nozzles **26** and extend longitudinally from nozzles **26** and tangentially to the core passage. However, it is normally preferred that each waterway **20** will take the shape of a spiral groove as illustrated in the drawing. This permits the area and shapes of the waterways and lands to more nearly approximate each other. The spiral arrangement of waterways **20** and lands **18** therebetween causes each waterway to partake of an increasing angle with respect to a radial line drawn from the axis of the bit through the center of nozzle **26**.

Area A is shown as that portion of face **14** which is adjacent the periphery of core passage **16** and is between the waterways proper and the core passage. Area B is shown as that portion of the surface on the lands adjacent the periphery of the core passage. It is preferred that area A be recessed with respect to area B. However, area A should not be recessed to the point where it will fall in the same plane as the jet stream. Area A is of course very narrow and in some cases may be as narrow as one-sixteenth of an inch. This arrangement permits the cuttings from around the periphery of the face of the bit near the core passage to pass into area A and thence into waterway **20** where they are jetted out by the jet stream from nozzle **26**. This prevents skidding along the inner cutting area and heating up of that portion of the bit which results in reduction in drilling rates and excessive bit throat wear. Area A is shown as not having diamonds; however, if desired, diamonds may be placed in this area.

The number of nozzles **26**, the number of waterways **20**, and the number of lands **18** should all be equal. This number will, of course, vary as the size of the core being cut, the size of the hole being drilled, and the nature of the rock formation being cored. However, in general there will be between about 4 to 12 such nozzles, waterways, and lands each.

A core bit substantially as described herein and illustrated in the drawing has been built and field tested and has proved to be markedly superior over former core bits. This bit has a 7½" outside diameter and a 3" core passage. The nozzle has a ⅜" diameter. The waterways are approximately ¼" deep at the nozzle and 1" deep at the periphery of the bit. The areas of the lands and waterways are substantially equal.

It will be understood that the apparatus shown in the above description is merely representative and illustrative and not limiting and that numerous modifications may be made therein without departing from the scope of the invention.

The invention claimed is:

1. A rotary coring bit comprising in combination a body having a drilling face and an axial core passage extending longitudinally therethrough, said drilling face containing a plurality of substantially uniformly spaced smoothly curved waterways to provide substantially uniformly spaced smoothly curved lands between said waterways, cutting elements secured to said lands for operating upon the bottom of the borehole, each of said curved waterways beginning closely adjacent to the periphery of said core passage and extending outwardly to the outer periphery of said face, a jet nozzle opening into each said waterway in each said land closely adjacent said core passage with each said nozzle having a discharge path which lies in a plane substantially tangential to the periphery of said core passage and fluid conduit means in the body of said bit in fluid communication with each nozzle.

2. An apparatus as defined in claim 1 in which said discharge path is also in a plane substantially perpendicular to the axis of said bit.

3. An apparatus as defined in claim 1 in which each nozzle is positioned in the same relative attitude to the bit and such that said discharge path is directed not more than about 30° downward from a plane perpendicular to the axis of said bit.

4. An apparatus as defined in claim 1 in which said drilling face is convex.

5. An apparatus as defined in claim 1 in which a portion of the lands of said face between said waterways and said core passage is recessed with respect to the cutting portion between said lands and said core passage.

6. In a rotary coring bit having a body which possesses a drilling face of a character to engage the bottom of a hole in which the bit is operating, a fluid conduit means therethrough and an axial core passage extending longitu-

dinally therethrough, the improvement which comprises a fluid nozzle in fluid communication with the fluid conduit means and positioned in said drilling face closely adjacent said core passage with said nozzle being of a character to discharge fluid in a path substantially tangential to the periphery of said core passage.

7. A rotary coring bit comprising a body having a drilling face adapted to engage the bottom of a hole in which the bit is operating and a core passage extending longitudinally therethrough and opening into said drilling face, said drilling face containing a plurality of substantially uniformly spaced generally spiral waterways to provide substantially uniformly spaced generally spiral lands between said waterways, each land being engageable with the bottom of the hole across substantially the full width of the land, cutting elements secured to said lands for operation upon the bottom of a hole, each of said spiral waterways commencing at said core passage and extending laterally outwardly therefrom to the outer portion of said body at an increasing angle to a radial line drawn from the body axis to the center of the commencement of said waterways, a fluid nozzle in each said land adjacent said core passage and opening into each said waterway with said nozzle being of a character to discharge fluid in a path substantially parallel to said face and substantially tangential to the periphery of said core passage and conduit means through said body fluidly communicating with said nozzle.

8. In a rotary coring bit including a body portion adapted to be connected to the lower end of a coring barrel and having a drilling face at its lower end, a core passage extending longitudinally through the bit, a plurality of substantially uniformly spaced smooth curved waterways in said face which define lands between said waterways, with each of said curved waterways beginning adjacent the periphery of said core passage and extending laterally outwardly, a drilling fluid passageway leading longitudinally through said bit to said waterways in the face of the bit, the improvement which comprises: a drilling fluid nozzle at the lower end of each said drilling fluid passageway positioned closely adjacent said core passage, each nozzle being arranged to discharge fluid into one of said waterways in a path substantially parallel to said face and substantially tangential to the periphery of said core passage, each portion of the lands of the face between the waterways and said core passage being recessed with respect to the portion of the cutting face immediately adjacent to the land and core passage but not recessed as much as the waterways.

9. In a rotary coring bit including a body portion adapted to be connected at its upper end to a string of drill pipe and having a drilling face at its lower end, a core passage extending longitudinally through the bit, a plurality of substantially uniformly spaced waterways beginning closely adjacent to the periphery of said core passage and extending outwardly and forming lands between said waterways, a plurality of drilling fluid passageways leading through the body of the bit from said drill string to said waterways, the improvement which comprises: a fluid nozzle at the lower end of each said drilling fluid passageway closely adjacent said core passage, each nozzle being arranged to discharge fluid into one of said waterways in a path essentially in a plane substantially tangential to the periphery of said core passage and also having a vertical component which is less than about 30° downward from the horizontal.

10. In a rotary coring bit having a body which possesses a drilling face of a character to engage the bottom of a hole in which the bit is operating and axial core passage extending longitudinallly therethrough, and in which the drilling face contains a plurality of spaced waterways and spaced lands, the improvement which comprises a fluid nozzle in each said land closely adjacent said core passage with said nozzle being of a character to discharge fluid in a path substantially parallel to said face and substantially tangential to the periphery of said core passage.

11. In a rotary drill bit: a body having a drilling face adapted to engage the bottom of a hole in which the bit is operating and a central inlet passage for receiving a core produced by the bit; said drilling face containing a plurality of spaced watercourses providing spaced lands extending substantially from said inlet passage to the periphery of the body; said body having a plurality of fluid discharge passages having outlets in said watercourses closely adjacent to said inlet passage; each discharge passage being directed to discharge fluid laterally from its outlet along the watercourse into which its outlet opens and laterally outwardly along a land adjacent thereto and in a direction toward the periphery of the body, said direction of discharge being substantially tangent to a circle of greater radius than said inlet passage and having a center coincident with the axis of said inlet passage; means for supplying fluid to inlet ends of said fluid discharge passages; and cutting elements secured to said lands.

12. In a rotary drill bit: a body having a drilling face adapted to engage the bottom of a hole in which the bit is operating and a central inlet passage for receiving a core produced by the bit; said drilling face containing a plurality of generally spiral watercourses spaced circumferentially from each other and extending outwardly from said inlet passage to the outer portion of said body to provide circumferentially spaced, generally spiral lands between said watercourses beginning at said inlet passage; the arcuate extent of each watercourse and land around the drilling face being substantially less than 360 degrees; said body having a plurality of fluid discharge passages having outlets in said watercourses closely adjacent to said inlet passage; each discharge passage being directed to discharge fluid laterally outwardly from its outlet along the watercourse into which its outlet opens and laterally outwardly along a land adjacent thereto in a direction toward the outer portion of said body at the outer ends of said watercourse and adjacent land, said direction of discharge being substantially tangent to a circle closely adjacent to and of greater radius than said inlet passage and having a center coincident with the axis of said inlet passage; means for supplying fluid to inlet ends of said fluid discharge passages; and cutting elements secured to said lands.

13. In a rotary drill bit: a body having a drilling face adapted to engage the bottom of a hole in which the bit is operating and a central inlet passage for receiving a core produced by the bit; said drilling face containing a plurality of spaced watercourses providing spaced lands extending substantially from said inlet passage to the periphery of the body; said body having a plurality of fluid discharge passages having outlets in said watercourses closely adjacent to said inlet passage; each discharge passage being directed to discharge fluid laterally along the watercourse into which its outlet opens from said outlet to the outer portion of said body and laterally outwardly along a land adjacent thereto and in a direction toward the periphery of the body, said direction of discharge being substantially tangent to a circle closely adjacent to and of greater radius than said inlet passage and having a center coincident with the axis of said inlet passage; means for supplying fluid to inlet ends of said fluid discharge passages; and cutting elements secured to said lands.

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