



(86) Date de dépôt PCT/PCT Filing Date: 2013/06/14
 (87) Date publication PCT/PCT Publication Date: 2013/12/19
 (85) Entrée phase nationale/National Entry: 2015/01/09
 (86) N° demande PCT/PCT Application No.: US 2013/045943
 (87) N° publication PCT/PCT Publication No.: 2013/188798
 (30) Priorité/Priority: 2012/06/14 (US61/659,677)

(51) Cl.Int./Int.Cl. *E21B 10/62* (2006.01),
E21B 10/627 (2006.01), *E21B 23/00* (2006.01)
 (71) Demandeur/Applicant:
BLOOMFIELD, JOHN, US
 (72) Inventeur/Inventor:
BLOOMFIELD, JOHN, US
 (74) Agent: MACPHERSON LESLIE & TYERMAN LLP

(54) Titre : DISPOSITIF ET PROCEDE DE FORAGE
 (54) Title: DRILLING DEVICE AND PROCESS

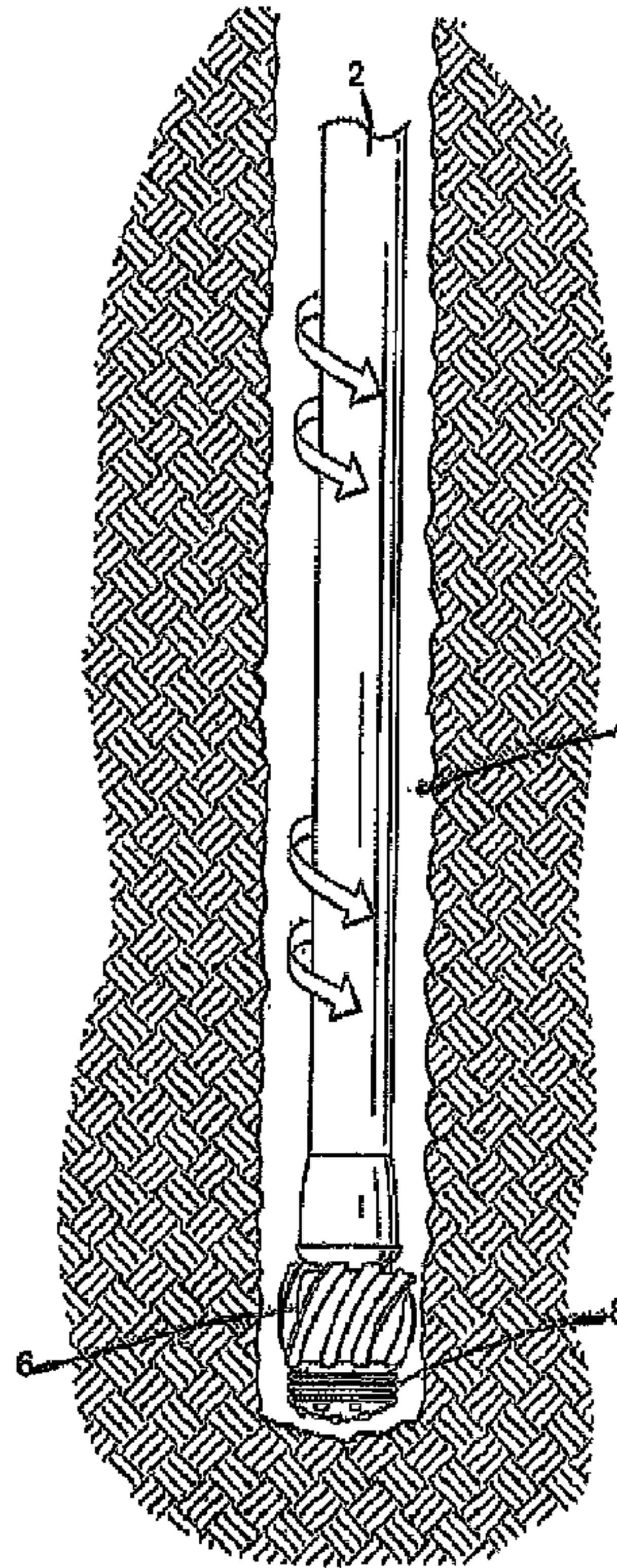


FIG. 1

(57) **Abrégé/Abstract:**

A plurality of cutting faces is attached sequentially at a distal end of a drill string. The forward most cutting face that is distal to the top of the hole is exposed and used for drilling until worn to a point of inefficiency. The forward most or distal cutting face is then

(57) **Abrégé(suite)/Abstract(continued):**

detached, exposing the next cutting face in the sequence. Detachment of the forward most cutting face is performed by remote actuation at the top of the drill string and/or outside the hole. A new cutting face is provided without the necessity of removing the drill string. The detachment process is repeated as long as drilling is continued and cutting faces remain.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau

WIPO | PCT

(10) International Publication Number
WO 2013/188798 A1(43) International Publication Date
19 December 2013 (19.12.2013)

- (51) International Patent Classification:
E21B 10/62 (2006.01) E21B 23/00 (2006.01)
E21B 10/627 (2006.01)
- (21) International Application Number:
PCT/US2013/045943
- (22) International Filing Date:
14 June 2013 (14.06.2013)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/659,677 14 June 2012 (14.06.2012) US
- (72) Inventor; and
(71) Applicant : BLOOMFIELD, John; 53 River Club Drive,
Hilton Head Island, SC 29926 (US).
- (74) Agent: KILLOUGH, B., Craig; Barnwell Whaley Patter-
son & Helms, LLC, P.O. Drawer H, Charleston, SC 29402
(US).
- (81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC,

[Continued on next page]

(54) Title: DRILLING DEVICE AND METHOD

(57) Abstract: A plurality of cutting faces is attached sequentially at a distal end of a drill string. The forward most cutting face that is distal to the top of the hole is exposed and used for drilling until worn to a point of inefficiency. The forward most or distal cutting face is then detached, exposing the next cutting face in the sequence. Detachment of the forward most cutting face is performed by remote actuation at the top of the drill string and/or outside the hole. A new cutting face is provided without the necessity of removing the drill string. The detachment process is repeated as long as drilling is continued and cutting faces remain.

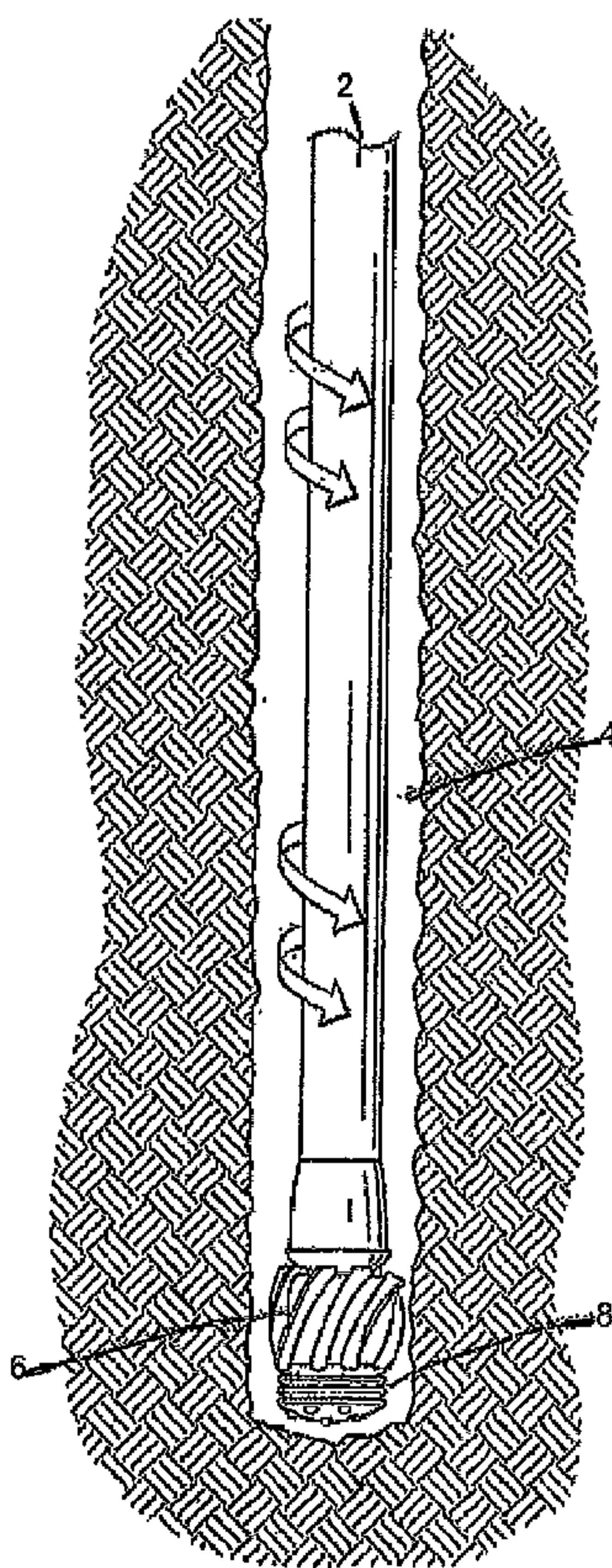


FIG. 1



WO 2013/188798 A1

WO 2013/188798 A1

SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,

EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

DRILLING DEVICE AND PROCESS

The contents of Provisional Application U.S. Serial No. 61/659,677 filed June 14, 2012, on which the present application is based and benefit claimed under 35 U.S.C. §119(e), is herein incorporated by reference

Field of the Invention

[0001] This invention relates to drilling of holes in the earth, and is more specifically related to a device and method for changing drill cutting faces of drill strings for use while the drill string is *in situ* in the hole.

Background of the Invention

[0002] Drilling for oil and gas involves a drill bit and hundreds of lengths of pipe. A common drill bit is cast metal or machined housing studded with multiple protrusions. The protrusions comprise a hard surfaced material, which may be a ceramic type material that is fortified with multiple industrial diamonds. The resulting cutting discs are known in the industry as polycrystalline diamond (PDC) cutters.

[0003] As the bit rotates it cuts through the earthen material. Pipe sections are sequentially joined as the drilled hole becomes deeper. The overall length of connected pipe sections can easily be 5,000 to 40,000 feet and is called the drill string.

[0004] Water, chemicals and solids mixtures, called "drilling mud," are forced through the pipe and ejected at high pressure through ports built into the drill bit. Drilling mud cools the bit, lubricates the cutting action, and washes the drilled earthen material out from the bottom of the hole, and up and around the exterior of the drill pipe. The mud eventually washes the material to the top of the hole where it is filtered and reused.

[0005] The drill bits are subject to wear, and eventually, wear out. The rate of wear depends on the hardness and abrasion characteristics of the drilled

earthen material. As wear progresses, the cutting discs become dull, and less and less effective. Changing bits requires removing the entire drill string from the hole to access the bit. Removal of the drill string requires pulling the top section of pipe up, unscrewing it, placing it aside, and repeating this sequence until removal is complete. A 9000 foot drill string, using common pipe lengths of 30 feet, requires retraction and removal of 300 pipe sections. Once the bit is above ground it is removed, and a new bit is attached. The entire drill string is then reconstructed, one pipe section at a time, and lowered into the hole to reach the point where the drilling stopped. The bit replacement process can take 36 hours or more for some holes. Drilling platforms operate on a continuous basis at a cost of several hundred thousand dollars per day in some cases. A lost day of drilling to replace bits once or twice a week becomes very expensive.

[0006] There is a need for a device and process that will allow a useful bit to be placed in position for use without removing the drill string from the hole.

Summary of the Invention

[0007] A plurality of cutting faces is attached sequentially at a distal end of a drill string. The forward most cutting face that is distal to the top of the hole is exposed and used for drilling until worn to a point of inefficiency. The forward most or distal cutting face is then detached, exposing the next cutting face in the sequence. Detachment of the forward most cutting face is performed by remote controlled actuation at the top of the drill string and/or outside the hole. A new cutting face is exposed without the necessity of removing the drill string. The detachment process is repeated as long as drilling is continued, and fresh cutting faces remain available for use.

Description of the Drawings

[0008] **Fig. 1** demonstrates the distal end of a drill string with a plurality of drill cutting faces in the form of cutting disks present on the mandrel.

[0009] **Fig. 2** demonstrates the drill string of **Fig. 1** and associated drill cutting faces being retracted from the bottom of the bore hole.

[0010] **Fig. 3** demonstrates the most distal drill cutting face being separated from the mandrel and discarded.

[0011] **Fig. 4** demonstrates the discarded drill cutting face at the bottom of the hole.

[0012] **Figs. 5 and 6** demonstrate the discarded drill cutting face fragmented into processable pieces.

[0013] **Fig. 7** demonstrates the drill string being advanced to the bottom of the bore hole.

[0014] **Fig. 8** demonstrates continued drilling operations with the next drill cutting face at the distal end of the drill string as drilling operations are continued.

[0015] **Fig. 9** is a perspective view of a mandrel for a drill string with the sequential cutting faces mounted to the mandrel.

[0016] **Fig. 10** shows the mandrel of **Fig. 9** with the sequential cutting faces spaced apart from the mandrel for demonstration purposes.

[0017] **Fig. 11** shows the mandrel of **Fig. 9** with the sequential cutting faces spaced apart from the mandrel for demonstration purposes, and showing the opposite side of the cutting faces from the side shown in **Fig. 10**.

Detailed Description of the Preferred Embodiments

[0018] The drawing figures demonstrate a forward, or distal, end of a drill string with the drill bit assembly comprised of a mandrel and associated cutting faces. The drill string in use may be of substantial length, and may be thousands of feet long. The drill string is formed by joining multiple sections of pipe. The drawing figures demonstrate only the most forward or distal section of pipe **2**, and depict only the last few feet of a hole **4** that may be thousands of feet deep.

[0019] Affixed to the end of the most distal pipe section, and at the most distal end of the pipe section, is a mandrel **6**. The most distal end of the mandrel is a plurality of drill cutting faces **8**. The drill cutting faces are used to cut away earth, rock, and other geological material. In one embodiment, the cutting faces are formed as a plurality of disks having cutting material **20**, such as PCD, embedded therein. The plurality of cutting faces is present sequentially on the mandrel as shown in the drawing figures.

[0020] Additionally, the mandrel portion of the bit may comprise PCD cutters **22** on the sides. These cutters do not suffer the extreme wear exposure that the multiple cutting faces of the tips experience, but the side mounted cutters assist with continually reaming the bore hole.

[0021] Each of the plurality of cutting faces is connected to the mandrel and/or to an adjacent cutting face. As the cutting face wears to the point of inefficiency at cutting and drilling the hole, the most distal cutting face is removed by remote controlled actuation. As demonstrated by **Fig. 3**, the most distal cutting face **10** is separated from the remaining cutting faces, which causes the worn and discarded cutting face to fall away from the remaining cutting faces that remain attached to the mandrel at the distal end of the drill string. **Fig. 4**.

[0022] In a preferred embodiment, each of the drill cutting faces is attached to the mandrel and/or an adjacent cutting face by an exploding fastener. Each disk may be connected to an adjacent cutting face and/or the mandrel by an exploding nut or an exploding bolt, or both. The exploding fastener may be remotely controlled to initiate the fastener explosion. Each exploding fastener responds to a different code or command, so that, in normal operation, the most distal drill cutting face is the only separated cutting face discarded by exploding the associated exploding fastener.

[0023] The exploding fastener may be exploded by an igniter that is excited electrically from an internal battery in the drill mandrel. Electrical energy is controlled by an internal micro-processor. The internal micro-processor is controlled by a remote surface control device using coding schemes and security algorithms transmitted to the internal micro-processor via a transceiver, which

may be present in both the mandrel and the surface controller, using RF energy and/or ultrasonic energy.

[0024] In one embodiment, the mandrel **6** attaches to a standard drill pipe. The mandrel accommodates several drill cutting faces each studded with multiple diamonds or other hardened material that acts as a material cutter. The drill cutting faces are nested within each other and held in a stack with a bolt, which may be an exploding bolt.

[0025] In one embodiment, each drill cutting face has an exploding charge embedded into it. After the worn cutting face is expelled from the mandrel or drill string, the explosive charge is remotely actuated so that it explodes (**Fig. 5**), leaving only small fragments **12**. The small fragments are flushed from the bore bottom, with the drilling mud ejected from the cutting face built in ports, as demonstrated by **Figs. 7** and **8**. The high pressure drilling mud is then allowed to flow and wash up the fragmented old cutting face without the drill string rotating for a few minutes. In this way, the discarded, worn cutting face does not interfere with drilling operations, and can be removed from the bore hole.

[0026] The discs may contain internal cavities where explosives are strategically placed. The disks may be machined or cast to possess certain thicknesses and/or score marks to weaken the disk at strategic points to facilitate fragmentation. **Fig 11**. The cutting discs may be formed of thicker and/or stronger materials where necessary to insure structural integrity while cutting, but may be formed of less material and/or weaker material at other points to facilitate fragmentation when discarded.

[0027] In a preferred embodiment, the plurality of drill cutting faces attached to the mandrel will be no fewer than two sequential drill cutting faces. The drill cutting faces are mounted to the mandrel at the beginning of the drilling operation. By way of example, six or more drill cutting faces may be present on the distal end of the drill string. The drill cutting faces are connected by exploding fasteners as described herein. As shown in **Figs. 9, 10** and **11**, three

cutting faces **8**, **10** and **14** are attached to the mandrel **6** by exploding fasteners **16**, **18**.

[0028] The communications link between the surface controller and the drill bit for remote actuation to discard the distal cutting disk is preferred to be wireless. Wireless technology links may include radio electromagnetic energy that is radiated and received, or mechanical ultrasonic energy generated and received by ultrasonic transducers. The use of wireless communications eliminates the extra effort of threading physical wires through the drill string, which would be cumbersome and unreliable. Even though the drill bit may be 3 miles below the earth's surface (and the earth is an excellent RF attenuator), the drill string, formed of metal pipe sections, is an excellent conduit for RF, and acts as a long antenna. If ultrasonic technology is utilized, the string provides an excellent conduit for the transfer of the ultrasonic energy to the receiver that is associated with the drill bit at the bottom of the drill bore.

[0029] The surface controller for wireless communication and actuation may comprise a physical container, RF transceiver or ultrasonic transceiver, micro-processor, software and/or other appropriate means for a plurality of digital inputs. Embedded into the disposable cutting face may be another RF transceiver powered by a small battery. Lithium battery technology is preferred for its long shelf life and low internal resistance for the high amperage output necessary to excite the explosive firing cap. The battery may also power an igniter for the explosive that fragments the cutting face, and in one embodiment, to power a timer that delays ignition for a time after the cutting face is separated from the mandrel.

[0030] When a drill bit is no longer achieving the desired or expected rate of penetration, the most distal cutting face that has been in use is discarded and the next most distal cutting face is exposed for use. The drill string is retracted, usually no more than the length of one pipe section, which may be 30 feet. In the preferred embodiment, a wireless code is sent to a small receiver embedded in the mandrel. The code may be sent by RF (radio frequency) or ultrasonic messaging. The receiver, upon receiving the proper code, actuates an

electronic circuit to initiate the charge in the exploding fastener, such as an exploding stacking bolt. The bolt explodes, causing the distal end cutting face to separate from the remaining drill cutting faces. This exposes the next cutting face in the sequence. The next disk comprises new cutters, such as sharp PCD material.

[0031] The drill string is then pulled upward toward the surface for several feet to isolate the mandrel and newly exposed cutting faces from the worn and separated cutting face. In an embodiment, separation of the worn cutting face invokes an internal electronic timer embedded within the core of the cutting face. The timer counts down several seconds before initiating a second explosion from within the worn cutting face. The explosion of the worn cutting face core fragments the core body.

[0032] Then drill string is then lowered to the bottom of the hole. The high pressure drilling mud then flushes the worn cutting face fragments away from the bottom of the bore hole and up and around the pipe of the drill string. After the fragments are beginning to migrate upwardly and away from the bottom of the bore hole, which generally takes only a few minutes, downward pressure is applied to the drill string, and the attached drill bit system. Rotation of the drill string resumes, which resumes the drilling process. This method allows a new cutting face to be exposed for use without pulling the entire drill string from the hole. The process may be repeated as long as an unused cutting faces are available in the sequence. The number of cutting faces that may be sequentially positioned or stacked for use may be to be from 2 to 6, subject to further study and experimentation.

[0033] The invention may be used with cone roller bit designs. Roller bits are bits that possess a plurality of rollers, such as two or three rollers, opposing the other. Stacking may require additional bit structure, such as a base, roller support arms, bearings and rollers. Explosive material may be integrated into the body and associated components. Larger detonation strength is likely to be required to sufficiently fragment the mass, and possibly a longer "flush" time may be required because of additional fragments.

[0034] The mandrel may comprise an internal cavity that is accessible, but sufficiently sealed against the environment to prevent dirt, water and other solids and liquids from entering the cavity. The cavity may accommodate a variety of devices, including electronic components. A replaceable battery pack may be used to supply the electrical energy to power electrical components. A micro-processor with a plurality of inputs and outputs and having support circuitry, power conditioners, buffers, and associated integrated circuits may function as a control or computer for the system to perform and provide monitoring functions, communications to and from surface controllers, and to initiate and control actions at the drill bit.

[0035] A variety and plurality of sensors may be part of the well drilling device and may be positioned in proximity to the drilling environment may interface with the control/computer to measure, monitor and record the operating environment, such as temperature, material density, drill bit pressure, and drill string and bit vibration. Additional sensors may include solid state gyroscopes for directional control and accelerometers for shock monitoring. Also, various sensors may monitor wear gradients and patterns of the cutting faces to facilitate the timing of cutting face replacement. All functions, monitoring and recording is preferred to be communicated to the surface controllers by either RF energy or ultrasonic energy generated and modulated by the control/computer. The communications link is preferred to be duplex, and the surface controllers can send instruction sets to the control/computer internal to the mandrel.

[0036] Various firing algorithms, coding and built in self tests may be utilized to promote safety. Examples include:

1. A prominent "wear point" with a signal conductor embedded below the wear point surface. When sufficient wear of the wear point's surface is experienced, the exposed signal conductor wire sends a signal to the processor that in turn relays the status to the surface control panel and invokes an annunciator.

2. Actuation codes for each exploding device are different. Pseudorandom number assignments may be used to ensure that no two explosive devices are assigned the same identifier or code.

3. Algorithmic schemes employ plural checks of each unique identifier, and check schemes over several interrogations and iterations. Sufficient time is available for even thousands of checks before detonation, which may take only a few seconds.

What is claimed is:

1. A well drilling device, comprising:
a plurality of cutting faces attached to mandrel and positioned sequentially on the mandrel;
an explosive device positioned between a first cutting face of the plurality of cutting faces and a second cutting face of the plurality of cutting faces; and
a remote actuator that actuates the explosive device and upon actuation of the explosive device, the explosive device explodes and separates the first cutting face from the mandrel.
2. A well drilling device as described in Claim 1, where individual cutting faces of the plurality of cutting faces of are positioned sequentially at an end of the mandrel in a nested formation.
3. A well drilling device as described in Claim 1, wherein each of the plurality of cutting faces is attached to the mandrel by an explosive device, and the exploding device is an exploding fastener.
4. A well drilling device as described in Claim 1, wherein the remote actuator actuates a selected explosive device of the plurality of explosive devices and separates a leading cutting face from the mandrel.
5. A well drilling device as described in Claim 1, wherein the first cutting face comprises a second exploding device that is constructed and arranged to explode the first cutting face into fragments subsequent to actuation of the exploding device.

6. A well drilling device as described in Claim 1, wherein each cutting face of the plurality of cutting faces comprises an exploding device that is positioned in a cavity of the cutting face and the exploding device and the cutting face are constructed and arranged to explode the cutting face into fragments upon actuation of the exploding device.
7. A well drilling device as described in Claim 1, wherein each of the plurality of cutting faces comprises a plurality of industrial diamonds.
8. A well drilling device as described in Claim 1, wherein the remote actuator comprises a two way communication link between a surface controller and the mandrel, wherein the two way communication link utilizes radio frequency energy or ultrasonic energy, and wherein the two way communication link transmits signals indicating bore hole conditions and cutting face conditions, and the two way communication link actuates cutting face separation and cutting face fragmentation.
9. A well drilling device as described in Claim 5, wherein the first cutting face comprises alternate sections of stronger and weaker fabrication facilitating fragmentation of the first cutting face into a plurality of substantially smaller fragments upon actuation of the second exploding device.

10. A well drilling device as described in Claim 6, wherein each of the cutting faces of the plurality of cutting faces comprises alternate sections of stronger and weaker fabrication facilitating fragmentation of the cutting faces into a plurality of substantially smaller fragments upon actuation of the exploding device that is positioned in the cavity of the cutting face.
11. A well drilling device as described in Claim 5, wherein the first cutting face is formed of a plurality of materials, each of the plurality of materials having structural strength that facilitates or retards fragmentation of the first cutting face after separation of the first cutting face after separation of the first cutting face from the mandrel.
12. A well drilling device as described in Claim 1, wherein the mandrel is attached to a drill string, and the mandrel comprises an internal cavity in which a battery and a micro-processor are contained, wherein the micro processor communicates with sensors that communicate with the well drilling device.
13. A well drilling device as described in Claim 1, wherein the mandrel is attached to a drill string.

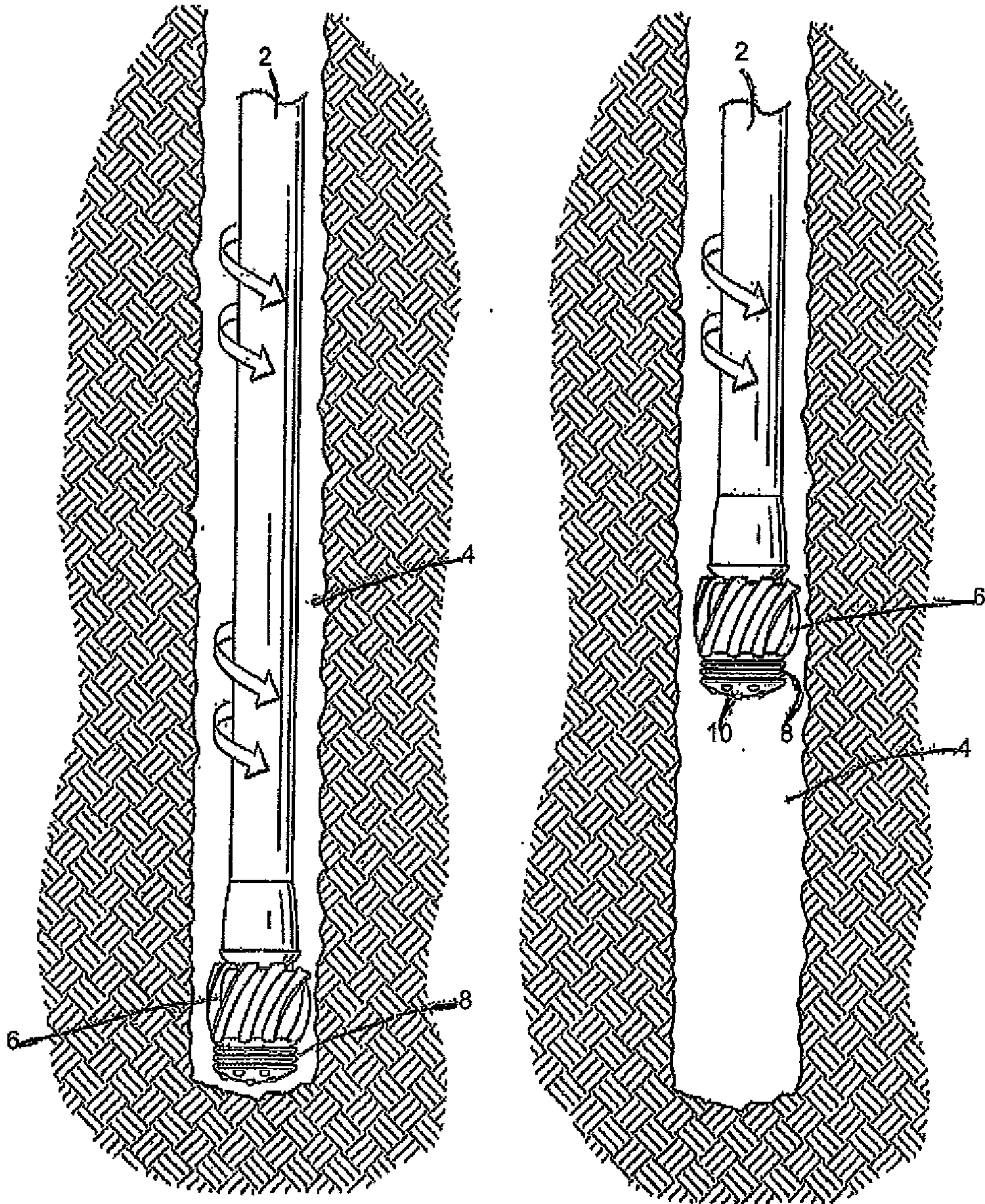


FIG. 1

FIG. 2

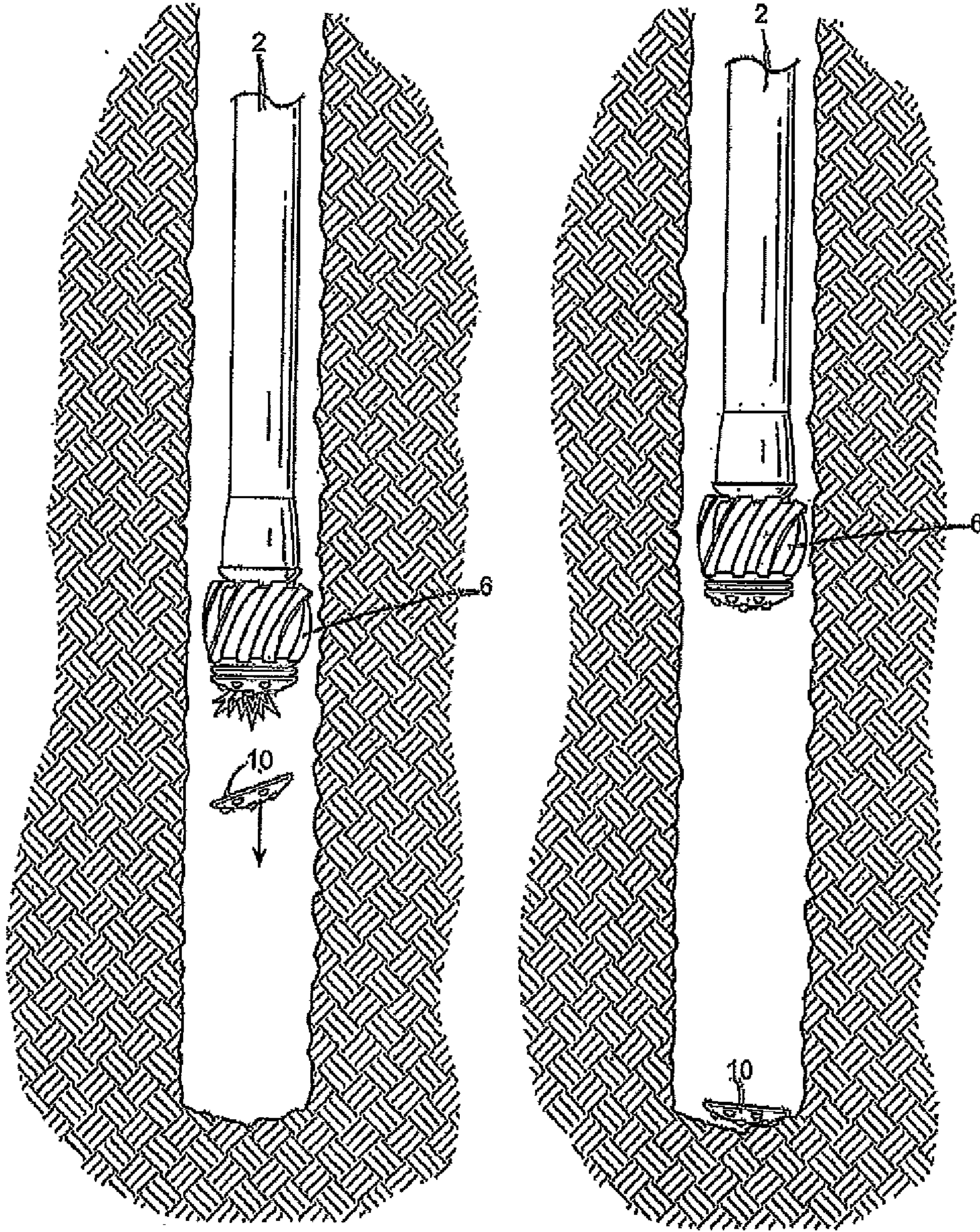


FIG. 3

FIG. 4

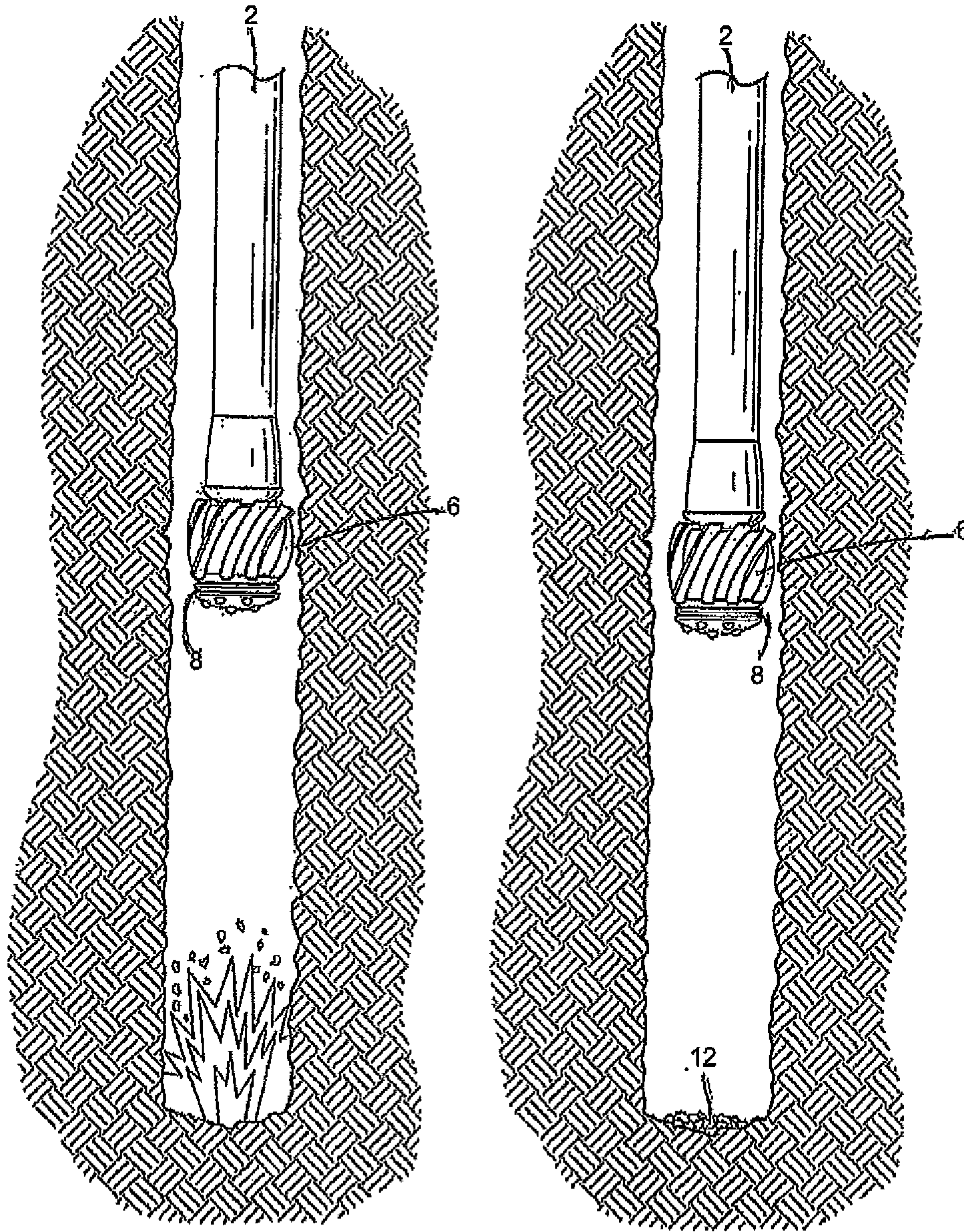


FIG. 5

FIG. 6

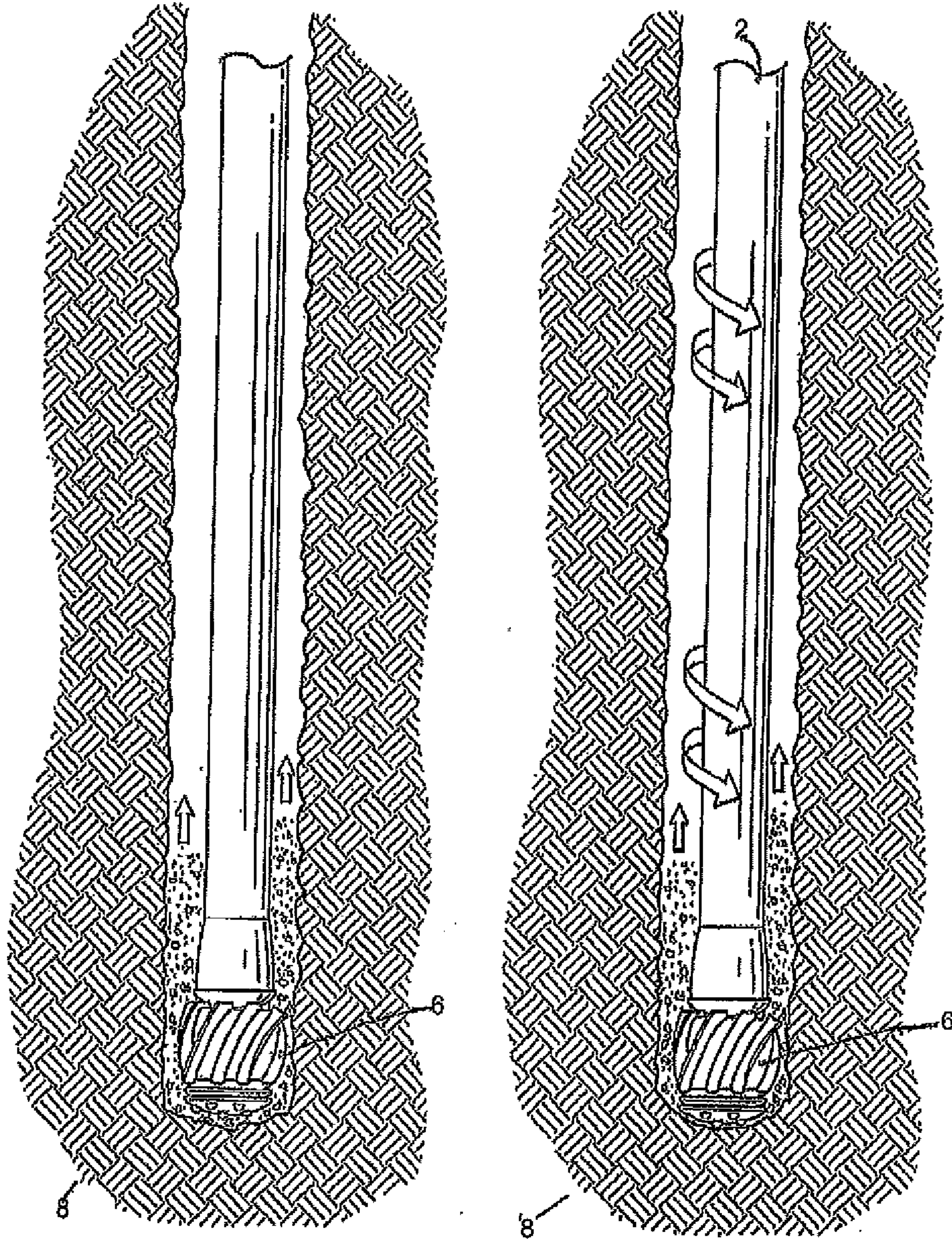


FIG. 7

FIG. 8

5/7

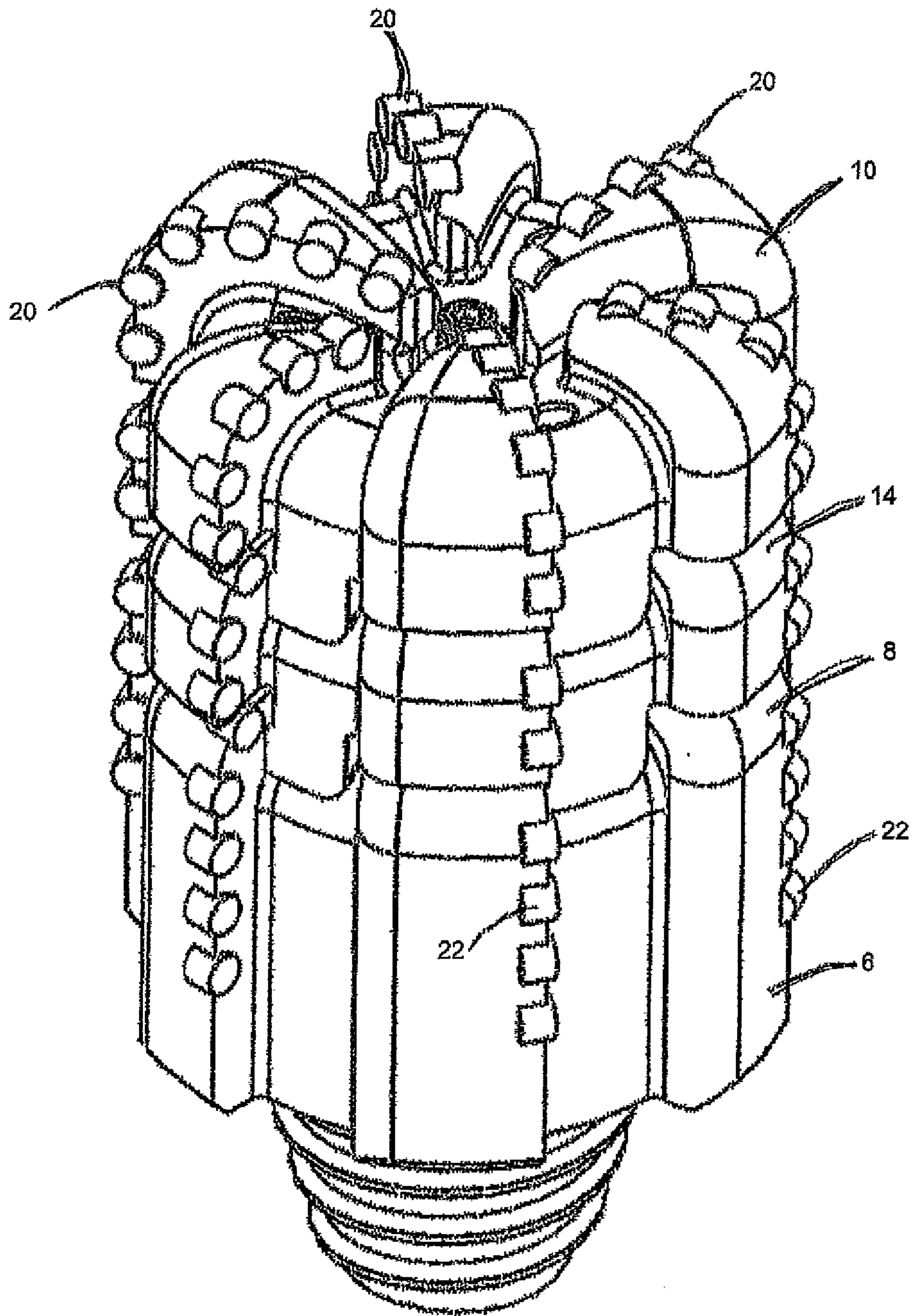


FIG. 9

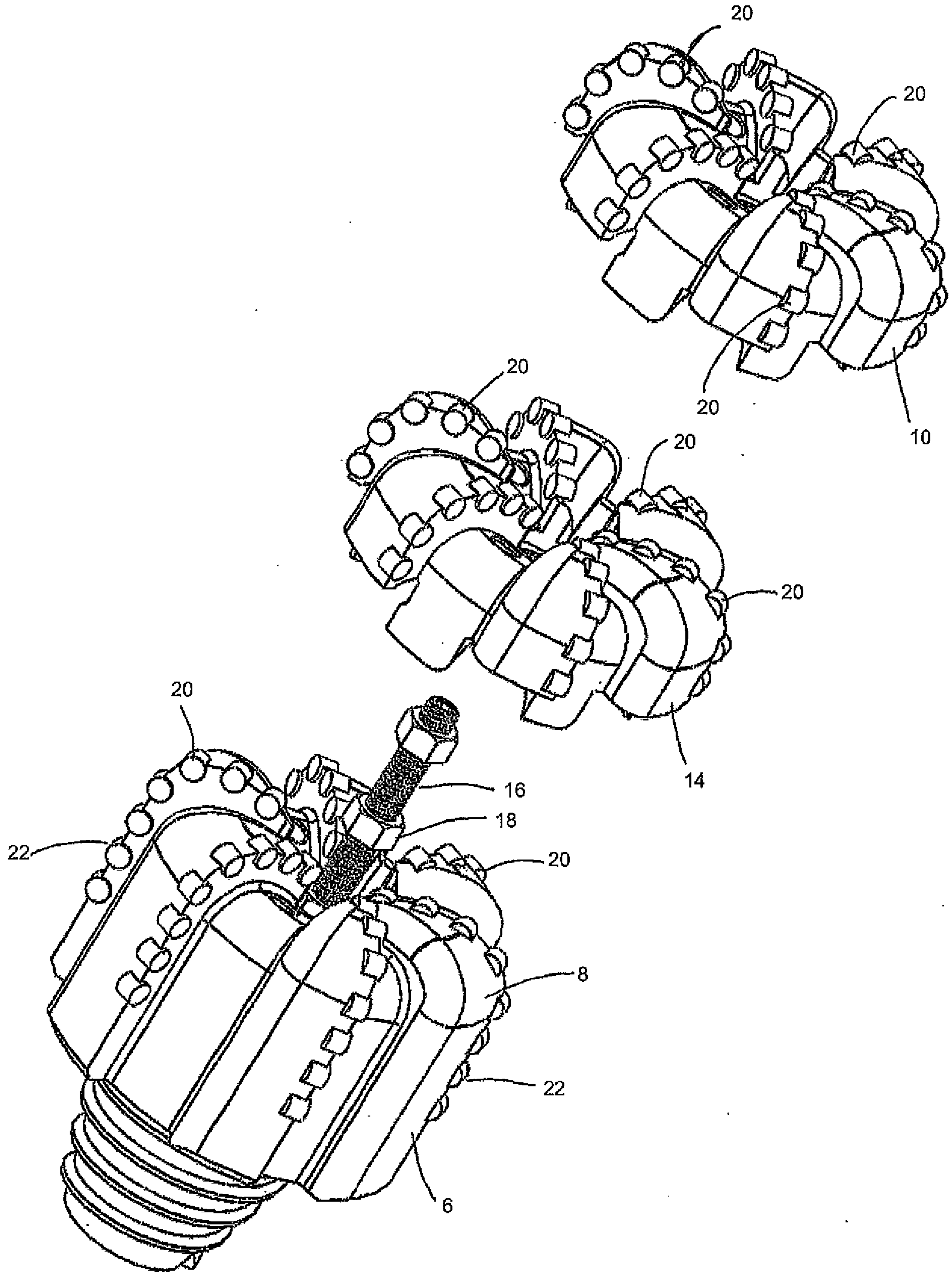


FIG. 10

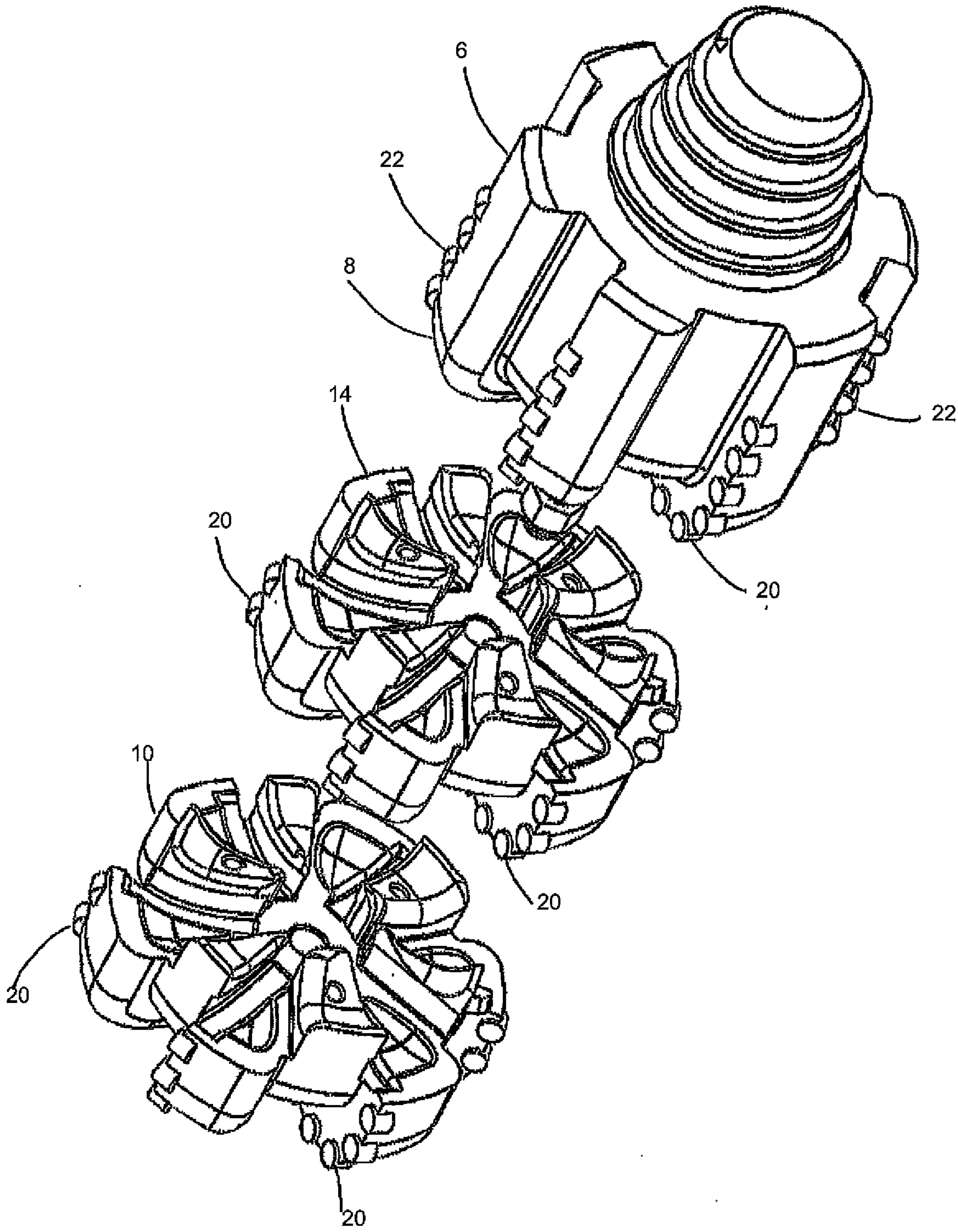


FIG. 11

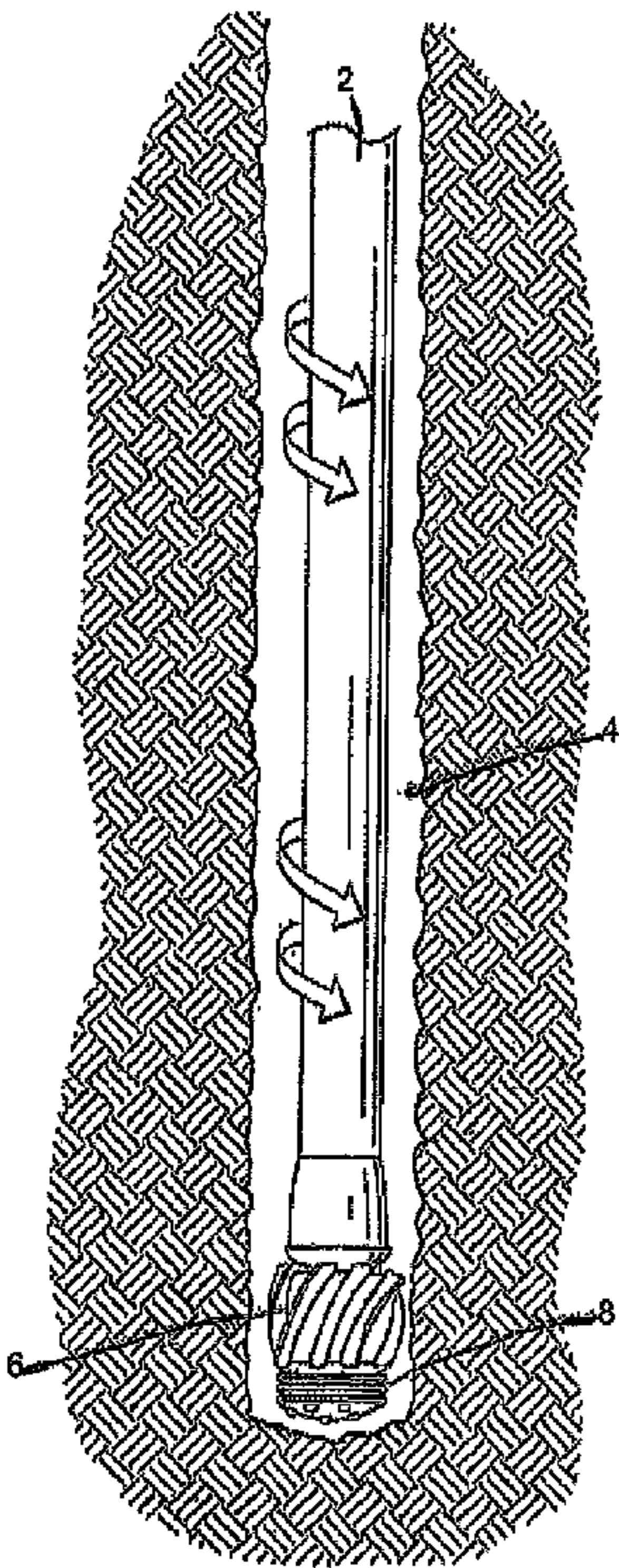


FIG. 1