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(54) **Cone Cutter for Rotary Cutting Bit**

(57) A cone cutter (103) for mounting at a rotary cutting bit (100) having a plurality of vent passageways (304) extending through the wall (401) between an inward (301) and an outward (302) facing surface of the cutter.

The passageways allow an exhaust flow of fluid from within the cavity and are optimised to direct the exhaust fluid flow stream radially outward and axially rearward of the cone cutter.

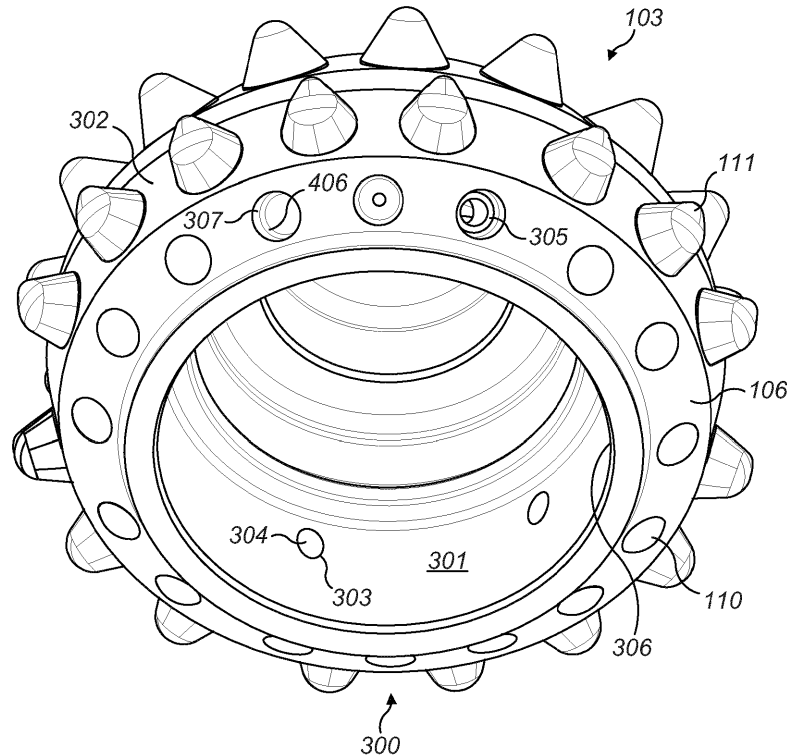


FIG. 3

Description

Field of invention

[0001] The present invention relates to a cone cutter for mounting at a rotary cutting bit and in particular, although not exclusively, to a cone cutter having a main body and a plurality of vent passageways extending through the wall of the body to be capable of directing a flow of a fluid outwardly from an internal cavity of the cutter.

Background art

[0002] Rotary drills have emerged as an effective tool for specific drilling operations such as the creation of blast holes and geothermal wells. The drill typically comprises a rotary drill bit having three journal arms that mount respective cone-shaped rolling cutters via bearing assemblies that includes rollers and balls to minimise friction during use.

[0003] Typically, the drill bit is attached to one end of a drill string that is driven into the borehole via a rig. The cutting action is achieved by generating axial feed and rotational drive forces that are transmitted to the drill bit via the drill rods couple end-to-end. Each of the cone-shaped cutters comprise hardened cutting elements typically referred to as buttons, inserts, chisels and the like being commonly formed from a cemented carbide material. The cutting buttons are positioned at discreet external annular rows on the cone cutter with different buttons at different axial regions being optimised to achieve the desired cutting action as the drill string and drill bit rotate.

[0004] So as to cool the antifricition bearings, air is typically supplied down the drill string through the journal arms and into the bearing assemblies. The air circulates around the bearings within each cavity of each cone cutter and is vented via the cavity mouth. Example rotating bits and cutters are described in US 3,193,028; US 3,921,735; US 4,688,651 and US 4,421,184.

[0005] However, existing cone cutters and rotary drill bits are disadvantageous for a number of reasons. Principally, the air is vented through the mouth region of the cone cutter cavity and this introduces problems and complexity with attempting to seal or partition the cavity and hence the bearing assembly from the dust laden environment within which the cutting bit is operational. It is not uncommon for dust and particles to pass into the cavity and cause premature wear of the bearings. Additionally, exhausting through the cavity mouth and around the spindle that mounts the bearing assembly at the journal arm causes undesirable agitation of the dust particulates around the region of the cone cutter that can lead to accumulation of dust and debris at undesirable locations that may be detrimental to the drilling rate and cause premature wear of the drill bit components. Accordingly, what is required is a cone cutter and a drill bit that addresses the above problem.

Summary of the Invention

[0006] It is an objective of the present invention to provide a cone cutter for a drill bit having an exhaust pathway for a fluid supplied to a bearing assembly that mounts the cone cutter at the drill bit that is effective to avoid contamination of the bearing assembly with rock particles, dust and fines whilst optimising the flow path to achieve maximum cooling of the bearings for a given volume of cooling fluid supplied to the drill bit.

[0007] It is a further specific objective to provide a fluid coolant exhaust at the cone cutter that is effective to dissipate cut rock fragments and dust away from the region of the journal arm and the base of the cone cutter. Accordingly, it is a further specific objective to provide an exhaust fluid flow passageway that is effective to direct the exhausted fluid axially rearward so as to entrain cut particles for axially rearward transport away from the cone cutter.

[0008] According to a first aspect of the present invention there is provided a cone cutter for mounting at a rotary cutting bit, the cone cutter comprising: a generally cone-shaped main body having an annular wall extending around a longitudinal axis of the cutter, the wall defined by a radially outward facing surface and a radially inward facing surface, an internal cavity defined by the inward facing surface suitable for mounting on a bearing assembly of a rotary cutting bit; a plurality of cutting buttons mounted at the outward facing surface; characterised by: a plurality of vent passageways extending through the wall between the outward and inward facing surfaces to allow a flow of a fluid from within the cavity to exit the main body through the wall.

[0009] The cone cutter may be further defined as comprising an apex region and a base region wherein the walls extend axially between the apex region and the base region. The cavity is open at the base region by way of a generally circular mouth. Preferably, the passageways extend transverse and optionally perpendicular to the axis within the wall at an axial position between the apex region and the base region. Optionally, the shape, configuration and size of the mouth is configured for positioning over and about an axle or spindle that supports the bearing assembly at the journal arm such that the mouth comprises a diameter being slightly greater than a diameter of the spindle.

[0010] Optionally, the cone cutter and in particular the outward facing surface may be considered to be divided into axial sections extending between the apex region and base region. The relative angular alignment of the outward facing surface at the different axial regions is different so as to create the cone-shaped profile. In particular, the cutter comprises a plurality of sections arranged axially at the outward facing surface, the sections comprising: a heel row provided towards a base of the cone having heel buttons; a drive row provided towards an apex of the cone having drive buttons; and a gauge row provided axially intermediate the heel and drive rows,

the gauge row comprising gauge buttons. Optionally, the heel row represents an 'under-cut' region of the cutter such that the outward facing surface is inclined at an opposite angle to the outward facing surface towards the dome region relative to the axis.

[0011] Preferably, the passageways emerge at the outward facing surface within the heel row. Directing the exhaust fluid flow through the axially rearward facing heel row of the cutter is advantageous to provide an exhaust fluid stream that projects axially rearward and radially outward from the cutter. This has the effect of transporting rearwardly and axially dust and debris particles away from the journal arm and in particular the region between the cutter and the journal. Such an arrangement is advantageous over conventional bit assemblies that exhaust the fluid through the cavity mouth as such arrangements can lead to dust particles being forced into the cavity. The axially rearward and radially outward flow path from the current passageways is effective to continuously clean the region of the journal arm immediately behind the cutter. Additionally, due to the transverse alignment of the passageways relative to the axis, air turbulence at an axially forward position of the cutter is minimised as the majority of the air stream is specifically directed axially rearward from the cutting buttons and is not deflected or reflected by the journal arm as with conventional cutting bit arrangements.

[0012] Preferably, the passageways continue through and emerge at respective heel buttons. Accordingly, the cutter comprises a plurality of specifically configured cutting buttons that have a central bore having a diameter corresponding to a diameter of each passageway so as to mate in co-alignment as a seamless continuous passageway extending through the wall and the respective cutting button. Exiting the passageways at cutting buttons is advantageous to protect the exit aperture of each passageway from damage caused by frictional contact with the rock and debris material within the borehole. However, according to further specific implementations, the passageways may exit the wall at the region of the outward facing surface between cutting buttons. In such arrangements, the exit aperture of the passageways may be protected by suitable annular shields or guards that surround the immediate vicinity of the edge that defines the exit aperture at the outward facing surface.

[0013] Preferably, the passageways comprise an elongate length extending between the outward and inward facing surfaces that is aligned at a declined angle through the wall relative to the axis such that the passageways emerge at the inward facing surface at an axial position closer to the apex of the cone than a region where the passageways emerge at the outward facing surface. Such an arrangement is advantageous to avoid debris particles and dust traveling radially inward through the passageways from the dust laden environment surrounding the cone cutter. Additionally, the transverse orientation of the passageways relative to the axis is effective to create a desired flow path of the coolant fluid within

the cavity and around the bearings. The under-cut region of the heel row is advantageous for the exhaust apertures of the passageways as this region is effectively shielded from the dust particles by the majority of the cone main body.

[0014] Optionally, an orientation of the passageways is substantially perpendicular to the outward facing surface at the heel row. The transverse alignment of the passageways is advantageous to provide a smooth air flow path from within the cavity and to assist with cooling of the bearing assembly by creating a desired air flow circuit within the cavity. Preferably, the passageways emerge at the inward facing surface at substantially the same axial position corresponding to the position of the gauge row. This relative axial position of the entry apertures of the respective passageways does not compromise the structural integrity of the cutter and is effective to optimise the air flow path and cooling of the bearing assembly.

[0015] Optionally, the outward facing surface at the heel row is inclined relative to the axis at an angle in the range 50 to 70° or 55 to 65°. This relative inclined orientation of the heel row surface enables the heel buttons to assist the cutting action of the gauge buttons and to exhaust the coolant fluid in a desired orientation as relatively focussed streams of fluid as the cone cutter rotates.

[0016] Optionally, at least some of the passageways emerge at the outward facing surface within the gauge row. Accordingly, the cone cutter may comprise a first set of passageways emerging at the heel row and a second set of passageways emerging at the gauge row. According to further specific embodiments, the cutter may comprise a further set of passageways emerging at the drive row. Optionally, any such further passageway may emerge at the outward facing surface within respective cutting buttons so as to protect the exit aperture of the passageways from frictional wear.

[0017] Preferably, the passageways comprise a length having a substantially uniform cross-sectional area between the inward and outward facing surfaces. A generally unchanging cross sectional area of the passageway is effective to provide a smooth and unrestricted exhaust of coolant fluid from within the cavity. Such an arrangement is also convenient for manufacturing. Optionally, the cross sectional area of each passageway decreases from the inward to the outward facing surface to reduce the likelihood of debris rock particles penetrating into the cavity and in contact with the bearings via the passageways. Optionally, a diameter of the passageways is substantially half a diameter of a base of each of the cutting buttons. Accordingly, the integrity of the cutting buttons that comprise a central bore is not unduly compromised. Such specifically configured buttons are therefore still capable of assisting with the cutting action of adjacent 'unmodified' buttons.

[0018] Preferably, the passageways are uniformly distributed around the axis. The even-spacing of the pas-

sageways around the axis in a circumferential direction provides a balanced fluid flow that does not compromise the rotational stability of the cutter mounted at the bearing assembly. Optionally, the entry and exit apertures of each of the set of passageway are positioned at the same axial location/height at the wall of the cutter. Again, such an arrangement provides a smooth exit fluid flow from the cutter and a controlled flow of fluid around the bearing assembly.

[0019] According to a second aspect of the present invention there is provided a rotary cutting bit for cutting rock comprising: at least one journal arm; a bearing assembly mounted at the journal arm; a cutter as claimed herein mounted at the bearing assembly via the cavity so as to be capable of rotation relative to the journal arm.

[0020] Optionally, the cutting bit may comprise three arms and three respective bearing assemblies and cutters. Such an arrangement is advantageous to optimise the cutting or drill rate with respect to the rotational force imparted to the drill string from the drill rig.

Brief description of drawings

[0021] A specific implementation of the present invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is an external perspective view of a rotary cutting bit for mounting at one of a drill string according to a specific implementation of the present invention;

Figure 2 is a further perspective view of a cutting head end of the cutting bit of figure 1 with one of the rotary cone cutters removed for illustrative purposes;

Figure 3 is an underside perspective view of one of the rotary cone cutters of figure 1;

Figure 4 is a cross sectional view of the cone cutter of figure 3;

Figure 5 is a further underside perspective cross sectional view of the cone cutter of figure 4;

Figure 6 is a magnified cross sectional view the cone cutter of figure 4 to illustrate the relative alignment of an internal fluid flow passageway extending through the main body of the cone cutter of figure 4 according to a specific implementation of the present invention.

Detailed description of preferred embodiment of the invention

[0022] Referring to figure 1, a cutting head 100 is formed as a cutting bit intended for rotatory crushing drilling of rock. The cutting bit 100 comprises a cutting end

101 and an axially rearward attachment end 102 configured for attachment to one end of a drill string (not shown) forming part of a drill assembly operated via a drilling machine or rig (not shown) configured to provide axial and rotational drive to the cutting bit 100 via the drill string. Cutting bit 100 comprises three journal arms 105 projecting axially forward from attachment end 102 and being aligned slightly radially outward such that cutting end 101 comprises a generally larger diameter than attachment end 102. A generally conical shaped cone cutter 103 is mounted at one end of each journal arm 105 so as to be capable of rotation relative to arm 105 and independent rotation about a separate axis relative to the general rotation of cutting bit 100 and the drill string (not shown). Referring to figure 2, a bearing assembly indicated generally by reference 200 is provided at an end 207 of each journal arm 105. Bearing assembly 200 may be mounted at journal arm end 207 via a suitable spindle or axle (not shown) and comprises a first raceways 201 located at a base region of bearing assembly 200 and a second raceway 203 positioned at a tip region of assembly 200. A third raceway 202 is positioned between the first and second raceways 201, 203. A first set of roller bearings 204 is mounted at first raceway 201 and a second set of roller bearings 206 is mounted at second raceway 203. A plurality of ball bearings 205 are mounted at third raceway 202 so as to provide a minimum-friction bearing assembly 200 upon which is mounted cone cutter 103.

[0023] Referring to figures 1 to 3, each cone cutter 103 comprises a generally cone or dome shaped configuration having a hollow structure. In particular, the annular cone cutter 103 comprises an internal cavity 300 defined by a radially internal facing surface 301. An opposed radially outward facing surface is indicated generally by reference 302 and represents a cutting face region of cutter 103. In the axial direction, cone cutter 103 may be divided into axial sections at the outer facing surface 302 and comprises a heel row 106, a gauge row 107, a drive row 108 and an inner or apex region 109. A plurality of sets of cutting buttons (indicated generally by reference 104) are provided at each respective axial section including in particular heel row buttons 110, gauge buttons 111 (and 112), drive buttons 113 and inner buttons 114. Each of the cutting buttons 104 comprises a working tip having a generally pointed configuration. However, as will be appreciated, each cutting button 104 or specific set of buttons 104 may be semi-spherical, conical, ballistic, semi-ballistic or chisel shaped. Each button 104 is formed from a wear resistant cemented carbide based material. Referring to figures 3 and 4 a wall 401 of the cone cutter 103 is defined generally between the inward facing surface 301 and the outward facing surface 302. A plurality of generally cylindrical recesses are formed within wall 401 at each axial section to extend radially inward from outward facing surface 301. Each recess 307 accommodates a corresponding cutting button 104 via conventional welding and/or press/shrink fitting.

[0024] In order to cool the bearing assembly 200 and

in particular the roller bearings 204, 206 and ball bearings 205, air is supplied through a conduit (not shown) within the journal arms 105 to exit onto the region of assembly 200 via an exit port (not shown). Cone cutter 103 is mounted at bearing assembly 200 via the positioning of assembly 200 within cavity 300 such that the inward facing surface 301 is orientated around bearings 204, 205, 206. The air is configured to penetrate and circulate between the region of bearing assembly 200 and the inward facing surface 301. As illustrated in figure 3, a base region of cavity 300 is defined by an annular edge 306 formed as a mouth in the underside of cone cutter 103. Mouth 306 is configured for positioning in close proximity to an annular shoulder 208 provided at a base region of assembly 200 and formed at journal arm end 207. Each cone cutter 103 comprises a plurality of vents that extend through the cone wall 401 to exhaust the cooling air circulating around bearing assembly 200. In particular, a plurality of passageways 304 extend through wall 401 between inward facing surface 301 and outward facing surface 302. Each passageway 304 is aligned transverse to a central longitudinal axis 400 extending through cone cutter 103 with each passageway comprising an entry aperture 303 provided at inward facing surface 301 and an exit aperture 305 provided at a trough region 406 of selected recesses 307. In particular, and according to the specific implementation of the present invention, passageways 304 are positioned to extend through cutter wall 401 in the axial vicinity of mouth 306. That is, each passageway entrance 303 is aligned axially approximately at the gauge row 107 whilst the passageway exit aperture 305 is positioned approximately at heel row 106. According to the specific implementation, six passageways 304 are provided through wall 401 and accordingly six respective heel row buttons 110 are modified so as to comprise a corresponding internal bore (or passageway) 402 extending between a base end 404 and an exit or cutting end 403. Passageways 304 and 402 are aligned coaxially so as to provide a single passageway extending from entry aperture 303 at internal cavity 300 and exiting at an aperture 405 provided at the button exit end 403. According to the specific implementation, a cross sectional area of passageway 304, 402 is approximately half of a cross sectional area of button 110 at base end 404.

[0025] Referring to figure 6, the air flow vent passageways 304, 402 are aligned transverse to axis 400 so as to be declined downwardly from axis 400. As such, entry aperture 303 is positioned axially closer to apex region 109 relative to exit aperture 405 that is positioned at an axially similar position to mouth 306. Such an arrangement is advantageous to avoid penetration of particles and debris via a reverse direction through passageways 304, 402 into the cavity 300 that would otherwise contaminate and accelerate wear of bearing assembly 200. Additionally, and according to the specific implementation, a cross sectional area of passageways 304, 402 is tapered so as to decrease from entry aperture 303 at

inward facing surface 301 to exit aperture 405 at the outer cutting exit end 403 of heel row button 110. However, according to further specific implementations, the cross sectional area of passageways 304, 402 may be substantially uniform between apertures 303 and 405.

[0026] Referring to figure 6, cutter external surface 302 at heel row region 106 is inclined relative to axis 400 and is orientated at transverse angle b . In particular, according to the specific implementation b is substantially 50 to 55°. Passageways 304, 402 are aligned perpendicular to the orientation of outward facing surface 302 at heel row 106 and are aligned at a declined angle a relative to axis 400. According to the specific implementation, angle a is substantially in the range 140 to 150° relative to axis 400. Accordingly, entry aperture 303 comprises a generally oval shape profile at inward facing surface 301. Each entry aperture 303 is aligned at the same axial position corresponding generally to the same axial position as gauge buttons 111. Positioning passageways 304, 402 to exit at the region of heel row section 106 is advantageous for a number of reasons. In particular, the exit airflow stream from each button exit aperture 405 is directed axially rearward and radially outward relative to axis 400. Accordingly, any dust or debris is prevented from accumulation at the region of journal arm shoulder 208 and in particular the interface region between cone cutter mouth 306 and journal arm 105. Such an arrangement prevents ingress of dust or particulates into cavity 300 and also eliminates accelerated frictional wear of arm 105 and cutter 103 due to the accumulation of debris at the junction between these two components 103, 105.

[0027] According to further specific implementations, additional or alternative fluid flow exit passageways 304, 402 may be provided at different axial positions through cone cutter wall 401. In particular, the fluid flow exit passageways 304, 402 may extend in the gauge row 107, the drive row 108 and/or the inner row 109. In such arrangements, specifically modified buttons 104 would accordingly be provided in the same manner as described referring to figures 1 to 6 and with reference to the heel row buttons 110.

Claims

1. A cone cutter (103) for mounting at a rotary cutting bit (100), the cone cutter (103) comprising:

a generally cone-shaped main body having an annular wall (401) extending around a longitudinal axis (400) of the cutter (103), the wall (401) defined by a radially outward facing surface (302) and a radially inward facing surface (301), an internal cavity (300) defined by the inward facing surface (301) suitable for mounting on a bearing assembly (200) of a rotary cutting bit (100);
a plurality of cutting buttons (104) mounted at

the outward facing surface (302);

characterised by:

a plurality of vent passageways (304) extending through the wall (401) between the outward (302) and inward (301) facing surfaces to allow a flow of a fluid from within the cavity (300) to exit the main body through the wall (401).

2. The cutter as claimed in claim 1 comprising a plurality of sections arranged axially at the outward facing surface (302), the sections comprising:

a heel row (106) provided towards a base of the cone cutter (103) having heel buttons (110); a drive row (108) provided towards an apex (109) of the cone cutter (103) having drive buttons (113); and

a gauge row (107) provided axially intermediate the heel (106) and drive (108) rows, the gauge row (107) comprising gauge buttons (111).

3. The cutter as claimed in claim 2 wherein the passageways (304) emerge at the outward facing surface (302) within the heel row (106).

4. The cutter as claimed in claim 3 wherein the passageways (304) continue through and emerge at respective heel buttons (110).

5. The cutter as claimed in claims 3 or 4 wherein the passageways (304) comprise an elongate length extending between the outward (302) and inward (301) facing surfaces that is aligned at a declined angle through the wall (401) relative to the axis (400) such that the passageways (304) emerge at the inward facing surface (301) at an axial position closer to the apex (109) of the cone cutter (103) than a region where the passageways (304) emerge at the outward facing surface (302).

6. The cutter as claimed in any one of claims 3 to 5 wherein an orientation of the passageways (304) is substantially perpendicular to the outward facing surface (302) at the heel row (106).

7. The cutter as claimed in any one of claims 3 to 6 wherein the passageways (304) emerge at the inward facing surface (301) at substantially the same axial position corresponding to the position of the gauge row (107).

8. The cutter as claimed in any one of claims 2 to 7 wherein the outward facing surface (302) at the heel row (106) is inclined relative to the axis (400) at an angle in the range 50 to 70°.

9. The cutter as claimed in any one of claims 2 to 8 wherein at least some of the passageways (304) emerge at the outward facing surface (302) within the gauge row (107).

10. The cutter as claimed in claim 9 wherein at least some of the passageways (304) continue through and emerge at respective gauge buttons (111).

11. The cutter as claimed in any preceding claim wherein the passageways (304) comprise a length having a substantially uniform cross-sectional area between the inward (301) and outward (302) facing surfaces.

12. The cutter as claimed in any preceding claim wherein a diameter of the passageways (304) is substantially half a diameter of a base (404) of each of the cutting buttons (104).

13. The cutter as claimed in any preceding claim wherein the passageways (304) are uniformly distributed around the axis (400).

14. A rotary cutting bit (100) for cutting rock comprising:

at least one journal arm (105);
a bearing assembly (200) mounted at the journal arm (105);
a cutter (103) as claimed in any preceding claim mounted at the bearing assembly (200) via the cavity (300) so as to be capable of rotation relative to the journal arm (105).

15. The bit as claimed in claim 14 comprising three journal arms (105) and three respective bearing assemblies (200) and cutters (103).

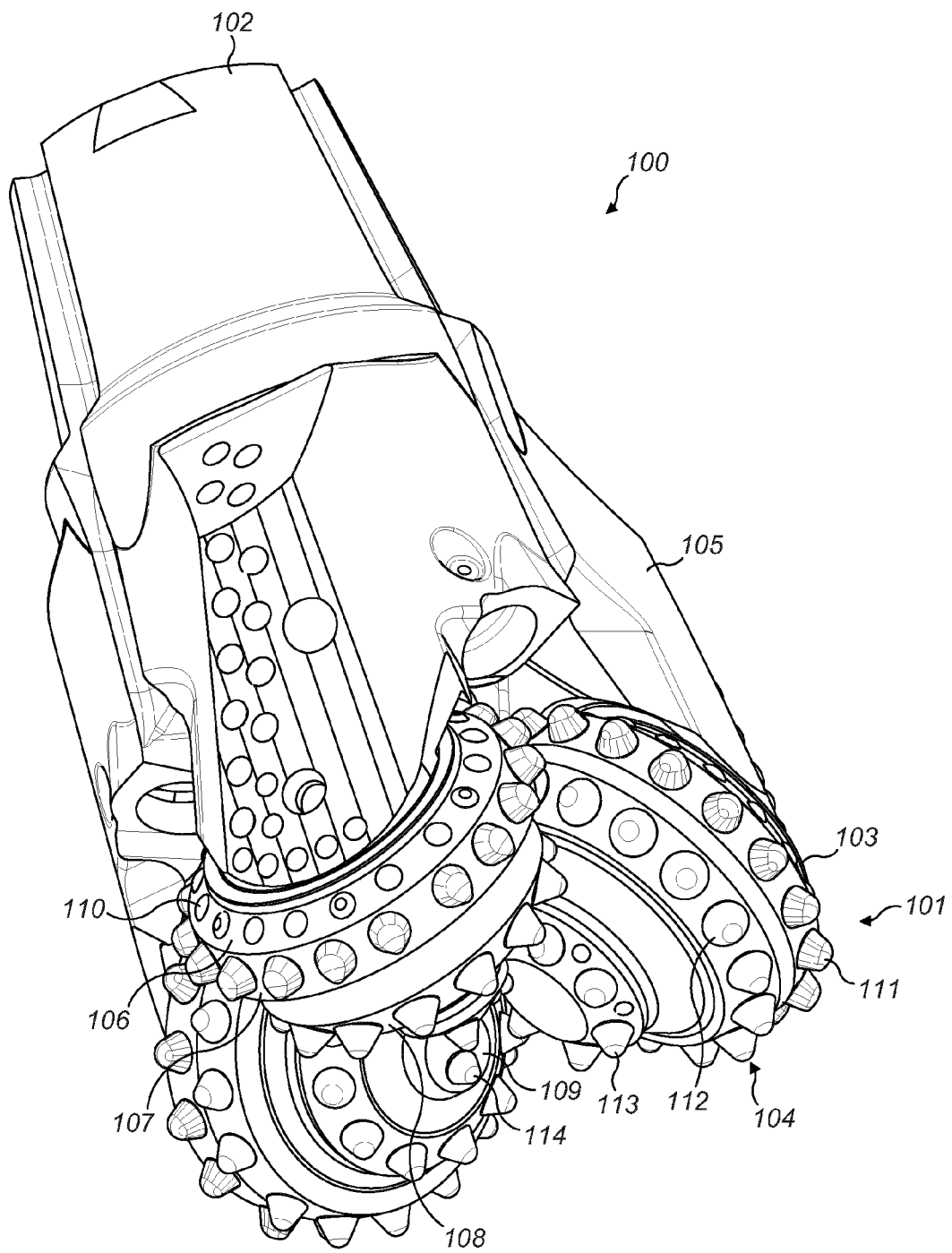


FIG. 1

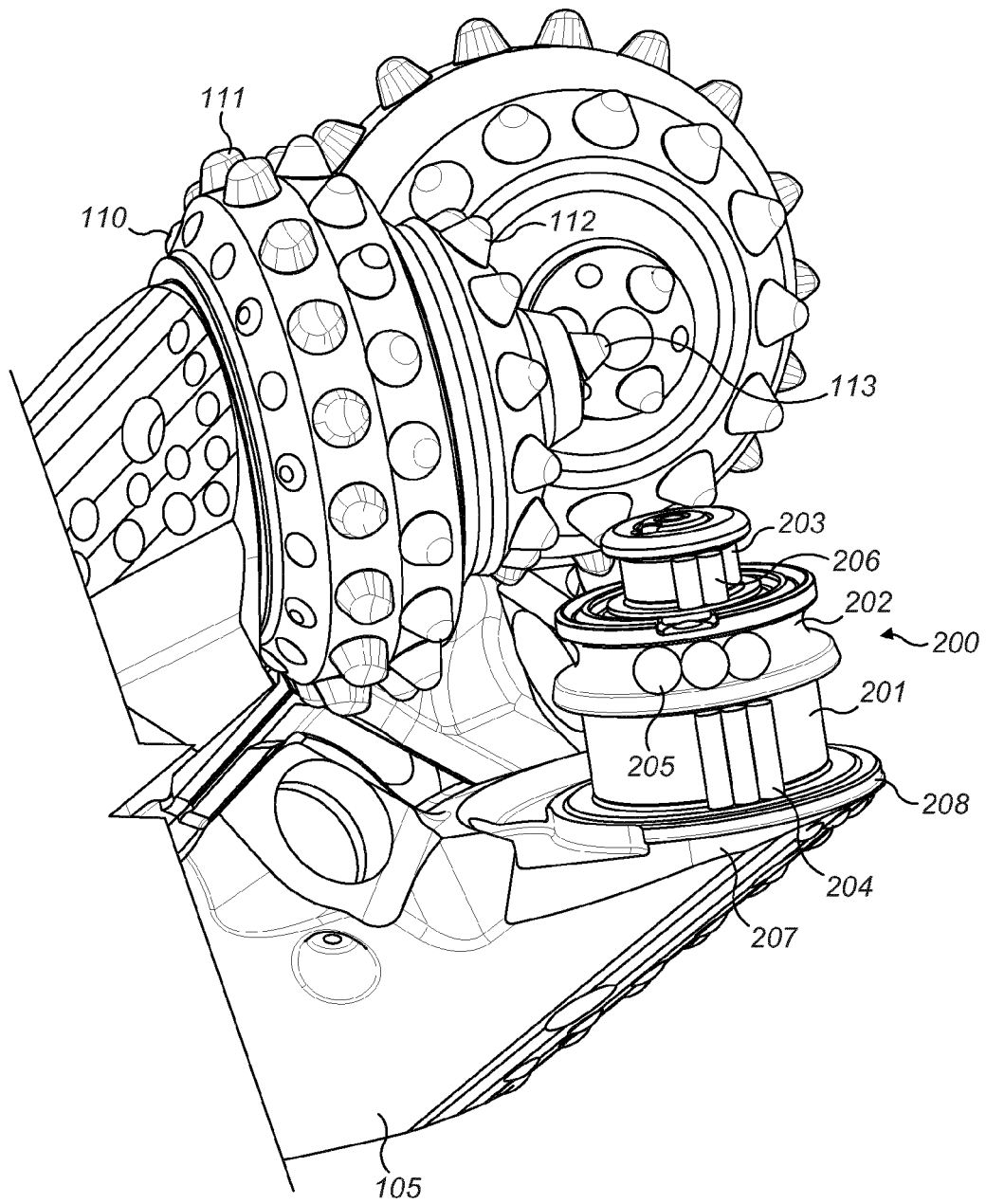


FIG. 2

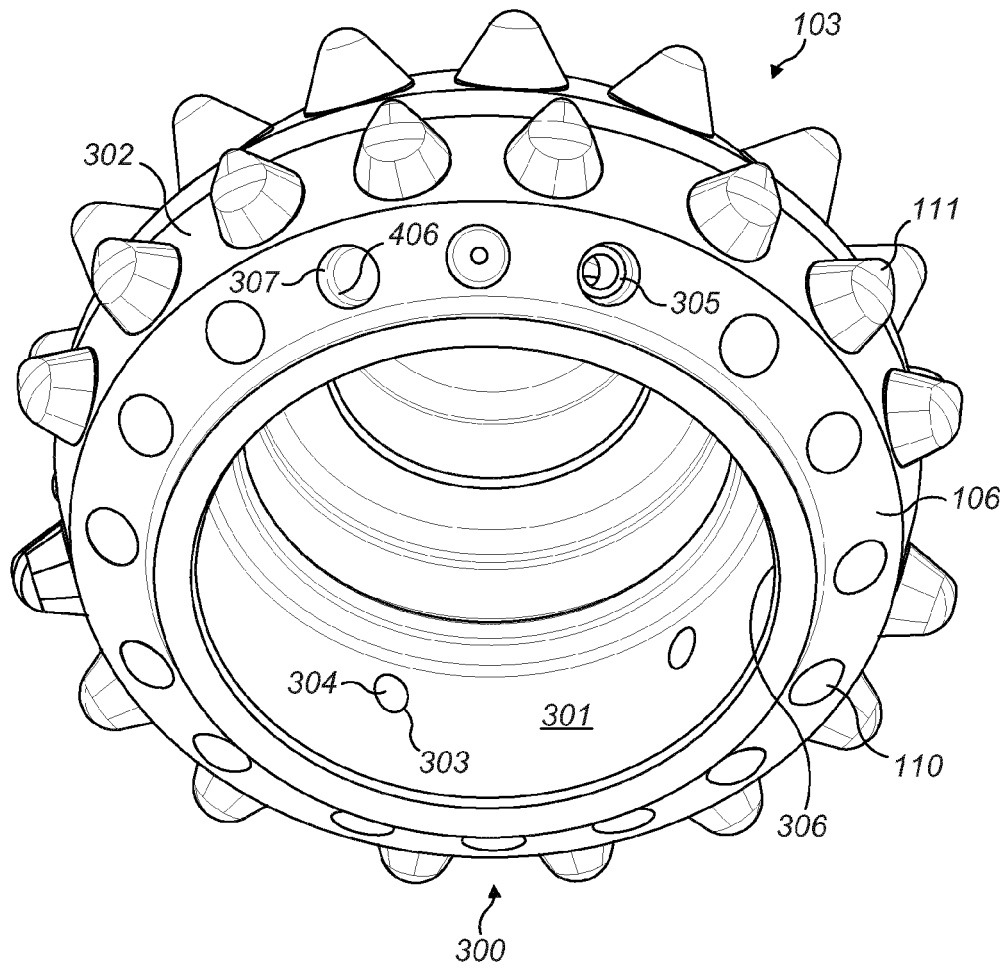


FIG. 3

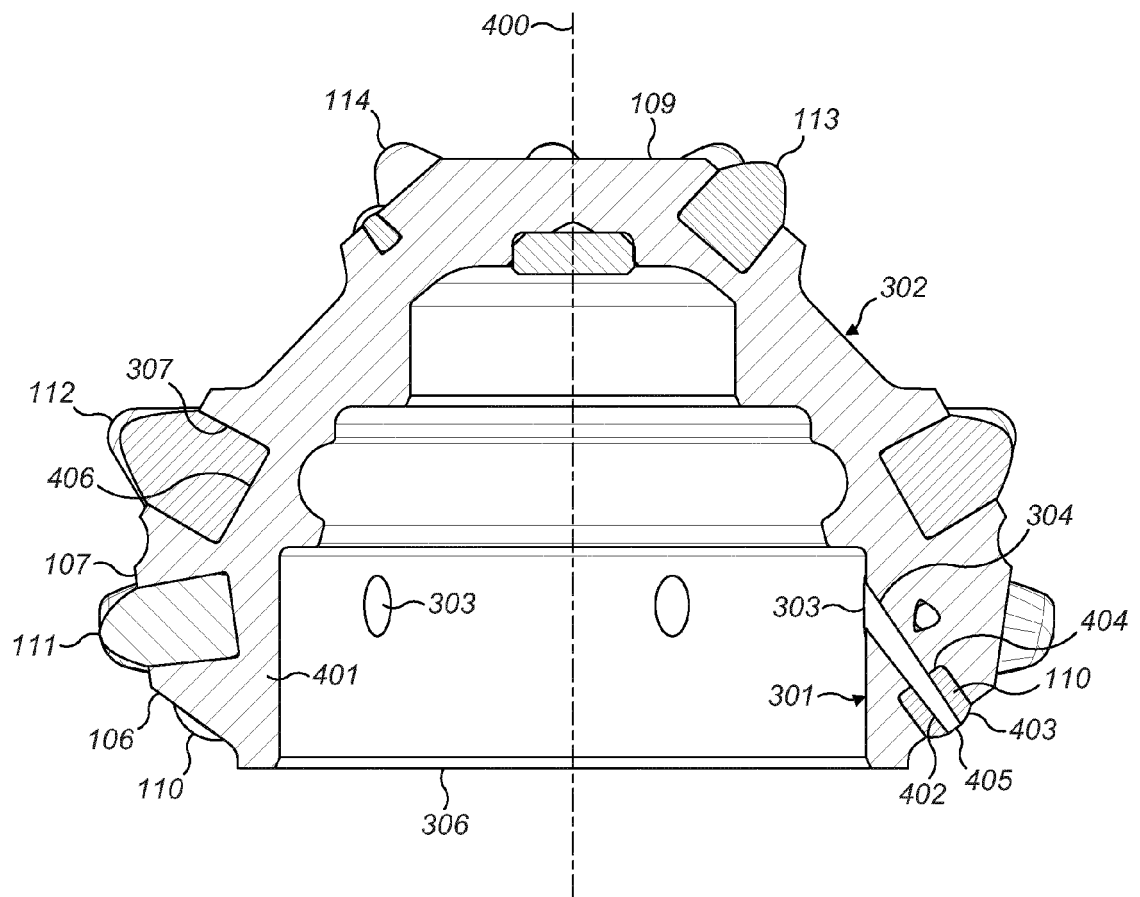


FIG. 4

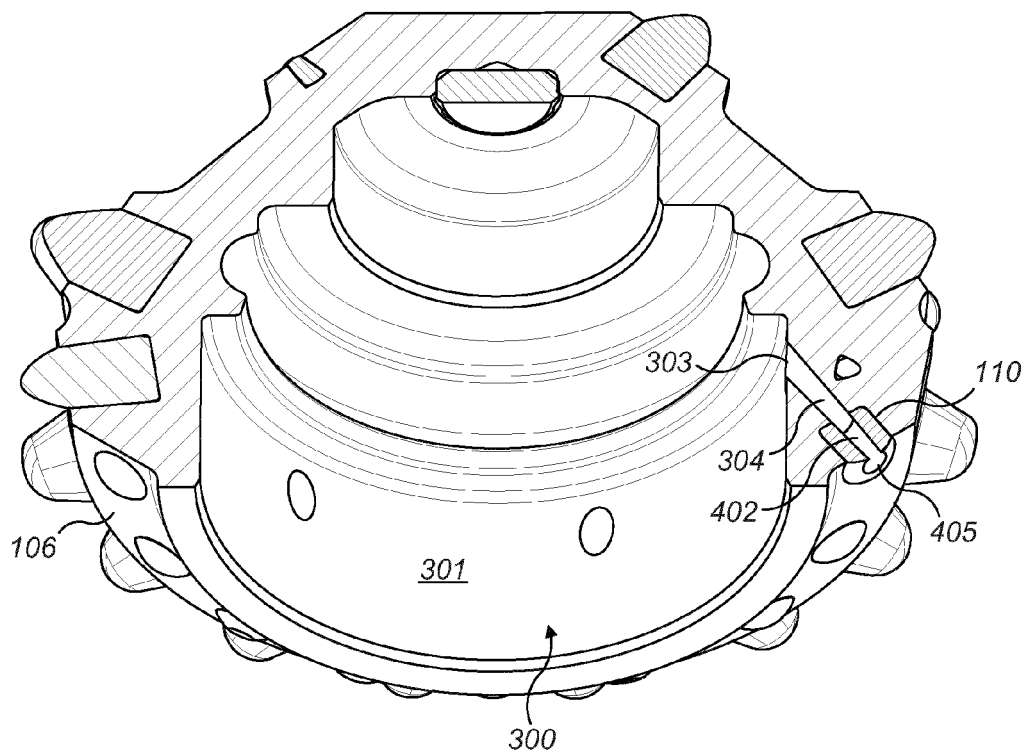


FIG. 5

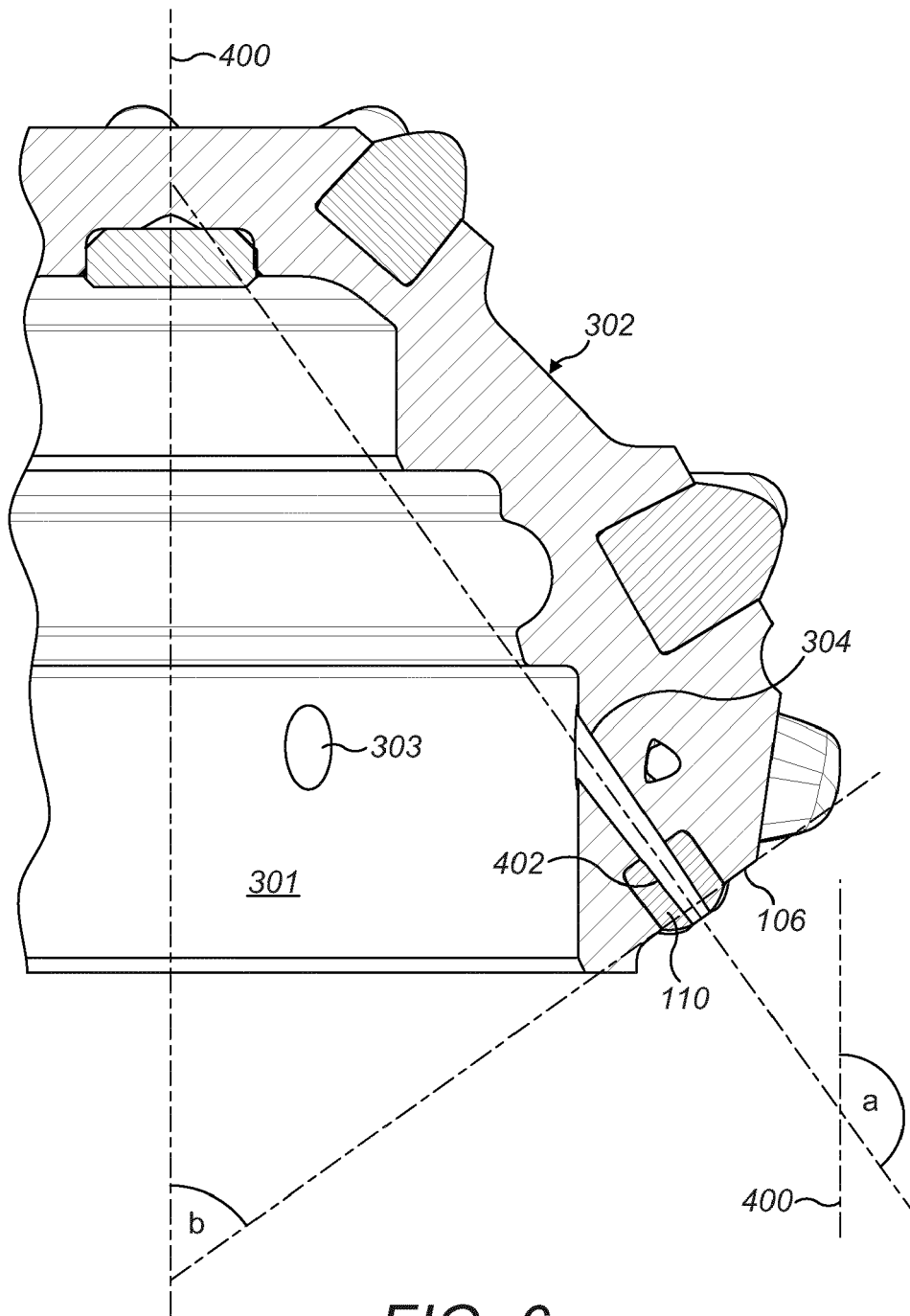


FIG. 6



EUROPEAN SEARCH REPORT

Application Number
EP 14 15 4781

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	US 4 688 651 A (DYSART THEODORE R [US]) 25 August 1987 (1987-08-25) * abstract; figure 1 *	1-15	INV. E21B10/23 E21B10/24
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			TECHNICAL FIELDS SEARCHED (IPC)
			E21B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 May 2014	Examiner Simunec, Duro
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 15 4781

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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20-05-2014

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REFERENCES CITED IN THE DESCRIPTION

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