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(54) SEGMENTS WITH ORIENTED DIAMOND PARTICLES AND TOOL INSERT EQUIPPED WITH THE SEGMENTS

(57) Segment (120) comprising a bond material (121) that is at least one of sintered, pressed, and infiltrated, and a plurality of diamond particles (122) being arranged according to at least one predetermined particle pattern in the bond material (121), the diamond particles (122) having outer geometries being predominantly composed of cubic faces including square and/or octagonal faces and/or of octahedral faces including triangular and/or hexagonal faces, wherein the outer geometries have at least one axis of rotational symmetry, wherein the segment has at least one direction of orientation and for at least 50 % of the plurality of diamond particles (122), the at least one axis of rotational symmetry of the diamond particles (122) is oriented in at least one defined angle with an accuracy of ± 15° with respect to the at least one direction of orientation.

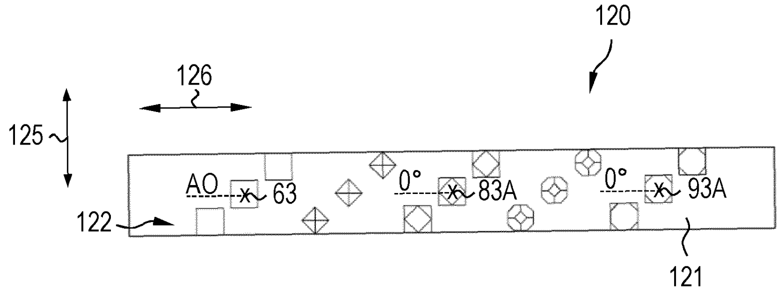

FIG. 9A

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Description

Technical field

[0001] The present invention relates to a segment according to the definition of claim 1 and to a tool insert according to the definition of claim 29.

Background of the invention

[0002] Segments for tool inserts known from prior art are composed of a bond material that is sintered, pressed and/or infiltrated, and a plurality of diamond particles arranged according to one or more predetermined particle pattern. The segments can be fabricated via powder metallurgy, in which a green body is built up layer by layer and then the green body is further processed by sintering, by pressing and/or by infiltrating to form the final segment.

[0003] Diamond particles, the hardest abrasive material currently known, are widely used on saws, drills, cut-off grinders, and other abrasive power tools to cut, form, and polish workpieces such as stone, concrete, asphalt, etc. Despite recent advancements in the positioning of diamond particles in defined locations within insert tool segments, the orientation of each diamond (the relationship between its principal crystal planes, faces and edges and the cutting direction of the tool insert) remains random.

[0004] The physical properties of diamonds are highly directional, due to the different spacings between the layers of atoms ("interatomic spacings") in different directions on different crystal faces. Consequently, the mechanical properties of diamond, such as hardness and abrasion resistance, vary according to which crystal plane is being acted upon and in which direction. Furthermore, diamond particles will cut with different face and edge geometries according to their orientation with respect to the cutting direction.

[0005] As the orientation of diamonds within insert tool segments for abrasive power tools remains random, diamond particles are currently not optimized for the mechanical properties and cutting geometries that may maximize efficiency for cutting, drilling, grinding, polishing, etc.

Summary of the invention

[0006] Therefore, the present invention was created to resolve the problems with the prior art as described above, and the object of the present invention is to provide a segment and a tool insert equipped with the segments, which allow to improve the cutting behavior and/or wear resistance.

[0007] The object is achieved according to an aspect of the invention by a segment characterized in that the segment has at least one direction of orientation and for at least 50 % of the plurality of diamond particles, the at least one axis of rotational symmetry of the diamond particles is oriented in at least one defined angle with an accuracy of ±15° with respect to the at least one direction of orientation.

[0008] The segment according to the invention comprises a bond material that is at least one of sintered, pressed, and infiltrated and a plurality of diamond particles being arranged according to a predetermined particle pattern and bonded in the bond material. At least 50 % of the plurality of diamond particles are not only arranged according to the particle pattern, but those diamond particles are additionally oriented in a defined projection with respect to the at least one direction of orientation of the segment.

[0009] The crystal structure and morphology of diamond gives diamond particles different mechanical properties such as hardness and wear resistance, and different cutting geometries depending on which crystal face is being acted on and in which direction. Diamond particles may be oriented in defined projections (such as cubic, octahedral, or dodecahedral projections) in order to take advantage of the particular mechanical properties of those crystal planes. Diamond particles oriented in given projections may then be given preferred angular orientations to achieve the desired mechanical properties and cutting geometries.

[0010] The orientation of the least 50 % of the plurality of diamond particles (so-called oriented diamond particles) is defined by means of the outer geometries of the diamond particles. The diamond particles have outer geometries which are predominantly composed of cubic faces including square and/or octagonal faces and/or of octahedral faces including triangular and/or hexagonal faces, wherein the outer geometries have at least one axis of rotational symmetry. Due to imperfections which occur during growing of the diamond particles, the outer geometries of the diamond particles may differ from their perfect rotational symmetry. Nevertheless, for most diamond particles of the plurality of diamond particles the outer geometry and the corresponding axes of rotational symmetry can be identified.

[0011] The segment may be fabricated via powder metallurgy, in which a green body is built up layer by layer and then the green body is further processed by sintering, by pressing and/or by infiltrating to form the final segment; known methods for further processing are for example hot-pressing, free-form sintering, free-form sintering with infiltrating, hot isostatic pressing, and subsequent heat treatments. The particle pattern is for example defined by a setting plate characterized by a defined arrangement of apertures to receive diamond particles. If the same type of setting plate is used, the particle pattern are called to be the same, even though the diamond particles may be arranged with an offset between particle layers.

[0012] Preferably, the least 50 % of the plurality of diamond particles are oriented in the at least one defined angle with an accuracy of ±10° with respect to the at least one direction of orientation. The smaller the cone of inaccuracy, the higher is the advantage that can be taken from the particular mechanical properties of the crystal planes.

[0013] Preferably, the at least one direction of orientation is arranged parallel to a height direction of the segment, to a length direction of the segment, to a width direction of the segment and/or to any other defined direction of the segment. The preferred direction of orientation may depend on the type of segment and the application of the tool insert equipped with the segments.

[0014] In a preferred version, the plurality of diamond particles include a first group of diamond particles having outer geometries being predominantly composed of cubic faces, and/or a second group of diamond particles having outer geometries being predominantly composed of octahedral faces, and/or a third group of diamond particles having outer geometries being predominantly composed of cubic faces and octahedral faces. The plurality of diamond particles which are arranged according to the at least one predetermined particle pattern originate from a distribution of diamond particles; the distribution includes a first group of diamond particles having outer geometries being predominantly composed of cubic faces, and/or a second group of diamond particles having outer geometries being predominantly composed of octahedral faces, and/or a third group of diamond particles having outer geometries being predominantly composed of cubic faces and octahedral faces.

[0015] Preferably, the first group of diamond particles includes cubic particles having outer geometries being predominantly composed of square faces, and/or the second group of diamond particles includes octahedral particles having outer geometries being predominantly composed of triangular faces, and/or the third group of diamond particles includes first cuboctahedral particles having outer geometries being predominantly composed of square faces and triangular faces, and/or second cuboctahedral particles having outer geometries being predominantly composed of octagonal faces and triangular faces, and/or third cuboctahedral particles having outer geometries being predominantly composed of square faces and hexagonal faces.

[0016] The first group, second group, and third group include all together five types of diamond particles which differ in their perfect outer geometries. The crystal structure and morphology of diamond gives diamond particles different mechanical properties such as hardness and wear resistance, and different cutting geometries depending on which crystal face is being acted on and in which direction. Diamond particles may be oriented in cubic, octahedral, or dodecahedral projections in order to take advantage of the particular mechanical properties of those crystal planes. Diamond particles oriented in given projections may then be given preferred angular orientations to achieve the desired mechanical properties and cutting geometries.

[0017] Preferably, for the first group of diamond particles, the at least one axis of rotational symmetry includes at least one first symmetry axis being substantially perpendicular to a cubic face and running substantially through the center point of that cubic face and/or at least one second symmetry axis running substantially through two diagonally opposing corners of the outer geometry and/or at least one third symmetry axis being substantially perpendicular to an edge of the outer geometry, running substantially through the center point of that edge and substantially crossing the diagonally opposing edge of the outer geometry.

[0018] For the cubic particles of the first group of diamond particles, the perfect outer geometries are predominantly formed as cubes, and the at least one axis of rotational symmetry includes several symmetry axes which are called first symmetry axes (opposing cubic faces), second symmetry axes (diagonally opposing corners), and third symmetry axes (diagonally opposing edges). The different axes of rotational symmetry allow different projections and/or angular orientations of the cubic particles with respect to the at least one direction of orientation of the segment.

[0019] Preferably, for the second group of diamond particles, the at least one axis of rotational symmetry includes at least one first symmetry axis being substantially perpendicular to an octahedral face and running substantially through the center point of that octahedral face and/or at least one second symmetry axis running substantially through two diagonally opposing corners of the outer geometry, and/or at least one third symmetry axis being substantially perpendicular to an edge of the outer geometry, running substantially through the center point of that edge and substantially crossing the diagonally opposing edge of the outer geometry.

[0020] For the octahedral particles of the second group of diamond particles, the perfect outer geometries are predominantly formed by triangular faces, and the at least one axis of rotational symmetry includes several symmetry axes which are called first symmetry axes (opposing octahedral faces), second symmetry axes (diagonally opposing corners), and third symmetry axes (diagonally opposing edges). The different axes of rotational symmetry allow different orientations of the octahedral particles with respect to the at least one direction of orientation of the segment.

[0021] Preferably, for the third group of diamond particles, the at least one axis of rotational symmetry includes at least one first symmetry axis being substantially perpendicular to a cubic face and running substantially through the center point of that cubic face and at least one further first symmetry axis being substantially perpendicular to an octahedral face and running substantially through the center point of that octahedral face and/or at least one second symmetry axis running substantially through two diagonally opposing corners of the outer geometry and/or at least one third symmetry axis being substantially perpendicular to an edge of the outer geometry, running substantially through the center point of that edge and substantially crossing the diagonally opposing edge of the outer geometry.

[0022] For the cuboctahedral particles of the third group of diamond particles, the perfect outer geometries are predominantly formed by cubic faces and octahedral faces, and the at least one axis of rotational symmetry includes several symmetry axes which are called first symmetry axes (opposing cubic faces or opposing octahedral faces), and/or second symmetry axes (diagonally opposing corners), and/or third symmetry axes (diagonally opposing edges).

[0023] Preferably, for the second cuboctahedral particles, the at least one third symmetry axis is substantially perpendicular to an edge defined by adjacent octagonal faces, and for the third cuboctahedral particles, the at least one third symmetry axis is substantially perpendicular to an edge defined by adjacent hexagonal faces.

[0024] Preferably, the at least 50 % of the plurality of diamond particles are oriented in at least one defined projection with respect to the at least one direction of orientation of the segment. By orienting the diamond particles at least partially in at least one defined projection with respect to the at least one direction of orientation, the cutting behavior and/or the wear resistance of the segment can be adapted to specific requirements.

[0025] Preferably, the at least one defined projection is selected from a cubic projection, an octahedral projection, and a dodecahedral projection. The crystal structure and morphology of diamond gives diamond particles different mechanical properties such as hardness and wear resistance, and different cutting geometries depending on which crystal face is being acted on and in which direction. Diamond particles may be oriented in cubic, octahedral, or dodecahedral projections in order to take advantage of the particular mechanical properties of those crystal planes. Diamond particles oriented in given projections may then be given preferred angular orientations to achieve the desired mechanical properties and cutting geometries.

[0026] In a first preferred version, the diamond particles are oriented in a cubic projection, wherein, for diamond particles of the first group and third group, a first symmetry axis being substantially perpendicular to a cubic face and running substantially through the center point of that cubic face is oriented in the at least one defined angle with respect to the at least one direction of orientation of the segment, and for diamond particles of the second group, a second symmetry axis is oriented in the at least one defined angle with respect to the at least one direction of orientation of the segment.

[0027] In a second preferred version, the diamond particles are oriented in an octahedral projection, for diamond particles of the first group, a second symmetry axis is oriented in the at least one defined angle with respect to the at least one direction of orientation of the segment, and for diamond particles of the second group and third group, a first symmetry axis being substantially perpendicular to an octahedral face and running substantially through the center point of that octahedral face is oriented in the at least one defined angle with respect to the at least one direction of orientation of the segment.

[0028] In a third preferred version, the diamond particles are oriented in a dodecahedral projection, for diamond particles of the first group, a third symmetry axis is oriented in the at least one defined angle with respect to the at least one direction of orientation of the segment, for diamond particles of the second group, a third symmetry axis is aligned with the at least one direction of orientation of the segment, and for diamond particles of the third group, a second symmetry axis or a third symmetry axis is oriented in the at least one defined angle with respect to the at least one direction of orientation of the segment.

[0029] Preferably, for the first cuboctahedral particles of the third group, a second symmetry axis is oriented in the at least one defined angle with respect to the at least one direction of orientation of the segment, for the second cuboctahedral particles of the third group, a third symmetry axis is oriented in the at least one defined angle with respect to the at least one direction of orientation of the segment, and for the third cuboctahedral particles of the third group, a third symmetry axis is oriented in the at least one defined angle with respect to the at least one direction of orientation of the segment.

[0030] In a preferred version, the plurality of diamond particles includes a first number of the diamond particles and a second number of the diamond particles, and the segment comprises at least one first section composed of the bond material and the first number of the diamond particles and at least one second section composed of the bond material and the second number of the diamond particles. By dividing the segment in at least one first section composed of the bond material and the first number of the diamond particles and in at least one second section composed of the bond material and the second number of the diamond particles, the cutting behavior and/or the wear resistance of the segment can be adapted to specific requirements of the different sections.

[0031] The first section can have at least one first predetermined particle pattern and/or at least one first defined projection for the first number of the diamond particles, and/or at least one first angular orientation of the diamond particles in the first defined projection, and the second section can have at least one second predetermined particle pattern and/or at least one second defined projection for the second number of the diamond particles and/or at least one second angular orientation of the diamond particles in the second defined projection.

[0032] Preferably, the segment comprises one first section and two second sections, the first section being arranged between the second sections in any defined direction of the segment. By dividing the segment in a first section and two second sections, a sandwich structure can be created which allows to adapt the cutting behavior and/or the wear resistance to specific requirements. To adapt the cutting behavior and/or the wear resistance of the different sections, the predetermined particle pattern and/or the defined projection of the diamond particles in the predetermined particle pattern and/or the angular orientation of the diamond particles in the defined projection can be varied.

[0033] Preferably, the segment comprises at least two first sections and/or at least two second sections, the first and second sections being arranged according to a regular pattern in the segment. By dividing the segment in at least two first section composed of the bond material and the first number of the diamond particles and/or in at least two second section composed of the bond material and the second number of the diamond particles, the cutting behavior and/or the wear resistance of the segment can be adapted to specific requirements of the different sections.

[0034] In a preferred version, the at least one predetermined particle pattern includes at least one first predetermined particle pattern, and the first number of the diamond particles is arranged according to the at least one first predetermined particle pattern, and the at least one predetermined particle pattern includes at least one second predetermined particle pattern, and the second number of the diamond particles is arranged according to the at least one second predetermined particle pattern. The second predetermined particle pattern may be different from the first predetermined particle pattern or may be identical to the first predetermined particle pattern. The particle pattern may be defined by a setting plate characterized by a defined arrangement of apertures to receive the diamond particles. If the same type of setting plate is used, the particle pattern are called to be identical, even though the diamond particles may be arranged with an offset between adjacent particle layers.

[0035] Preferably, the first number of the diamond particles is at least partially oriented in a first defined projection with respect to the at least one direction of orientation. To adapt a behavior of the at least one first section, such as wear resistance, the predetermined particle pattern and/or the first defined projection of the first number of the diamond particles in the first predetermined particle pattern can be varied. The second number of the diamond particles may be randomly oriented (no defined projection) or may be arranged in a second defined projection, and in that second projection oriented in a second angular orientation.

[0036] For the diamond particles that are oriented in a defined projection with respect to the at least one direction of orientation, their angular orientation in the defined projection can be varied by rotating the outer geometry about the symmetry axis that is oriented with respect to the at least one direction of orientation. The cutting behavior of a diamond particle may be dependent of the angular orientation, wherein an edge leading orientation or a tip leading orientation may be preferred angular orientations. The tip leading orientation may lead to ploughing effects with increased normal forces and decreased cutting forces, and the edge leading orientation may result in thicker chips and higher cutting forces indicating an enhanced material removal rate. Similarly, by varying the angular orientation the directional mechanical properties of diamond may also be exploited to optimize cutting behavior.

[0037] Preferably, the first defined projection is selected from a cubic projection, an octahedral projection, and a dodecahedral projection. By orienting the first number of the diamond particles at least partially in a cubic, octahedral, or dodecahedral projection, the cutting behavior and/or the wear resistance of the first section(s) can be adapted to specific requirements. Whereas the first number of the diamond particles is at least partially oriented in the first defined projection, the second number of the diamond particles may be randomly oriented or at least partially oriented in a second defined projection with respect to the at least one direction of orientation.

[0038] In a first preferred version, the second number of the diamond particles is randomly oriented. By orienting the second number of the diamond particles randomly (no defined projection), diamond particles may be easily incorporated into sections of the segment where the optimal mechanical properties and cutting geometries facilitated by oriented diamond are not required.

[0039] In a second preferred version, the second number of the diamond particles is at least partially oriented in a second defined projection with respect to the at least one direction of orientation. By orienting the second number of the diamond particles at least partially in a second defined projection, the cutting behavior and/or the wear resistance of the second sections can be adapted to the specific requirements. The cutting behavior and/or the wear resistance can be adapted by means of a predetermined particle pattern and/or a defined projection of the diamond particles in predetermined particle pattern and/or an angular orientation of the diamond particles in the defined projection.

[0040] The second defined projection may be different from the first defined projection or may be identical to the first defined projection, wherein the angular orientation of the diamond particles may differ between the first and second defined projection. The cutting behavior and/or wear resistance of different sections of a segment can be adapted to specific requirements by using different predetermined particle pattern and/or different defined projections and/or different angular orientations of the diamond particles in a defined projection.

[0041] Preferably, the second defined projection is selected from a cubic projection, an octahedral projection, and a dodecahedral projection. By orienting the second number of the diamond particles at least partially in a cubic, octahedral, or dodecahedral projection, the cutting behavior and/or the wear resistance of the second section(s) can be adapted to specific requirements.

[0042] Preferably, the first and second defined projections are both selected from a cubic projection, or both selected from an octahedral projection, or both selected from a dodecahedral projection. By orienting the first number and second number of the diamond particles in the same type of projection (cubic or octahedral or dodecahedral projection), the cutting behavior and/or the wear resistance of the different sections can be adapted by means of the angular orientation of the diamond particles in the first and second defined projections.

[0043] Preferably, the first defined projection and the second defined projection differ in an angular orientation of the diamond particles with respect to the at least one direction of orientation. By using different angular orientations for the diamond particles of the first defined projection and the second defined projection, the cutting behavior and/or the wear resistance of the different sections can be adapted to specific requirements.

[0044] Preferably, the angular orientation of the diamond particles in the first and second defined projections differ by half of the rotational symmetry angle of the corresponding symmetry axis that is oriented with respect to the at least one direction of orientation. By using angular orientations for the diamond particles in the first and second defined projections that differ by half of the corresponding rotational symmetry angle, the diamond particles may be oriented in edge leading orientations or in tip leading orientations. The tip leading orientation may lead to ploughing effects with increased normal forces and decreased cutting forces, and the edge leading orientation may result in thicker chips and higher cutting forces indicating an enhanced material removal rate. Similarly, by varying the angular orientation the directional mechanical properties of diamond may also be exploited to optimize cutting behavior.

[0045] In a preferred version, the plurality of diamond particles includes a first number of the diamond particles, a second number of the diamond particles, and a third number of the diamond particles, and the segment comprises at least one first section composed of the bond material and the first number of the diamond particles, at least one second section composed of the bond material and the second number of the diamond particles, and at least one third section composed of the bond material and the third number of the diamond particles.

[0046] By dividing the segment in a first section composed of the bond material and the first number of the diamond particles, a second section composed of the bond material and the second number of the diamond particles, and a third section composed of the bond material and the third number of the diamond particles, the cutting behavior and/or wear resistance of the segment can be adapted to specific requirements. The first section can have at least one first predetermined particle pattern and/or at least one first defined projection of at least a part of the first number of the diamond particles and/or a first angular orientation of the diamond particles in the first defined projection, the second section can have at least one second predetermined particle pattern and/or at least one second defined projection of at least a part of the second number of the diamond particles and/or a second angular orientation of the diamond particles in the second defined projection, and the third section can have at least one third predetermined particle pattern and/or at least one third defined projection of at least a part of the third number of the diamond particles and/or a third angular orientation of the diamond particles in the third defined projection.

[0047] Preferably, at least 80 % of the plurality of diamond particles that are arranged according to at least one predetermined particle pattern are oriented in the at least one defined angle with an accuracy of ±15° with respect to the at least one direction of orientation. The higher the amount of diamond particles oriented in defined projections, the higher is the advantage that can be taken from the particular mechanical properties of the crystal planes.

[0048] Preferably, the least 80 % of the plurality of diamond particles are oriented in the at least one defined angle with an accuracy of ±10° with respect to the at least one direction of orientation. The smaller the cone of inaccuracy, the higher is the advantage that can be taken from the particular mechanical properties of the crystal planes.

[0049] According to a further aspect of the present invention, there is provided a tool insert, comprising a base body configured to connect the tool insert to a power tool, and including a connection surface, and two or more segments according to the invention, wherein the segments are connected to the connection surface. A tool insert comprising two or more segments according to the invention has the advantage that the cutting behavior and/or the wear resistance of the tool insert can be adapted to the requirements by means of the segments.

[0050] Preferably, the tool insert is configured as core bit, saw blade, cutting disk, or grinding cup wheel. Tool inserts configured as core bit, saw blade, cutting disk, or grinding cup wheel for abrasive power tools can benefit from segments according to the invention.

[0051] Preferably, the two or more segments include first segments and second segments that are different from the first segments. The first and second segments may be arranged alternating in a circumferential direction of the connection surface or being arranged in any regular or unregular pattern on the connection surface. By using first segments and second segments that are different from the first segments, the cutting behavior and/or wear resistance of the tool insert can be adapted to different requirements by means of the segments.

[0052] Preferably, the tool insert further comprises at least one additional segment connected to the connection surface. The segments according to the invention and the additional segments may be arranged alternating in a circumferential direction of the connection surface or being arranged in any regular or unregular pattern on the connection surface. By using segments according to the invention and using additional segments, the cutting behavior and/or wear resistance of the tool insert can be adapted to different requirements by means of the different types of segments.

Brief Description of the drawings

[0053] The aspects of the invention are described or explained in more detail below, purely by way of example, with reference to working examples shown schematically in the drawing. Identical elements are labelled with the same reference numerals in the figures. The described embodiments are generally not shown true in scale, and they are also not to be interpreted as limiting the invention. Specifically,

FIGS. 1A, B show a first exemplary version of a tool insert according to the present invention configured as core bit (FIG. 1A) including a core barrel and a plurality of segments (FIG. 1B),

FIGS. 2A, B show a second exemplary version of a tool insert according to the present invention configured as blade (FIG. 2A) including a steel blade and a plurality of segments (FIG. 2B),

FIG. 3 shows a third exemplary version of a tool insert according to the present invention configured as grinding wheel,

FIGS. 4A-E show five different types of diamond particles having outer geometries composed of cubic faces and/or of octahedral faces called cubic particle (FIG. 4A), octahedral particle (FIG. 4B), first cuboctahedral particle (FIG. 4C), second cuboctahedral particle (FIG. 4D), and third cuboctahedral particle (FIG. 4E),

FIGS. 5A, B show the diamond particles of FIGS. 4A-E in a cubic projection (FIG. 5A) in a first angular orientation of 0° (FIG. 5A) and a second angular orientation of 45° (FIG. 5B),

FIGS. 6A, B show the diamond particles of FIGS. 4A-E in an octahedral projection in a first angular orientation of 0° (FIG. 6A) and a second angular orientation of 60° (FIG. 6B),

FIGS. 7A, B show the diamond particles of FIGS. 4A-E in dodecahedral projection in a first angular orientation of 0° (FIG. 7A) and a second angular orientation of 90° (FIG. 7B),

FIGS. 8A, B illustrate the orientation of the symmetry axis of a diamond particle to a direction of orientation of the segment,

FIGS. 9A, B show a first exemplary version of a segment according to the present invention in a top view (FIG. 9A) and in a side view (FIG. 9B),

FIGS. 10A-C show a second exemplary version of a segment according to the present invention in a top view (FIG. 10A), in a first side view (FIG. 10B), and in a second side view (FIG. 10C), and

FIGS. 11A-C show a third exemplary version of a segment according to the present invention in a top view (FIG. 11A), in a first side view (FIG. 11B), and in a second side view (FIG. 11C).

Detailed Description

[0054] Reference will now be made in detail to the present preferred embodiment, an example of which is illustrated in the accompanying drawings. It is to be understood that the technology disclosed herein is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings. The technology disclosed herein is capable of other embodiments and of being practiced or of being carried out in various ways.

[0055] Th term "diamond particles" refer to particles of either natural or synthetic crystalline diamonds. The term "predetermined particle pattern" refers to a non-random particle pattern of the diamond particles that is identified prior to construction of a tool insert, and which individually places or locates each diamond particle in a defined relationship with the other diamond particles, and with the configuration of the tool insert.

[0056] **FIGS. 1A, B** show a first exemplary version of a tool insert according to the present invention configured as core bit **10.** The core bit 10 comprises a base body formed as core barrel **11,** a cutting section **12** including a plurality of segments, and a connection end **13.**

[0057] The cutting section 12 includes a first number of first segments **14** and a second number of second segments **15** that can be different from the first segments 14. The first segments 14 and second segments 15 can both be segments according to the present invention, or only the first segments 14 or the second segments 15 are segments according to the present invention. By using different segments according to the invention or by combining segments according to the invention and additional segments, the cutting behavior and/or wear resistance of the tool insert can be adapted to different requirements by means of the different types of segments.

[0058] In the exemplary version shown in FIG. 1A, the first segments 14 and second segments 15 are arranged in an alternating manner. Alternatively, the first segments 14 and second segments 15 can be arranged in any regular or non-regular pattern at the connection surface

16 of the core barrel 11.

[0059] As shown in FIG. 1A, the core barrel 11 and the cutting section 12 are formed as one-piece and the first and second segments 14, 15 are fixed, e.g., by brazing, soldering, welding, or the like as well, to a connection surface **16** of the core barrel 11. Alternatively, the core barrel 11 and the cutting section 12 may be formed as two pieces that can be connected via a removable connection.

[0060] As shown in FIG. 1A, the core barrel 11 and the connection end 13 are formed as two pieces that are connected via a threaded joint **17,** wherein a female part of the threaded joint is connected to the core barrel 11 and a male part of the threaded joint is connected to the connection end 13. Alternatively, the core barrel 11 and the connection end 13 may be formed as one-piece.

[0061] In the exemplary version shown in FIG. 1A, the first segments 14 and second segments 15 have a similar outer shape **18** that is shown in FIG. 1B. The segments 14, 15 have a height between an upper face **UF** and a lower face **LF** in a height direction **21,** a width between a first side face **SF1** and a second side face **SF2** in a width direction **22,** and a length between a first end face **EF1** and a second end face **EF2** in a length direction **23.**

[0062] As different workpieces to be processed, such as concrete, granite, stone, marble, and the like, have different natures, the bond material and diamond particles used for the segments should also be different. When the workpiece to be processed is hard, the bond material should be softer to let the new diamond particles be exposed more easily and participate in processing, and, when the workpiece to be processed is soft, the bond material should be harder to hold the diamond particles longer to extend the service life of the segments.

[0063] **FIGS. 2A, B** show a second exemplary version of a tool insert according to the present invention configured as diamond blade **30** that can be used with diamond wall saws, cut-off grinder, etc. The diamond blade 30 comprises a base body formed as steel blade **31,** a cutting section **32** including a plurality of segments, and a tool holder **33.**

[0064] The cutting section 32 includes a first number of first segments **34,** a second number of second segments **35,** and a third number of third segments **36.** In the exemplary version shown in FIG. 2A, the first segments 34 and second segments 35 are both segments according to the present invention, and the third segments 36 are not segments according to the present invention. The first segments 34, second segments 35, and third segments 36 are arranged in FIG. 2A in an alternating manner along a circumferential direction of the steel blade. Alternatively, the first segments 34, second segments 35, and third segments 36 can be arranged and connected to the steel blade 31 in any regular or non-regular pattern.

[0065] In the exemplary version shown in FIG. 2A, the first segments 34, second segments 35, and third segments 36 have a similar outer shape **38** that is shown in FIG. 2B. The segments have a height between an upper face **UF** and a lower face **LF** in a height direction **41,** a width between a first side face **SF1** and a second side face **SF2** in a width direction **42,** and a length between a first end face **EF1** and a second end face **EF2** in a length direction **43.**

[0066] **FIG. 3** shows a third exemplary version of a tool insert according to the present invention configured as grinding wheel **50.** The grinding wheel 50 comprises a base body formed as cup wheel **51,** a cutting section **52** including a plurality of segments, and a tool holder **53.**

[0067] The cutting section 52 includes a first number of segments **54** according to the present invention and a second number of additional segments **55** that differ from the present invention. The segments 54 and additional segments 55 can be arranged in two circularly formed rows, e.g., the segments 54 in a first outer row and the additional segments 55 in a second inner row, or the segments 54 and additional segments 55 can be arranged in any regular or non-regular pattern.

[0068] The segments according to the present invention that are used for the tool inserts 10, 30, 50 are composed of a bond material that is at least one of sintered, pressed, and infiltrated, and of a plurality of diamond particles being arranged according to at least one predetermined particle pattern in the bond material. The diamond particles that are used for the segments according to the present invention can be classified in a first group of diamond particles having outer geometries being predominantly composed of cubic faces, in a second group of diamond particles having outer geometries being predominantly composed of octahedral faces, and in a third group of diamond particles having outer geometries being predominantly composed of cubic faces and octahedral faces. The term "cubic faces" summarizes square faces and octagonal faces, and the term "octahedral faces" summarizes triangular faces, and hexagonal faces.

[0069] **FIGS. 4A to E** show five different types of diamond particles having outer geometries. The diamond particles have outer geometries which are predominantly composed of cubic faces including square and/or octagonal faces and/or of octahedral faces including triangular and/or hexagonal faces, wherein the outer geometries have at least one axis of rotational symmetry.

[0070] Due to imperfections which occur during crystallographic growth of the diamond particles, the outer geometries of the diamond particles may differ from their perfect rotational symmetry. Nevertheless, for most diamond particles of the plurality of diamond particles the outer geometry and the corresponding axes of rotational symmetry can be identified.

[0071] The axes of rotational symmetry include several symmetry axes which are called first symmetry axes related to opposing faces, second symmetry axes related to diagonally opposing corners, and third symmetry axes related to diagonally opposing edges. The different symmetry axes allow different orientations of the diamond particles with respect to the at least one direction of orientation of the segment.

[0072] FIG. 4A shows a diamond particle **60** of the first group of diamond particles having an outer geometry being predominantly composed of cubic faces, the diamond particle of FIG. 4A is called "cubic particle". The outer geometry of the cubic particle 60 is composed of six square faces **61,** which are arranged in three pairs of opposing square faces 61.

[0073] The cubic particle 60 has a plurality of axes of rotational symmetry including six first symmetry axes **63,** four second symmetry axes **64,** and six third symmetry axes **65.** The first symmetry axes 63 are defined to be substantially perpendicular to one of the square faces 61 and run substantially through the center point **66** of that face 61, the second symmetry axes 64 are defined to run substantially through two diagonally opposing corners **67A, 67B,** and the third symmetry axes 65 are defined to be substantially perpendicular to an edge **68A,** run substantially through the center point **69** of that edge and cross substantially the diagonally opposing edge **68B.**

[0074] For cubic particles 60 with perfect outer geometry, the first symmetry axes 63 of two opposing square faces and the third symmetry axes 65 of two diagonally opposing edges are coaxially aligned. Due to imperfections of the outer geometry, which occur during growing of the cubic particles 60, the first symmetry axes of two opposing square faces and the third symmetry axes of two diagonally opposing edges may have a parallel offset or can be inclined to each other.

[0075] FIG. 4B shows a diamond particle **70** of the second group of diamond particles having outer geometries being predominantly composed of octahedral faces, the diamond particle of FIG. 4B is called "octahedral particle". The outer geometry of the octahedral particle 70 is composed of eight triangular faces **72,** which are arranged in four pairs of opposing triangular faces 72.

[0076] The octahedral particle 70 has a plurality of axes of rotational symmetry including first symmetry axes **73,** second symmetry axes **74,** and third symmetry axes **75.** The first symmetry axes 73 are defined to be substantially perpendicular to one of the triangular faces 72 and run substantially through the center point **76** of that face 72, the second symmetry axes 74 are defined to run substantially through two diagonally opposing corners **77A, 77B,** and the third symmetry axes 75 are defined to be substantially perpendicular to an edge **78A,** run substantially through the center point **79** of that edge and cross substantially the diagonally opposing edge **78B.**

[0077] For octahedral particles 70 with perfect outer geometry, the first symmetry axes 73 of two opposing triangular faces and the third symmetry axes 75 of two diagonally opposing edges are coaxially aligned. Due to imperfections of the outer geometry, which occur during growing of the octahedral particles 70, the first symmetry axes of two opposing triangular faces and the third symmetry axes of two diagonally opposing edges may have a parallel offset or can be inclined to each other.

[0078] FIGS. 4C to E show diamond particles of the third group of diamond particles having outer geometries being predominantly composed of cubic faces and octahedral faces. The diamond particles differ in the type of the cubic faces and/or in the type of the octahedral faces.

[0079] FIG. 4C shows a diamond particle **80** of the third group of diamond particles having an outer geometry being predominantly composed of square faces **81** and triangular faces **82,** the diamond particle 80 of FIG. 4C is called "first cuboctahedral particle". The outer geometry of the first cuboctahedral particle 80 is composed of six square faces 81, which are arranged in three pairs of opposing square faces, and of eight triangular faces 82, which are arranged in four pairs of two opposing triangular faces.

[0080] The first cuboctahedral particle 80 has a plurality of axes of rotational symmetry including first symmetry axes **83A, 83B** and second symmetry axes **84.** Since symmetry axes that are related to diagonally opposing edges do not align with major diamond crystal directions, those axes are not used for the orientation of first cuboctahedral particles 80.

[0081] The first symmetry axes 83A are defined to be substantially perpendicular to one of the square faces 81 and run substantially through the center point **86A** of that face 81, and the first symmetry axes 83B are defined to be substantially perpendicular to one of the triangular faces 82 and run substantially through the center point **86B** of that face 82. The second symmetry axes 84 are defined to run substantially through two diagonally opposing corners **87A, 87B.**

[0082] For first cuboctahedral particles 80 with perfect outer geometry, the first symmetry axes of two opposing square or triangular faces are coaxially aligned. Due to imperfections of the outer geometry, which occur during growing of the first cuboctahedral particles, the first symmetry axes of two opposing square or triangular faces may have a parallel offset or can be inclined to each other.

[0083] FIG. 4D shows a diamond particle **90** of the third group of diamond particles having an outer geometry being predominantly composed of octagonal faces **91** and triangular faces **92,** the diamond particle of FIG. 4D is called "second cuboctahedral particle". The outer geometry of the second cuboctahedral particle 90 is composed of six octagonal faces 91, which are arranged in three pairs of opposing octagonal faces 91, and of eight triangular faces 92, which are arranged in four pairs of two opposing triangular faces 92.

[0084] The second cuboctahedral particle 90 has a plurality of axes of rotational symmetry including first symmetry axes **93A, 93B** and third symmetry axes **95.** Since symmetry axes that are related to diagonally opposing corners do not align with major diamond crystal directions, those axes are not used for the orientation of second cuboctahedral particles 90.

[0085] The first symmetry axes 93A are defined to be substantially perpendicular to one of the octagonal faces 91 and run substantially through the center point **96A** of that face 91, and the first symmetry axes 93B are defined to be substantially perpendicular to one of the triangular faces 92 and run substantially through the center point **96B** of that face 92. The third symmetry axes 95 are defined to be substantially perpendicular to an edge **98A,** run substantially through the center point **99** of that edge and cross substantially the diagonally opposing edge **98B.**

[0086] For second cuboctahedral particles 90 with perfect outer geometry, the first symmetry axes of two opposing octagonal or triangular faces and the third symmetry axes of two diagonally opposing edges are coaxially aligned. Due to imperfections of the outer geometry, which occur during growing of the second cuboctahedral particles, the first symmetry axes of two opposing octagonal or triangular faces and the third symmetry axes of two diagonally opposing edges may have a parallel offset or can be inclined to each other.

[0087] FIG. 4E shows a diamond particle **100** of the third group of diamond particles having an outer geometry being predominantly composed of square faces **101** and hexagonal faces **102,** the diamond particle of FIG. 4E is called "third cuboctahedral particle". The outer geometry of the third cuboctahedral particle is composed of six square faces, which are arranged in three pairs of opposing square faces, and of eight hexagonal faces, which are arranged in four pairs of two opposing hexagonal faces.

[0088] The third cuboctahedral particle 100 has a plurality of axes of rotational symmetry including first symmetry axes **103A, 103B** and third symmetry axes **105.** Since symmetry axes that are related to diagonally opposing corners do not align with major diamond crystal directions, those axes are not used for the orientation of third cuboctahedral particles 100.

[0089] The first symmetry axes 103A are defined to be substantially perpendicular to one of the square faces 101 and run substantially through the center point **106A** of that face 101, and the first symmetry axes 103B are defined to be substantially perpendicular to one of the hexagonal faces 102 and run substantially through the center point **106B** of that face 102. The third symmetry axes 105 are defined to be substantially perpendicular to an edge **108A,** run substantially through the center point **109** of that edge and cross substantially the diagonally opposing edge **108B.**

[0090] For third cuboctahedral particles with perfect outer geometry, the first symmetry axes of two opposing triangular or hexagonal faces and the third symmetry axes of two diagonally opposing edges are coaxially aligned. Due to imperfections of the outer geometry, which occur during growing of the third cuboctahedral particles, the first symmetry axes of two opposing triangular or hexagonal faces and the third symmetry axes of two diagonally opposing edges may have a parallel offset or can be inclined to each other.

[0091] **FIGS. 5A, B** show the diamond particles 60, 70, 80, 90, 100 of FIGS. 4A to E in a cubic projection in a first angular orientation (FIG. 5A) and a second angular orientation (FIG. 5B).

[0092] The cubic projection of the diamond particles is defined with respect to a direction of orientation of the segment; in the exemplary version shown in FIGS. 5A, B, the direction of orientation is oriented perpendicular to the plane of projection.

[0093] In the cubic projection, for diamond particles of the first group (cubic particle 60) and diamond particles of the third group (first, second, and third cuboctahedral particles 80, 90, 100), a first symmetry axis 63, 83A, 93A, 103A that is substantially perpendicular to a cubic face 61, 81, 91, 101 and runs substantially through the center point 66, 86, 96, 106 of that cubic face 61, 81, 91, 101 is oriented to the direction of orientation of the segment, and for diamond particles of the second group (octahedral particle 70), a second symmetry axis 74 is oriented to the direction of orientation of the segment.

[0094] FIG. 5A shows the diamond particles 60, 70, 80, 90, 100 of FIGS. 4A to E in a first angular orientation, which is defined as 0°, and FIG. 5B in a second angular orientation, which is defined as 45°. The first and second angular orientation differ by a rotational angle of 45° about that symmetry axis of the diamond particles that is aligned to the direction of orientation.

[0095] **FIGS. 6A, B** show the diamond particles 60, 70, 80, 90, 100 of FIGS. 4A to E in an octahedral projection in a first angular orientation (FIG. 6A) and a second angular orientation (FIG. 6B).

[0096] In the octahedral projection, for diamond particles of the first group (cubic particle 60), a second symmetry axis 64 is oriented to the direction of orientation of the segment, and for diamond particles of the second group (octahedral particle 70) and diamond particles of the third group (first, second, and third cuboctahedral particles 80, 90, 100), a first symmetry axis 73, 83B, 93B, 103B that is substantially perpendicular to an octahedral face 71, 81, 91, 101 and runs substantially through the center point of that octahedral face is oriented to the direction of orientation of the segment.

[0097] FIG. 6A shows the diamond particles 60, 70, 80, 90, 100 of FIGS. 4A to E in a first angular orientation, which is defined as 0°, and FIG. 6B in a second angular orientation, which is defined as 60°. The first and second angular orientation differ by a rotational angle of 60° about that symmetry axis of the diamond particles that is aligned to the direction of orientation.

[0098] **FIGS. 7A, B** show the diamond particles 60, 70, 80, 90, 100 of FIGS. 4A to E in an octahedral projection in a first angular orientation (FIG. 7A) and a second angular orientation (FIG. 7B).

[0099] In the dodecahedral projection, for diamond particles of the first group (cubic particle 60), a third symmetry axis 65 is oriented to the direction of orientation of the segment, for diamond particles of the second group (octahedral particle 70), a third symmetry axis 75 is oriented to the direction of orientation of the segment, and for diamond particles of the third group (first, second, and third cuboctahedral particles 80, 90, 100), a second symmetry axis or a third symmetry axis is oriented to the direction of orientation of the segment.

[0100] FIG. 7A shows the diamond particles 60, 70, 80, 90, 100 of FIGS. 4A to E in a first angular orientation, which is defined as 0°, and FIG. 7B in a second angular orientation, which is defined as 90°. The first and second angular orientation differ by a rotational angle of 90° about that symmetry axis of the diamond particles that is aligned to the direction of orientation.

[0101] **FIGS. 8A, B** illustrate the orientation of the symmetry axis of a diamond particle to a direction of orientation **111** of the segment. FIG. 8A shows a first cuboctahedral particle 80 with its first symmetry axis 83B and FIG. 8B shows an octahedral particle 70 with its second symmetry axis 74.

[0102] The first symmetry axis 83B and the second symmetry axis 74 are oriented in an angle ϕ with an accuracy of $\pm 15°$ with respect to the direction of orientation 111. The direction of orientation 111 can be arranged parallel to a height direction, a width direction, a length direction, and/or any other defined direction of a segment.

[0103] Preferably, the least 50 % of the plurality of diamond particles are oriented in the at least one defined angle ϕ with an accuracy of $\pm 10°$ with respect to the direction of orientation 111. The smaller the cone of inaccuracy, the higher is the advantage that can be taken from the particular mechanical properties of the crystal planes of the diamond particles.

[0104] **FIGS. 9A, B** show a first exemplary version of a segment **120** according to the present invention composed of a bond material **121** that is at least one of sintered, pressed, and infiltrated and a plurality of diamond particles **122** in a top view (FIG. 9A) and in a side view (FIG. 9B).

[0105] The segment 120 has an outer shape including a height in a height direction **124,** a width in a width direction **125,** and a length in a length direction **126.** The outer shape of the segment 120 is similar to the segments 34, 35, 36 of the diamond blade 30 shown in FIGS. 2A, B. Although, the outer shape of the segment 120 differs from the segments 14, 15 and segments 54, the concept of orienting the diamond particles 122 with respect to the direction of orientation is applicable to all segments for abrasive power tools.

[0106] The bond material 121 is at least one of sintered, pressed, and infiltrated, and characterized by at least one feature selected from a chemical composition, a powder morphology, and a degree of alloying. The diamond particles 122 are selected from a distribution of diamond particles, the distribution being characterized by a particle size, a crystal perfection, a toughness and/or a diamond growth morphology. The plurality of diamond particles 122 includes at least one of the five types of the diamond particles 60, 70, 80, 90, 100 shown in the FIGS. 4A to E having at least one axis of rotational symmetry and having outer geometries being composed of cubic faces 61, 81, 91, 101 and/or of octahedral faces 72, 82, 92, 102.

[0107] The plurality of diamond particles 122 is divided in three particle layers which are stacked in the width direction 125 and called first, second, and third particle layer. The segment 120 may be fabricated via powder metallurgy, in which a green body is built up layer by layer from a powdery or granular bond material and from the plurality of diamond particles 122 and the green body is further processed to form the segment 120 by sintering, pressing, and/or infiltrating.

[0108] The diamond particles 122 of the first particle layer are arranged according to a first predetermined particle pattern and at least partially oriented in a first defined projection, the diamond particles 122 of the second particle layer are arranged according to a second predetermined particle pattern and at least partially oriented in a second defined projection, and the diamond particles 122 of the third particle layer are arranged according to a third predetermined particle pattern and at least partially oriented in a third defined projection.

[0109] In the exemplary version of FIGS. 9A, B, the diamond particles 122 of the first, second, and third particle pattern are arranged according to the same particle pattern PP, and the first, second, and third defined projection are a cubic projection PRO with respect to a direction of orientation being the height direction 124. The first, second, and third particle pattern can have an offset in the height direction 124 and/or in the length direction 126, as shown in FIG. 9A for the length direction 126.

[0110] To adapt the cutting behavior and/or the wear resistance of the segment, the particle pattern PP, the projection PRO of the diamond particles 122 in the particle pattern PP and/or the angular orientation AO of the diamond particles 122 in the projection PRO can be varied. Instead of one particle pattern, two or more particle pattern can be used to arrange the diamond particles 122. Instead of the cubic projection, the diamond particles 122 can be oriented in an octahedral projection or a dodecahedral projection, and/or instead of the same angular orientation, the diamond particles 122 can be arranged in different angular orientations.

[0111] The side view of the segment 120 in FIG. 9B shows the particle pattern of the first particle layer comprising 15 diamond particles 122 arranged in five columns of three diamond particles 122. The number of columns in a layer, and the number of diamond particles 122 in a column depends on the application of the tool insert and the size of the diamond particles 122. The particle pattern PP shown in FIG. 9B is simplified in order to be able to illustrate the orientation of the diamond particles 122 in the segment and shows a limited number of enlarged diamond particles compared to practice.

[0112] **FIGS. 10A-C** show a second exemplary version of a segment **130** according to the present invention composed of a bond material **131** that is at least one of sintered, pressed, and infiltrated and a plurality of diamond particles **132** in a top view (FIG. 10A), in a first side view (FIG. 10B) and in a second side view (FIG. 10C).

[0113] The segment 130 has an outer shape including a height in a height direction **134,** a width in a width direction **135,** and a length in a length direction **136.** The outer shape of the segment 130 is similar to the segments 34, 35, 36 of the diamond blade 30 shown in FIGS. 2A, B. Although, the outer shape of the segment 130 differs from the segments 14, 15 and segments 54, the concept of orienting the diamond particles 132 with respect to the direction of orientation is applicable to all segments for abrasive power tools.

[0114] The bond material 131 is at least one of sintered, pressed, and infiltrated, and characterized by at least one feature selected from a chemical composition, a powder morphology, and a degree of alloying. The diamond particles 132 are selected from a distribution of diamond particles, the distribution being characterized by a particle size, a crystal perfection, a toughness and/or a diamond growth morphology. The plurality of diamond particles 132 includes at least one of the five types of the diamond particles 60, 70, 80, 90, 100 shown in the FIGS. 4A to E having at least one axis of rotational symmetry and having outer geometries being composed of cubic faces and/or of octahedral faces.

[0115] The plurality of diamond particles 132 is divided in a first number $\mathbf{N_1}$ of diamond particles 132 and a second number $\mathbf{N_2}$ of diamond particles 132. The segment 130 has a sandwich structure in the width direction 135 and comprises a first section $\mathbf{S_1}$ composed of the bond material 131 and the first number N_1 of diamond particles 132, and two second sections $\mathbf{S_2}$ composed of the bond material 131 and the second number N_2 of diamond particles 132.

[0116] By using a sandwich structure with a first section S_1 and two second sections S_1, the cutting behavior and/or the wear resistance of the segment 130 can be adapted to specific requirements. To adapt the cutting behavior and/or the wear resistance of the sections, the predetermined particle pattern and/or the defined projection of the diamond particles 132 in the predetermined particle pattern and/or the angular orientation of the diamond particles 132 in the defined projection can be varied.

[0117] The diamond particles 132 of the first section S_1 are arranged according to a first predetermined particle pattern $\mathbf{PP_1}$ and at least partially oriented in a first defined projection **PRO,** (FIG. 10B), and the diamond particles 132 of the second sections S_2 are arranged according to a second predetermined particle pattern $\mathbf{PP_2}$ and at least partially oriented in a second defined projection $\mathbf{PRO_2}$ (FIG. 10C).

[0118] In the exemplary version of FIGS. 10A-C, the first and second predetermined particle pattern PP_1, PP_2 are identical and the first and second defined projections PRO_1, PRO_2 are cubic projections. The first number of diamond particles 132 is arranged in the cubic projection in a first angular orientation $\mathbf{AO_1}$ (FIG. 10B), and the second number of diamond particles 132 is arranged in the cubic projection in a second angular orientation $\mathbf{AO_2}$ (FIG. 10C). The first and second angular orientations AO_1, AO_2 are defined with respect to the length direction 136 of the segment 130.

[0119] The diamond particles 132 may be oriented in a cubic, octahedral, or dodecahedral projection in order to take advantage of the particular mechanical properties of their crystal planes. Diamond particles oriented in a given projection may then be given preferred angular orientations to achieve the desired mechanical properties and cutting geometries.

[0120] **FIGS. 11A-C** show a third exemplary version of a segment **140** according to the present invention composed of a bond material **141** that is at least one of sintered, pressed, and infiltrated and a plurality of diamond particles **142** in a top view (FIG. 11A), in a first side view (FIG. 11B) and in a second side view (FIG. 11C).

[0121] The segment 140 has an outer shape including a height in a height direction **144,** a width in a width direction **145,** and a length in a length direction **146.** The outer shape of the segment 140 is similar to the segments 34, 35, 36 of the diamond blade 30 shown in FIGS. 2A, B. Although, the outer shape of the segment 140 differs from the segments 14, 15 and segments 54, the concept of orienting the diamond particles 142 with respect to the direction of orientation is applicable to all segments for abrasive power tools.

[0122] The bond material 141 is at least one of sintered, pressed, and infiltrated, and characterized by at least one feature selected from a chemical composition, a powder morphology, and a degree of alloying. The diamond particles 142 are selected from a distribution of diamond particles, the distribution being characterized by a particle size, a crystal perfection, a toughness and/or a diamond growth morphology. The plurality of diamond particles 142 includes at least one of the five types of the diamond particles 60, 70, 80, 90, 100 shown in the FIGS. 4A to E having at least one axis of rotational symmetry and having outer geometries being composed of cubic faces and/or of octahedral faces.

[0123] The plurality of diamond particles 142 is divided in a first number $\mathbf{N_1}$ of diamond particles 142 and a second number $\mathbf{N_2}$ of diamond particles 142. The segment 140 has a sandwich structure in the width direction 145 and comprises a first section $\mathbf{S_1}$ composed of the bond material 141 and the first number N_1 of diamond particles 142, and two second sections $\mathbf{S_2}$ composed of the bond material 141 and the second number N_2 of diamond particles 142.

[0124] The diamond particles 142 of the first section S_1 are arranged according to a first predetermined particle pattern $\mathbf{PP_1}$ and at least partially oriented in a first defined projection $\mathbf{PRO_1}$ (FIG. 11B), and the diamond particles 142 of the second sections S_2 are arranged according to a second predetermined particle pattern $\mathbf{PP_2}$ and at least partially oriented in a second defined projection $\mathbf{PRO_2}$ (FIG. 11C).

[0125] In the exemplary version of FIGS. 11A-C, the first and second predetermined particle pattern PP_1, PP_2 are identical and the first and second defined projections PRO_1, PRO_2 are octahedral projections. The first number of diamond particles 142 is arranged in the octahedral projection PRO_1 in a first angular orientation $\mathbf{AO_1}$ (FIG. 11B), and the second number of diamond particles 142 is arranged in the octahedral projection PRO_2 in a second angular orientation $\mathbf{AO_2}$ (FIG. 11C). The first and second angular orientations AO_1, AO_2 are defined with respect to the length direction 146 of the segment 140.

Claims

1. A segment (14, 15; 34, 35; 54; 120; 130; 140), comprising:

- a bond material (121; 131; 141) that is at least one of sintered, pressed, and infiltrated, and
- a plurality of diamond particles (122; 132; 142) being arranged according to at least one predetermined particle pattern (PP; PP_1, PP_2) in the bond material (121; 131; 141), the diamond particles (122; 132; 142) having outer geometries being predominantly composed of cubic faces (61; 81; 91; 101) including square and/or octagonal faces and/or of octahedral faces (72; 82; 92; 102) including triangular and/or hexagonal faces, wherein the outer geometries have at least one axis of rotational symmetry,

characterized in that the segment has at least one direction of orientation (111) and for at least 50 % of the plurality of diamond particles (122; 132; 142), the at least one axis of rotational symmetry of the diamond particles is oriented in at least one defined angle ($\Phi \pm 15°$) with respect to the at least one direction of orientation (111).

2. The segment of claim 1, wherein the at least one direction of orientation (111) is arranged parallel to a height direction (21; 41; 124; 134; 144) of the segment, to a width direction (22; 42; 125; 135; 145) of the segment, to a length direction (23; 43; 126; 136; 146) of the segment, and/or to any other defined direction of the segment.

3. The segment of any one of claims 1 to 2, wherein the plurality of diamond particles (122; 132; 142) includes a first group of diamond particles (60) having outer geometries being predominantly composed of cubic faces (61), and/or a second group of diamond particles (70) having outer geometries being predominantly composed of octahedral faces (72), and/or a third group of diamond particles (80; 90; 100) having outer geometries being predominantly composed of cubic faces (81; 91; 101) and octahedral faces (82; 92; 102).

4. The segment of claim 3, wherein the first group of diamond particles includes cubic particles (60) having outer geometries being predominantly composed of square faces (61), and/or the second group of diamond particles includes octahedral particles (70) having outer geometries being predominantly composed of triangular faces (72), and/or the third group of diamond particles includes first cuboctahedral particles (80) having outer geometries being predominantly composed of square faces (81) and triangular faces (82), and/or second cuboctahedral particles (90) having outer geometries being predominantly composed of octagonal faces (91) and triangular faces (92), and/or third cuboctahedral particles (100) having outer geometries being predominantly composed of square faces (91) and hexagonal faces (92).

5. The segment of any one of claims 3 to 4, wherein for the first group of diamond particles (60), the at least one axis of rotational symmetry includes at least one first symmetry axis (63) being substantially perpendicular to a cubic face (61) and running substantially through the center point (66) of that cubic face (61) and/or at least one second symmetry axis (64) running substantially through two diagonally opposing corners (67A, 67B) of the outer geometry and/or at least one third symmetry axis (65) being substantially perpendicular to an edge (68A) of the outer geometry, running substantially through the center point (69) of that edge (68A) and substantially crossing the diagonally opposing edge (68B) of the outer geometry.

6. The segment of any one of claims 3 to 4, wherein for the second group of diamond particles (70), the at least one axis of rotational symmetry includes at least one first symmetry axis (73) being substantially perpendicular to an octahedral face (72) and running substantially through the center point (76) of that octahedral face (72) and/or at least one second symmetry axis (74) running substantially through two diagonally opposing corners (77A, 77B) of the outer geometry, and/or at least one third symmetry axis (75) being substantially perpendicular to an edge (78A) of the outer geometry, running substantially through the center point (79) of that edge (78A) and substantially crossing the diagonally opposing edge (78B) of the outer geometry.

7. The segment of any one of claims 3 to 4, wherein for the third group of diamond particles (80; 90; 100), the at least one axis of rotational symmetry includes at least one first symmetry axis (83A; 93A; 103A) being substantially perpendicular to a cubic face (81; 91; 101) and running substantially through the center point of (86A; 96A; 106A) that cubic face and at least one further first symmetry axis (83B; 93B; 103B) being substantially perpendicular to an octahedral face (82; 92; 102) and running substantially through the center point (86B; 96B; 106B) of that octahedral face and/or at least one second symmetry axis (84; 94; 104) running substantially through two diagonally opposing corners (87A, 87B; 97A, 97B; 107A, 107B) of the outer geometry and/or at least one third symmetry axis (85; 95; 105) being substantially perpendicular to an edge (88A; 98A; 108A) of the outer geometry, running substantially through the center point (89A; 99A; 109A) of that edge and substantially crossing the diagonally opposing edge (88B; 98B; 108B) of the outer geometry.

8. The segment of claim 7, wherein for the second cuboctahedral particles (90), the at least one third symmetry axis (95) is substantially perpendicular to an edge defined by adjacent octagonal faces (91), and for the third cuboctahedral particles (100), the at least one third symmetry axis (105) is substantially perpendicular to an edge defined by adjacent hexagonal faces (102).

9. The segment of any one of claims 3 to 8, wherein the at least 50 % of the plurality of diamond particles (122; 132; 142) are oriented in at least one defined projection (PRO) with respect to the at least one direction of orientation (111) of the segment.

10. The segment of claim 9, wherein the at least one defined projection (PRO) is selected from a cubic projection, an octahedral projection, and a dodecahedral projection.

11. The segment of claim 10, wherein in a cubic projection, for diamond particles of the first group (60) and third group (80; 90; 100), a first symmetry axis (63; 83A; 93A; 103A) being substantially perpendicular to a cubic face (61; 81; 91; 101) and running substantially through the center point of that cubic face is oriented in the at least one defined angle ($\phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment, and for diamond particles of the second group (70), a second symmetry axis (74) is oriented in the at least one defined angle ($\Phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment.

12. The segment of claim 10, wherein in an octahedral projection, for diamond particles of the first group (60), a second symmetry axis (64) is oriented in the at least one defined angle ($\phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment, and for diamond particles of the second group (70) and diamond particles of the third group (80; 90; 100), a first symmetry axis (73; 83B; 93B; 103B) being substantially perpendicular to an octahedral face (72; 82; 92; 102) and running substantially through the center point of that octahedral face is oriented in the at least one defined angle ($\Phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment.

13. The segment of claim 10, wherein in a dodecahedral projection, for diamond particles of the first group (60), a third symmetry axis (65) is oriented in the at least one defined angle ($\phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment, for diamond particles of the second group (70), a third symmetry axis (75) is oriented in the at least one defined angle ($\phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment, and for diamond particles of the third group (80; 90; 100), a second symmetry axis (84) or a third symmetry axis (95; 105) is oriented in the at least one defined angle ($\Phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment.

14. The segment of claim 13, wherein for the first cuboctahedral particles (80) of the third group, a second symmetry axis (84) is oriented in the at least one defined angle ($\phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment, for the second cuboctahedral particles (90) of the third group, a third symmetry axis (95) is oriented in the at least one defined angle ($\phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment, and for the third cuboctahedral particles (100) of the third group, a third symmetry axis (105) is oriented in the at least one defined angle ($\Phi \pm 15°$) with respect to the at least one direction of orientation (111) of the segment.

15. The segment of any one of claims 1 to 14, wherein the plurality of diamond particles (132; 142) includes a first number (N_1) of the diamond particles and a second number (N_2) of the diamond particles, and the segment comprises at least one first section (S_1) composed of the bond material (131; 141) and the first number of the diamond particles (132; 142) and at least one second section (S_2) composed of the bond material (131; 141) and the second number of the diamond particles (132; 142).

16. The segment of claim 15, comprising one first section (S_1) and two second sections (S_2), the first section (S_1) being arranged between the second sections (S_2) in any defined direction of the segment.

17. The segment of claim 15, comprising at least two first sections and/or at least two second sections, the first and second sections being arranged according to a regular pattern in the segment.

18. The segment of any one of claims 15 to 17, wherein the at least one predetermined particle pattern includes at least one first predetermined particle pattern (PP_1), and the first number (N_1) of the diamond particles (132; 142) is arranged according to the at least one first predetermined particle pattern (PP_1), and the at least one predetermined particle pattern includes at least one second predetermined particle pattern (PP_2), and the second number (N_2) of the diamond particles (132; 142) is arranged according to the at least one second predetermined particle pattern (PP_2).

19. The segment of any one of claims 15 to 18, wherein the first number (N_1) of the diamond particles (132; 142) is at least partially oriented in a first defined projection (PRO_1) with respect to the at least one direction of orientation (111).

20. The segment of claim 19, wherein the first defined projection (PRO_1) is selected from a cubic projection, an octahedral projection, and a dodecahedral projection.

21. The segment of any one of claims 18 to 20, wherein the second number (N_2) of the diamond particles is randomly oriented.

22. The segment of any one of claims 18 to 20, wherein the second number (N_2) of the diamond particles (132; 142) is at least partially oriented in a second defined projection (PRO_2) with respect to the at least one direction of orientation (111).

23. The segment of claim 22, wherein the second defined projection (PRO_2) is selected from a cubic projection, an octahedral projection, and a dodecahedral projection.

24. The segment of any one of claims 22 to 23, wherein the first and second defined projections (PRO_1, PRO_2) are both selected from a cubic projection, or both selected from an octahedral projection, or both selected from a dodecahedral projection.

25. The segment of claim 24, wherein the first defined projection (PRO_1) and the second defined projection (PRO_2) differ in an angular orientation (AO_1, AO_2) of the diamond particles (132; 142) with respect to the at least one direction of orientation (111).

26. The segment of claim 25, wherein the angular orientation (AO_1, AO_2) of the diamond particles (132; 142) in the first and second defined projections differ by half of the rotational symmetry angle of the corresponding symmetry axis that is oriented with respect to the at least one direction of orientation (111).

27. The segment of any one of claims 1 to 14, wherein the plurality of diamond particles includes a first number of the diamond particles, a second number of the diamond particles, and a third number of the diamond particles, and the segment comprises at least one first section composed of the bond material and the first number of the diamond particles, at least one second section composed of the bond material and the second number of the diamond particles, and at least one third section composed of the bond material and the third number of the diamond particles.

28. The segment of any one of claims 1 to 27, wherein at least 80 % of the plurality of diamond particles (122; 132; 142) that are arranged according to at least one predetermined particle pattern (PP) are oriented in the at least one defined angle ($\Phi \pm 15°$) with respect to the at least one direction of orientation (111).

29. A tool insert (10; 30; 50), comprising:

- a base body (11; 31; 51) configured to connect the tool insert (10; 30; 50) to a power tool, and including a connection surface (16; 37; 56), and
- two or more segments (14, 15; 34, 35; 54; 120; 130; 140) according to any one of claims 1 to 28, wherein the segments (14, 15; 34, 35; 54; 120; 130; 140) are connected to the connection surface (16; 37; 56).

30. The tool insert of claim 29, configured as core bit (10), saw blade (30), cutting disk (30), or grinding cup wheel (50).

31. The tool insert of any one of the claims 29 to 30, wherein the two or more segments (14, 15; 34, 35) include first segments (14; 34) and second segments (15; 35) that are different from the first segments (14; 34).

32. The tool insert of any one of the claims 29 to 31, further comprising at least one additional segment (15; 36; 55) connected to the connection surface (16; 37; 56).

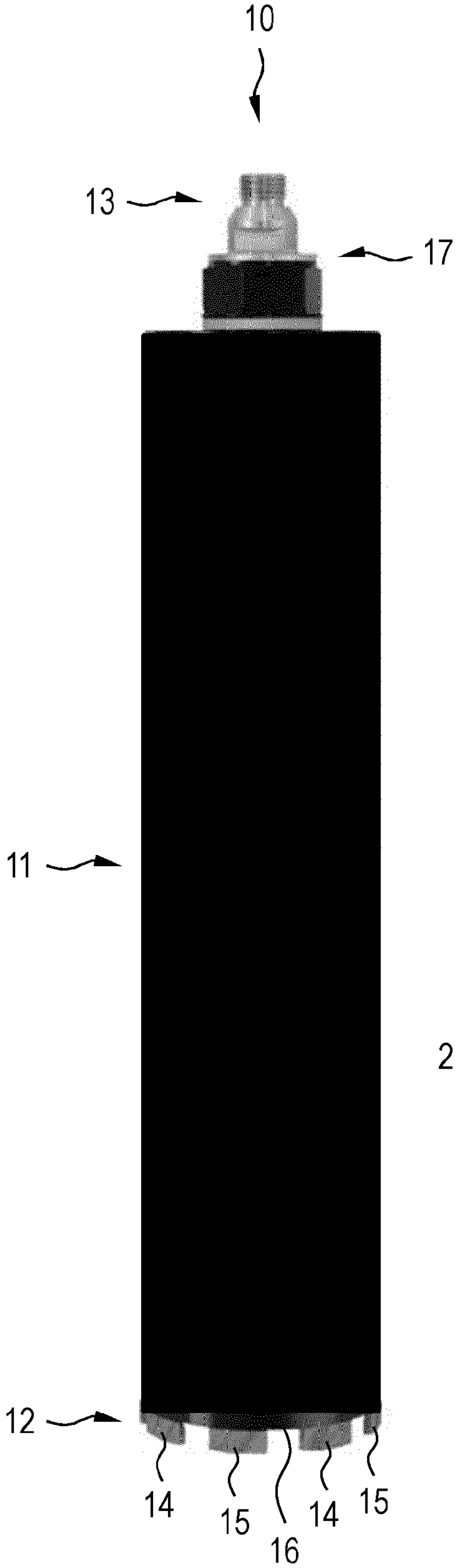


FIG. 1A

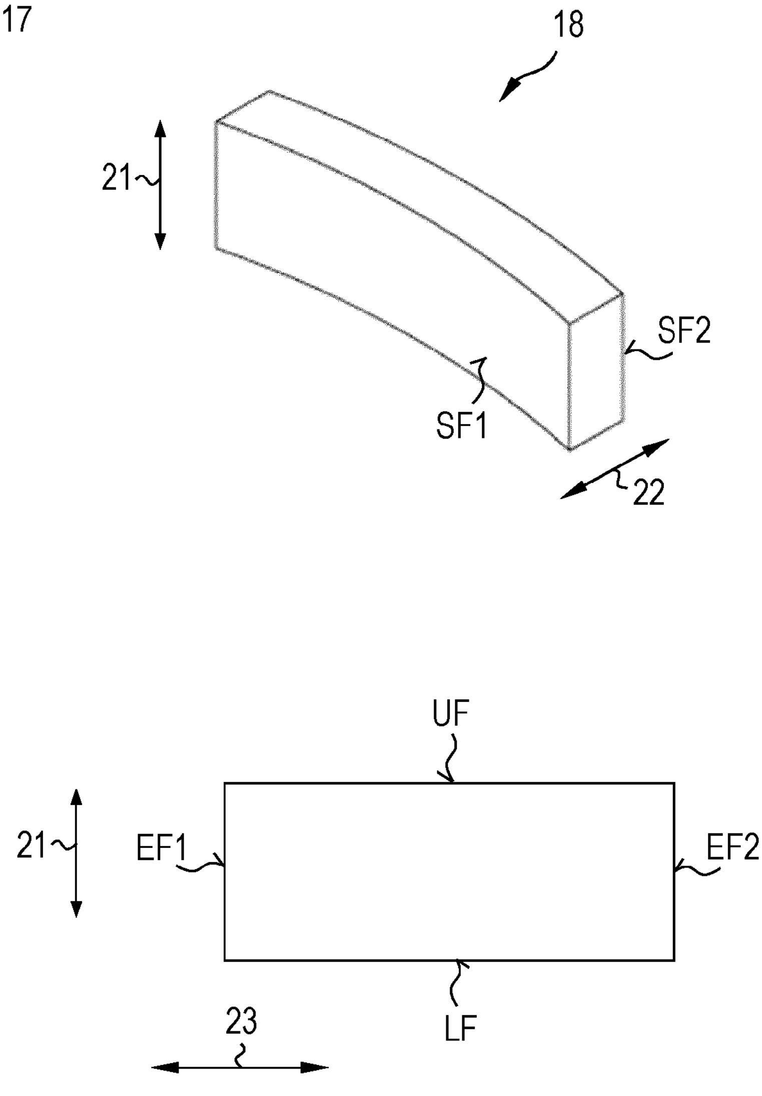


FIG. 1B

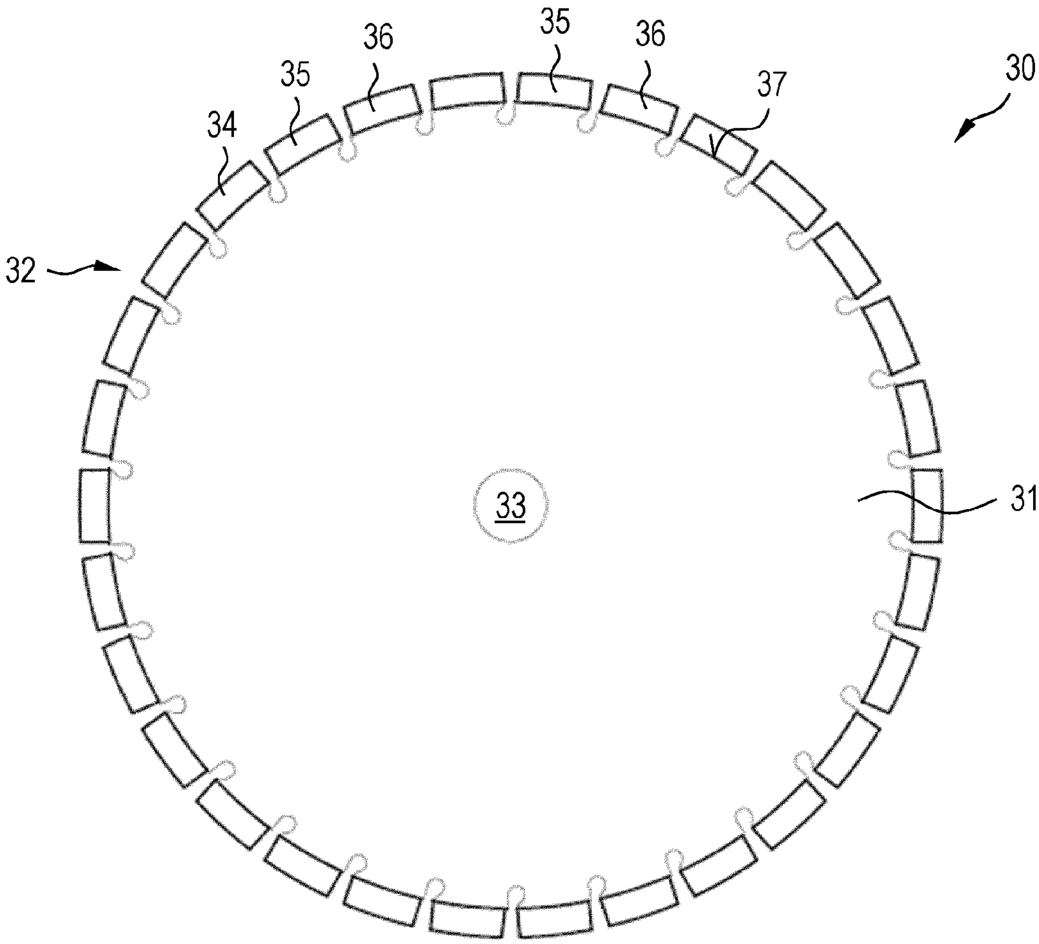


FIG. 2A

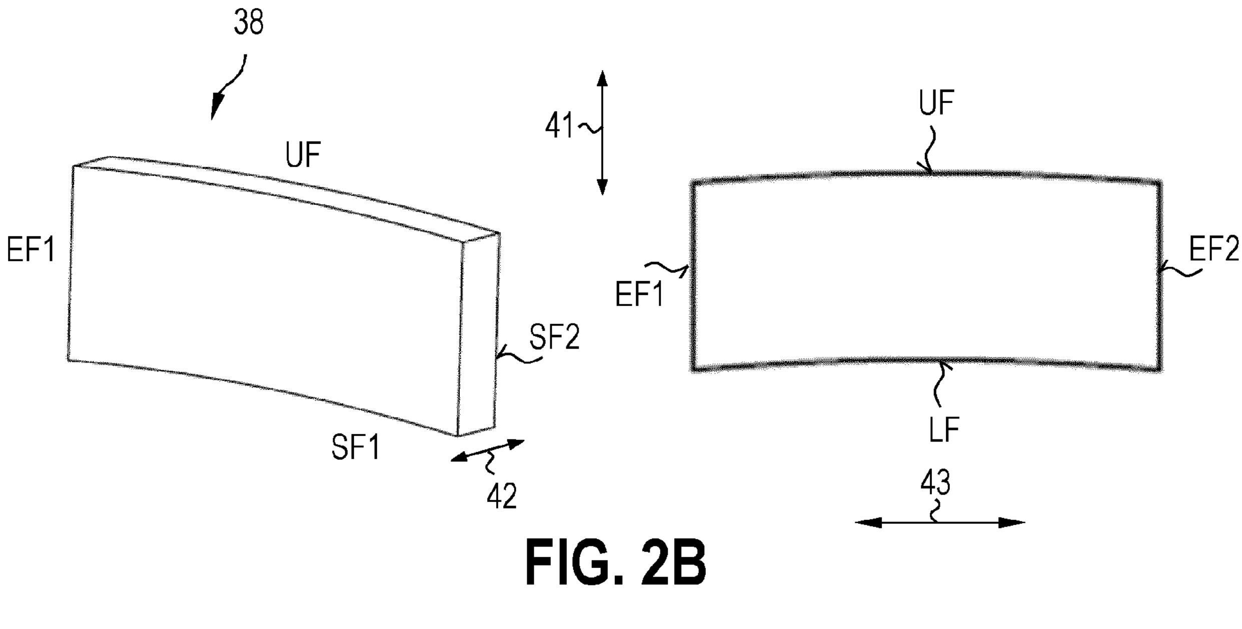


FIG. 2B

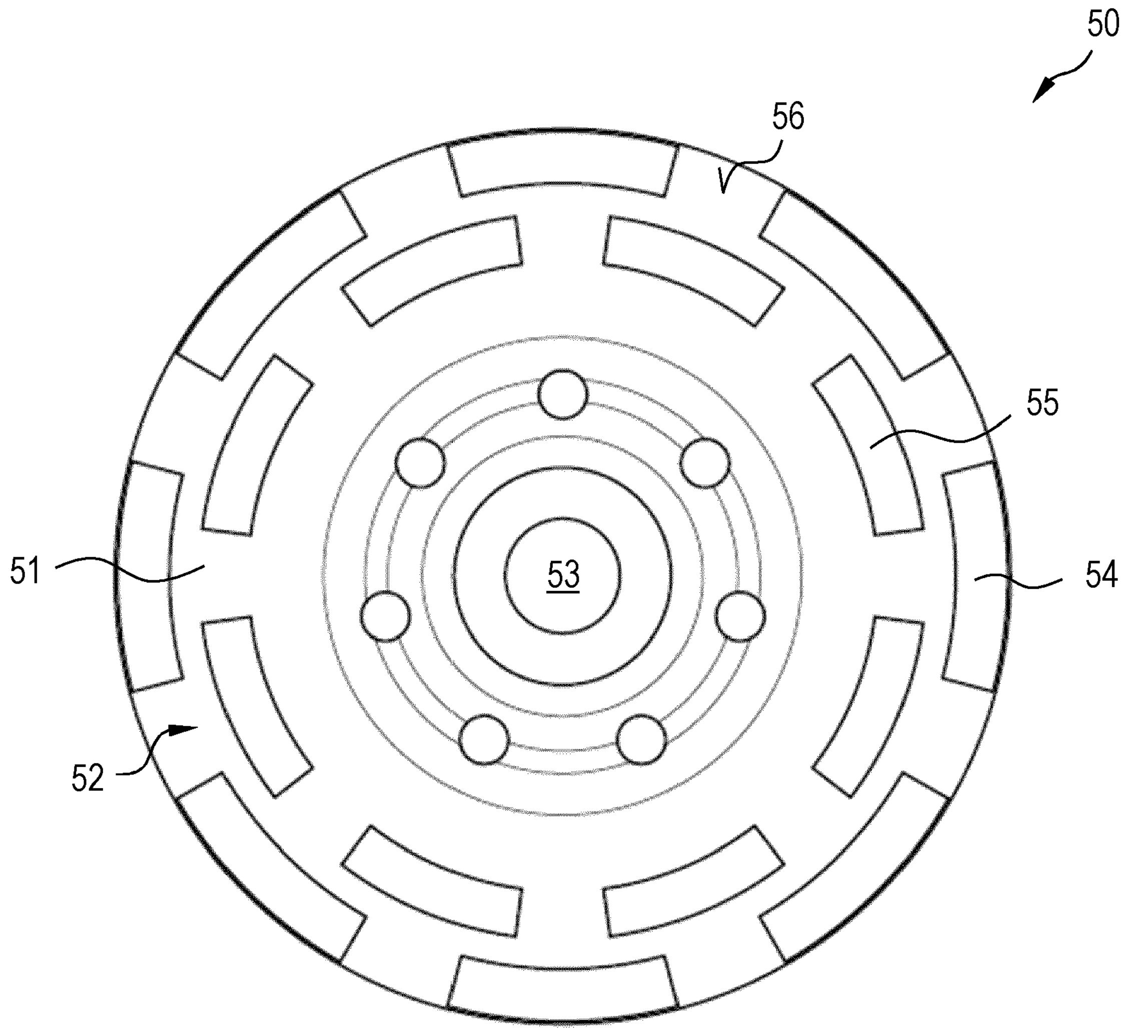
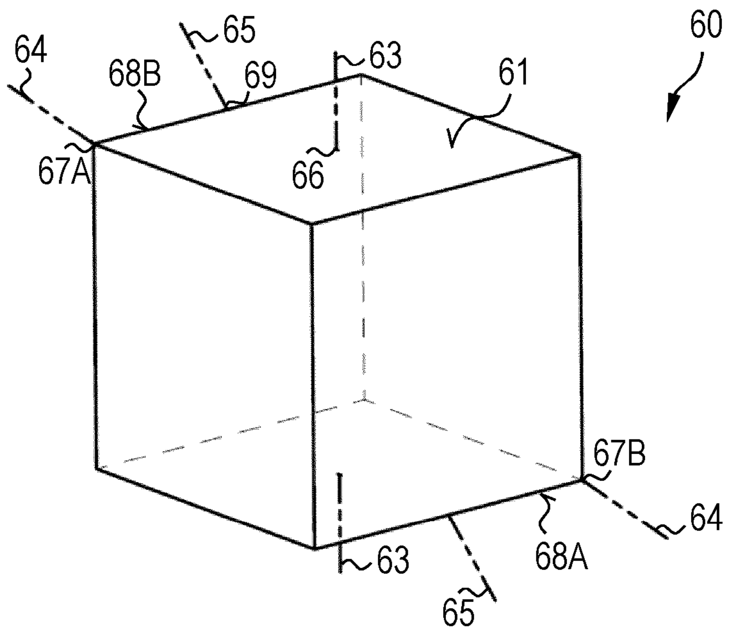


FIG. 3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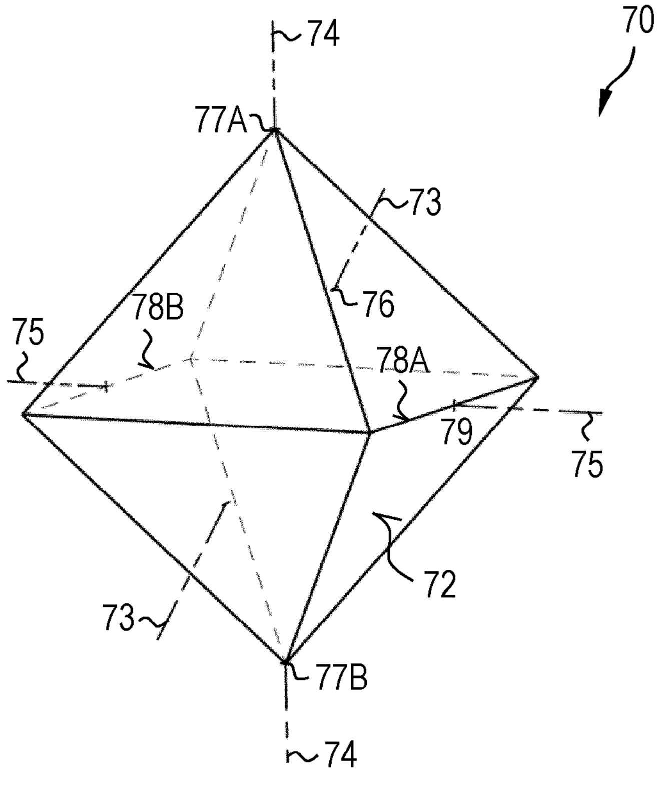
63
63
64
64
65
65
66
67A
67B
68A
68B
69

FIG. 4A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78B
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77B
74

FIG. 4B

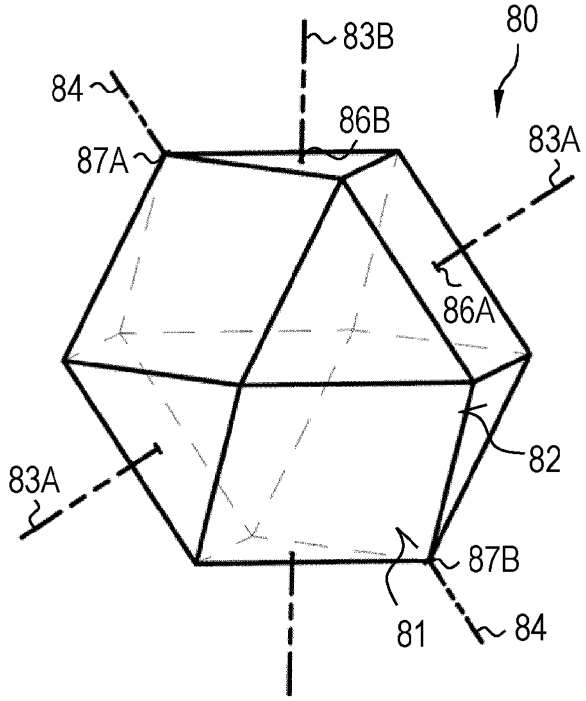


FIG. 4C

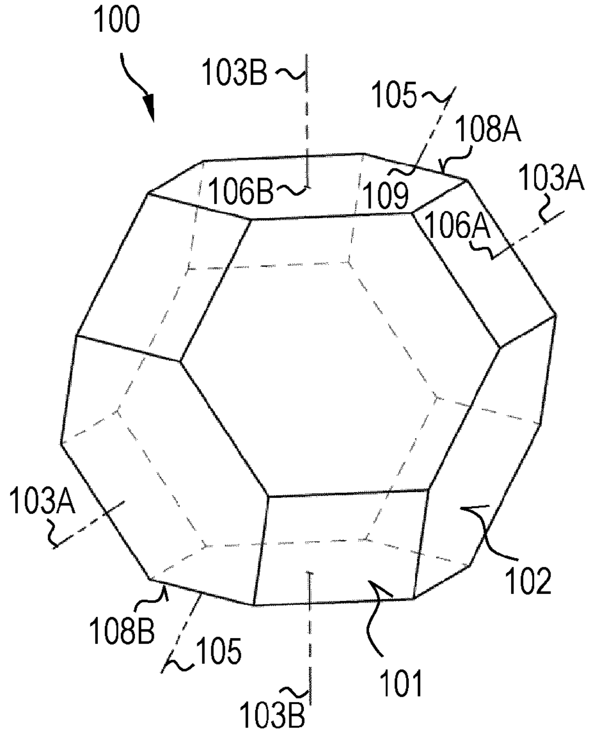


FIG. 4E

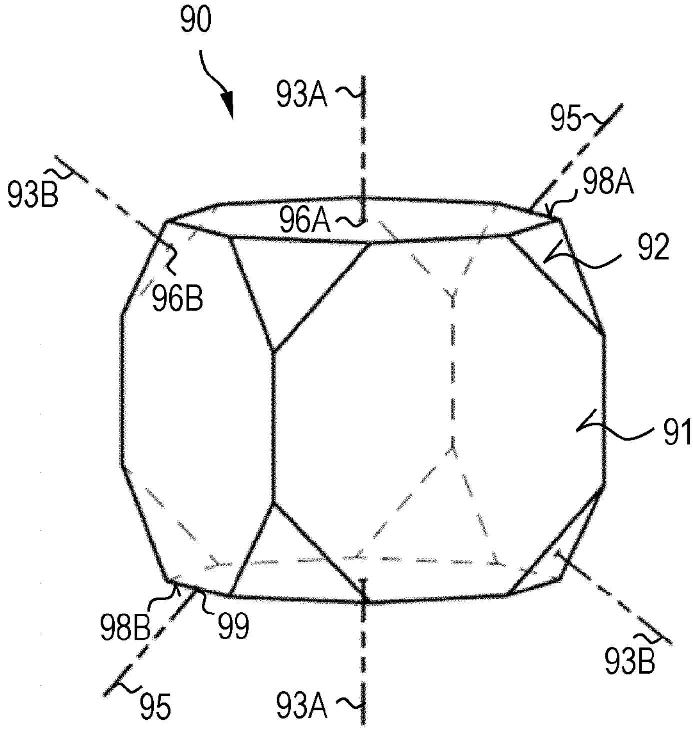
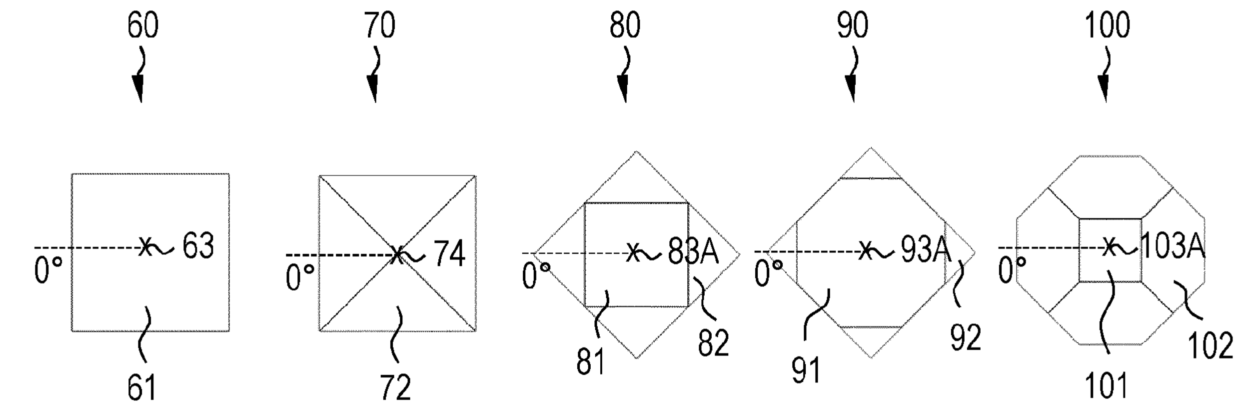


FIG. 4D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70
80
90
100
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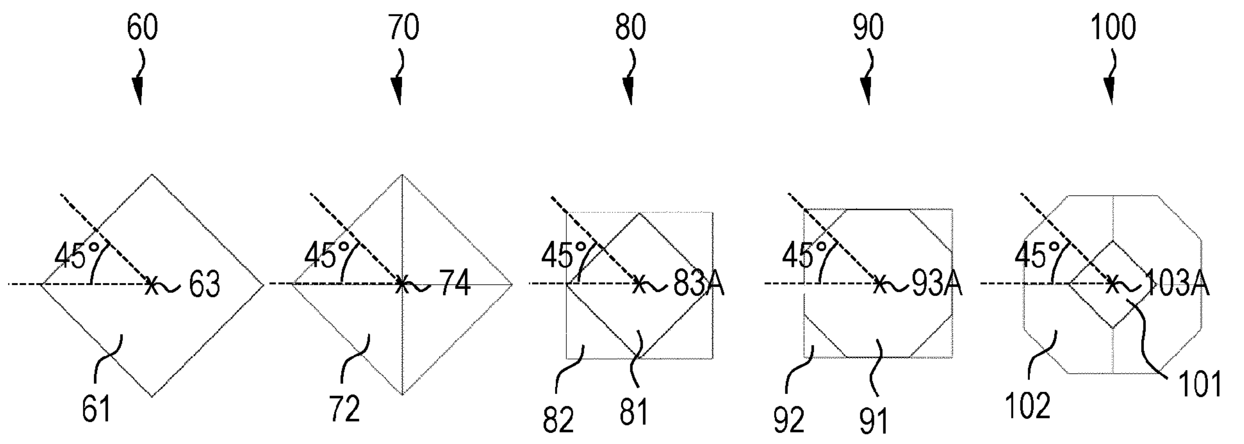
63
74
83A
93A
103A
61
72
81
82
91
92
101
102

FIG. 5A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93A
103A
61
72
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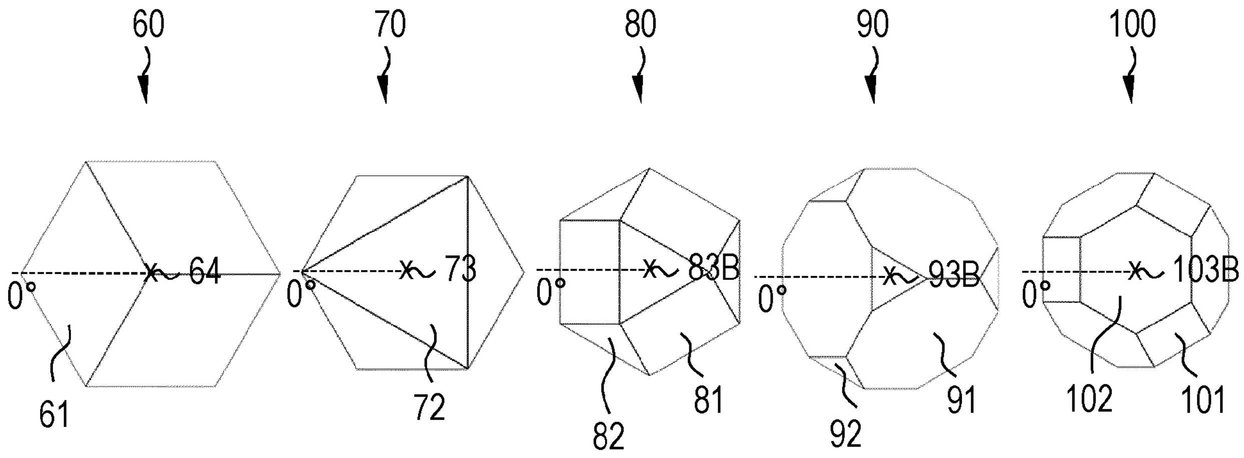
92
91
102
101

FIG. 5B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70
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100
64
0°
73
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83B
0°
93B
0°
103B
0°
61
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82
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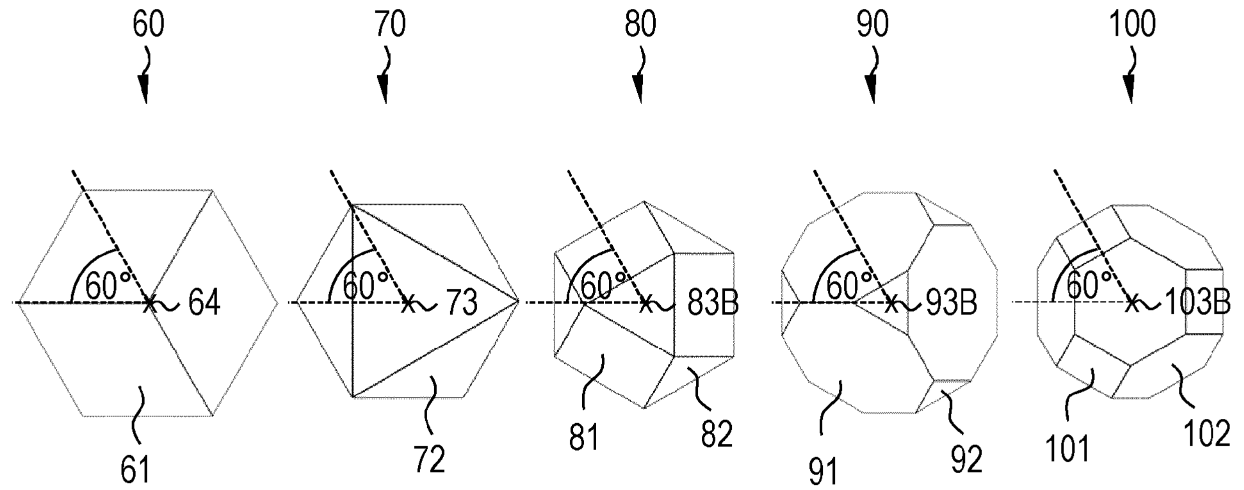
92
91
102
101

FIG. 6A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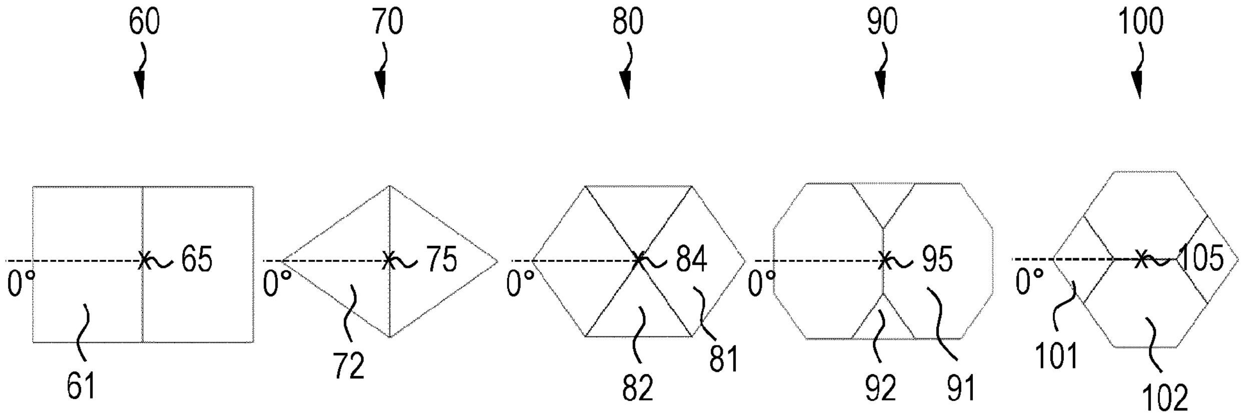
60°
103B
61
72
81
82
91
92
101
102

FIG. 6B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0°
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0°
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84
0°
95
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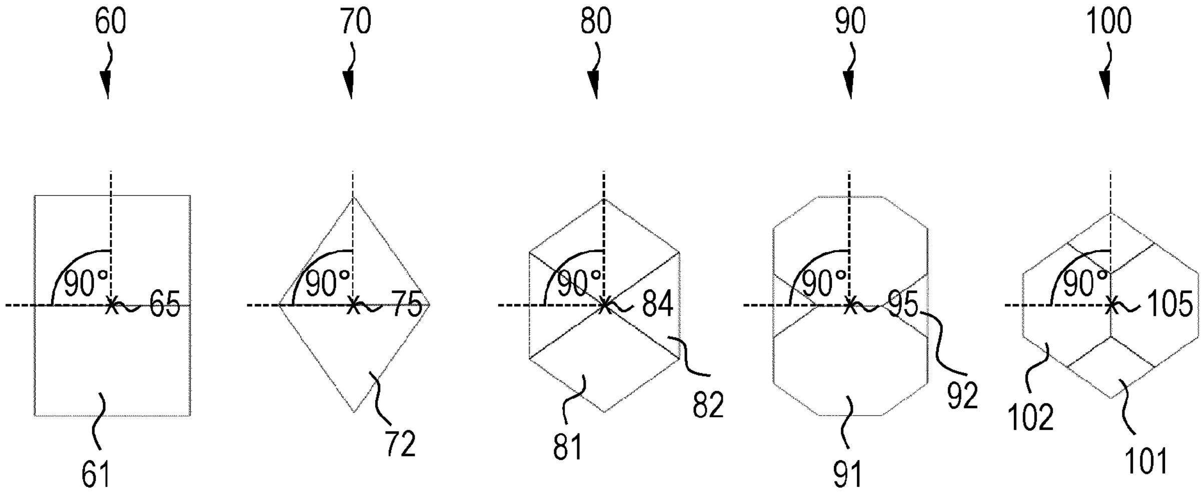
105
61
72
82
81
92
91
101
102

FIG. 7A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90°
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90°
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90°
95
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105
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72
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82
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92
102
101

FIG. 7B

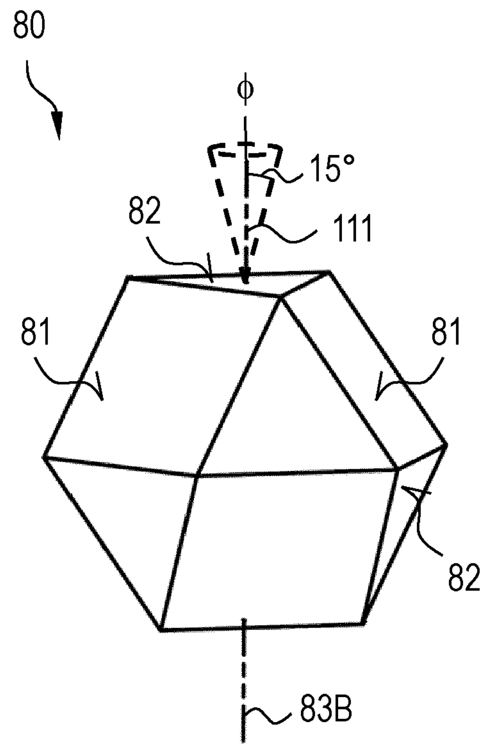


FIG. 8A

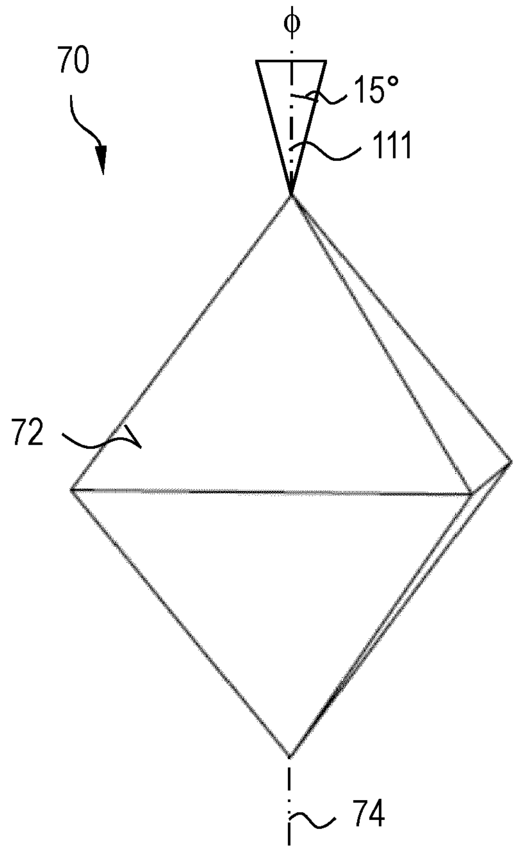
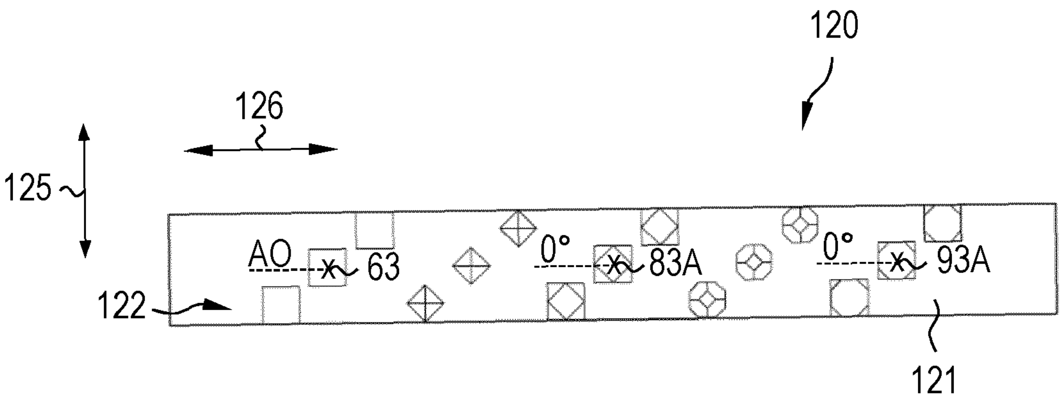


FIG. 8B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126
125
AO
63
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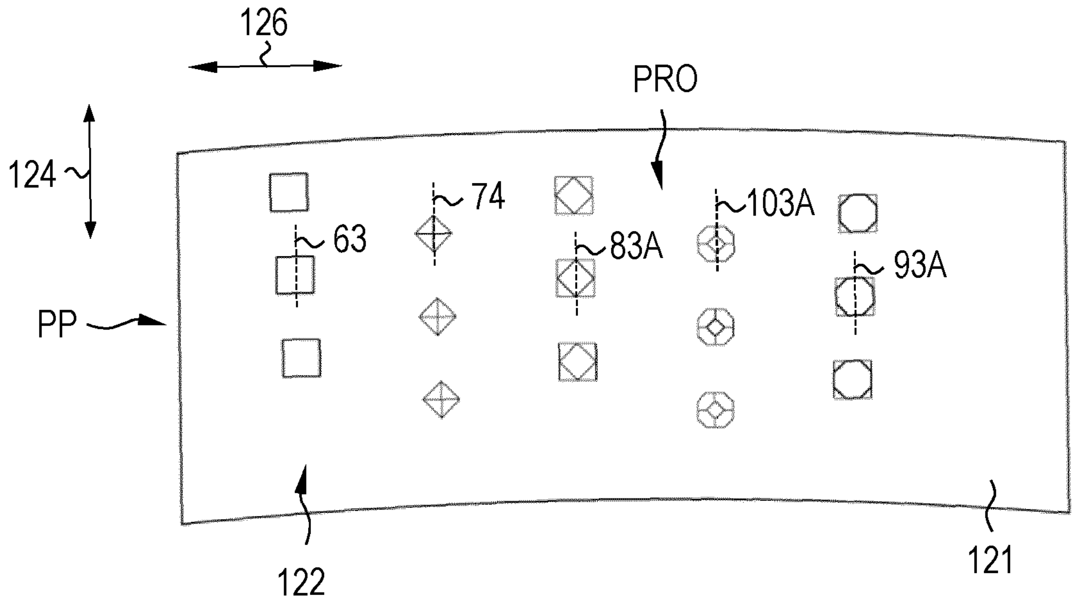
83A
0°
93A
122
121

FIG. 9A


126
PRO
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74
103A
63
83A
93A
PP
122
121

FIG. 9B

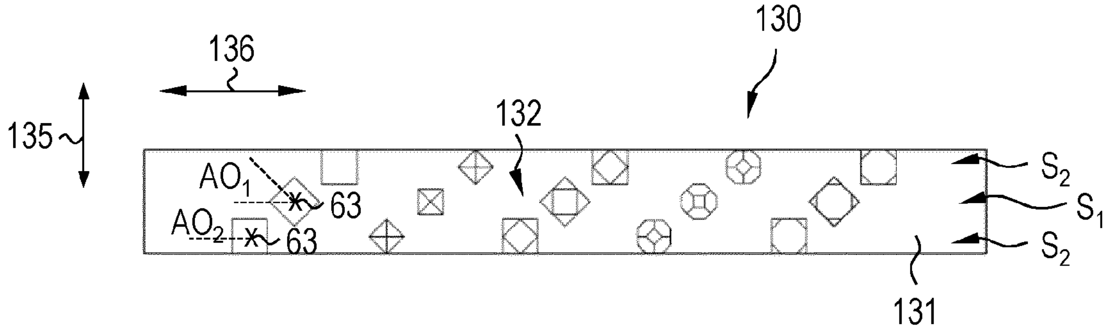

FIG. 10A

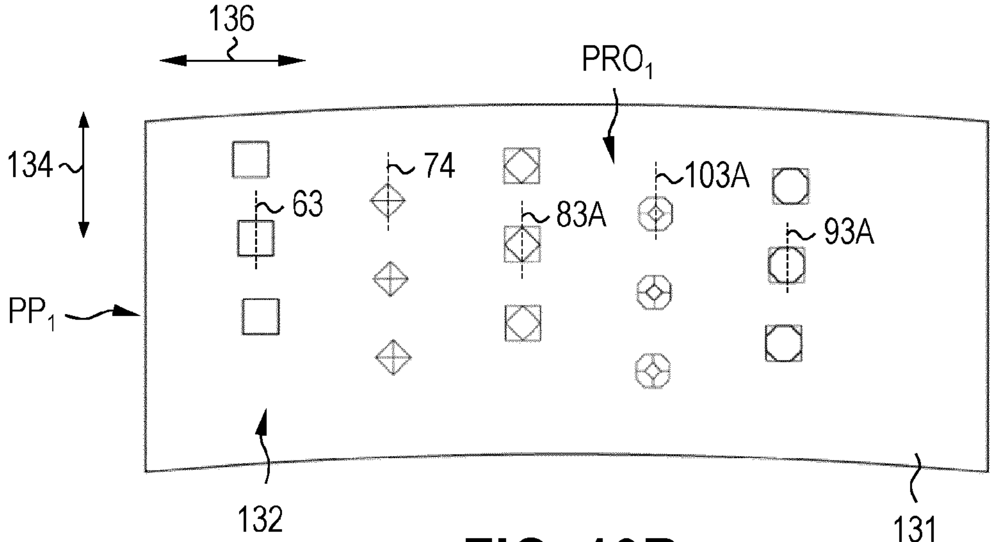

FIG. 10B

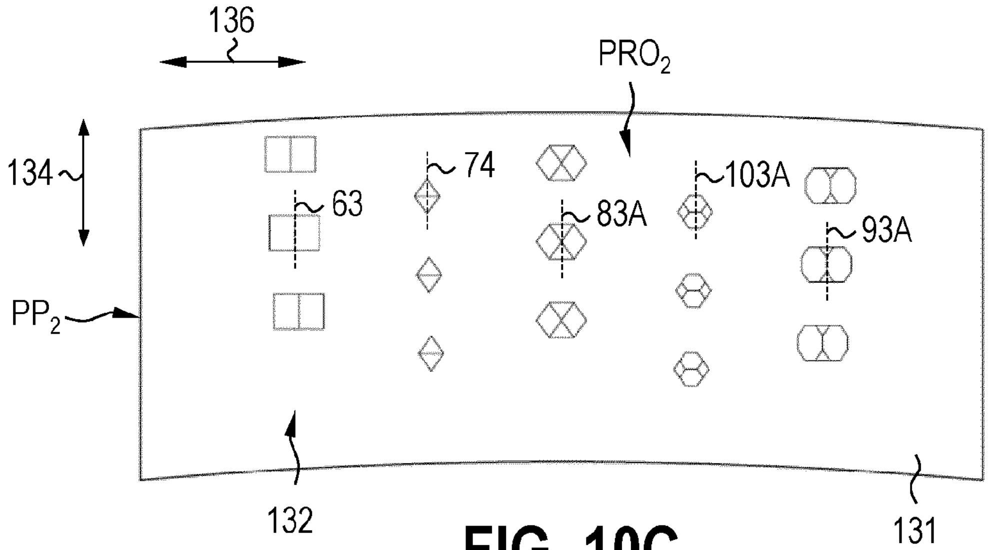

FIG. 10C

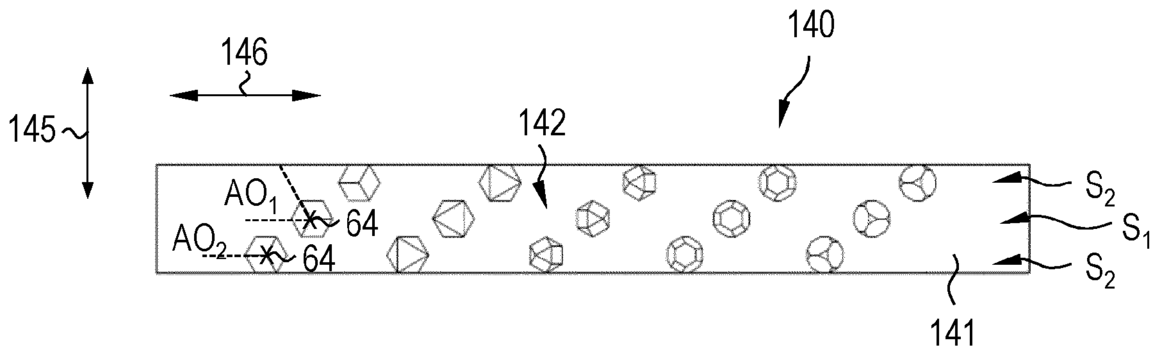

FIG. 11A

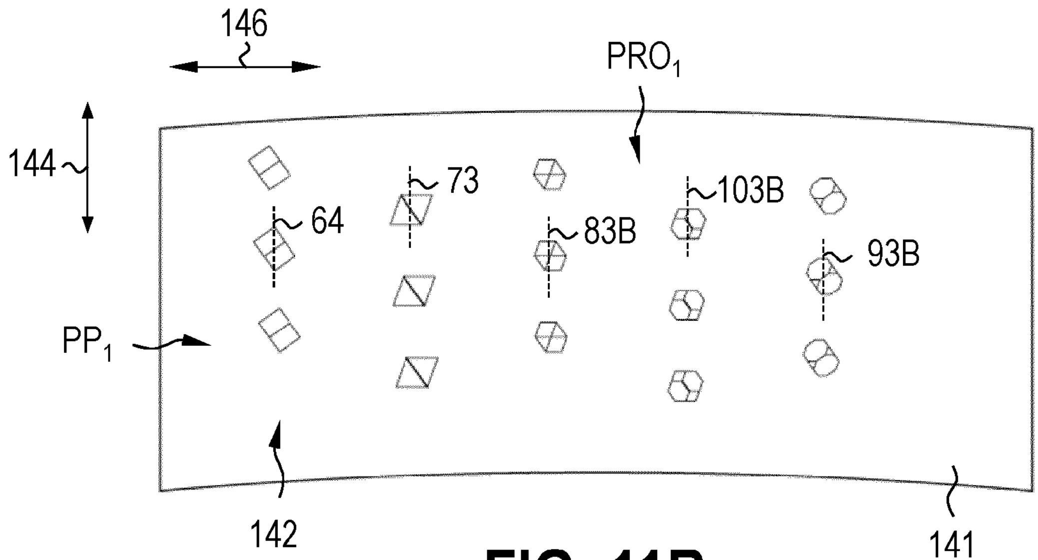

FIG. 11B

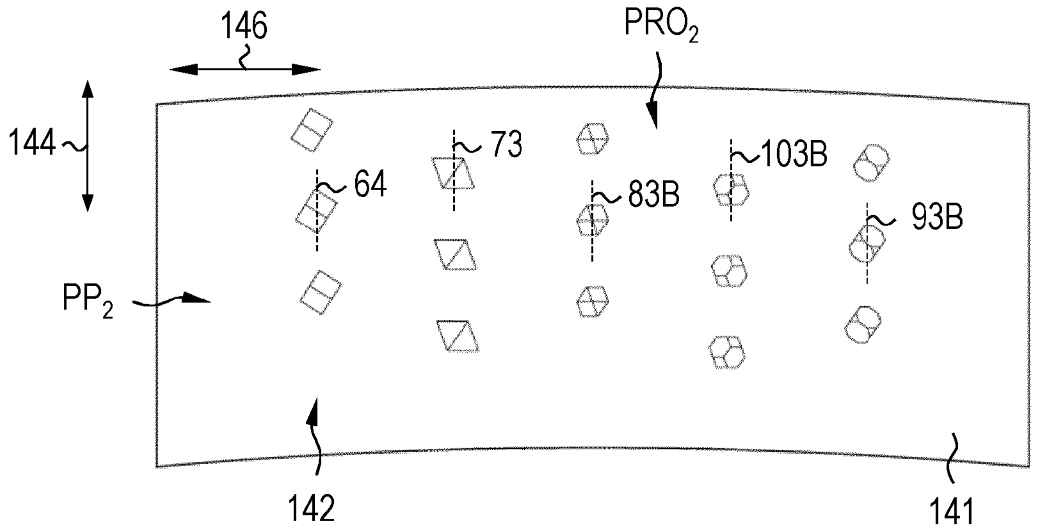

FIG. 11C

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EUROPEAN SEARCH REPORT

Application Number
EP 23 19 1021

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Y	US 2006/073774 A1 (SUNG CHIEN-MIN [TW]) 6 April 2006 (2006-04-06) * paragraphs [0032], [0050] - [0054]; figure 1 *	11-14	
Y	WO 2018/080778 A1 (3M INNOVATIVE PROPERTIES CO [US]) 3 May 2018 (2018-05-03) * paragraphs [0106], [0109], [0131], [0132], [0137], [0140], [0161], [0166], [0171], [0186], [0203], [0210]; figures 11,12 *	11-14	
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	31 January 2024	Kornmeier, Martin

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