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(54) **DRILL BIT WITH CURVED SLUDGE GROOVES**

(57) A percussive drill bit having a head and an axially rearward skirt. A plurality of ribs project radially outward at the skirt and define lengthwise extending channels. The ribs and channels, in the lengthwise direction are curved or angled to deviate from a longitudinal axis of the drill bit to facilitate rearward transport of fines and flushing fluid.

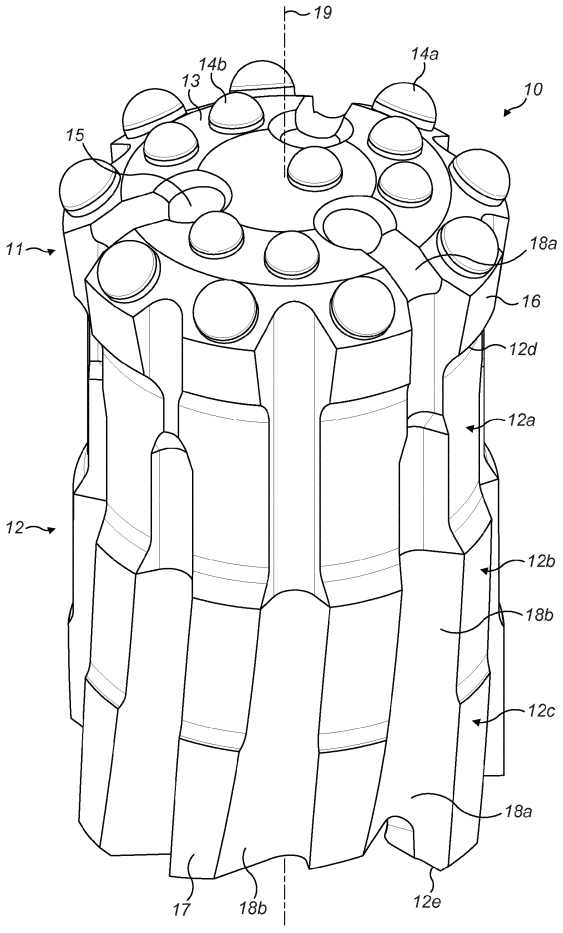

FIG. 1

EP 3 617 439 A1

Description

Field of invention

[0001] The present invention relates to a rock drill bit and in particular, although not exclusively, to a percussive rock drill bit having a head and an axially rearward skirt along which lengthwise ribs project radially outward to define sludge channels configured for the axially rearward transport of fluid and cut rock.

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, a drill string is typically used in which a plurality of rods are coupled end-to-end via threaded joints as the depth of the bore 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. WO 2006/033606 discloses a typical drill bit comprising a drill head that mounts a plurality of hard cutting inserts, commonly referred to as buttons. Such buttons comprise a carbide based material to enhance the lifetime of the drill bit.

[0003] 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 rock cuttings from the boring region to be conveyed rearward around the outside of the drill string.

[0004] The effectiveness of the drill bit to bore into rock is dependent upon the rearward transport of the rock fragments from the cutting region. The cut rock combined with the flushing fluid typically forms a sludge and it is important the sludge is transported rearwardly during cutting to avoid recrushing of the rock and a corresponding shortening of the operational lifetime of the drill bit. Additionally, non-transported sludge acts to block the bore and inhibit axially rearward extraction of the drill bit in addition to increasing the risk of possible collapse of the borehole during bit extraction. Accordingly, there is a need for a drill bit to address these problems.

Summary of the Invention

[0005] It is an objective of the present invention to provide a drill bit and in particular a percussive rock drill bit to facilitate axially rearward transport of flushing fluid and cut rock typically in the form of a sludge from the forward cutting region of the borehole.

[0006] It is a further objective to provide a drill bit that minimises unnecessary recrushing or grinding of rock fragments so as to extend the operational lifetime of the drill bit.

[0007] It is a yet further objective to provide a drill bit to facilitate rearward extraction following forward drilling and to prevent borehole collapse as the drill string and the drill bit are extracted rearwardly.

[0008] The objectives are achieved by providing a drill bit having a skirt extending axially rearward from a cutting head that comprises sludge grooves specifically adapted for the axially rearward transport of rock debris and flushing fluid both during axially forward drilling and axially rearward extraction of the drill bit. The sludge grooves at the skirt are defined by axially extending ribs that in the lengthwise direction of the ribs between the bit head and an axially rearwarmost part of the skirt are bent or curved relative to the longitudinal axis of the drill bit so as to be aligned oblique to the longitudinal axis. That is, the ribs that define the sludge grooves (referred to herein as channels) have a length component that may be regarded as deflected so as to deviate in a circumferential direction around the axis. Optionally, the lengthwise path of the ribs and the channels may be helical around the axis.

[0009] According to a first aspect of the present invention there is provided a drill bit comprising: a head having cutting elements to abrade rock by rotation of the drill bit about its longitudinal axis; a skirt extending axially rearward from the head; a plurality of ribs projecting radially outward and extending axially along the skirt to define axially extending channels, the rib and channels each having a length extending axially in a direction between the head and an axially rearward end of the skirt; characterised in that: in the lengthwise direction at least a part of the ribs and channels are bent or curved such that the lengthwise part of the ribs or channels is oblique to the longitudinal axis.

[0010] The ribs and channels comprise a corresponding width aligned in the circumferential direction and a depth extending in a radial direction. The width and depth may be uniform along the length of the ribs and channels or may be non-uniform. However, with any variation of the width and depth, the lengthwise path of the ribs and channels along the skirt in a direction between the head and an axially rearwardmost part of the skirt is non-parallel i.e., oblique to the longitudinal axis so as to extend at least to some extent in the circumferential direction around the axis.

[0011] Reference within this specification to the ribs or channels being oblique to the longitudinal axis encompass the alignment of the ribs and channels being non-parallel to the bit longitudinal axis over at least a portion of their length. The orientation of the ribs or channels relative to the axis encompasses a general orientation with each rib being defined generally by a leading face, a leading edge, a land face, a trailing edge and a trailing face. Such faces and edges may be linear or curved but importantly at least some or all (over at least a part of their respective axial length) are aligned non-parallel to the longitudinal axis.

[0012] Optionally, the part of the ribs and channels that are oblique to the longitudinal axis are positioned at an axially rearward part of the skirt. Optionally, an axially

forward part of the ribs and channels are aligned generally parallel to the longitudinal axis. The linear axially forward part is effective to provide immediate rearward transport of the cut rock and flushing fluid whilst the oblique aligned axially rearward portion of the ribs and channels is effective to encourage the sludge to follow a helical or swirling flow pathway over the external surface of the drill string rearward from the drill bit.

[0013] Optionally, the axially rearward part extends up to 20%, 30%, 40%, 50%, 60%, 70%, 80% or 90% of the length of the skirt between an axially rearwardmost region of the head and the axially rearward end of the skirt. Preferably the axially rearward part extends over a majority of the length of the skirt. Preferably the axially rearward part extends over 30 to 80%, 40 to 80%, 50 to 80% or 50 to 70% of the length of the skirt between an axially rearwardmost region of the head and the axially rearward end of the skirt.

[0014] Optionally, the lengthwise part of the ribs and channels are at least part helical around the axis. This alignment is effective to provide a non-linear flow of the sludge axially rearward along the borehole and avoid the drill bit becoming stuck during extraction.

[0015] Preferably, each rib comprises a leading face and a trailing face separated by a radially outward facing land face, the leading and trailing faces at least partial defining the channels. The transition from the leading face to the trailing face within anyone channel may be continuously curved over a trough region of each channel.

[0016] Preferably, in the lengthwise direction both the leading and trailing faces of the ribs are bent or curved in the same circumferential direction around the axis so as to be aligned oblique to the longitudinal axis. Such an arrangement is effective to appropriately channel the flushing fluid and cut rock into what may be considered a helical or swirling flow pathway over the external surface of the drill string.

[0017] Preferably, in the lengthwise direction, at least a part of a leading edge and a trailing edge of the ribs at the junction between the land face and the respective leading face and trailing face is bent or curved so as to be aligned oblique to the longitudinal axis. Preferably, the part of the leading edge and the trailing edge that are oblique to the longitudinal axis are positioned at an axially rearward part of the skirt.

[0018] Preferably, at a cross sectional plane perpendicular to the longitudinal axis, the leading face is aligned generally normal to the rotational direction of the bit about the longitudinal axis. This configuration is beneficial to induce the flow of the sludge in the circumferential direction (approximately helical flow path) within the bore. Optionally, in the cross sectional plane perpendicular to the longitudinal axis, the trailing face is aligned transverse to the rotational direction of the bit and/or oblique to the leading face.

[0019] Optionally, an angle by which the ribs are bent or curved such that their length deviates in a circumferential direction is in the range 1 to 20°, 1 to 18°, 1 to 16°, 1 to 14°, 1 to 12°, 2 to 12°, 3 to 10°, 3 to 8° or 4 to 6° relative to the longitudinal axis. Such oblique alignment of the ribs is effective to prevent the drill bit getting stuck during extraction by appropriately directing the flushing fluid and cut rock axially rearward away from the drill bit. Preferably, the drill bit further comprises an internal bore and passageways extending axially from a forward end of the bore to emerge as openings at a forward cutting face of the head, at least some of the channels extending axially along the head in communication with the openings. Optionally, approximately half of the channels are provided in communication with the openings at the cutting face.

[0020] Preferably, the cutting elements comprise cutting buttons embedded into the head. The cutting buttons may be formed from a superhard carbide material according to conventional arrangements. As will be appreciated, the present drill bit may comprise any head configuration in addition to different cutting button distributions at the cutting head. Preferably, the cutting buttons include gauge buttons, medial buttons and radially inner buttons provided at the cutting face.

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 a perspective view from above of a percussive drill bit according to a specific implementation of the present invention;

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

Figure 3 is a perspective view from below of the drill bit of figure 2;

Figure 4 is a rear end perspective view of the drill bit of figure 3; and

Figure 5 is a cross sectional perspective view of the drill bit of figure 3;

Detailed description of preferred embodiment of the invention

[0022] Referring to figures 1 to 3, a percussive drill bit 10 comprises a cutting head 11 from which extends axially rearward an elongate skirt 12. Head 11 comprises a forward facing cutting face 13 that, according to the specific implementation is domed in a forward cutting direction. A plurality of superhard cutting buttons are embedded into cutting face 13 and include radially outer gauge buttons 14a and inner buttons 14b as will be appreciated. Head 11 is provided with a raised annular

shoulder 16 the axially forward region of which mounts gauge buttons 14a.

[0023] Referring to figure 5, skirt 12 is hollow and comprises an internal bore 26 centred on a longitudinal axis 19 of bit 10. A set of flushing fluid passageways 27 extend axially forward from a forward end 28 of bore 26 to emerge at cutting face 13 as openings 15. According to the specific implementation, three fluid passageways are provided in communication with bore 26 to emerge at cutting face 13. A respective groove or channel 18a projects radially outward from each opening 15 in a direction from axis 19 to head shoulder 16. Channels 18a are recessed into cutting face 13 and also shoulder 16 to extend axially rearward from head 11 along the full axial length of skirt 12. Bit 10 comprises two types of flushing groove including a first channel 18a in fluid communication with each respective passageway 27 (and opening 15) and a second channel 18b that terminates at its axially forward end at neck 12d and does not extend over a medial region of face 13 towards axis 19.

[0024] Referring to figures 1 and 3, the skirt 12 comprises an axial length, centred on axis 19 and extending between a neck 12d (representing an axially rearwardmost region of shoulder 16) and an axially rearwardmost end 12e of skirt 12. Along its length, skirt 12 may be considered to be divided into a number of axial sections defined by the maximum external diameter of the skirt 12 (within each section). A first section 12a immediately axially rearward of neck 12d, comprises a smallest diameter; a second middle section 12b is radially enlarged relative to first section 12a and an axially rearwardmost third section 12c is radially enlarged relative to the first and second sections 12a, 12b. Respective annular step regions 29 provide a transition between the different diameter sections 12a, 12b, 12c.

[0025] Each of the channels 12a, 12b along the length of skirt 12 between neck 12d and rearward end 12e are defined (i.e., flanked) by axially extending ribs indicated generally by reference 17. That is, ribs 17 extend the full length of skirt 12 from head 11 to skirt rearward end 12e. A thickness in the circumferential direction of each rib 17 is non-uniform and changes in a direction of axis 19 between neck 12d and skirt rearward end 12e. Moreover, each rib 17 is curved (alternatively termed angled or bent) in its lengthwise direction between neck 12d and skirt rearward end 12e so as to deviate or deflect in the circumferential direction. According to the specific implementation, each of the ribs 17 is bent within the rearward second and third sections 12b, 12c but are substantially linear within the axially forward section 12a immediately behind head 11. Accordingly, channels 18a, 18b are also bent (alternatively termed angled or curved) so as to deviate in the circumferential direction within the second and third sections 12b, 12c. As such, at least a portion of the axial length of ribs 17 and channels 18a, 18b (within sections 12b, 12c) are aligned oblique to axis 19. According to the specific implementation, ribs 17 and channels 18a, 18b (within sections 12b, 12c) follow a part helical path around axis 19 between a rearward end of first section 12a and skirt rearward end 12e.

[0026] Referring to figure 2, an angle θ by which each rib 17 is bent or deflected in its lengthwise direction from axis 19 (so as to be oblique/non-parallel to axis 19) may be in the range 1 to 20°, 3 to 10° or 3 to 8°. Such deviation refers to the general lengthwise path of ribs 17 within the second and third sections 12b, 12c. As illustrated in figure 2, the combined rearward sections 12b, 12c represents a majority of the length of skirt 12 as each section 12a, 12b, 12c represents generally a respective third of the length of skirt 12. An axial length over which the ribs 17 (and channels 18a, 18b) are oblique relative to axis 19 may be in the range 20-100%, 30-90%, 40-80% or 50-70%.

[0027] Referring to figures 2 to 4, each rib 17 and channel 18a, 18b may be defined further to include a radially innermost trough 22 which in the lengthwise direction is flanked at a first side by a leading face 20 and an opposite side by a trailing face 25. Faces 20, 25 are so named with reference to the rotational direction R (figure 4). Each rib 17 comprises a land face 23 representing a radially outermost region of skirt 12 within each section 12a, 12b, 12c. The land face 23 is terminated at each side (in a circumferential direction around axis 19) by a leading edge 21 at the junction with leading face 20 and a trailing edge 24 at the junction with trailing face 25.

[0028] The angle θ by which each rib 17 and channel 18a, 18b extends oblique to axis 19 may be defined relative to the general lengthwise pathway of the ribs 17 and channels 18a, 18b or with reference to the relative orientation of trough 22, leading faces 20, leading edge 21, land face 23, trailing edge 24 and/or trailing face 25. According to the specific implementation, trailing edge 24 is bent at a greater angle relative to leading edge 21 such that a thickness in the circumferential direction of each rib 17 decreases in the axially rearward direction towards skirt rearward end 12e over second and third sections 12b, 12c. Accordingly, a width in the circumferential direction of each channel 18a, 18b increases in the axially rearward direction over sections 12b, 12c. Where the leading and/or trailing edges 21, 24 are curved along their length, a radius of the leading edge 21 may be greater than a corresponding radius of trailing edge 24 so as to provide a corresponding non-parallel alignment of leading face 20 and trailing face 25.

[0029] Referring to figure 4, leading face 20 comprises at least a radially outer portion that is aligned on a radial spoke 30 and normal to the rotational direction R so as to be aligned perpendicular to a tangent of an imaginary circle centred on axis 19. Trailing face 25 is aligned transverse to spoke 30 and leading face 20 so as to be declined radially inward from land face 23.

[0030] The non-linear lengthwise path of each of the ribs 17 and channels 18a, 18b at least within the second and third sections 12b, 12c is advantageous to facilitate axially rearward transport of cuttings mixed with the flushing fluid that is typically represented as a sludge. That is,

the angled or curved lengthwise orientation of ribs 17 and channels 18a, 18b, facilitate the rearward passage of the sludge from the cutting region at head 11 and axially rearward along the as-formed bore. Additionally, the oblique alignment of ribs 17 and channels 18a, 18b facilitate axially rearward extraction of the drill bit 10 that is also rotated in direction R during extraction. Removing cut debris and flushing fluid from around the external region of the skirt 12 and at the head 11 reduces the risk of the drill bit 10 getting stuck within the bore during extraction in addition to minimising possible bore collapse during extraction.

[0031] According to further embodiments, the curved or angled lengthwise deviation of ribs 17 and channels 18a, 18b may extend the full axial length of skirt 12 between neck 12d and rearward end 12e. The angle by which each rib 17 is aligned relative to axis 19 may the same for all ribs 17 and at all regions of each rib 17 or the angle of deviation may be different for different ribs 17 and at different regions of each rib 17. Accordingly, a width of each channel 18a, 18b may be the same between neck 12d and skirt rearward end 12e or may vary in a lengthwise direction.

Claims

1. A drill bit (10) comprising:

a head (11) having cutting elements (14a, 14b) to abrade rock by rotation of the drill bit (10) about its longitudinal axis (19);
a skirt (12) extending axially rearward from the head (11);
a plurality of ribs (17) projecting radially outward and extending axially along the skirt (12) to define axially extending channels (18a, 18b), the rib and channels each having a length extending axially in a direction between the head (11) and an axially rearward end (12e) of the skirt (12);
characterised in that:

in the lengthwise direction at least a part of the ribs (17) and channels (18a, 18b) are bent or curved such that the lengthwise part of the ribs (17) or channels (18a, 18b) is oblique to the longitudinal axis.

2. The drill bit as claimed in claim 1 wherein the part of the ribs (17) and channels (18a, 18b) that are oblique to the longitudinal axis (19) are positioned at an axially rearward part of the skirt (12).

3. The drill bit as claimed in claim 2 wherein an axially forward part of the ribs (17) and channels (18a, 18b) are aligned generally parallel to the longitudinal axis (19).

4. The drill bit as claimed in claims 2 or 3 wherein said axially rearward part extends up to 20%, 30%, 40%, 50%, 60%, 70%, 80% or 90% of the length of the skirt between an axially rearwardmost region (12d) of the head (11) and the axially rearward end (12e) of the skirt (12).

5. The drill bit as claimed in any preceding claim wherein the lengthwise part of the ribs and channels are at least part helical around the axis (19).

6. The drill bit as claimed in any preceding claim wherein each rib comprises a leading face (20) and a trailing face (25) separated by a radially outward facing land face (23), the leading and trailing faces (20, 25) at least partial defining the channels (18a, 18b).

7. The drill bit as claimed in claim 5 wherein in the lengthwise direction both the leading and trailing faces (20, 25) of the ribs (17) are bent or curved in the same circumferential direction around the axis (19) so as to be aligned oblique to the axis (19).

8. The drill bit as claimed in claims 6 or 7 wherein in the lengthwise direction, at least a part of a leading edge (21) and a trailing edge (24) of the ribs (17) at the junction between the land face (23) and the respective leading face (20) and trailing face (25) is bent or curved so as to be aligned oblique to the axis (19).

9. The drill bit as claimed in claim 8 wherein the part of the leading edge (21) and the trailing edge (24) that are oblique to the axis (19) are positioned at an axially rearward part of the skirt (12).

10. The drill bit as claimed in any preceding claim when dependent on claim 6 wherein at a cross sectional plane perpendicular to the longitudinal axis, the leading face (21) is aligned generally normal to the rotational direction (R) of the bit about the axis (19).

11. The drill bit as claimed in claim 10 wherein in the cross sectional plane perpendicular to the axis (19), the trailing face (25) is aligned transverse to the rotational direction (R) of the bit (10) and/or oblique to the leading face (20).

12. The drill bit as claimed in any preceding claim wherein an angle (θ) by which the ribs (17) are bent or curved such that their length deviates in a circumferential direction is in the range 1 to 20° relative to the axis (19).

13. The drill bit as claimed in claim 12 wherein the range is 3 to 10°, 3 to 8° or 4 to 6°.

14. The drill bit as claimed in any preceding claim com-

prising an internal bore (26) and passageways (27) extending axially from a forward end (28) of the bore (26) to emerge as openings (15) at a forward cutting face (13) of the head (11), at least some of the channels (18a) extending axially along the head (11) in communication with the openings (15).

15. The drill bit as claimed in any preceding wherein the cutting elements comprise cutting buttons (14a, 14b) embedded into the head (11).

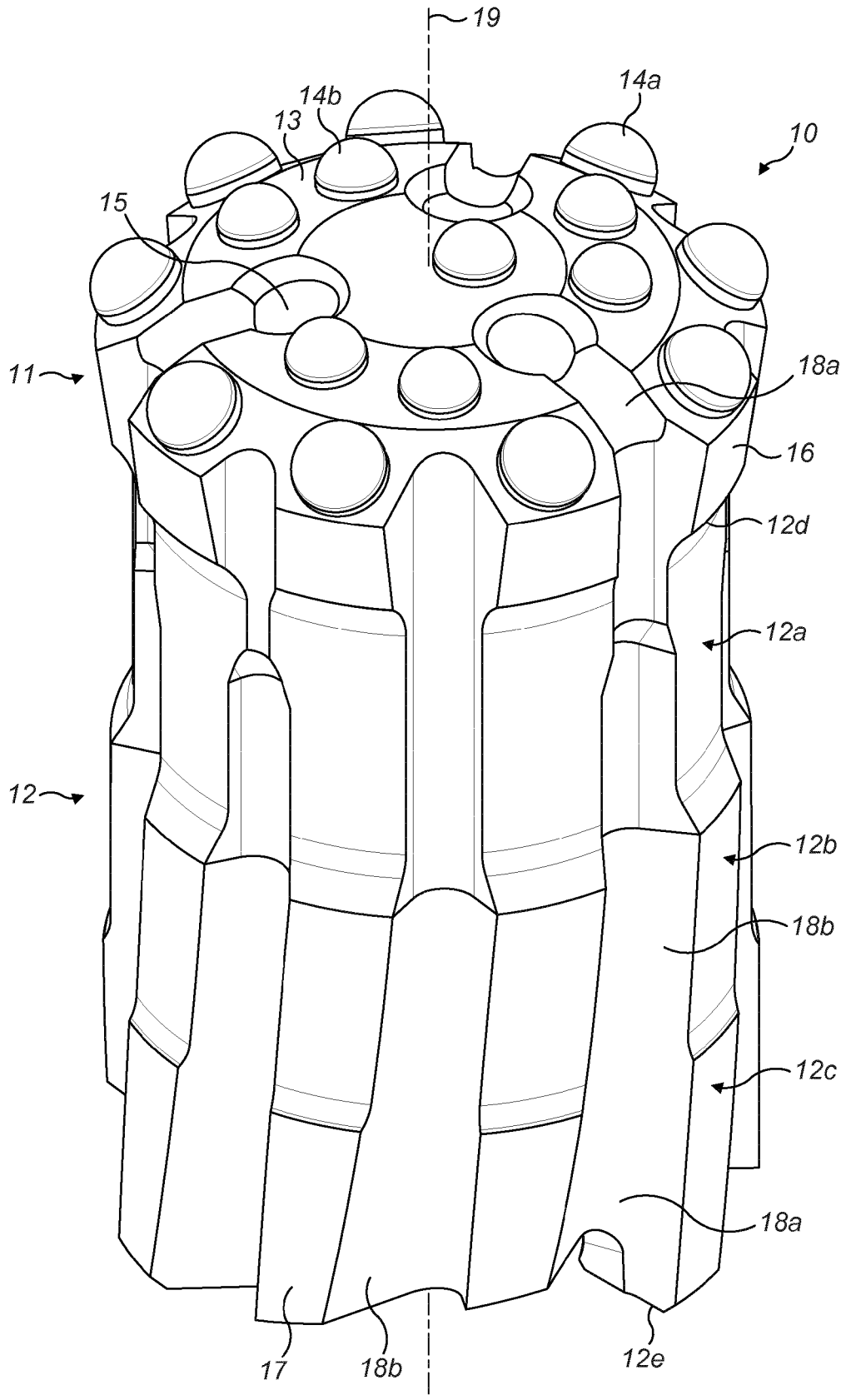

FIG. 1

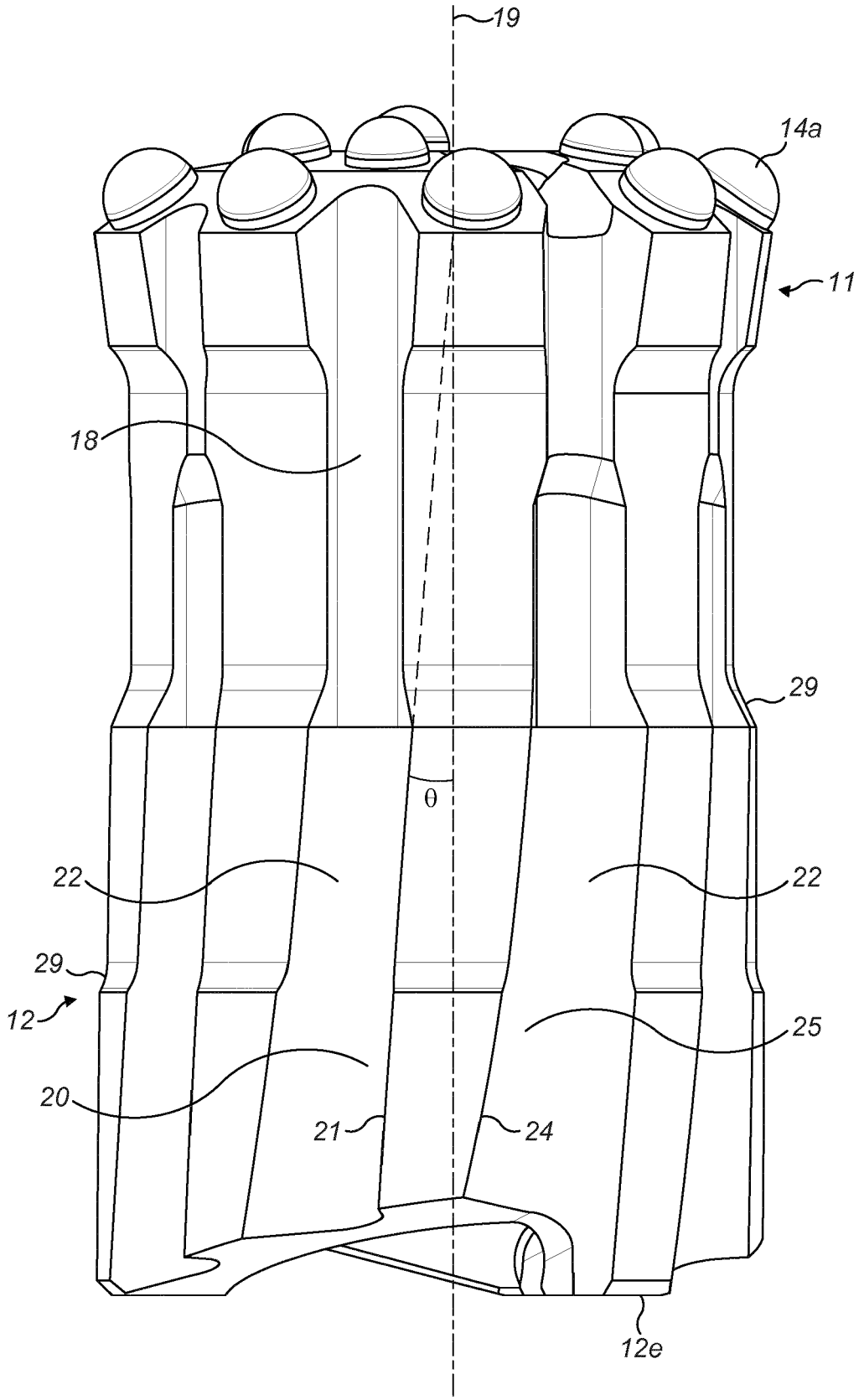

FIG. 2

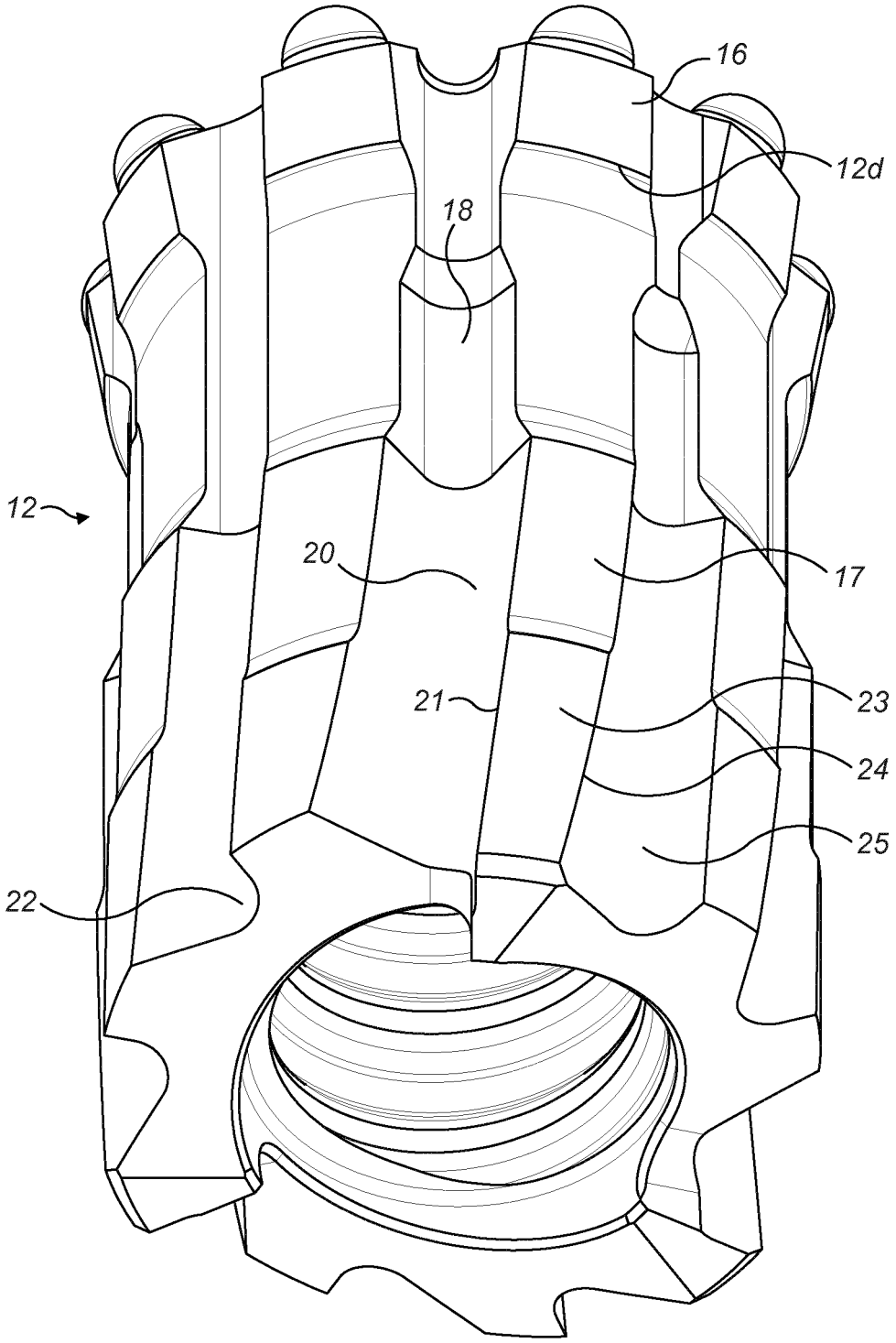

FIG. 3

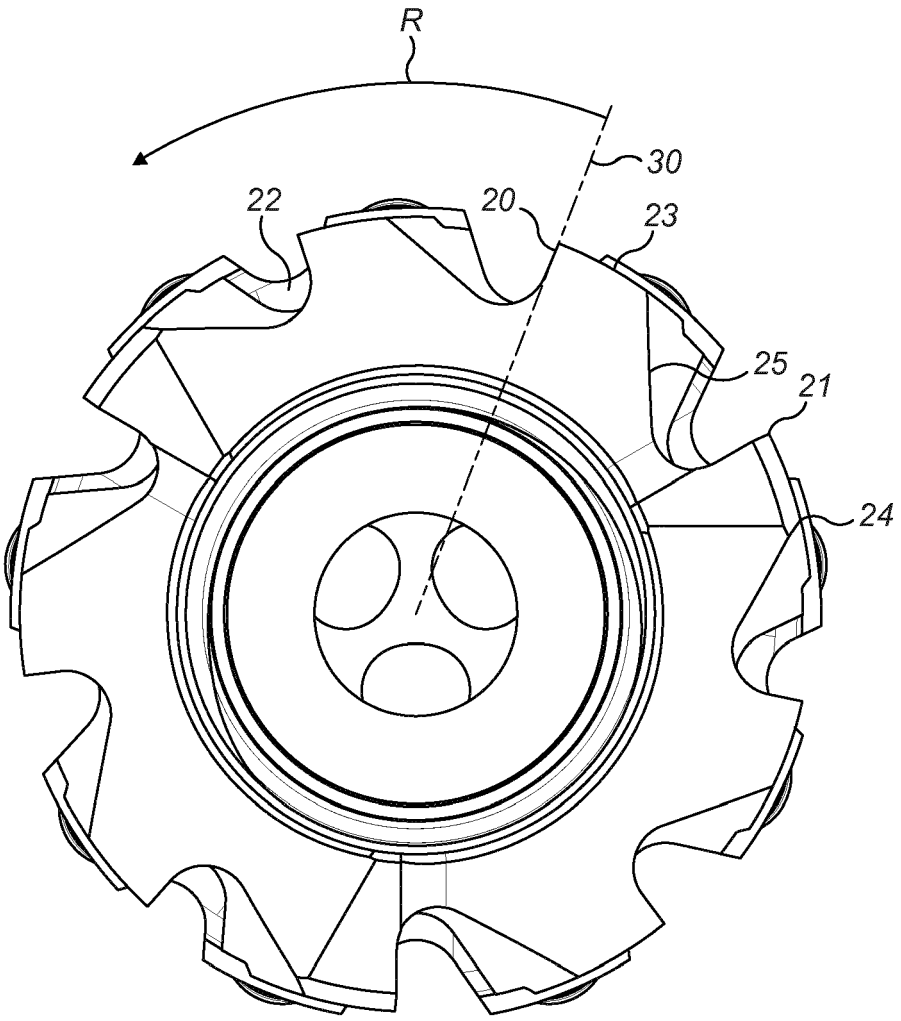

FIG. 4

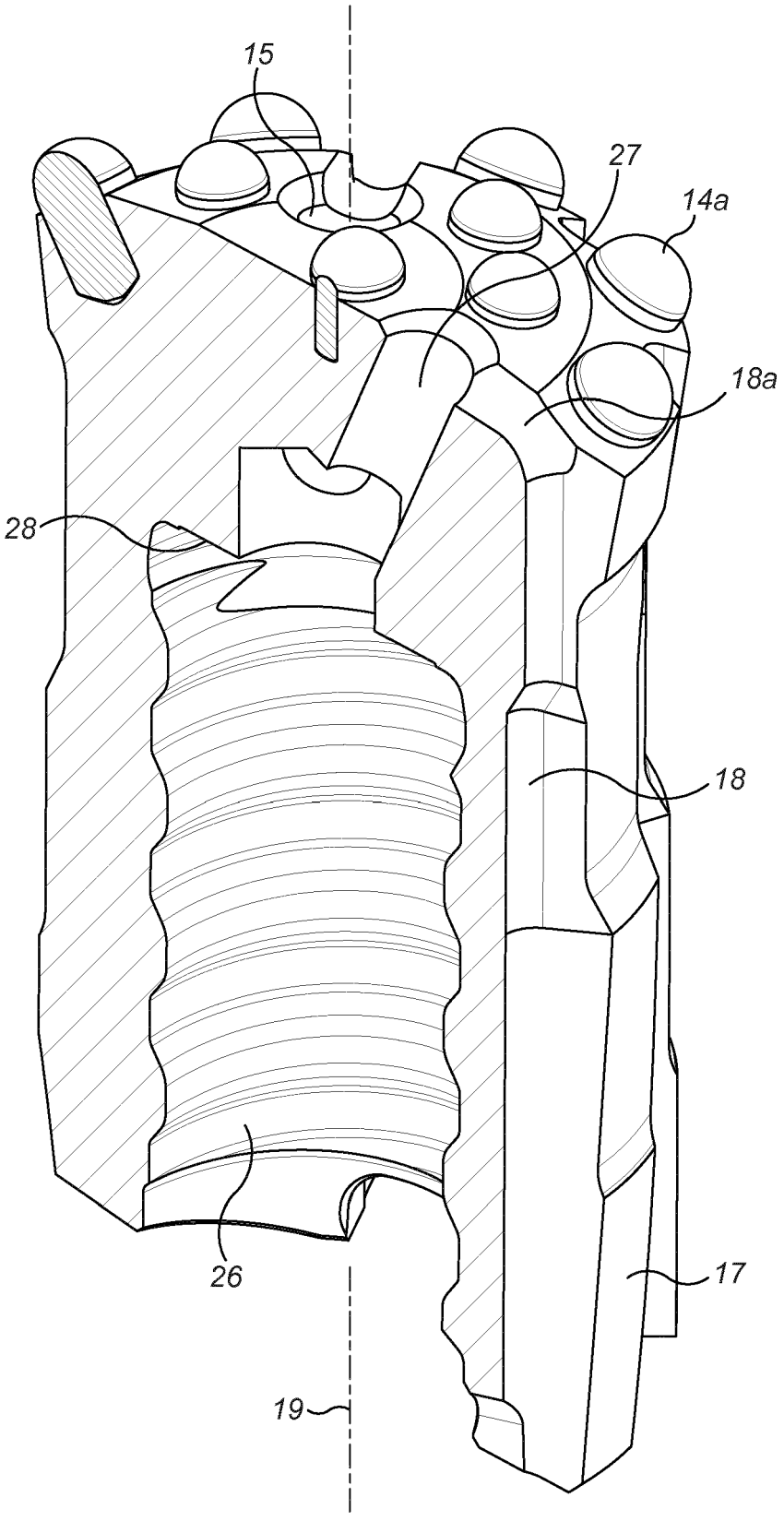

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 18 19 1621

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 February 2019	Morrish, Susan

CATEGORY OF CITED DOCUMENTS

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