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(54) **Percussive rock drill bit**

(57) A percussive rock drill bit comprising a head provided at one end of a rearwardly projecting skirt. The head comprises an outer collar that defines, in part, a rearwardly projecting recess formed in the forwardmost

region of the head. Peripheral gauge buttons are provided at the collar to surround side and front facing buttons formed at the head recess. The drill bit is effective to provide stabilised cutting to minimise lateral deflection.

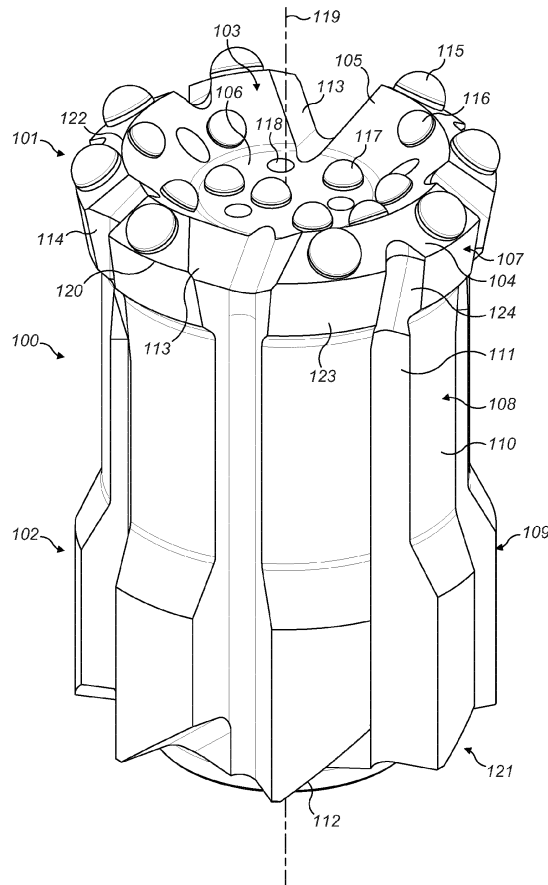


FIG. 1

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Description

Field of invention

[0001] The present invention relates to a percussive rock drill bit and in particular, although not exclusively, to a drill bit formed with a cutting head mounting a plurality of peripheral gauge buttons and front buttons configured to cut material via a guiding cone action to optimize the rock breaking and cutting operation.

Background art

[0002] Percussion drill bits are widely used both for drilling relatively shallow bores in hard rock and for creating deep boreholes. For the latter application, drill strings are typically used in which a plurality of rods are added to the string via coupling sleeves as the depth of the hole increases. A terrestrial machine is operative to transfer a combined impact and rotary drive motion to an upper end of the drill string whilst a drill bit positioned at the lower end is operative to crush the rock and form the boreholes. Fluid is typically flushed through the drill string and exits at the base of the borehole via apertures in the drill head to flush the drill cuttings from the boring region to be conveyed backward and up through the bore around the outside of the drill string. It is a typical requirement that the borehole should be as straight as possible particularly where the drilling is directed to a predetermined target deep below the earth surface. This commonly involves the drill bit passing through many different types of rock formation. Example percussive drill bits are disclosed in US 3,388,756; US 3,357,507, US 2008/0087473; and WO 2009/067073.

[0003] The drill bit typically comprises a drill head that mounts a plurality of hard cutting inserts, typically referred to as buttons. Such buttons comprise a carbide based material to enhance the lifetime of the drill bit. In particular, WO 2006/033606 discloses a rock drill bit having a head with a plurality of peripheral gauge buttons distributed circumferentially at an outer perimeter of the drill head. The gauge buttons are configured to engage material to be crushed and to determine the diameter of the borehole. The head also mounts a plurality of front buttons provided at a recessed front face of the drill head for engaging material to be crushed at the axial region immediately in front of the drill head.

[0004] However, conventional drill bits are susceptible to deflection and non-uniform bore creation due for example to anomalies in the rock structure such as cracks, fissures and sudden changes in the rock structure and type. There is therefore a need for an improved percussive drill bit that addresses these problems.

Summary of the Invention

[0005] It is an objective of the present invention to provide a percussive rock drill bit configured to aggressively

break through subterranean materials including in particular rock and minerals via a combined impact and rotary motion. In particular, it is a specific objective to provide a drill bit that impacts through fault and cracks in the rock via a cutting action in which the drill bit is self-stabilising via a shape profile created in the rock during rotation.

[0006] The objectives are achieved by providing a drill bit head having a plurality of cutting inserts aligned and positioned at different regions of a cutting head to perform different functions and in particular to stabilise the drill head as it is rotated and advanced through the subterranean material. In particular, the inventors have identified advantages with providing a head having outer peripheral gauge buttons that are tilted outwardly from a central longitudinal axis of the drill bit and are positioned axially forwardmost of any other component of the drill head. Additionally, the drill head, at a forward facing region, comprises a rearwardly projecting cavity or recess within which are mounted front facing buttons, (positioned at the lowest region of the cavity) and side buttons (positioned at the circumferential cavity sides and radially inside the gauge buttons). The front and side buttons of the cavity are effective to create a 'cone' shaped projection in the rock as the drill bit is rotated and advanced. This cone formation is provided by the relative size and orientation of the front and side buttons. In particular, the side buttons are tilted radially inward towards the axis such that a tip (or a leading cutting edge) of the buttons is positioned closer to the axis than a base of the buttons embedded in the drill head. Additionally, the peripheral gauge buttons are advantageously tilted radially outward such that their tip (or leading cutting edge) is positioned radially furthest from the axis than a base region of the buttons embedded in the drill head.

[0007] It is a further advantage of the subject invention that the outer peripheral gauge buttons are effective to create an annular groove in the rock during rotation with this annular groove surrounding the guiding cone. The inventors have identified that this annular groove is effective to further stabilise the drill head during rotation and advancement. This is achieved, in part, via the relative axial positioning of the gauge buttons being axially forwardmost of the side and front buttons.

[0008] According to a first aspect of the present invention there is provided a percussive rock drill bit comprising: a head coupled to a rearwardly projecting skirt, a longitudinal axis extending through the head and the skirt; the head having a front face and an outer collar being raised and projecting axially forward of the front face, the collar having an inner sloping surface being inclined relative to the axis and being radially inward facing such that the front face and the sloping surface define a rearwardly projecting cavity in a forward region of the bit; a plurality of gauge buttons distributed over the collar and mounted at the head to tilt radially outward from the axis; a plurality of front buttons distributed over the front face; characterised by: a plurality of side buttons distrib-

uted over the inner sloping surface of the collar wherein at least a portion of each gauge button is positioned axially forwardmost of each side button.

[0009] Preferably, each side button is mounted at the head to tilt radially inward towards the axis.

[0010] Reference within the specification to 'buttons' encompasses inserts adapted specifically to be harder than the main body of the drill (being typically steel) including the drill head. The cutting inserts may typically comprise a carbide based material such as cemented carbide or tungsten carbide for example.

[0011] Optionally, a diameter or width of the gauge buttons is greater than a diameter or width of the side buttons. Optionally, a diameter or width of the gauge buttons is greater than a diameter or width of the front buttons.

[0012] Optionally, the gauge buttons are tilted radially outward from the axis at an angle in the range 30 to 50°, 30 to 45°, 35 to 45°. Optionally, the side buttons are tilted radially towards from the axis at an angle in the range 30 to 50°, 30 to 45°, 35 to 45°. Preferably, the gauge buttons are tilted radially outward from the axis at an angle of substantially 40° and the side buttons are tilted radially towards the axis at an angle of substantially 40°.

[0013] Preferably, the collar comprises a peripheral surface extending around the inner sloping surface and orientated to be declined relative to the axis to be radially outward facing, the gauge buttons projecting from the gauge surface.

[0014] Preferably, the drill bit further comprises axially projecting channels extending from a peripheral region of the cutting head and along the length of the skirt. Optionally, the drill head further comprises radially extending grooves formed in the peripheral collar. Preferably, the drill bit further comprises an annular flange provided at an axially rearward end, the flange comprising a plurality of rearward facing teeth with a cutting region to provide a cutting action when the drill bit is rotated for extraction from the borehole.

[0015] Preferably, the drill bit further comprises at least one fluid supply conduit formed internally within the drill bit and extending axially rearward from the cutting head and in particular the front face. Preferably, the drill bit further comprises an axially inner bore extending lengthwise within the main body of drill bit to mount the drill bits on a shaft of the terrestrial machine to impart the impact and rotary motion.

[0016] Optionally, the gauge, front and/or side buttons comprise any one or a combination of the following: a domed shape configuration; a rounded shape configuration; a conical shape configuration; a ballistic shape configuration; a semi-spherical shape configuration; a flat end configuration. Preferably, the buttons (optionally turned hardened inserts) are embedded into the cutting head via conventional manufacturing methods known to those skilled in the art.

[0017] Optionally, the drill bit comprises eight gauge buttons. Optionally, the drill bit comprises six side buttons. Optionally, the drill bit comprises four front buttons.

[0018] Preferably, the collar comprises at least one groove extending axially between an end peripheral surface and the front face. Optionally, collar comprises at least one channel extending from an end peripheral surface axially towards the front face.

Brief description of drawings

[0019] 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 upper perspective view of the percussive rock drill bit having a skirt and a drill head mounting a plurality of cutting inserts (buttons) according to a specific implementation of the present invention;

Figure 2 is a lower perspective view of the drill bit of figure 1;

Figure 3 is a plan view of the head region of the drill bit of figure 2;

Figure 4 is an external side elevation view of the drill bit of figure 2;

Figure 5 is a cross sectional side view through A-A of figure 4;

Figure 6 is a magnified view of the inserts mounted at the bit head of figure 5.

Detailed description of preferred embodiment of the invention

[0020] Referring to figures 1 to 4 a drill bit 100 comprises a drill head 101 formed at one end of a generally elongate shaft 108. An opposite end of shaft 108 is flared radially outward to provide an annular flange 109. Shaft 108 and flange 109 collectively define a skirt 102 that represents a trailing region of drill bit 100 as it is advanced through the rock or subterranean material via the leading drill head 101. A plurality of axially extending channels 111 are recessed into the outer surface of skirt 101 and extends almost the entire axial length of drill bit 100. Channels 111 terminate at head region 101 to create depressions 114 that extend radially inward towards a central longitudinal axis 119 (extending through drill bit 100) from a radially outermost peripheral edge 120 of head 101. The circumferentially spaced apart channels 111 define intermediate axially extending ridges 110 that are also provided over the substantially entire axial length of drill bit 100.

[0021] A plurality of cutting teeth 112 are provided at an axially rearward region 121 of skirt 102 and in particular annular flange 109. Teeth 112 comprise an axially rearward facing cutting surface 200 configured to facilitate extraction of the drill bit 100 backwards through the

borehole created by the advancing head 101. Teeth 112 are formed at the end regions of each ridge 110.

[0022] Head 101 is flared radially outward relative to shaft 108 and comprises a maximum diameter being approximately equal to a diameter of flange 109 to form a raised outer collar represented generally by reference 107. Collar 107 forms a perimeter of a cavity 103 that projects axially rearward from a forwardmost annular rim 122 of collar 107. Cavity 103 is also defined, in part, by a sloping side surface 105 that is tilted radially outward from axis 119. The inclined side surface 105 is terminated at an upper end by annular rim 122 and at a lower end by a front facing surface 106. Front surface 106 is aligned substantially perpendicular to axis 119 and comprises a generally circular configuration.

[0023] Collar 107 is further defined, in part, by a peripheral surface 104 that extends circumferentially and radially outward beyond rim 122. Peripheral surface 104 is terminated by radially outermost edge 120. Surface 104 is tilted radially outward from axis 119 so as to be generally outward facing whilst cavity side surface 105 is orientated to be generally inward facing towards axis 119. A head trailing surface 123 extends axially rearward of peripheral surface 104 and is also orientated transverse to axis 119 so as to decrease the diameter of collar 107 towards a diameter of shaft 108. According to the shape profile and configuration of head 101 and in particular the peripheral raised collar 107, cavity region 103 comprises a generally bowl or dish-shaped configuration in which the sides of the bowl are defined by sloping surface 105 and the base of the bowl is defined by front surface 106. A pair of diametrically opposed grooves 113 are formed within collar 107 from axially forwardmost rim 122 to an axial depth aligned with front surface 106. Each groove 113 comprises a generally V-shaped configuration in which a width of the groove at its lower region (corresponding to front face 106) is smaller than a corresponding width at an upper region (corresponding to rim 122). Some channels 111 terminate at head 101 to form depressions 114 recessed axially and extending radially through the forwardmost region of collar 107 from rim 122. Depressions 114 and grooves 113 allow debris material to pass radially outward from cavity 103 to a region outside of drill bit 100. Additionally some channels 111 terminate at head 101 to form indents 124 in the radially outermost region 120 of collar 107, where such indents 124 do not extend radially through the collar wall to emerge at cavity 103.

[0024] Drill head 101 comprises three types of hardened cutting inserts (referred to herein as buttons). A first set of buttons 115 are positioned at peripheral surface 104 and are configured as gauge buttons to determine and maintain a predetermined diameter of the borehole formation. Gauge buttons 115 are tilted radially outward so as to be generally inclined and outward facing from axis 119 consistent with peripheral surface 104. Gauge buttons 115 are embedded within and distributed circumferentially around the perimeter region of collar 107 to

project axially forward of rim 122 and to represent collectively an axially forwardmost cutting edge of drill bit 100. A second set of buttons 117 are embedded in front facing surface 106 at the cavity base region 103. Buttons 117 are aligned generally with axis 119. A third set of buttons 116 are embedded in the collar side wall at the inward facing sloping surface 105. Buttons 116 are positioned at a region radially intermediate the outer peripheral gauge buttons 115 and radially inner front facing buttons 117. Side buttons 116 are mounted at the collar wall region to tilt radially inward towards axis 119 having an opposite angle of inclination to gauge buttons 115. Side buttons 116 are provided at different axial heights at sloping surface 105 such that at least one button is provided at an axially lower position (towards front surface 106); at least one button 116 is positioned axially higher (towards peripheral rim 122) and at least one button 116 is positioned axially between these two upper and lower buttons 116. Accordingly, the relative position of buttons 116 over surface 105 ensures a continuous cutting edge is formed over the entire axial length of surface 105 between rim 122 and front surface 106. Additionally and referring to figure 3, each gauge button 115 comprises a region 300 that extends radially outward beyond the outermost edge 120 of collar 107.

[0025] Referring to figures 5 and 6 each of the three types of cutting button 115, 116, 117 comprises a generally dome-shaped cutting surface provided at one end of a generally elongate main body. The main body of each button 115, 116, 117 is embedded within drill head 101 such that only the domed surface protrudes to represent semi spherical cutting surfaces. Outer gauge buttons 115 comprise a domed end portion having a diameter greater than that of side and front buttons 116, 117. Side buttons 116, 117 comprise approximately equal diameter domed head portions. The elongate main body of gauge buttons 115 are tilted radially outward as illustrated by reference 502 relative to longitudinal axis 119. The inclined angle α is typically between 30 to 45° and is substantially 40°. Accordingly, the domed head surface 115 projects generally radially outward from axis 119. Additionally, each elongate main body of side buttons 116 is mounted at head 101 so as to tilt towards axis 119 to be generally inward facing. An angle of inclination β of side buttons 116 is represented by reference 503 and is typically between 30 to 45° and is substantially 40° relative to axis 119. As illustrated in figure 5, the front buttons 117 comprise a main body that is aligned substantially parallel with axis 119 as indicated by reference 504.

[0026] Drill bit 100 comprises an elongate central bore 200 extending from the axially rearward region 121 to head 101. An opening 501 of bore 200 is flared radially outward and a corresponding innermost region 500 of bore 200 is also flared radially outward to engage and mate with a driving tool coupled to the terrestrial machine to impart the hammer-like impacting force and a rotary motion to bit 100. A plurality of fluid conduits 118 extend

from bore 200 to emerge from front facing surface 106 to provide a fluid flow pathway. Accordingly, a fluid may be provided to drill bit 100 to flow through bore 200 and conduits 118 to the cavity region 103. Cutting debris is then flushed from head 101 via grooves 113 and depressions 114 to be carried rearwardly through channels 111. Referring to figure 6, each gauge button 115 comprises a region 500 of the domed cutting surface that is positioned axially forward from a corresponding region 501 of the domed cutting surface of each side button 116. Accordingly, the axially forwardmost region 500 of gauge button 115 is positioned axially proud of the axially forwardmost region 501 of side button 116 by a distance d. According to the specific implementation, distance d is substantially 0.3 to 1.5 mm and is in particular 0.5 or 0.7 mm.

[0027] In use, drill bit 100 is configured to rotate about axis 119. As the gauge buttons 115 are positioned axially forwardmost and radially outermost, these cutting components 115 provide the principal cutting action through the rock. In particular, the radially outward tilting orientation of gauge buttons 115 provides that cutting head 101 creates an annular groove in the rock at the leading end region of drill bit 100. This as-formed groove is effective to stabilise bit 100 and inhibit undesirable lateral deflection from axis 119 during advancement. Additionally, the relative orientation and configuration of side buttons 116 and front facing buttons 117 (mounted within recess 103) are effective to create a 'guide cone' in the rock as drill bit 100 advances. This guide cone projects rearwardly into cavity 103 from rim 122 and is surrounded by the as-formed annular groove created by gauge buttons 115. The formation of the guide cone is optimised by the tilting angular alignment of side buttons 116 to be inward facing towards axis 119. The relative axial positioning of gauge regions 115 relative to side button regions 116 ensures the leading groove is continually formed circumferentially around the guide cone to provide a combined means of anchorage of the drill bit 100 within the borehole. The present configuration of the three types of cutting insert 115, 116, 117 provide that the drill bit 100 is effective to aggressively break through fault and cracks in the rock.

[0028] The present invention is not limited to the above described embodiments. Different alternatives, modifications and equivalents might be used. The above mentioned embodiments should therefore, not be considered limiting to the scope of the invention, which is defined by the patent claims.

Claims

1. A percussive rock drill bit (100) comprising:

a head (101) coupled to a rearwardly projecting skirt (102), a longitudinal axis (119) extending through the head (101) and the skirt (102); the head (101) having a front face (106) and an

outer collar (107) being raised and projecting axially forward of the front face (106), the collar (107) having an inner sloping surface (105) being inclined relative to the axis (119) and being radially inward facing such that the front face (106) and the sloping surface (105) define a rearwardly projecting cavity (103) in a forward region of the bit (100);

a plurality of gauge buttons (115) distributed over the collar (107) and mounted at the head (101) to tilt radially outward from the axis (119); a plurality of front buttons (117) distributed over the front face (106);

characterised by:

a plurality of side buttons (116) distributed over the inner sloping surface (105) of the collar (107) wherein at least a portion of each gauge button (115) is positioned axially forwardmost of each side button (116).

2. The drill bit as claimed in claim 1 wherein each side button (116) is mounted at the head (101) to tilt radially inward towards the axis (119).
3. The drill bit as claimed in claims 1 or 2 wherein a diameter or width of the gauge buttons (115) is greater than a diameter or width of the side buttons (116).
4. The drill bit as claimed in any preceding claim wherein a diameter or width of the gauge buttons (115) is greater than a diameter or width of the front buttons (117).
5. The drill bit as claimed in any preceding claim wherein the gauge buttons (115) are tilted radially outward from the axis (119) at an angle in the range 30 to 45°.
6. The drill bit as claimed in any preceding claim wherein the side buttons (116) are tilted radially towards from the axis (119) at an angle in the range 30 to 45°.
7. The drill bit as claimed in claims 5 or 6 wherein the gauge buttons (115) and the side buttons (116) are tilted at an angle of substantially 40°.
8. The drill bit as claimed in any preceding claim wherein the collar (107) comprises a peripheral surface (104) extending around the inner sloping surface (105) and orientated to be declined relative to the axis (119) to be radially outward facing, the gauge buttons (115) projecting from the peripheral surface (104).
9. The drill bit as claimed in any preceding claim wherein the gauge (115), front (117) and/or side (116) buttons comprise any one or a combination of the following:

- a domed shape configuration
- a rounded shape configuration
- a conical shape configuration
- a ballistic shape configuration
- a semi-spherical shape configuration
- a flat end configuration.

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10. The drill bit as claimed in any preceding claim comprising eight gauge buttons (115).

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11. The drill bit as claimed in any preceding claim comprising six side buttons (116).

12. The drill bit as claimed in any preceding claim comprising four front buttons (117).

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13. The drill bit as claimed in any preceding claim wherein the collar (107) comprises at least one groove (113) extending axially between an end peripheral surface (104) and the front face (106).

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14. The drill bit as claimed in any preceding claim wherein the collar (107) comprises at least one channel (114) extending from an end peripheral surface (104) axially towards the front face (106).

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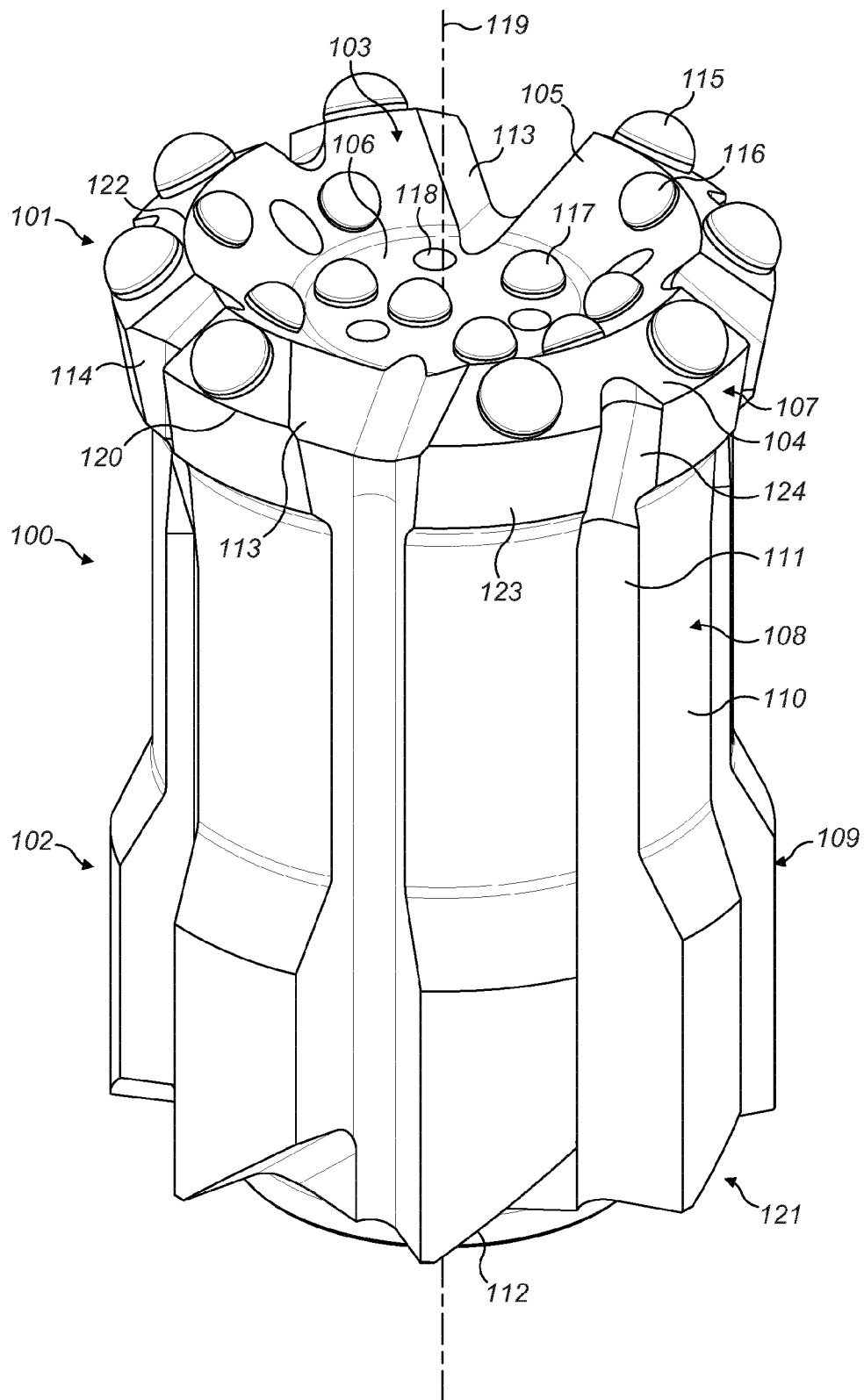


FIG. 1

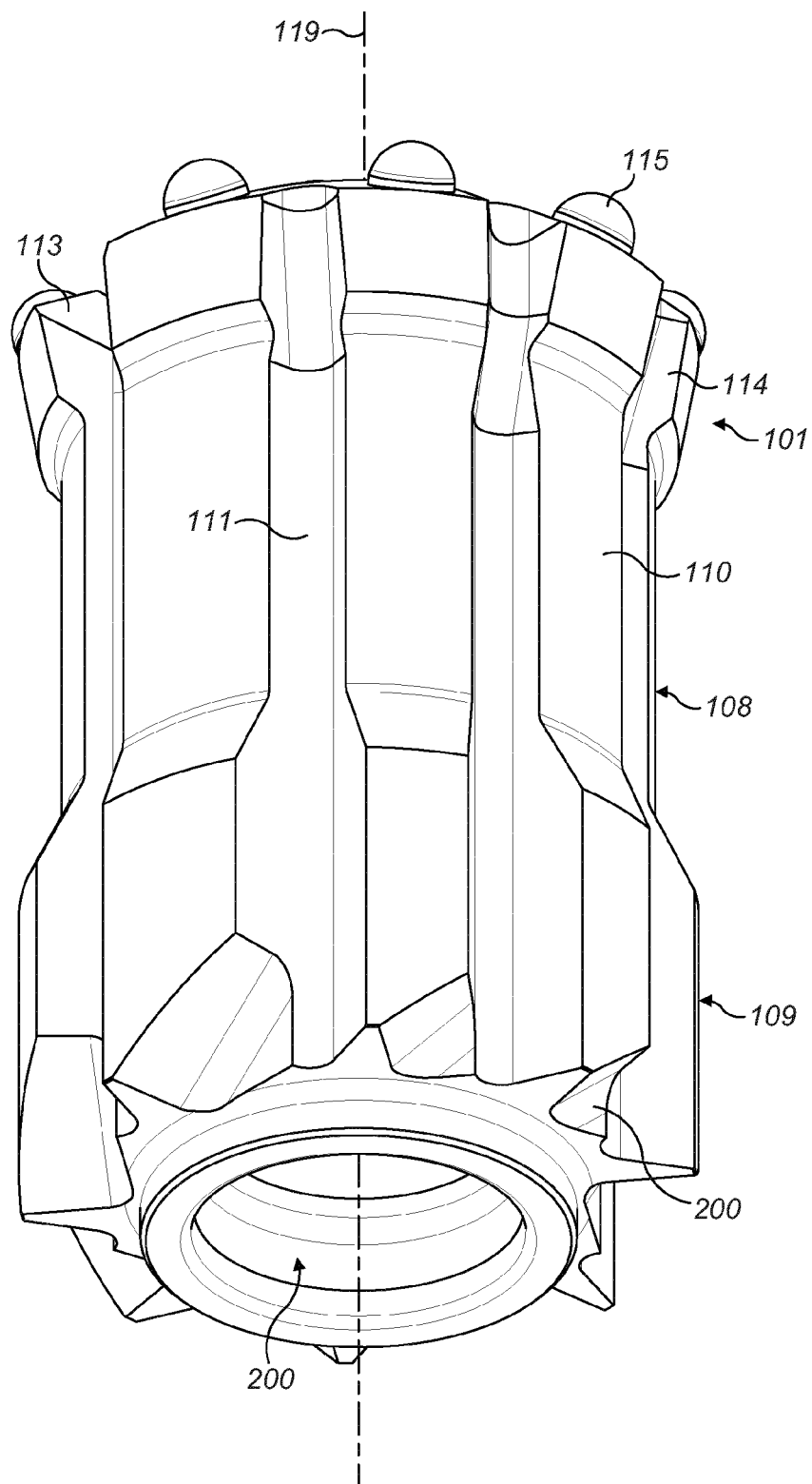


FIG. 2

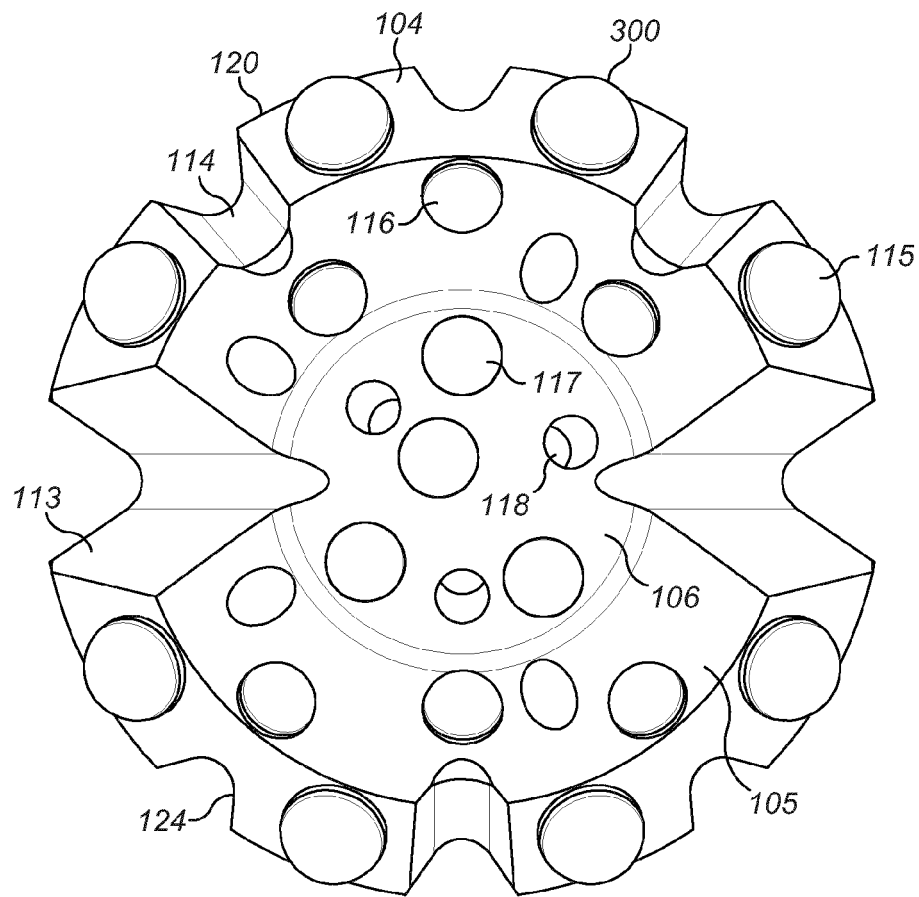


FIG. 3

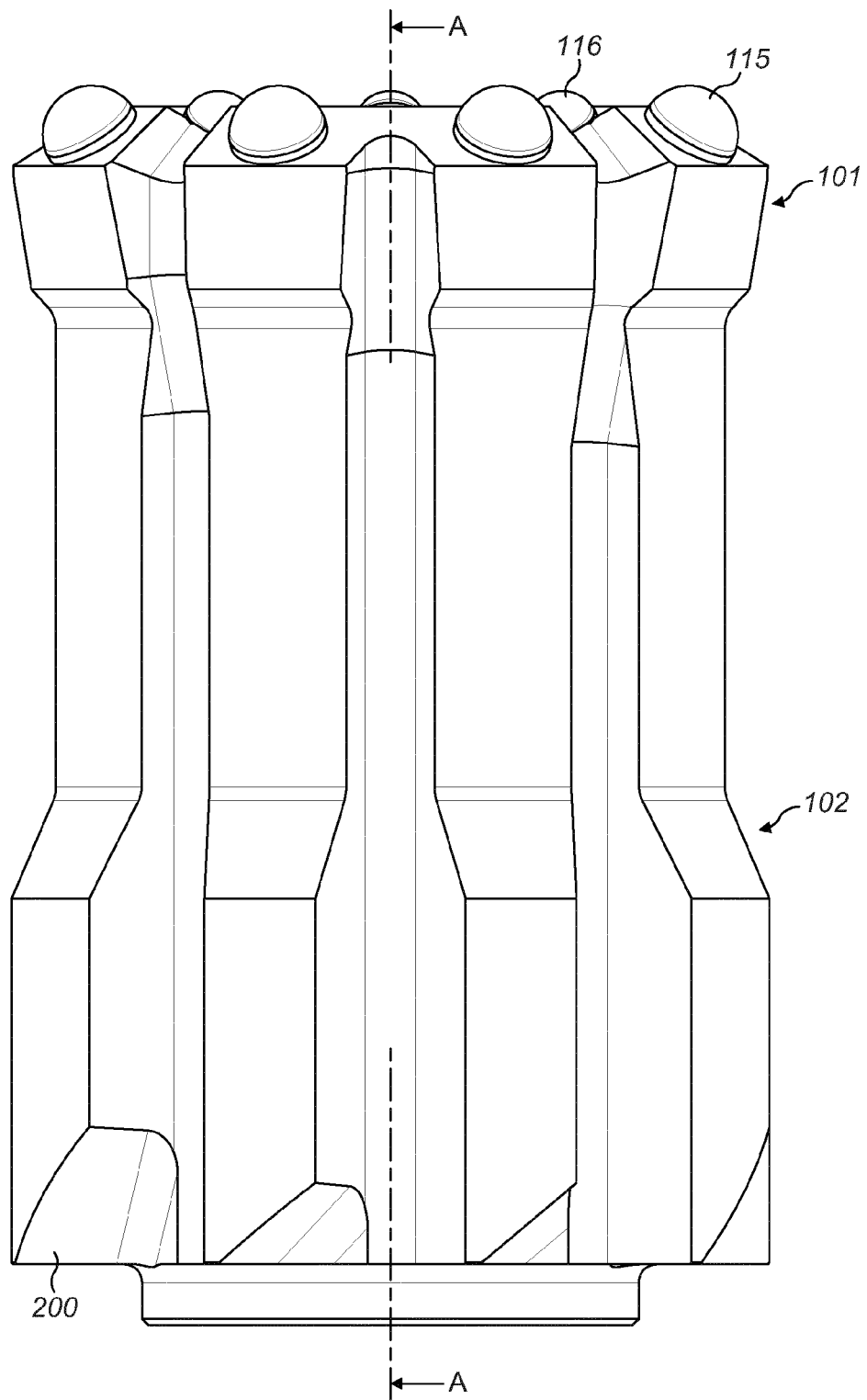


FIG. 4

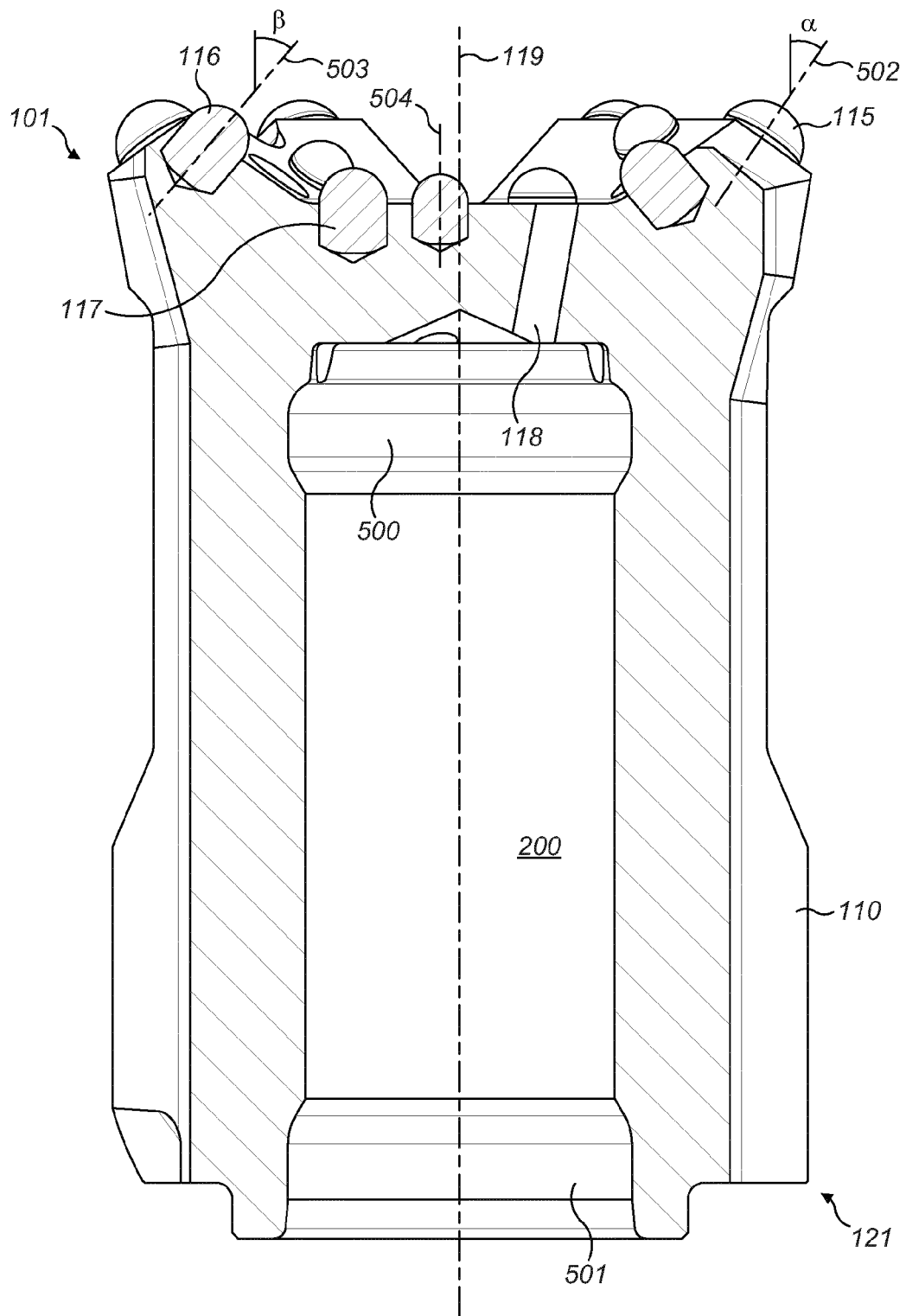


FIG. 5

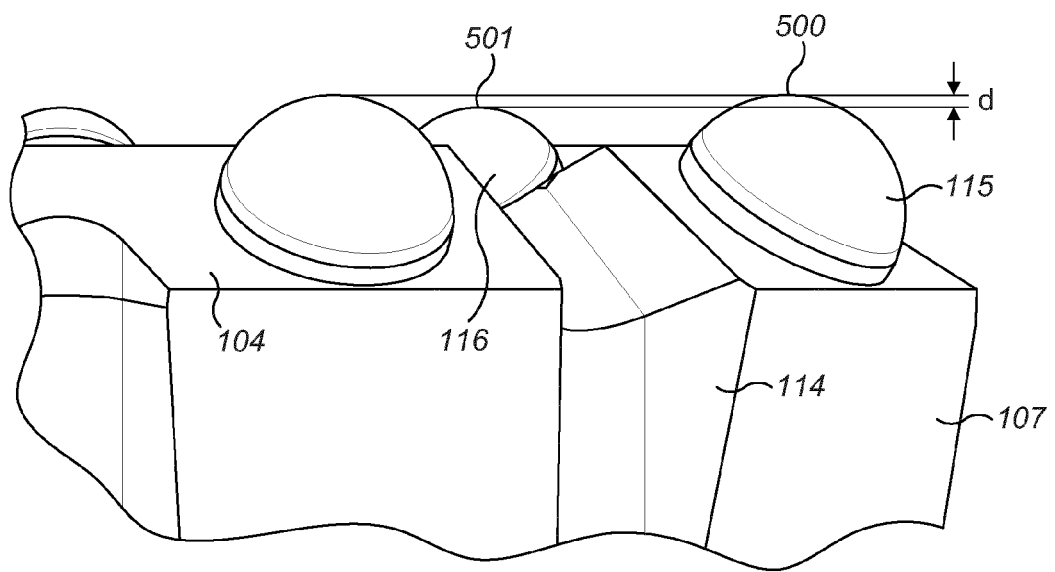


FIG. 6



EUROPEAN SEARCH REPORT

Application Number
EP 13 16 6428

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 3 955 635 A (SKIDMORE SAM C) 11 May 1976 (1976-05-11) * column 2, line 14 - column 4, line 9; figures 1,2,4,7 *	1-14	INV. E21B10/36
X,D	US 2008/087473 A1 (HALL DAVID R [US] ET AL) 17 April 2008 (2008-04-17) * paragraph [0046]; figure 11 *	1	
X	US 2008/078584 A1 (LYON LELAND H [US]) 3 April 2008 (2008-04-03) * paragraph [0044]; figures 4-7 *	1	
A	WO 2012/174607 A1 (DRILLING TOOLS AUSTRALIA PTY LTD [AU]; SANFEAD BRIAN THOMAS [AU]) 27 December 2012 (2012-12-27) * abstract; figures 4-7 *	1-14	
			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 12 September 2013	Examiner Strømmen, Henrik
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.**

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The members are as contained in the European Patent Office EDP file on
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12-09-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3955635 A	11-05-1976	NONE	
US 2008087473 A1	17-04-2008	NONE	
US 2008078584 A1	03-04-2008	US 2008078584 A1 WO 2008042258 A2	03-04-2008 10-04-2008
WO 2012174607 A1	27-12-2012	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 3388756 A [0002]
- US 3357507 A [0002]
- US 20080087473 A [0002]
- WO 2009067073 A [0002]
- WO 2006033606 A [0003]