(11) Application No. AU 2011201710 A1

(19) AUSTRALIAN PATENT OFFICE

(54) Title
Core drill bit with extended matrix height

(51)[6] International Patent Classification(s)
E21B 10/26 (2006.01) 20060101AFI2011041
E21B 10/26 9BHAU

(21) Application No: 2011201710 (22) Application Date: 2011.04.15

(43) Publication Date : 2011.05.12
(43) Publication Journal Date : 2011.05.12

(62) Divisional of:
2007333850

(71) Applicant(s)
Longyear TM, Inc.

(72) Inventor(s)
Drivdahl, Kristian Shayne; Rupp, Michael

(74) Agent/Attorney
Phillips Ormonde Fitzpatrick, 367 Collins Street, Melbourne, VIC, 3000

2011201710 15 Apr 2011

ABSTRACT

Core drill bits with extended matrix heights are described. The core drill bits have a series of slots or openings that are not located at the tip of the cutting portion and are therefore enclosed in the body of the matrix. The slots may be staggered and/or stepped throughout the matrix. As the matrix of the drill bit erodes through normal use, the fluid/debris notches at the tip of the bit are eliminated. As the erosion progresses, the slots become exposed and then they function at the proximal face of the bit as fluid/debris ways. This configuration allows the matrix height to be extended and lengthened without substantially reducing the structural integrity of the drill bit. With an extended matrix height, the drill bit can last longer and require less tripping in and out of the borehole to replace the drill bit.

DIV 909507

2011201710 15 Apr 2011

AUSTRALIA

Patents Act

COMPLETE SPECIFICATION
(ORIGINAL)

Class Int. Class

Application Number:
Lodged:

Complete Specification Lodged:
Accepted:
Published:

Priority

Related Art:

Name of Applicant:

Longyear TM, Inc.

Actual Inventor(s):

Kristian Shayne Drivdahl, Michael Rupp

Address for Service and Correspondence:

PHILLIPS ORMONDE FITZPATRICK
Patent and Trade Mark Attorneys
367 Collins Street
Melbourne 3000 AUSTRALIA

Invention Title:

CORE DRILL BIT WITH EXTENDED MATRIX HEIGHT

Our Ref : 909507
POF Code: 1062/495201

The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

6006q

2011201710 15 Apr 2011

CORE DRILL BIT WITH EXTENDED MATRIX HEIGHT

The present application is a divisional application from Australian Patent Application No. 2007333850, the entire disclosure of which is incorporated herein by reference.

CLAIM OF PRIORITY

This application claims priority of United States Patent Application No. 11/610,680, filed on December 14, 2006, the entire disclosure of which is incorporated herein by reference.

FIELD

This application relates generally to in-ground drill bits. In particular, this application relates to core drill bits with an extended matrix height and methods of making and using such drill bits.

BACKGROUND

Often, core drilling processes are used to retrieve a sample of a desired material. The core drilling process connects multiple lengths of drilling rod together to form a drill string that can extend for thousands of feet. The drill bit is located at the very tip of the drill string and is used to perform the actual cutting operation. As the core drill bit cuts its way through the desired material, cylindrical samples are allowed to pass through the hollow center of the drill bit, through the drill string, and then can be collected at the opposite end of the drill string. Many types of core drill bits are currently used, including diamond-impregnated core drill bits. A portion of this drill bit is generally formed of steel or a matrix containing a powdered metal or a hard particulate material, such as tungsten carbide. This matrix material is then infiltrated with a binder, such as a copper alloy. As shown in Figure 1, the matrix 202 of the drill bit 200 is generally impregnated with synthetic diamonds or super-abrasive materials (e.g., polycrystalline diamond). As the drill bit grinds and cuts through various materials, the matrix 202 of the drill bit 200 erodes, exposing new layers of the sharp synthetic diamond or other super-abrasive materials.

The drill bit may continue to cut efficiently until the matrix of the drill bit is totally consumed. At that point, the drill bit becomes dull and must be replaced with a new drill bit. This replacement begins by removing (or tripping out) the entire drill string out of the hole that has been drilled (or the borehole). Each section of the drill rod must be sequentially removed from the borehole. Once the drill bit is replaced, the entire drill string must be assembled section by section and then tripped back into the borehole. Depending on the depth of the borehole and the characteristics of the materials being drilled, this process may need to be repeated multiple times for a single borehole. As a result, drill bits that last longer need to be replaced less often.

The matrix heights for these drill bits are often limited by several factors, including the need to include fluid/debris ways 206 in the matrix, as shown in Figure 1. These fluid/debris ways serve several functions. First, they allow flushing for debris produced by the cutting action of the bit to be removed. Second, they allow drilling muds or fluids to be used to lubricate and cool the drill bit. Third, they help maintain hydrostatic equilibrium around the drill bit and thereby prevent fluids and gases from the material being drilled from entering the borehole and causing blow out.

These fluid/debris ways are placed in the matrix at the tip of the cutting portion of the core drill bit. Because the cutting portion of the core drill bit rotates under pressure and has gaps 208 resulting from the fluid/debris ways 206, the cutting portion can lose structural integrity and then become susceptible to vibration, cracking, and fragmentation. To avoid these problems, the matrix height of diamond-impregnated core drill bits is often limited to heights of 16 millimeters (or about 5/8 of an inch) or less. However, with these shorter heights, the drill bits need to be replaced often because they wear down quickly.

A reference herein to a patent document or other matter which is given as prior art is not to be taken as an admission or a suggestion that that document or matter was known or that the information it contains was part of the common general knowledge as at the priority date of any of the claims.

SUMMARY

Core drill bits with extended matrix heights are described in this patent application. The core drill bits have a series of slots or openings that are not located at the tip of the cutting portion and are therefore enclosed in the body of the matrix. The slots may be staggered and/or stepped throughout the matrix. As the matrix of the drill bit erodes through normal use, the fluid/debris notches at the tip of the bit are eliminated. As the erosion progresses, the slots become exposed and then they function at the proximal face of the bit as fluid/debris ways. This configuration allows the matrix height to be extended and lengthened without substantially reducing the structural integrity of the drill bit. With an extended matrix height, the drill bit can last longer and require less tripping in and out of the borehole to replace the drill bit.

BRIEF DESCRIPTION OF THE DRAWINGS

The following description can be better understood in light of Figures, in which:

DIV 909507

Figure 1 illustrates a conventional core drill bit;

Figure 2 illustrates a view of some embodiments of a core drill bit with an extended matrix height;

Figure 3 shows an illustration of a side view of some embodiments of a conventional core drill bit next to some embodiments of a core drill bit with an extended matrix height;

Figure 4 shows a view of some embodiments of a core drill bit with enclosed fluid/debris slots;

Figure 5 shows a side view of some embodiments of a drill bit with an extended matrix height that has been eroded down, as depicted by hatching; and

Figure 6 shows a comparative view of two drill bits used in an exemplary drilling process.

Together with the following description, the Figures demonstrate and explain the principles of the apparatus and methods for using the apparatus. In the Figures, the thickness and configuration of components may be exaggerated for clarity. The same reference numerals in different Figures represent the same component.

DETAILED DESCRIPTION

The following description supplies specific details in order to provide a thorough understanding. Nevertheless, the skilled artisan would understand that the apparatus and associated methods of using the apparatus can be implemented and used without employing these specific details. Indeed, the apparatus and associated methods can be placed into practice by modifying the illustrated apparatus and associated methods and can be used in conjunction with any apparatus and techniques conventionally used in the industry. For example, while the description below focuses on an extended matrix height for diamond-impregnated core drill bits, the apparatus and associated methods can be equally applied in carbide, ceramic, or other super-abrasive core drill bits. Indeed, the apparatus and associated methods may be implemented in many other in-ground drilling applications, such as sonic drills, percussive drills, reverse-circulation drills, oil & gas drills, navi-drills, full-hole drills, and the like.

Core drill bits that maintain their structural integrity while extending the length or height of the matrix are described below. One example of such a core drill bit is illustrated in Figure 2. As shown in Figure 2, the drill bit 20 may contain a first section 21 that connects to the rest of the drill (i.e., a drill rod). The drill bit 20 may also contain a second section 23 that is used to cut the desired materials during the drilling process. The body of the drill bit has an outer surface 8 and an inner surface 4 that contains a hollow portion therein. With this configuration, pieces of the material being drilled can pass through the hollow portion and up through the drill string.

The drill bit 20 may be any size suitable for collecting subterranean core samples. Accordingly, the drill bit 20 may be used to collect core samples of any suitable size. While the drill bit may have any desired diameter and may be used to remove and collect core samples with any desired diameter, the diameter of the drill bit may often range from about 1 to about 12 inches. As well, while the kerf of the drill bit (the radius of the outer surface minus the radius of the inner surface) may be any width, it may generally range from about ½ of an inch to about 6 inches.

The first section 21 of the drill bit 20 may be made of any suitable material. In some embodiments, the first section may be made of steel or a matrix casting with a hard particulate material in a binder. Some non-limiting examples of a suitable hard particulate material may include those known in the art, as well as tungsten carbide, tungsten, iron, cobalt, molybdenum, and combinations thereof. Some non-limiting examples of a binder that can be used may include those known in the art, as well as copper alloys, silver, zinc, nickel, cobalt, molybdenum, and combinations thereof.

In some embodiments, the first section 21 may contain a chuck end 22, as is shown in Figure 2. This chuck end 22, sometimes called a blank, bit body, or shank, may be used for any appropriate purpose, including connecting the drill bit to the nearest drill rod. Thus, the chuck end 22 can be configured as known in the art to connect the drill bit 20 to any desired type of drill rod. For example, the chuck end 22 may include any known mounting structure for attaching the drill bit to any conventional drill rod (e.g., a threaded pin connection used to secure the drill bit to the drive shaft at the end of a drill string).

The embodiments illustrated in Figure 2 show the second section 23 of the core drill bit 20 may comprise a cutting portion 24. The cutting portion 24, often called the crown, may be constructed of any material known in the art. Some non-limiting examples of suitable materials may include a powder of tungsten carbide, boron nitride, iron, steel, cobalt, molybdenum, tungsten, and/or a ferrous alloy. The material(s) may be placed in a mold (e.g., a graphite mold). The powder may then be sintered and infiltrated with a molten binder, such as a copper, iron, silver, zinc, or nickel alloy, to form the cutting portion.

2011201710 15 Apr 2011

In some embodiments, the second section 23 of the drill bit may be made of one or more layers. For example, Figure 2 illustrates that the cutting portion 24 may contain two layers. The first layer may be the previously mentioned matrix layer 16, which performs the cutting operation. The second layer may be a backing layer 18, which may connect the matrix layer 16 to the first and/or second section of the drill bit. In these embodiments, the matrix layer 16 may contain cutting media that may abrade and erode the material being drilled. Any suitable cutting media may be used in the matrix layer 16, including, but not limited to, natural or synthetic diamonds (e.g., polycrystalline diamond compacts). In some embodiments, the cutting media may be embedded or impregnated into the matrix layer 16. Additionally, any desired size, grain, quality, shape, grit, concentration, etc. of cutting media may be used in the matrix layer 16, as is known in the art.

The cutting portion 24 of the drill bit may be manufactured to any desired specification or may be given any desired characteristic. In this way, the cutting portion may be custom-engineered to possess optimal characteristics for drilling specific materials. For example, a hard, abrasion-resistant matrix may be made to drill soft, abrasive, unconsolidated formations, while a soft ductile matrix may be made to drill an extremely hard, non-abrasive, consolidated formation. In this way, the bit matrix hardness may be matched to particular formations, allowing the matrix layer 16 to erode at a controlled and desired rate.

The height A of the drill bit matrix (as shown in Figure 2) can be extended to be longer than those currently known in the art while maintaining its structural integrity. Conventional matrix heights may often be limited to 16 millimeters or less because of the need to maintain structural stability. In some embodiments, the matrix height A can be increased to be several times these lengths. In some circumstances, the matrix height can range from about 1/2 to about 6 inches. In other circumstances, the matrix height can range from about 1 to about 5 inches. In yet other circumstances, the matrix height can range between about 1 and about 3.5 inches. Indeed, in some circumstances, the matrix height may be about 3 inches.

Figure 3 illustrates one example of drill bit 20 with the extended matrix height next to a conventional core drill bit 40. In Figure 3, the first section 21 of the drill bit 20 is roughly the same size as a corresponding first section 42 of the conventional drill bit 40. Nevertheless, the corresponding matrix height A- of the conventional drill bit 40 is roughly half the height of the extended matrix height A of the drill bit 20.

The cutting portion 24 of the drill bit can contain a plurality of fluid/debris ways 28 and 32, as shown in Figure 2. For instance, the fluid/debris ways 28 and 32 may be located at or distal to the proximal face 36 as well as along the length of the matrix of the drill bit 20. Those fluid/debris ways located at the proximal face 36 will be referred to as notches, while those located distal to the proximal face 36 will be referred to as slots 32. The fluid/debris ways may have different configurations to influence the hydraulics, fluid/debris flow, as well as the surface area used in the cutting action.

The cutting matrix 16 may have any known number of fluid/debris notches 28 that provide the desired amount of fluid/debris flow and also allow the cutting portion to maintain the structural integrity needed. For example, Figure 2 shows the drill bit 20 may have three fluid/debris notches 28. In some embodiments, the drill bit may have fewer notches, such as two or even one fluid/debris notch. In other embodiments, though, the drill may have more notches, such as 4, 5, or even more.

The fluid/debris notches 28 may be evenly spaced around the circumference of the drill bit. For example, Figure 2 depicts that the drill bit 20 may have three fluid/debris notches 28 that are evenly spaced apart from each other. In other embodiments, however, the notches 28 need not be evenly spaced around the circumference.

The fluid/debris notches 28 may have any characteristic that allows them to operate as intended and any configuration known in the art. For example, the fluid/debris notches 28 may completely penetrate through the matrix of the drill bit. According to some embodiments, Figure 2 illustrates that the fluid/debris notches 28 may penetrate through the matrix so as to have an opening 13 on the outer surface 8 of the drill bit 20 and an opening 14 on the inner surface 4 of the drill bit 20.

The fluid/debris notches 28 may have any shape that allows them to operate as intended. In some non-limiting examples of the types of shapes the notches 28 can have, the notches 28 may be rectangular (as illustrated in Figure 2), square, triangular, circular, trapezoidal, polygonal, elliptical, or any combination thereof.
The fluid/debris notches 28 may be any size (e.g., width, height, length, diameter, etc.) that will allow them to operate as intended and as known in the art. For example, the drill bit could have many small fluid/debris notches. In another example, the drill bit may have a few large fluid/debris notches and some small notches. In the example depicted in Figure 2, however, the drill bit 20 contains just a few (3) large fluid/debris notches 28.

2011201710 15 Apr 2011

The opening 13 of the fluid/debris notches that is located on the outer surface 8 of the drill bit 20 may be larger or smaller than the opening 14 on the inner surface 4, or vice versa. Additionally, the two openings may have similar or dissimilar shapes. By way of non-limiting example, the opening 13 on the outer surface 8 could be a small square-shaped opening and the opening 14 on the inner surface 4 could be a larger, rectangular-shaped opening. Thus, in some embodiments, the inner walls of the notches (e.g., the notch inner wall 15 in Figure 2) need not always be planar, but may have any desired shape. For example, while the inner walls of the notches may be substantially planar, in other embodiments, the inner walls of the notches may be bowed, curved, rounded, irregular, etc.

Each of the fluid/debris notches 28 may be configured in the same or different manner. For instance, the notches 28 depicted in Figure 2 are each made with substantially the same configuration. However, in other embodiments, the notches 28 can be configured so as to have different sizes, shapes, and/or other characteristics than other notches 28.

The fluid/debris notches 28 may also be placed in the matrix 16 with any desired orientation. For example, the notches 28 may point to the center of the circumference of the drill bit. In other words, the notches 28 may be formed to run substantially perpendicular to the circumference of the drill bit, as is illustrated in Figure 2. However, in other embodiments, the fluid/debris notches 28 may be formed to point away from the center of the circumference of the drill bit. For example, the notch opening 13 on the outer surface 8 and the opening 14 on the inner surface 4 of the drill bit 20 may be offset longitudinally and/or laterally from each other.

The cutting matrix 16 of the drill bit also contains one or more fluid/debris slots (or slots) 32. These slots 32 may have an opening 10 on the outer surface 8 of the drill bit 20 and an opening 12 on the inner surface 4 of the drill bit 20. Because they may be enclosed in the body of the matrix, or surrounded by the matrix on all sides except at the openings 10 and 12, the fluid/debris slots 32 may be located in any part of the matrix 16 except the proximal face 36. As the matrix erodes away, the fluid/debris slots 32 are progressively exposed as the erosion proceeds along the length of the matrix. As this happens, the fluid/debris slots then become fluid/debris notches. In this manner, drill bits with such fluid/debris slots may have a continuous supply of fluid/debris ways until the extended matrix is worn completely away. Such a configuration may therefore allow a longer matrix height while maintaining the structural integrity of the cutting matrix of the drill bit.

The matrix 16 may have any number of fluid/debris slots 32 that allows it to maintain the desired structural integrity and flow of fluid/debris. In some embodiments, the drill bit may have 0 to 200 slots. In other embodiments, however, the drill bit may have 1 to 20 slots. In still other embodiments, the drill bit may contain anywhere from 1 to 6 or even 1 to 3 slots. In the examples of the drill bit shown in Figure 2, the drill bit 20 contains 6 fluid/debris slots 32.

The fluid/debris slots 32 may be evenly spaced around the circumference of the drill bit. For example, Figure 2 shows the drill bit may have 6 slots that are substantially evenly spaced around the circumference. In other situations, though, the slots 32 need not be evenly spaced around the circumference or within the matrix.

The fluid/debris slots 32 may have any shape that allows them to operate as intended. Some non-limiting examples of the types of shapes the slots can have may include shapes that are rectangular (as illustrated in Figure 2), triangular, square, circular, trapezoidal, polygonal, elliptical, or any combination thereof.

The fluid/debris slots 32 may have of any size (e.g., height, width, length, diameter, etc.) that will allow them to operate as intended. For example, a drill bit could have many small fluid/debris slots. In another example, a drill bit may have a few large fluid/debris slots and some small slots. In the example depicted in Figure 2, for instance, the drill bit 20 contains just six large fluid/debris slots 32.

The fluid/debris slots 32 may be configured in the same or different manner. The slots 32 depicted in Figure 2 are made with substantially the same configuration. However, in other embodiments, the slots can be configured with different sizes, shapes, and/or other characteristics. For example, the bit may have multiple rows of thin, narrow fluid/debris slots. Nevertheless, in another example, the described drill bit may have a single row of tall, wide fluid/debris slots.

The fluid/debris slots 32 may also be placed in the matrix with any desired orientation. For example, Figure 2 shows the slots 32 may be formed so as to be oriented toward the center of the circumference of the drill bit. Therefore, in some embodiments, the slots 32 may be perpendicular to the circumference of the drill bit. However, in other embodiments, the slots 32 may be formed so as to be oriented away from the center of the circumference of the drill bit. For example, the slot opening 10 on the outer surface 8 and the slot opening 12 on the inner surface 4 of the drill bit 20 may be offset longitudinally and/or laterally from each other.

The drill bits may include one or multiple layers (or rows) of fluid/debris slots and each row may contain one or more fluid/debris slots. For example, Figure 4 shows a drill bit 20 that has six fluid/debris slots 32. In Figure 4, the drill bit 20 has three fluid/debris slots 32 in a first row 90. Further away from the proximal face 36, Figure 4 shows the drill bit 20 may have a second row 92 of three more fluid/debris slots 32. As another example of a drill bit with six slots, the drill bit 20 could be configured to have 3 rows of two slots each, or even 6 rows of one slot each. The rows can contain the same or a different number of slots. Also, the number of fluid/debris slots in each row may or may not be equal to the number of fluid/debris notches 28 in the proximal face 36 of the drill bit.

The first opening 10, shown in Figure 2, of the fluid/debris slots (on the outer surface 8) may be larger or smaller (or have a different shape) than the second opening 12 on the inner surface 4. By way of non-limiting example, the first opening 10 could have a small trapezoidal shape and the second opening 12 could have a larger, rectangular-shaped opening. Accordingly, in some embodiments, the inner walls of the slots (e.g., the inner slot wall 17 in Figure 2) need not always be planar, as illustrated in Figure 2, but may have any desired shape. For example, while the inner surfaces of the slots may be substantially planar, in other embodiments, the inner surfaces of the notches may be bowed, curved, rounded, irregular, etc.

In some instances, a portion of the fluid/debris slots 32 may overlap one or more fluid/debris slots or notches in any desired manner. For example, a portion of the fluid/debris slots 32 may laterally overlap one or more fluid/debris notches. As well, in another example, a portion of a fluid/debris slot may laterally overlap another slot. Thus, before a fluid/debris slot (which has become a notch) erodes completely, the other fluid/debris slot may be opened to become a notch, allowing the drill bit to continue to cut efficiently.

The fluid/debris slots may be placed in the drill bit in any configuration that provides the desired fluid dynamics. For example, in some embodiments, the fluid/debris slots may be configured in a staggered manner throughout the matrix of the drill bit. They may also be staggered with the fluid/debris notches. The slots and/or notches may be arranged in rows and each row may have a row of fluid/debris slots that are offset to one side of the fluid/debris slots and/or notches in the row just proximal to it. Additionally, even though the slots/notches may not be touching, they may overlap laterally as described above.

In some embodiments, the fluid/debris notches 28 and/or slots 32 may be configured in a stepped manner. Thus, each notch in the proximal face may have a slot located distally and to one side of it (i.e., to the right or left). Each slot in the next row may then have another slot located distally and off to the same side as the slot/notch relationship in the first row.

In some embodiments, the fluid/debris notches and/or slots may be configured in both a staggered and stepped manner, as shown in Figure 2. In Figure 2, three fluid/debris notches 28 are located in the proximal face 36 of the cutting portion 24 of the drill bit 20. Distally and in the clockwise direction of each fluid/debris notch, a corresponding fluid/debris slot is located and slightly laterally overlaps the notch. Distally and in the clockwise direction of these fluid/debris slots 32, a second set of fluid/debris slots 32 is located.

As shown in Figure 2, the cutting portion 24 may optionally contain flutes 40. These flutes may serve many purposes, including aiding in cooling the bit, removing debris, improving the bit hydraulics, and making the fluid/debris notches and/or slots more efficient. The flutes may be placed in the drill bit in any configuration. In some embodiments, the flutes may be located on the outer surface 8 and may therefore be called outer flutes. In another embodiment, the flutes may be located on the inner surface 4 and may therefore be called inner flutes. In yet another embodiment, the flutes may be located in between the inner 4 and the outer surface 8 of the drill bit 20 and may therefore be called face flutes. In still other embodiments, the flutes may be located in the drill bit in any combination of these flute locations.

The flutes 40 may have any desired characteristic. For example, the size (e.g., length, width, amount of penetration into the cutting portion, etc.), shape, angle, number, location, etc. of the flutes may be selected to obtain the desired results for which the flutes are used. The flutes may have any positional relationship relative to the fluid/debris notches and/or slots, including that relationship shown in Figure 2. In the example provided below, an increase in the penetration rate was observed in drill bits comprising flutes as well as fluid/debris notches and slots. This increased penetration rate was likely due, in part, to the increased bit face flushing, which may be partially due to the combination of larger waterways and the inner and outer flutes.

The cutting portion 24 of the drill bit may have any desired crown profile. For example, the cutting portion of the drill bit may have a V-ring bit crown profile, a flat face bit crown profile, a stepped bit crown profile, an angled-tapered crown profile, or a semi-round bit crown profile. In some embodiments, the drill bit has the crown profile illustrated in Figure 2.

In addition to the previously mentioned features, any additional feature known in the art may optionally be implemented with the drill bit 20. For example, the drill

2011201710 15 Apr 2011

bit may have additional gauge protection, hard-strip deposits, various bit profiles, and combinations thereof. Protector gauges may be included to reduce the damage to the well's casing and to the drill bit as it is lowered into the casing. The first section of the drill bit may have hard-metal strips applied to it so as to prevent its premature erosion. The drill bit may also optionally contain natural diamonds, polycrystalline diamonds, thermally stable diamonds, tungsten carbide, pins, cubes, or other superhard materials for gauge protection on the inner or outer surface of the core drill bit.

Another feature that can be included is a partial or complete filling of the slots with a material that remains in the slots until that slot containing the material is near to, or exposed at, the face of the bit. At that point, the material erodes away to leave the slot open. In these embodiments, the slots may be filled with any soft or brittle material that prevents fluid from flowing through them and forces fluid to be pushed through the notches and across the face, thereby leaving the fluid pressure as high as possible at the fact of the bits. Such filler materials may then break away or disintegrate faster than the matrix and allow fluid to flow once the slots are eroded into notches. Possible filler materials include silicones, clays, ceramics, plastics, foam, etc.

The drill bits described above can be made using any method that provides them with the features described above. The first section can be made in any manner known in the art. For instance, the first section (i.e., the steel blank) could be machined, sintered, or infiltrated. The second section can also be made in any manner known in the art, including infiltration, sintering, machining, casting, or the like. The notches 28 and slots 32 can be made in the second section either during or after such processes by any suitable method. Some non-limiting examples of such methods may include the use of inserts in the molding process, machining, water jets, lasers, Electrical Discharge Machining (EDM), and infiltration.

The first section 21 can then be connected to the second section 23 of the drill bit using any method known in the art. For example, the first section may be present in the mold that is used to form the second section of the drill bit and the two ends of the body may be fused together. Alternatively, the first and second sections can be mated in a separate process, such as by brazing, welding, mechanical bonding, adhesive bonding, infiltration, etc.

The drill bits may be used in any drilling operation known in the art. As with other core drill bits, they may be attached to the end of a drill string, which is in turn

2011201710 15 Apr 2011

connected to a drilling rig. As the core drill bit turns, it grinds/cuts away the materials in the subterranean formations that are being drilled. The matrix layer 16 and the fluid/debris notches 28 erode over time. As the matrix layer 16 erodes, the fluid/debris slots 32 may be exposed and become fluid/debris notches. As more of the matrix layer erodes, additional fluid/debris slots are then exposed to become fluid/debris notches. This process may continue until the matrix of the drill bit has been consumed and the drill string needs be tripped out for bit replacement.

Figure 5 shows one example of a worn drill bit 80. In Figure 5, the entire row of fluid/debris notches 128 in the cutting portion 124 of the drill bit 80 has been eroded, as shown by the hatching. Additionally, a first row 106 of fluid/debris slots 132 has eroded. Thus, a second row 108 of fluid/debris slots 132 remains to act as notches 128. Despite this erosion, the drill bit in this condition may still be used just as long as a conventional drill bit.

Using the drill bits described above may provide several advantages. First, the height of the matrix may be increased beyond those lengths conventionally used without sacrificing structural integrity. Second, the usable life of the drill bit can be magnified by about 1.5 to about 2.5, or more, times the normal usable life. Third, the drilling process may become more efficient since less tripping in and out if the drill string is needed. Fourth, the penetration rate of the drill bits can be increased by up to about 25% or more. Fifth, since the bit surface consistently replaces itself with a consistent cutting surface area, the drill bit may have consistent cutting parameters.

The following non-limiting Example illustrates some embodiments of the described drill bit and associated methods of using the drill bit.

EXAMPLE

A first, conventional drill bit was obtained off-the-shelf. The first drill bit was manufactured to have an ALPHA 7COM® (Boart Longyear Co.®) formulation and measured to have a matrix height of about 12.7 millimeters. The first drill bit had a bit size of about 2.965 inches outer diameter (OD) X 1.875 inches inner diameter (ID) (NQ). The first drill bit is depicted as Drill #1 in Figure 6.

A second drill bit was manufactured to contain the slots described above. The second drill bit was also made with an Alpha 7COM® (Boart Longyear Co.®) formulation, but contained three notches and six rectangular slots with a size of about 0.470 inches wide by about 0.334 inches high. The second drill bit was also manufactured with nine inner flutes with a diameter of about 0.125 inches and nine

2011201710 15 Apr 2011

outer flutes with a diameter of about 0.187 inches. The second drill bit was also manufactured with a matrix height of about 25.4 millimeters and a bit size of about 2.965 inches OD X about 1.875 inches ID (NQ). The second drill bit is depicted as Drill #2 in Figure 6.

Both drill bits were then used to drill through a medium hard granite formation using a standard drill rig. Before its matrix was worn out and needed to be replaced, the first drill bit was able to drill through about 200 meters, at penetration rate of about 6-8 inches per minute. The second drill bit was then used on the same drill rig to drill through similar material further down in the same drill hole. Before the matrix on the second drill bit wore out and needed to be replaced, the second drill bit was able to drill through about 488 meters, at penetration rate of about 8-10 inches per minute.

The second drill bit was therefore able to increase the penetration rate by up to about 25%. As well, the usable life of the second drill bit was extended to be about 2.5 times longer that the comparable, conventional drill bit.

In addition to any previously indicated modification, numerous other variations and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of this description, and appended claims are intended to cover such modifications and arrangements. Thus, while the information has been described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred aspects, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, form, function, manner of operation and use may be made without departing from the principles and concepts set forth herein. Also, as used herein, examples are meant to be illustrative only and should not be construed to be limiting in any manner.

2011201710 15 Apr 2011

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An in-ground, core drill bit for retrieving a core sample, comprising:

a shank portion having a first end for attaching to a drill rod, an opposing second end, and a central axis therethrough, said shank portion defining an interior space about said central axis for receiving the core sample; and

a cutting portion secured to and extending axially away from said second end of said shank portion, said cutting portion having an inner surface, and outer surface, and a cutting face, wherein said cutting portion includes a crown height of about 2 inches to about 6 inches, said_cutting portion comprising:

at least one enclosed fluid slot positioned within said crown, said at least one enclosed fluid slot extending from said inner surface to said outer surface, and

at least one outer flute extending at least partially into said outer surface, said at least one outer flute extending axially from said at least one enclosed fluid slot to said shank portion.

2. The drill bit of claim 1, wherein said crown height ranges from about 2 to about 5 inches.

3. The drill bit of claim 1, wherein said crown height is about 3 inches.

4. The drill bit of claim 1, further comprising a fluid notch extending axially into said cutting face, said fluid notch extending from said inner surface of said cutting portion to said outer surface of said cutting portion.

5. The drill bit of claim 4, wherein said at least one enclosed fluid slot becomes an exposed fluid notch as said cutting portion erodes during drilling.

6. The drill bit of claim 5, wherein said at least one enclosed fluid slot is circumferentially offset from said fluid notch.

7. The drill bit of claim 1, wherein said cutting portion comprises a matrix infiltrated with diamond cutting media.

8. A drill bit, comprising: an annular shank;

an annular crown extending axially from said shank, said crown including a cutting face, an inner surface, and an outer surface, wherein said crown has an axial length from said shank to said cutting face of about 1 inch to about 6 inches;

at least one fluid notch extending into said cutting face, said at least one fluid notch extending from said inner surface to said outer surface;

at least one enclosed fluid slot positioned within said crown, said at least one enclosed fluid slot extending from said inner surface to said outer surface; and

at least one outer flute extending radially into said outer surface, said at least one outer flute extending axially from said at least one enclosed fluid slot to said cutting face.

9. The drill bit of claim 8, wherein said at least one outer flute extends from said shank to said cutting face.

10. The drill bit of claim 8, further comprising at least one additional enclosed fluid slot, said at least one additional enclosed fluid slot being circumferentially offset from one or more of said at least one fluid notch and said at least one enclosed fluid slot.

11. The drill bit of claim 10, wherein said at least one additional enclosed fluid slot is axially offset from said at least one enclosed fluid slot.

12. The drill bit of claim 8, wherein said at least one enclosed fluid slot becomes a fluid notch as the crown erodes during drilling.

13. The drill bit of claim 8, wherein said at least one enclosed fluid slot has a first opening in said outer surface of said crown and a second opening in said inner surface of said crown, wherein said first opening of said at least one enclosed fluid slot is larger than said second opening of said at least one enclosed fluid slot.

14. The drill bit of claim 8, further comprising at least one inner flute extending radially into said inner surface, said at least one inner flute extending axially from said at least one enclosed fluid slot to said cutting face.

15. The drill bit of claim 8, wherein said at least one fluid slot has a circumferential width

2011201710 15 Apr 2011

and an axial height, wherein said circumferential width is approximately equal to said axial height.

16. The drill bit of claim 8, wherein said at least one fluid notch has a first opening in said outer surface of said crown and a second opening in said inner surface of said crown, wherein said first opening of said at least one fluid notch is larger than said second opening of said at least one fluid notch.

17. A drilling system comprising:

a drill rig;

a drill string adapted to be secured to and rotated by said drill rig; and

a core drill bit adapted to be secured to said drill string, said drill bit including (i) a shank portion having a first end for attaching to a drill rod, an opposing second end, and a central axis therethrough, said shank portion defining an interior space about said central axis for receiving a core sample, and (ii) a cutting portion secured to and extending axially away from said second end of said shank portion, said cutting portion having an inner surface, and outer surface, and a cutting face, wherein said cutting portion includes a crown height of about 2 inches to about 6 inches, said cutting portion comprising at least one enclosed fluid slot positioned within said crown, said at least one enclosed fluid slot extending from said inner surface to said outer surface, and at least one outer flute extending at least partially into said outer surface, said at least one outer flute extending axially from said at least one enclosed fluid slot to said shank portion.

18. The drilling system of claim 17, wherein said core drill bit further comprises a fluid notch extending axially into said cutting face, said fluid notch extending from said inner surface of said cutting portion to said outer surface of said cutting portion.

19. The drilling system of claim 18, wherein said at least one enclosed fluid slot is circumferentially offset from said fluid notch.

20. An in-ground, core drill bit for retrieving a core sample, comprising:

a shank portion having a first end for attaching to a drill rod, an opposing second end, and a central axis therethrough, said shank portion defining an interior space about said central axis for receiving the core sample; and

DIV 909507

2011201710 15 Apr 2011

a cutting portion secured to and extending axially away from said second end of said shank portion, said cutting portion having an inner surface, and outer surface, and a cutting face, wherein said cutting portion includes a crown height of about 2 or more inches, said cutting portion comprising:

at least one enclosed fluid slot positioned within said crown, said at least one enclosed fluid slot extending from said inner surface to said outer surface, and

at least one inner flute extending at least partially into said inner surface, said at least one inner flute extending axially from said at least one enclosed fluid slot to said shank portion.

DIV 909507

2011201710 15 Apr 2011

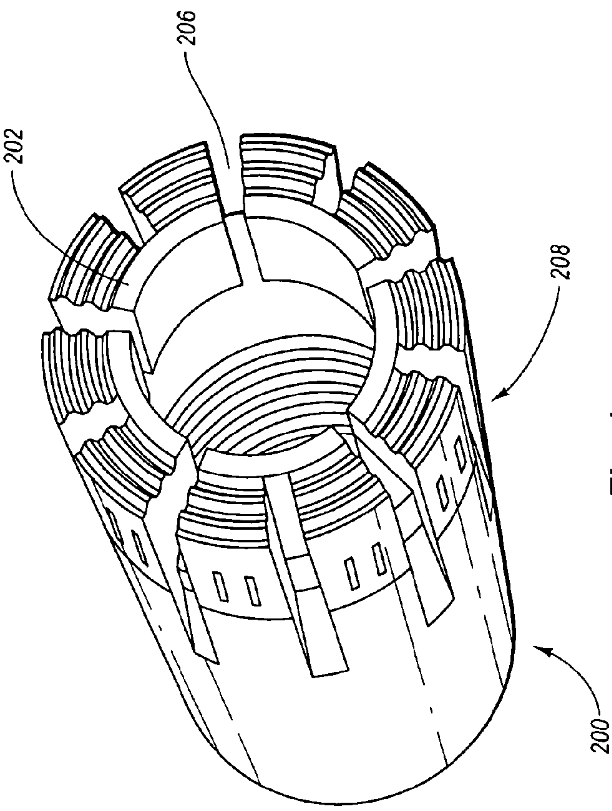


Fig. 1
(Prior Art)

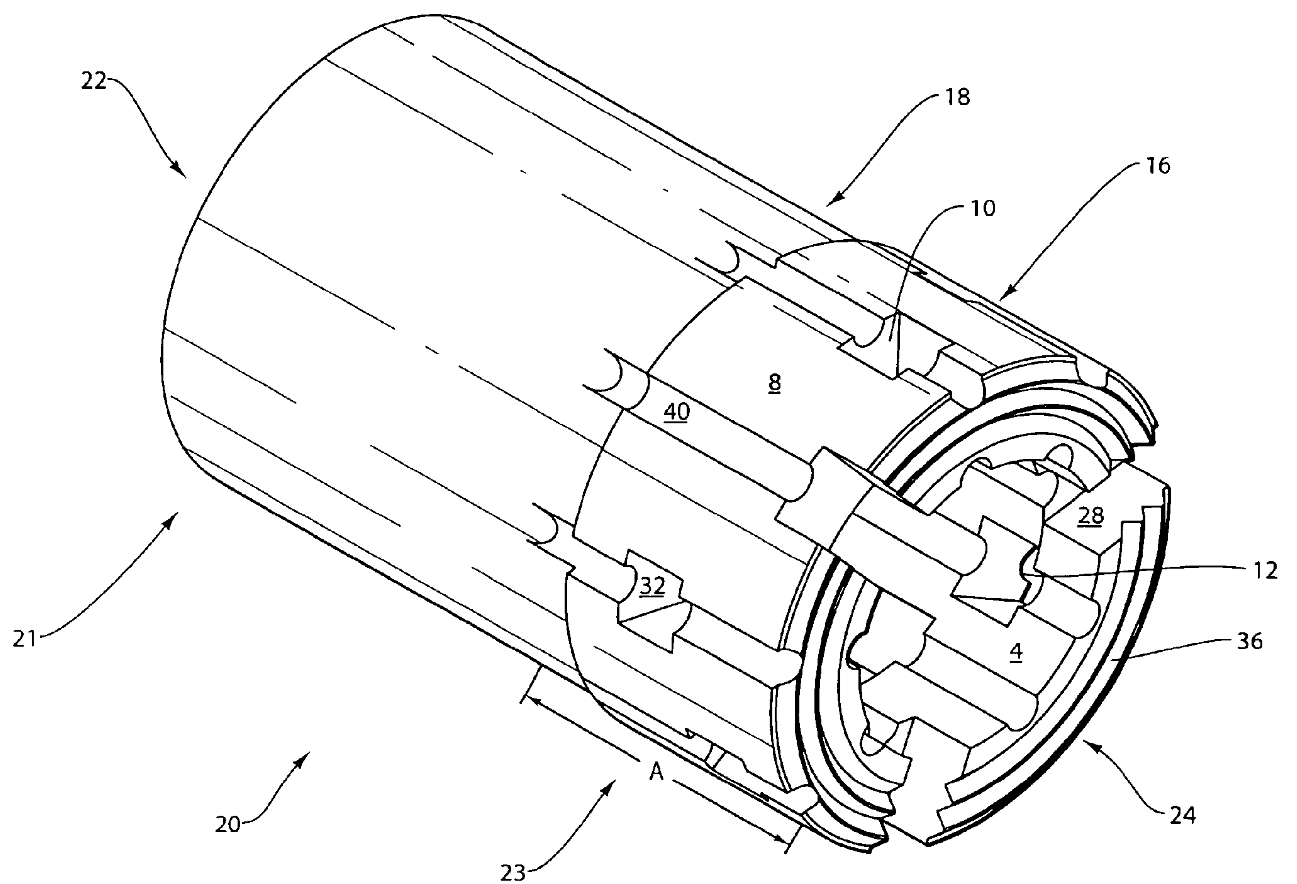


Fig. 2

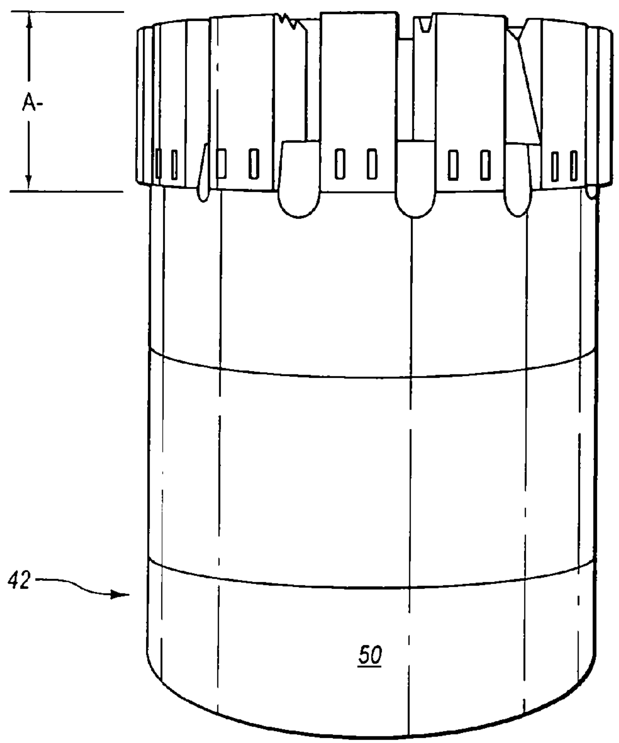


Fig. 3A
(Prior Art)

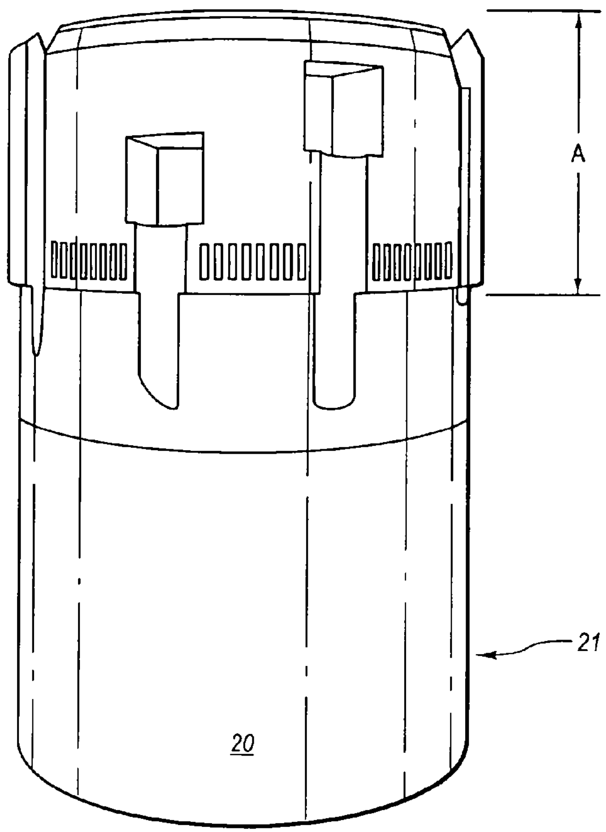


Fig. 3B

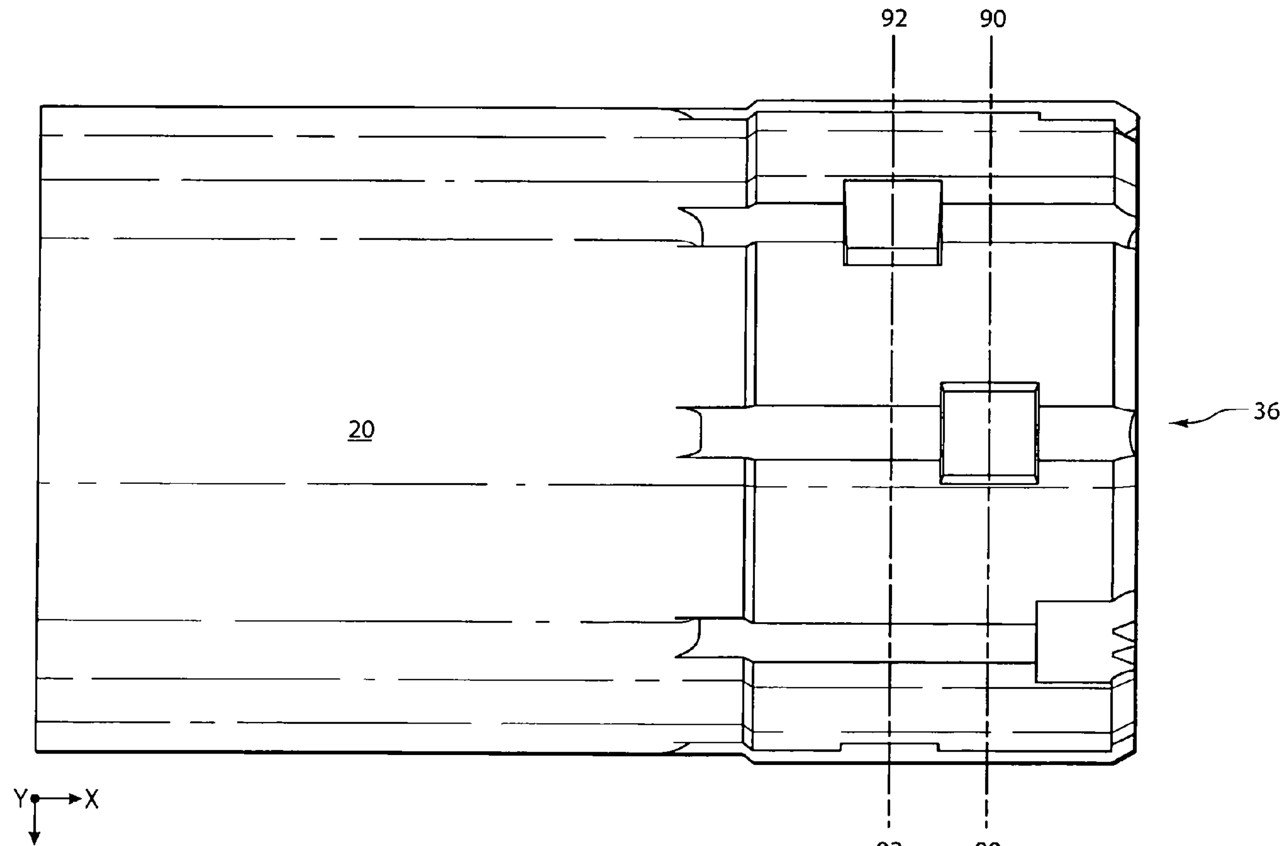


Fig. 4

2011201710 15 Apr 2011

5/6

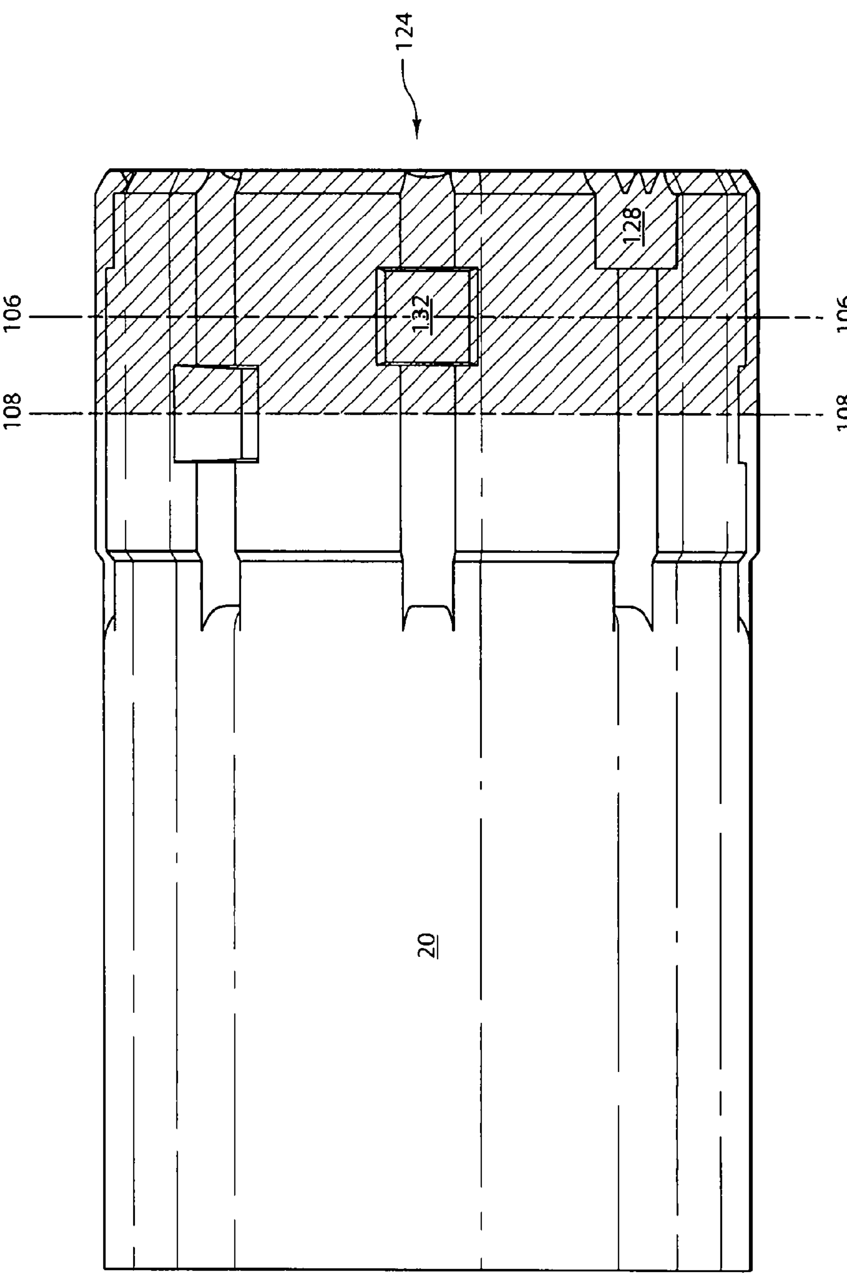
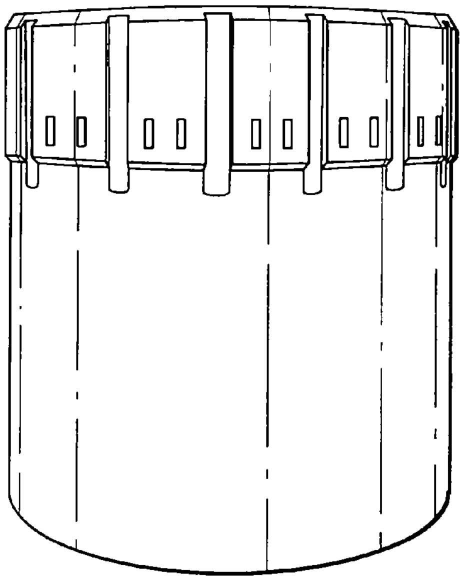
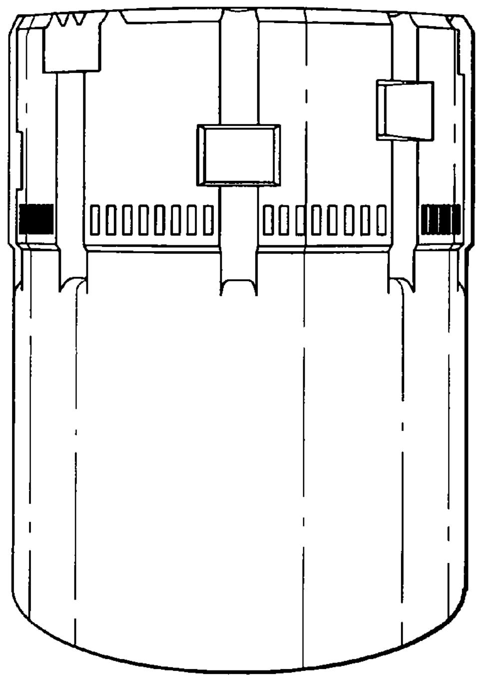


Fig. 5



Drill #1

Fig. 6A
(Prior Art)



Drill #2

Fig. 6B