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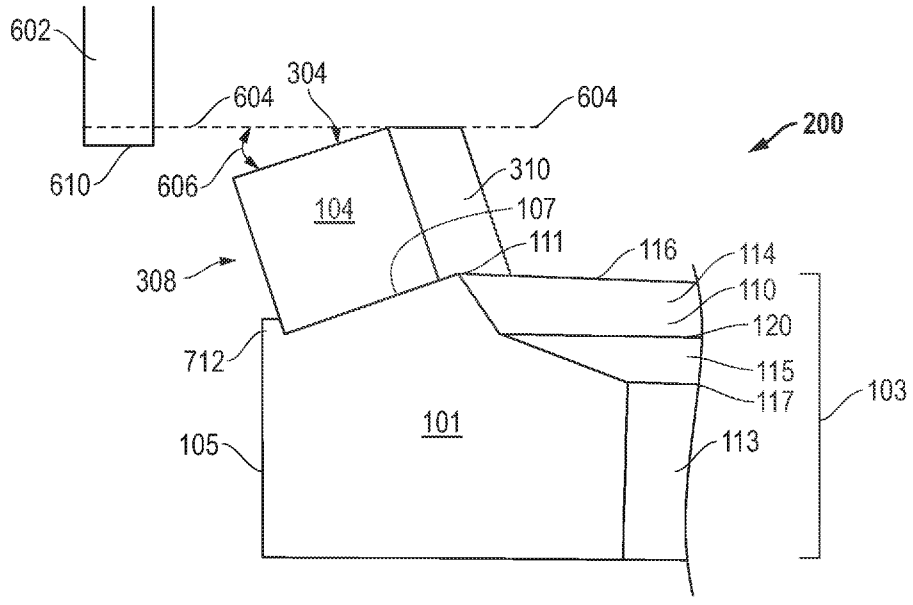

FIG. 7

(57) Abstract: An abrasive article includes a base having an annular shape including an inner annular surface defining a central opening, an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface and wherein the inner annular surface of the base comprises an inner annular surface portion defining an exit vector having a non-intersecting arrangement with respect to the plurality of abrasive segments.

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GRINDING RING WITH IMPROVED SWARF EXTRACTION

TECHNICAL FIELD

The present disclosure is directed to an abrasive article for shaping materials, and more particularly to segmented grinding wheels or rings having one or more abrasive segments thereon.

Certain construction materials, such as bricks, can be formed with substantial dimensional variations from brick to brick. Modern techniques for assembling a plurality of bricks together typically require that such bricks conform to particular dimensional tolerances, which can be performed by a grinding operation. A typical grinding operation can include the passing of a brick through a grinding apparatus, including two grinding rings on opposing sides of the brick for grinding two opposite faces of the brick at the same time.

SUMMARY

In an embodiment, an abrasive article includes a base having an annular shape including an inner annular surface defining a central opening and an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface and wherein the inner annular surface of the base comprises an inner annular surface portion defining an exit vector having a non-intersecting arrangement with respect to the plurality of abrasive segments.

In another embodiment, an abrasive article includes a base having an annular shape including an inner annular surface defining a central opening and an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface, wherein the inner annular surface of the base comprises an inner annular curvature defining an exit vector, wherein each of the abrasive segments includes an inner major surface defining an abrasive vector and wherein the intersection of the exit vector and the abrasive vector is spaced apart from the abrasive segments.

In yet another embodiment, an abrasive article includes a base having an annular shape including an inner annular surface defining a central opening and an abrasive assembly configured to be releasably coupled to the base, wherein the

abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface, wherein the inner annular surface of the base comprises an inner annular surface portion configured to direct swarf away from the inner major surface of the plurality of abrasive segments.

In a further embodiment, an abrasive article includes a base having an annular shape including an inner annular surface defining a central opening and an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface, wherein the inner annular surface of the base comprises an inner annular surface portion defining an exit angle having a value of no greater than about 150 degrees.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure may be better understood, and its numerous features and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

FIG. 1A includes a perspective view illustration of a base of an abrasive article in accordance with an embodiment.

FIG. 1B includes a top plan view illustration of an abrasive article that includes abrasive segments in accordance with an embodiment.

FIG. 2 includes a close-up plan view of an abrasive article that includes abrasive segments in accordance with an embodiment taken at Circle 2 of FIG. 1B.

FIG. 3 includes a perspective view of an abrasive segment in accordance with an embodiment.

FIG. 4 includes a top plan view of an abrasive segment in accordance with an embodiment.

FIG. 5 includes a side plan view of an abrasive segment in accordance with an embodiment illustrating a first side surface portion.

FIG. 6 includes a side plan view of an abrasive segment in accordance with an embodiment illustrating an outer major surface.

FIG. 7 includes a cross-sectional view of an abrasive article that includes an abrasive segment in accordance with a particular embodiment taken at Line 7-7 of FIG. 2.

FIG. 7A includes a cross-sectional view of an abrasive article that includes an abrasive segment in accordance with a particular embodiment taken at Line 8-8 of FIG. 2.

FIG. 8 includes a cross-sectional view of an abrasive article that includes an abrasive segment in accordance with a particular embodiment taken at Line 7-7 of FIG. 2.

FIG. 9 includes a cross-sectional view of an abrasive article that includes an abrasive segment in accordance with a particular embodiment.

FIG. 10 includes a close-up view of an intersection point of FIG. 9.

FIG. 11 includes a perspective view of a portion of an abrasive article having abrasive segments in accordance with an embodiment.

FIG. 12 includes a cross-sectional view of an abrasive article that includes an abrasive segment in accordance with an embodiment taken at Line 10-10 of FIG. 2.

FIG. 13 includes a plan view of a grinding system in accordance with a particular embodiment.

FIG. 14 includes a perspective view illustration of a base of a grinding system in accordance with a particular embodiment.

FIG. 15 includes an image of a conventional grinding wheel CS1.

FIG. 16 includes an image of a conventional grinding wheel CS1.

FIG. 17 includes a perspective view illustration of a grinding wheel SN1 formed in accordance with a particular embodiment.

Skilled artisans appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the invention. The use of the same reference symbols in different drawings indicates similar or identical embodiments.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

The following is generally directed to abrasive articles, and more particularly, segmented grinding wheels and segmented grinding rings used to grind industrial materials such as ceramic, stone, concrete, and/or brick. In particular, the following abrasive articles disclosed herein may be useful for the finishing of building materials.

FIG. 1A includes a perspective view illustration of a base of an abrasive article in accordance with an embodiment. As illustrated, an abrasive article 100 can include a grinding ring having a base 101. The base 101 can have a cylindrical, three-dimensional shape. More particularly, the base 101 can have an annular shape defining a central opening 102 extending through the base 101. The central opening 102 may be suitable for attachment of the base 101 to a machine equipped for rotation of the base 101 for carrying out shaping operations. For example, a spindle of a machine may be engaged within the central opening 102 of the base 101, which may be in turn connected to a rotor suitable for rotating the base 101.

In accordance with an embodiment, the base 101 can be made from an inorganic material, such as a metal or metal alloy. In certain instances, the base can be formed of a metal alloy such as steel. For example, the base 101 can include heat treatable steel alloys, such as 30CrNiMo8, 25CrMo4, 75Cr1, C60, or simple construction steel like St 37, St 57, and St 60. The base 101 can have a tensile strength of at least about 600 N/mm^2. It will be appreciated that the base 101 can be formed by a variety of metallurgical techniques known in the art.

As generally illustrated in FIG. 1A, the base 101 can have a receiving surface 107 for receiving an abrasive segment and a rear surface 109 opposite the receiving surface 107 extending generally perpendicular to the rotation axis 108 and extending through a center point in the central opening 102. The base 101 can have an outer annular surface 105 extending generally axially between the receiving surface 107 and the rear surface 109. The outer annular surface 105 can also extend circumferentially around the base 101, defining the outer peripheral surface of the base 101. Further, the base 101 can have an inner annular surface 103 opposite the outer annular surface 105 and extending generally axially between the receiving surface 107 and the rear surface 109. The inner annular surface 103 can also extend circumferentially around the inner diameter of the body of the base 101 defining the inner peripheral surface of the base 101. It will be appreciated that the inner annular surface 103 can define the central opening 102 of the base 101.

FIG. 1B includes a top view illustration of an abrasive article in accordance with an embodiment. As illustrated, the abrasive article 200 can include a grinding ring having a base 101 as generally described in FIG. 1A. The central opening 102 can have a diameter that defines an inner diameter (ID) of the base 101. The body of

the base 101 can include an outer diameter (OD) extending through the center point, or rotation axis 108, of the central opening 102 and between the outer annular surface 105 of the base 101.

In accordance with an embodiment, the inner diameter (ID) of the base 101 can be defined by an inner radius of curvature, and the outer diameter (OD) can be defined by an outer radius of curvature. In accordance with an embodiment, the outer diameter (OD) can be greater than the inner diameter (ID), and the outer radius of curvature can be greater than the inner radius of curvature. In accordance with an embodiment, the outer diameter (OD) of the base 101 can be at least about 400 mm, such as at least 450 mm, at least 500 mm, at least 550 mm, at least 600 mm, at least about 650 mm, at least about 700 mm, at least about 750 mm, or at least 800 mm. In a non-limiting embodiment, the outer diameter (OD) of the base 101 can be not greater than 1100 mm, not greater than 1000 mm, not greater than 950 mm, not greater than 900 mm, not greater than 850 mm, not greater than 800 mm, not greater than 750 mm, or not greater than 700 mm. It will be appreciated that the outer diameter (OD) of the base 101 can be within a range between any minimum or maximum value noted above. In an embodiment, the outer diameter of the base 101 can be within a range between 400 and 1100 mm. In a certain embodiment, the outer diameter of the base 101 can be within a range of between 600 mm and 950 mm.

FIG. 2 includes a close-up plan view of a portion of the abrasive article FIG. 1B, taken at Circle 2 of FIG. 1B and illustrating abrasive segments in accordance with an embodiment. As illustrated, a plurality of abrasive segments 104 can be attached to the base 101 of the abrasive article 200. The abrasive segments 104 can be brazed, or otherwise welded, affixed, coupled, or attached to the base 101. In accordance with another embodiment, the abrasive segments 104 can be attached to an abrasive assembly, which in turn can be configured to be releasably coupled to a receiving surface 107 of the base 101, as will be discussed further herein.

In accordance with an embodiment, the abrasive article 200 can include a plurality of abrasive segments 104 coupled to the base 101. For instance, the abrasive article 200 can include at least 30 abrasive segments 104 coupled to the base 101, such as at least 35, at least 40, at least 45, at least 50, at least 55, at least 60, at least 65, or at least 70 abrasive segments 104 coupled to the base 101. In a non-limiting embodiment, the abrasive article 200 can include not greater than 120 abrasive

segments 104 coupled to the base 101, such as not greater than 115, not greater than 110, not greater than 105, not greater than 100, not greater than 95, not greater than 90, not greater than 85, not greater than 80, or not greater than 75 abrasive segments 104 coupled to the base 101. It will be appreciated that the number of abrasive segments 104 coupled to the base 101 can be within a range between and including any minimum and maximum value noted above.

Referring to FIG. 3 through FIG. 6, details concerning an abrasive segment 104 according to an embodiment are illustrated. Specifically, FIG. 3 includes a perspective view of the abrasive segment 104; FIG. 4 includes a top plan view of the abrasive segment 104; FIG. 5 includes a side plan view illustrating a first side surface portion 312 of the abrasive segment 104; and FIG. 6 includes a side plane view illustrating an outer major surface 308 of the abrasive segment 104. As illustrated in FIG. 3 through FIG. 6, the abrasive segment 104 can include a body 302. In accordance with an embodiment, the body 302 of the abrasive segment 104 can include abrasive grains contained within a matrix material. Notably, the abrasive segment 104 can be a bonded abrasive article wherein the abrasive grains are contained within a three-dimensional matrix of material. The abrasive grains can include an abrasive particulate material having a Mohs hardness of at least 4, such as at least 5, at least 6, at least 7, at least 8, or even at least 9. In certain instances, the abrasive grains can include a superabrasive material, such as diamond, cubic boron nitride, or a combination thereof. In one embodiment, the abrasive grains consist essentially of diamond.

The abrasive particles can be selected to have a particle size of not less than about 400 US mesh, such as not less than about 100 US mesh, such as between about 16 and 100 US mesh. Further, depending on the intended application of the abrasive article, the size of the abrasive grains can be between about 30 and 60 US mesh.

The matrix material of the abrasive segment 104 can include an inorganic material, such as a vitreous bond, metal bond, metal alloy bond, and a combination thereof. In particular instances, the matrix material may include a metal or metal alloy, and particularly, can be formed from a transition metal element or even a combination of transition metal elements.

The abrasive segment 104 can be an infiltrated bonded abrasive article. In such instances, the abrasive segment 104 can include abrasive grains contained within

a metal matrix, wherein the abrasive segment 104 further includes an interconnected network of pores, which can be filled with an infiltrant material. The metal matrix can include a metal element or metal alloy, including a plurality of metal elements.

As noted above, the abrasive segment 104 can be formed such that an infiltrant is present within the interconnected network of pores within the body 302 of the abrasive segment 104. The infiltrant can partially fill, substantially fill, or even completely fill the volume of the pores extending through the volume of the abrasive segment 104. In accordance with one particular design, the infiltrant can be a metal or metal alloy material. See, for example, U.S. Patent No. 8,568,205 B2 (disclosing bonded abrasive tools having a continuous metal phase for bonding an abrasive component to a carrier).

As illustrated in FIG. 3 through FIG. 6, the body 302 of the abrasive segment 104 can include a top surface 304, a bottom surface 306 opposite the top surface 304, an outer major surface 308, and an inner major surface 310 opposite the outer major surface 308. In accordance with an embodiment, the abrasive segment 104 can be mounted on the base 101 of the grinding ring 200 such that the inner major surface 310 faces the rotation axis 108 and the outer major surface 308 faces away from the rotation axis 108. The outer major surface 308 and the inner major surface 310 can each extend between the top surface 304 and the bottom surface 306. The body 302 of the abrasive segment 104 can further include a first side surface portion 312 and a second side surface portion 314 opposite the first side surface portion 312. The first side surface portion 312 and the second side surface portion 314 can also each extend between the top surface 304 and the bottom surface 306. In accordance with an embodiment, the outer major surface 308, inner major surface 310, first side surface portion 312, and second side surface portion 314, can define an outer peripheral surface of the body 302 of the abrasive segment 104.

In accordance with an embodiment, the body 302 of the abrasive segment 104 can have a certain width, length, and height. In a certain aspect, the body 302 of the abrasive segment 104 can have an overall width, W, defined as the greatest distance as measured from the outer major surface 308 and the second surface portion 310. For instance, the overall width, W, can be at least 8 mm, such as at least 9 mm, at least about 10 mm, at least about 11 mm, or at least about 12 mm. In a non-limiting embodiment, the overall width, W, can be not greater than 20 mm, such as no greater

than 19 mm, no greater than 18 mm, no greater than 17 mm, no greater than about 16 mm, no greater than 15 mm, not greater than 14 mm, not greater than 13 mm, not greater than 12 mm, not greater than 11 mm, not greater than 10 mm, not greater than 9 mm, or not greater than 8 mm. The overall width can be within a range between and including any of the minimum and maximum width values noted above.

In another aspect, a width of the abrasive segment 104 can vary along its length, L. For instance, at least the outer major surface 308 can include a non-linear shape, such that the width, W, varies along the length, L, of the body 302. In accordance with an embodiment, the abrasive segment 104 can include a minimum width, Wm, defined as the minimum distance between the outer major surface 308 and the second surface portion 310. In a particular instance, the minimum width, Wm, can be located at the center, C, of the length, L, of the body 302, equidistant between the first side surface portion 312 and the second side surface portion 314, as illustrated in FIG. 3 and FIG. 4. In an embodiment, the minimum width, Wm, can be at least 8 mm, such as at least 9 mm, at least about 10 mm, at least about 11 mm, or at least about 12 mm. In a non-limiting embodiment, the minimum width, Wm, can be not greater than 20 mm, such as not greater than 19 mm, not greater than 18 mm, not greater than 17 mm, not greater than about 16 mm, or not greater than 15 mm. The minimum width, Wm, can be within a range between and including any of the minimum and maximum width values noted above.

As particularly illustrated in FIG. 3, the body 302 of the abrasive segment 104 can have an overall height, H, defined as the greatest distance between the bottom surface 306 to the top surface 304. In a certain aspect, the overall height, H, of the body can be at least 10 mm, such as at least 11 mm, at least 12 mm, at least 13 mm, at least 14 mm, at least 15 mm, at least 16 mm, at least 17 mm, at least 18 mm, at least 19 mm, or at least 20 mm. The overall height, H, may be no greater than about 25 mm, no greater than about 24 mm, no greater than about 23 mm, no greater than about 22 mm, no greater than about 21 mm, no greater, or not greater than 20 mm. The overall height, H, can be within a range between and including any of the minimum and maximum overall height values noted above.

In one aspect, a height of the abrasive segment 104 can be the same as measured at different surfaces of the body 302. In another aspect, a height of the abrasive segment 104 can be different at a certain surface of the body 302 than a

different surface of the body 302. For instance, the height as measured at the outer major surface 308 can be different than the height as measured at the inner major surface 310. The difference between a height at the outer major surface 308 and the inner major surface 310 can be at least 5%, such as at least 10%, at least 15%, at least 20%, at least 25%, at least 30%, at least 35%, or even at least 40%. In a non-limiting embodiment, the difference between a height at the outer major surface 308 and the inner major surface 310 can be not greater than 50%, such as not greater than 45%, not greater than 40%, not greater than 35%, not greater than 30%, not greater than 25%, not greater than 20%, not greater than 15%, or even not greater than 10%. It will be appreciated that the difference between a height at the outer major surface 308 and the inner major surface 310 can be within a range of any minimum or maximum value noted above.

As particularly illustrated in FIG. 4, the body 302 of the abrasive segment 104 can further have an overall length, L, defined as the greatest distance between the first side surface portion 312 and the second side surface portion 314. In a certain aspect, the body 302 of the abrasive segment 104 can have an overall length, L, of at least 10 mm, such as at least 11 mm, at least 12 mm, at least 13 mm, at least 14 mm, at least 15 mm, at least 16 mm, at least 17 mm, at least 18 mm, or at least 19 mm. The overall length, L, can be not greater than about 30 mm, such as not greater than about 29 mm, not greater than about 28 mm, not greater than about 27 mm, not greater than about 26 mm, not greater than about 25 mm, not greater than 24 mm, not greater than 23 mm, not greater than 22 mm, not greater than 21 mm, or not greater than 20 mm. The overall length, L, can be within a range between and including any of the minimum and maximum overall length values noted above.

In another aspect, the first side surface portion 312 can include a surface area defined with respect to a surface area of the outer major surface 308. In accordance with an embodiment, the surface area of the first side surface portion 312 can be less than the surface area of the outer major surface 308. For example, the surface area of the first side surface portion 312 can be less than 90% of the surface area of the outer major surface 308, such as less than 80%, less than 70%, less than 60%, less than 50%, less than 40%, or less than 30%. In a non-limiting embodiment, the surface area of the first side surface portion 312 can be at least 20% of the surface area of the outer major surface 308, such as at least 30%, at least 40%, at least 50%, at least 60%, at

least 70%, or at least 80%. It will be appreciated that the surface area of the first side surface portion 312 with respect to the surface area of the outer major surface 308 can be within a range of any minimum and maximum value noted above.

In another aspect, the surface area of the first side surface portion 312 can have the same relationship with a surface area of the inner major surface 310 as noted above regarding the relationship of the surface area of the first side surface portion 312 to the surface area of the outer major surface 308. Similarly, it will also be appreciated that the surface area of the second side surface portion 314 with respect to the surface area of the outer major surface 308 can have the same relationship as noted above with respect to the relationship of the surface area of the first side surface portion 312 with respect to the surface area of the outer major surface 308. Still further, it will also be appreciated that the surface area of the second side surface portion 314 with respect to the surface area of the inner major surface 310 can have the same relationship as noted above with respect to the relationship of the surface area of the first side surface portion 312 with respect to the surface area of the outer major surface 308.

FIG. 7 illustrates a cross-section view of the grinding ring 200 taken along line 7-7 in FIG. 2. As illustrated, the base 101 can have an axial flange 712. The axial flange 712 can be formed integrally with the base 101 or can be attached or mounted on the base 101 such that it forms a portion of the outer annular surface 105 of the base 101. In another embodiment, the axial flange 712 can be part of a mounting assembly configured to be attached to the base 101, as discussed further herein. As further illustrated in FIG. 7, the abrasive segment 104 can be mounted on the receiving surface 107 of the base 101 between the inner annular surface 103 and the outer annular surface 105, in accordance with an embodiment. In a particular embodiment, the abrasive segment 104 can be mounted on the receiving surface 107 in direct contact with the axial flange 712.

As previously described, the grinding ring 200 may rotate around the rotation axis 108 (FIG. 1). With respect to FIG. 7, the grinding ring 200 can rotate such that the base 101 and the abrasive segment 104 would illustratively move into (or out of) the page. A workpiece 602 can move in a direction along a working axis 604 so that the workpiece 602 can be abraded by the grinding ring 200 as it rotates. In a

particular aspect, the working axis 604 can be substantially perpendicular to the rotation axis 108.

As depicted in FIG. 7, the top surface 304 can define a working angle 606 with respect to the working axis 604. During operation, the abrasive segment 104 can remove a portion of material 610 from the workpiece 602 at a particular grinding depth determined in part by a height of the abrasive segment. In particular, the height as measured at the outer major surface 308 can be substantially the same as the height as measured at the inner major surface 310, thereby defining a certain working angle 606. In another instance, the height as measured at the outer major surface 308 can be different than the height as measured at the inner major surface 310, thereby defining a working angle 606 that may be different than the working angle 606 depicted in FIG. 7.

As depicted in FIG. 8, the height as measured at the outer major surface 308 can be less than that the height as measured at the inner major surface 310, thereby defining a working angle 606 that may be less than the working angle 606 depicted in FIG. 7, that is, if the shape of the base 101 and the receiving surface 107 are the same. In any instance, the working angle 606 can be at least about 8 degrees, such as at least about 9 degrees, at least about 10 degrees, at least about 11 degrees, at least about 12 degrees, or at least about 13 degrees. In a non-limiting embodiment, the working angle 606 may be not greater than 20 degrees, not greater than 19 degrees, not greater than 18 degrees, not greater than 17 degrees, not greater than 16 degrees, or not greater than 15 degrees. The working angle 606 can be within a range between and including any of the minimum and maximum angle values described above.

In general, an overall size of a construction block, e.g., a brick, can be changed by moving the construction block through a space established by a pair of opposing parallel grinding rings such that each grinding ring contacts a separate face of the construction block. A grinding system for such an operation can be configured using a first grinding ring and a second grinding ring parallel to the first grinding ring.

As can be seen in FIG. 7 and FIG. 8, the inner annular surface 103 can include an inner annular surface portion 110 and an inner annular ring portion 113. In an embodiment, the inner annular ring portion 113 defines a surface opposite the outer annular surface 105 and extending generally axially between the receiving surface 107 and the rear surface 109. In one embodiment, the inner annular surface portion

110 may define a shaped surface portion such that the swarf generated from a grinding operation is directed away from the plurality of abrasive segments 104. Through empirical research, it has been found that in some instances, the portion of the inner annular surface 110 that may be adjacent to the inner exposed surface 111 may direct the swarf at the abrasive segments 104. The swarf may erode the inner major surface 310 of the abrasive segments 104. Accordingly, in one embodiment, at least a portion 110 of the inner annular surface can have a shaped surface portion sufficient to direct the swarf away from the inner major surfaces 310 of the abrasive segments 104.

In a first aspect, the inner annular surface portion 110 as illustrated in FIG. 7, can have a linear shape as viewed in cross-section. In accordance with a particular embodiment, the linear shape of the inner annular surface portion 110 can be defined by a first annular surface 114 and a second annular surface 115. In a particular embodiment, the first annular surface 114 can be adjacent and abutting the inner exposed portion 111 at an inner edge 116. In still another embodiment, the second annular surface 115 can be adjacent and abutting the inner annular ring surface 113 at an edge 117.

FIG. 7A illustrates a cross-section view of the grinding ring 200 taken along line 8-8 in FIG. 2. In a particular embodiment, the first annular surface 114 and the second annular surface 115 can abut at an edge 120 at a surface angle 118 as viewed in cross-section. The first annular surface 114 and the second annular surface 115 can define a surface angle 118 such that swarf accumulated during a grinding operation is directed away from the inner major surface 310 of the abrasive segments 104. In a particular embodiment, the surface angle 118 can be at least 90 degrees, such as at least 95, such as at least 100 degrees, at least 105 degrees, at least 110 degrees, at least 115 degrees, at least 120 degrees, at least 125 degrees, at least 130 degrees, at least 135 degrees, at least 140 degrees, at least 145 degrees, at least 150 degrees, at least 155 degrees, at least 160 degrees, at least 165 degrees, or at least 170 degrees. The surface angle 118 can be not greater than 180 degrees, such as not greater than 175 degrees, not greater than 170 degrees, not greater than 165 degrees, or even not greater than 160 degrees. The exit angle can be within a range between and including any of the minimum and maximum overall values noted above.

In another aspect, the inner annular surface portion 110 as illustrated in FIG. 8, the inner annular surface portion 110 can have a curved shape as viewed in cross-section. In accordance with an embodiment, the curved shape of the inner annular surface portion 110 can have a shape defined by a sinusoidal shape, an elliptical shape, a portion of a circle, a portion of an oval, a convex shape, a concave shape, or any combination thereof. In a particular instance, the curved shape of the inner annular surface portion 110 can be a concave shape.

In accordance with an embodiment, the full length of the curved shape of the inner annular surface portion 110 can be defined by a certain radius of curvature. A radius of curvature is defined as both the inverse of a curve and the distance from the curve to the center of curvature of the curve. In an embodiment, the radius of curvature of the curved shape of the inner annular surface portion 110 can be at least 10 mm, such as at least 11 mm, at least 12 mm, at least 13 mm, at least 14 mm, at least 15 mm, or at least 16 mm. In a non-limiting embodiment, the radius of curvature of the curved shape of the inner annular surface portion 110 can be not greater than 30 mm, such as not greater than 29 mm, not greater than 28 mm, not greater than 27 mm, not greater than 26 mm, not greater than 25 mm, or not greater than 24 mm. It will be appreciated that the radius of curvature of the curved shape of the inner annular surface portion 110 can be within any minimum and maximum value noted above. In a certain instance, the radius of curvature of the curved shape of the inner annular surface portion 110 can be within a range of at least 10 mm and not greater than 30 mm. In a certain instance, the radius of curvature of the curved shape of the inner annular surface portion 110 can be within any minimum and maximum value noted above.

As can be seen in FIG. 7 and FIG. 8, the receiving surface 107 of the base 101 can include an inner exposed portion 111 having an exposed length, L2, as will be discussed further herein.

FIG. 9 illustrates a cross-section view of a grinding ring 900 in accordance with an embodiment. The grinding ring 900 includes a base 101, an abrasive segment 104, an outer annular surface 105, an inner annular surface 103, an inner annular ring surface 113, an inner exposed portion 111, and an inner annular surface portion 110. As generally illustrated, the inner annular surface portion 110 can define an exit vector 901. In accordance with an embodiment, the exit vector 901 can define the

trajectory of the swarf ejected from the inner annular surface portion 110 during a grinding operation. In a particular embodiment, the exit vector 901 is defined by a line drawn tangent to the curvature of the inner annular surface portion 110 at the inner edge 116.

In accordance with an embodiment, the exit vector 901 can have a non-intersecting arrangement with respect to the abrasive segment 104. In still another embodiment, the exit vector 901 can have a non-intersecting arrangement with respect to the abrasive segment 104 such that the exit vector 901 does not intersect any portion of the abrasive segment 104. In yet another embodiment, the exit vector 901 can have a non-intersecting arrangement with respect to the abrasive segment 104 such that the exit vector 901 does not intersect any portion of the inner major surface 310 of the abrasive segment 104.

As further illustrated, the inner major surface 310 of the abrasive segment 104 can define an abrasive vector 902. In accordance with an embodiment, the abrasive vector 902 can be perpendicular to the top surface 304 of the abrasive segment 104 when viewed in cross-section. In accordance with a further embodiment, the exit vector 901 and abrasive vector 902 can intersect at an intersection point 903. In still another embodiment, the intersection point 903 can be spaced apart from the abrasive segment 104.

FIG. 10 includes a close-up plan view of a portion of the abrasive article taken at Circle 3 of FIG. 9 and illustrating the intersection point 903. In one aspect, the intersection point 903 defined by the intersection of the exit vector 901 and abrasive vector 902 can be spaced apart from the abrasive segment 104 by a distance, d. In a certain aspect, the intersection point 903 can be spaced apart from the abrasive segment 104 by a distance, d, of at least 1 mm, such as at least 2 mm, at least 3 mm, at least 4 mm, at least 5 mm, at least 6 mm, at least 7 mm, at least 8 mm, at least 9 mm, or at least 10 mm. The distance, d, can be not greater than about 25 mm, not greater than 24 mm, not greater than 23 mm, not greater than 22 mm, not greater than 21 mm, not greater than 20 mm, not greater than 19 mm, not greater than 18 mm, not greater than 17 mm, not greater than 16 mm, or not greater than 15 mm. The distance, d, can be within a range between and including any of the minimum and maximum overall length values noted above.

In accordance with an embodiment, the intersection point 903 can be spaced apart from the abrasive segment 104 by a distance, d, relative to the height, H, of the abrasive segment 104. In an embodiment, the distance, d, can be less than the height, H, of the abrasive segment 104. In other embodiments, the distance, d, can be not greater than 90% of the height, H, of the abrasive segment 104, such as not greater than 80% of the height, or not greater than 70%, not greater than 60%, not greater than 50%, or even not greater than 40%. Still the distance, d, can be at least 10%, at least 20%, or even at least 30% of the height, H, of the abrasive segment 104. It will be appreciated that the distance, d, can be within a range between any of the minimum and maximum percentages noted above.

In accordance with an embodiment, the receiving surface 107 of the base 101 can include an inner exposed portion 111 having an exposed length, L2, defining a distance between the inner annular surface portion 110 and the abrasive segment 104 along the receiving surface 107. In a certain aspect, the inner exposed portion 111 can have an exposed length, L2, of at least 4 mm, at least 5 mm, at least 6 mm, at least 7 mm, at least 8 mm, at least 9 mm, or at least 10 mm. The exposed length, L2, can be not greater than about 25 mm, not greater than 24 mm, not greater than 23 mm, not greater than 22 mm, not greater than 21 mm, or not greater than 20 mm. The exposed length, L2, can be within a range between and including any of the minimum and maximum overall length values noted above.

In accordance with an embodiment, the inner exposed portion 111 can have an exposed length, L2, relative to the width, W_R, of the receiving surface 107 as viewed in cross-section. In an embodiment, exposed length, L2, can be not greater than 50% of the width, W_R, of the receiving surface 107, such as not greater than 40% of the height, or not greater than 30%, not greater than 20%, not greater than 10%, or even not greater than 5%. Still the distance, d, can be at least 1%, at least 5%, at least 10%, at least 15%, or even at least 20% of the width, W_R, of the receiving surface 107. It will be appreciated that the exposed length, L2, can be within a range between any of the minimum and maximum percentages noted above.

In accordance with an embodiment, the exit vector 901 and the exposed portion 111 can define an exit angle 112. The exit angle 112 can be such that the swarf accumulated during a grinding operation is directed away from the inner major surface 310 of the abrasive segments 104. In a particular embodiment, the exit angle

112 can be defined by the exit vector 901 and the exposed portion 111 as illustrated in FIG. 9. In a certain aspect, the exit angle can be at least 45 degrees, such as at least 47 degrees, such as at least 50 degrees, at least 53 degrees, at least 55 degrees, at least 58 degrees, at least 60 degrees, at least 63 degrees, at least 70 degrees, at least 73 degrees, at least 75 degrees, at least 78 degrees, at least 80 degrees, at least 83 degrees, at least 85 degrees, at least 88 degrees, or at least 90 degrees. The exit angle can be not greater than 90 degrees, such as not greater than 85 degrees, not greater than 80 degrees, not greater than 75 degrees, or even not greater than 70 degrees. The exit angle can be within a range between and including any of the minimum and maximum overall values noted above.

FIG. 11 includes a perspective view of a portion of an abrasive article 200 having abrasive segments 104 in accordance with an embodiment, and FIG. 12 includes a cross-sectional view of an abrasive article 200 of FIG. 11 as corresponding to a view taken at Line 10-10 of abrasive article 200 of FIG. 2. As generally illustrated, the base 101 can have an axial flange 712 at the outer annular surface 105 of the base 101. As further illustrated, the axial flange 712 can be a portion of an abrasive assembly 914 configured to be releasably coupled to the base 101. In accordance with an embodiment, the abrasive assembly 914 can have a receiving surface 907 for receiving an abrasive segment 104 and a rear surface 909 opposite the receiving surface 907, both of which can extend generally perpendicular to the rotation axis 108. The abrasive assembly 914 can have an outer annular surface 905 extending generally axially between the receiving surface 907 and rear surface 909, and an inner annular surface 903 opposite the outer annular surface 905. The outer annular surface 905 can also extend circumferentially around the body of the abrasive assembly and can define an outer peripheral surface of the abrasive article 200 (e.g., grinding ring). This configuration allows for the abrasive assembly 914 to be releasably coupled to the base 101. In accordance with an embodiment, the abrasive assembly 914 can be releasably coupled to the base 101 such that the abrasive assembly 914 can be easily replaced during a grinding operation.

As further illustrated, the abrasive segment 104 can be mounted on the receiving surface 907 of the abrasive assembly 914. In a particular embodiment, the abrasive segment 104 can be mounted on the receiving surface 907 of the abrasive assembly 914 in direct contact with the axial flange 712. The outer major surface 308

of the abrasive segment 104 can be adjacent to the outer annular surface 105 of the base 101. In a particular embodiment, the outer major surface 308 can be adjacent to the outer annular surface 105 of the abrasive assembly 914.

In still other embodiments, the abrasive article 200 can be part of a grinding system 1300. FIG. 13 illustrates a grinding system 1300. The grinding system 1300 can include a first grinder 1002 and a second grinder 1004 opposite the first grinder 1002. In general, each grinder 1002, 1004 can include a motor 1010, and a shaft 1012 can extend from the motor 1010. Further, a grinding ring 1014 can be mounted on each shaft 1012. The grinding ring 1014 can include a grinding ring according to one or more embodiments described herein. As depicted in FIG. 13, the grinding rings 1014 are spaced apart from each other so that a working space 1016 is established therebetween. A conveyor system 1018 can be disposed within the working space 1016.

During operation, the motors 1010 can be energized to rotate the shafts 1012, and the grinding rings 1014 connected thereto. One or more bricks 1020 can be placed on the conveyor system 1018 and moved into and through the working space 1016 between the grinding rings 1014 so that two faces of the brick 1020 contact the grinding rings 1014.

In a particular embodiment, the grinding system 1300 is placed inside a cabin 1350, encapsulating the grinding system 1300. The cabin 1350 prevents dust particles from escaping the grinding system 1300 and contaminating the outside environment 1360. In a particular embodiment, an air pipe 1370 is connected to the motor 1010. The air pipe 1370 supplies clean air from the outside environment 1360 into the motor 1010. The air pipe 1370 can comprise any material, including metallic and non-metallic materials. In a particular embodiment, the air pipe includes a non-metallic material. The non-metallic material can comprise a thermoplastic material, thermosetting material, concrete material, vitrified clay material, glass material, or any combination thereof. In still another embodiment, the air pipe 1370 includes a metallic material. The metallic material can comprise cast iron, carbon steel, alloy steel, stainless steel, Inconel, or any combination thereof.

FIG. 14 illustrates a perspective view of a grinding system 1300 comprising a motor 1010 and an air pipe 1370 connected to the motor 1010. The air pipe 1370 is connected to the outside environment 1360 and allows for clean air outside of the

cabin 1350 (not shown) to be pumped into the motor 1010. Applicants have found supplying clean air from outside the cabin prevents abrasion of the grinding system components, including the motor, shaft, and grinders.

EMBODIMENTS

Embodiment 1. An abrasive article, comprising: a base having an annular shape including an inner annular surface defining a central opening; an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface; and wherein the inner annular surface of the base comprises an inner annular surface portion defining an exit vector having a non-intersecting arrangement with respect to the plurality of abrasive segments.

Embodiment 2. The abrasive article of embodiment 1, wherein an inner major surface of the abrasive segments defines an abrasive vector and wherein the exit vector and abrasive vector intersect at an intersection point.

Embodiment 3. The abrasive article of embodiment 2, wherein the intersection point is spaced apart from the abrasive segments by a distance, d.

Embodiment 4. The abrasive article of embodiment 3, wherein the distance, d, is at least 6 mm.

Embodiment 5. The abrasive article of embodiment 3, wherein the distance, d, is not greater than 20 mm.

Embodiment 6. The abrasive article of embodiment 3, wherein the distance, d, is within a range of at least 6 mm and not greater than 20 mm.

Embodiment 7. The abrasive article of embodiment 1, wherein the base includes an inner exposed portion having a length, L2.

Embodiment 8. The abrasive article of embodiment 7, wherein the length, L2, is at least 1 mm.

Embodiment 9. The abrasive article of embodiment 7, wherein the length, L2, is not greater than 20 mm.

Embodiment 10. The abrasive article of embodiment 7, wherein the length, L2, is at least 1 mm and not greater than 20 mm.

Embodiment 11. The abrasive article of embodiment 1, wherein the inner annular surface portion comprises a curved shape.

Embodiment 12. The abrasive article of embodiment 1, wherein the inner annular surface portion comprises a linear shape.

Embodiment 13. The abrasive article of embodiment 1, wherein the inner annular surface portion comprises a first annular surface and a second annular surface.

Embodiment 14. The abrasive article of embodiment 13, wherein the first annular surface and the second annular surface abut at an edge defining a surface angle.

Embodiment 15. The abrasive article of embodiment 14, wherein the surface angle is at least about 90 degrees and not greater than about 180 degrees.

Embodiment 16. An abrasive article, comprising: a base having an annular shape including an inner annular surface defining a central opening; an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface; wherein the inner annular surface of the base comprises an inner annular surface portion defining an exit vector; wherein each of the abrasive segments includes an inner major surface defining an abrasive vector; and wherein the intersection point of the exit vector and the abrasive vector is spaced apart from the abrasive segments.

Embodiment 17. The abrasive article of embodiment 16, wherein the intersection point is spaced apart from the abrasive segments by a distance, d.

Embodiment 18. The abrasive article of embodiment 17, wherein the distance, d, is at least 6 mm.

Embodiment 19. The abrasive article of embodiment 17, wherein the distance, d, is not greater than 20 mm.

Embodiment 20. The abrasive article of embodiment 17, wherein the distance, d, is within a range of at least 6 mm and not greater than 20 mm.

Embodiment 21. The abrasive article of embodiment 16, wherein the base includes an inner exposed portion having a length, L2.

Embodiment 22. The abrasive article of embodiment 21, wherein the length, L2, is at least 1 mm.

Embodiment 23. The abrasive article of embodiment 21, wherein the length, L2, is not greater than 20 mm.

Embodiment 24. The abrasive article of embodiment 21, wherein the length, L2, is at least 1 mm and not greater than 20 mm.

Embodiment 25. An abrasive article, comprising: a base having an annular shape including an inner annular surface defining a central opening; an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface; wherein the inner annular surface of the base comprises an inner annular surface portion configured to direct swarf away from the inner major surface of the plurality of abrasive segments.

Embodiment 26. The abrasive article of embodiment 25, wherein the inner annular surface portion defines an exit vector having a non-intersecting arrangement with respect to the plurality of abrasive segments.

Embodiment 27. The abrasive article of embodiment 26, wherein an inner major surface of the abrasive segments defines an abrasive vector and wherein the exit vector and abrasive vector intersect at an intersection point.

Embodiment 28. The abrasive article of embodiment 27, wherein the intersection point is spaced apart from the abrasive segments by a distance, d.

Embodiment 29. The abrasive article of embodiment 28, wherein the distance, d, is at least 6 mm.

Embodiment 30. The abrasive article of embodiment 28, wherein the distance, d, is not greater than 20 mm.

Embodiment 31. The abrasive article of embodiment 28, wherein the distance, d, is within a range of at least 6 mm and not greater than 20 mm.

Embodiment 32. The abrasive article of embodiment 25, wherein the base includes an inner exposed portion having a length, L2.

Embodiment 33. The abrasive article of embodiment 32, wherein the length, L2, is at least 1 mm.

Embodiment 34. The abrasive article of embodiment 32, wherein the length, L2, is not greater than 20 mm.

Embodiment 35. The abrasive article of embodiment 32, wherein the length, L2, is at least 1 mm and not greater than 20 mm.

Embodiment 36. The abrasive article of embodiment 25, wherein the inner annular surface portion comprises a curved shape.

Embodiment 37. The abrasive article of embodiment 25, wherein the inner annular surface portion comprises a linear shape.

Embodiment 38. The abrasive article of embodiment 25, wherein the inner annular surface portion comprises a first annular surface and a second annular surface.

Embodiment 39. The abrasive article of embodiment 38, wherein the first annular surface and the second annular surface abut at an edge defining a surface angle.

Embodiment 40. The abrasive article of embodiment 39, wherein the surface angle is at least about 90 degrees and not greater than about 180 degrees.

Embodiment 41. An abrasive article, comprising: a base having an annular shape including an inner annular surface defining a central opening; an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface; wherein the inner annular surface of the base comprises an exit angle having a value of no greater than about 90 degrees.

Embodiment 42. The abrasive article of embodiment 41, wherein the exit angle is at least about 45 degrees.

Embodiment 43. The abrasive article of embodiment 41, wherein the exit angle is not greater than about 80 degrees.

Embodiment 44. The abrasive article of embodiment 41, wherein the exit angle is at least about 45 degrees and not greater than about 90 degrees.

Embodiment 45. The abrasive article of embodiment 41, wherein the exit angle is at least about 50 degrees and not greater than about 80 degrees.

Embodiment 46. The abrasive article of embodiment 41, wherein the inner annular surface portion defines an exit vector having a non-intersecting arrangement with respect to the plurality of abrasive segments.

Embodiment 47. The abrasive article of embodiment 46, wherein the exit vector and an inner exposed portion define the exit angle.

Embodiment 48. The abrasive article of embodiment 46, wherein an inner major surface of the abrasive segments defines an abrasive vector and wherein the exit vector and abrasive vector intersect at an intersection point.

Embodiment 49. The abrasive article of embodiment 48, wherein the intersection point is spaced apart from the abrasive segments by a distance, d.

Embodiment 50. The abrasive article of embodiment 49, wherein the distance, d, is at least 6 mm.

Embodiment 51. The abrasive article of embodiment 49, wherein the distance, d, is not greater than 20 mm.

Embodiment 52. The abrasive article of embodiment 49, wherein the distance, d, is within a range of at least 6 mm and not greater than 20 mm.

Embodiment 53. The abrasive article of embodiment 41, wherein the base includes an inner exposed portion having a length, L2.

Embodiment 54. The abrasive article of embodiment 53, wherein the length, L2, is at least 1 mm.

Embodiment 55. The abrasive article of embodiment 53, wherein the length, L2, is not greater than 20 mm.

Embodiment 56. The abrasive article of embodiment 53, wherein the length, L2, is at least 1 mm and not greater than 20 mm.

EXAMPLE

A sample grinding wheel SN1 was formed to include an inner annular surface portion defining an exit vector having a non-intersecting arrangement with respect to the plurality of abrasive segments according to an embodiment described herein, and as shown in FIG. 17. A comparative sample grinding wheel CS1 was formed identical to sample SN1 but instead including abrasive segments without an inner annular surface portion defining an exit vector having a non-intersecting arrangement with respect to the plurality of abrasive segments. A grinding operation was performed using sample CS1. The resulting brick of the grinding operation using sample CS1 is shown in FIGs. 15 and 16. As illustrated, sample CS1 demonstrated increased wear inside the ring on the inner major surface of the abrasive segments. The abrasive wear reduces the active segment surface putting extensive force on the workpiece which can lead to reduced grinding performance.

As used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having,” or any other variation thereof are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of features is not necessarily limited only to those features but may include other features not expressly listed or other features that are inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, “or”

refers to an inclusive-or and not to an exclusive-or. For example, a condition A or B is satisfied by any one of the following: A is true (or present), and B is false (or not present), A is false (or not present), and B is true (or present), and both A and B are true (or present).

The use of "a" or "an" is employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the embodiments of the disclosure. This description should be read to include one or at least one, and the singular also includes the plural, or vice versa, unless it is clear that it is meant otherwise.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. The materials, methods, and examples are illustrative only and not intended to be limiting. To the extent not described herein, many details regarding specific materials and processing acts are conventional and may be found in textbooks and other sources within the scintillation and radiation detection arts.

An abrasive article as described herein can be used to perform a grinding operation while experiencing less wear on the abrasive segments than a comparative abrasive article not having an inner annular surface portion as described herein. Further, an abrasive article as described herein can be used to perform a grinding operation while providing a more desirable finish to a workpiece and reducing wear on the workpiece (e.g., cracks, fractures, etc.) as compared to a comparative abrasive article not having an inner annular surface portion as described herein. The inner annular surface portion according to the embodiments herein provide increased longevity and effectiveness by reducing wear that can manifest during a grinding operation on the body of the abrasive segment. As such, the need for replacing or repairing abrasive articles can be substantially reduced, and the process time for grinding bricks to an acceptable surface finish and dimensional tolerance can be substantially reduced.

Note that not all of the activities described above in the general description or the examples are required, that a portion of a specific activity may not be required, and that one or more further activities may be performed in addition to those described. Still further, the order in which activities are listed is not necessarily the order in which they are performed.

Certain features that are, for clarity, described herein in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination. Further, reference to values stated in ranges includes each and every value within that range.

Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems and any feature(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims.

The specification and illustrations of the embodiments described herein are intended to provide a general understanding of the structure of the various embodiments. The specification and illustrations are not intended to serve as an exhaustive and comprehensive description of all of the elements and features of apparatus and systems that use the structures or methods described herein. Separate embodiments may also be provided in combination in a single embodiment, and conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination. Further, reference to values stated in ranges includes each and every value within that range. Many other embodiments may be apparent to skilled artisans only after reading this specification. Other embodiments may be used and derived from the disclosure, such that a structural substitution, logical substitution, or another change may be made without departing from the scope of the disclosure. Accordingly, the disclosure is to be regarded as illustrative rather than restrictive

WHAT IS CLAIMED IS:

1. An abrasive article, comprising:

a base having an annular shape including an inner annular surface defining a central opening;

an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface; and

wherein the inner annular surface of the base comprises an inner annular surface portion defining an exit vector having a non-intersecting arrangement with respect to the plurality of abrasive segments.

2. The abrasive article of claim 1, wherein an inner major surface of the abrasive segments defines an abrasive vector and wherein the exit vector and abrasive vector intersect at an intersection point.

3. The abrasive article of claim 2, wherein the intersection point is spaced apart from the abrasive segments by a distance, d.

4. The abrasive article of claim 3, wherein the distance, d, is at least 6 mm.

5. The abrasive article of claim 3, wherein the distance, d, is not greater than 20 mm.

6. The abrasive article of claim 3, wherein the distance, d, is within a range of at least 6 mm and not greater than 20 mm.

7. The abrasive article of claim 1, wherein the base includes an inner exposed portion having a length, L2.

8. The abrasive article of claim 7, wherein the length, L2, is at least 1 mm.

9. The abrasive article of claim 7, wherein the length, L2, is not greater than 20 mm.

10. The abrasive article of claim 1, wherein the inner annular surface portion comprises a curved shape.

11. The abrasive article of claim 1, wherein the inner annular surface portion comprises a linear shape.

12. The abrasive article of claim 1, wherein the inner annular surface portion comprises a first annular surface and a second annular surface.

13. The abrasive article of claim 12, wherein the first annular surface and the second annular surface abut at an edge defining a surface angle, wherein the surface angle is at least about 90 degrees and not greater than about 180 degrees.

14. An abrasive article, comprising:

a base having an annular shape including an inner annular surface defining a central opening;

an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface;

wherein the inner annular surface of the base comprises an inner annular surface portion configured to direct swarf away from the inner major surface of the plurality of abrasive segments.

15. An abrasive article, comprising:

a base having an annular shape including an inner annular surface defining a central opening;

an abrasive assembly configured to be releasably coupled to the base, wherein the abrasive assembly comprises a receiving surface including a plurality of abrasive segments coupled to the receiving surface;

wherein the inner annular surface of the base comprises an exit angle having a value of not greater than about 90 degrees.

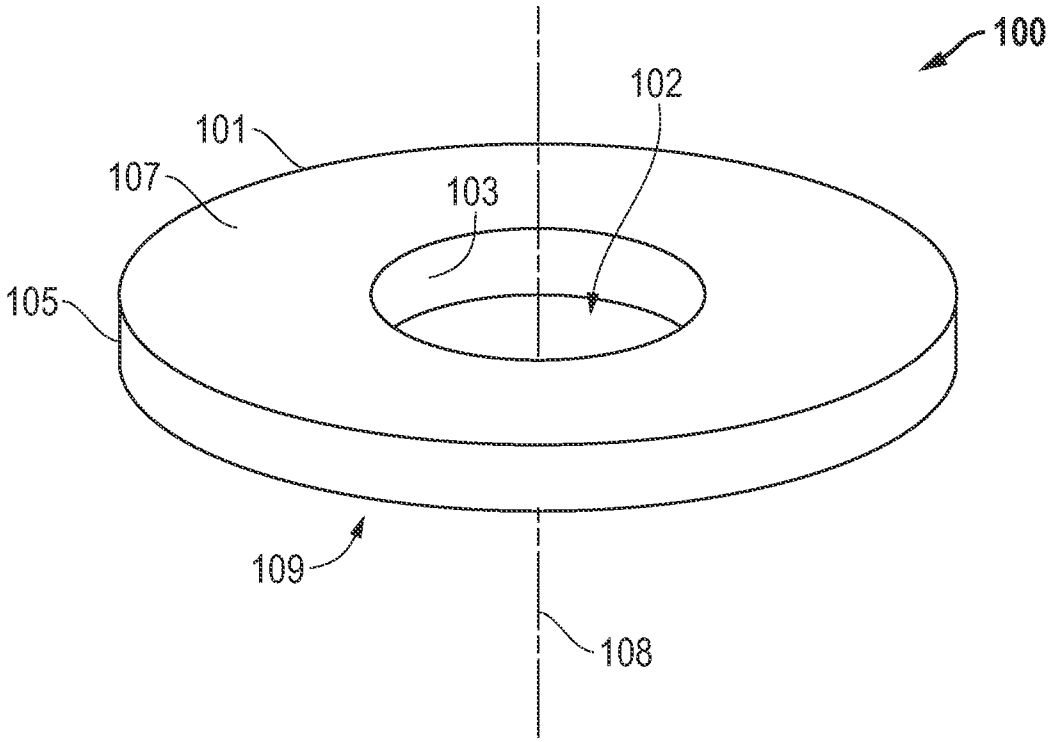

FIG. 1A

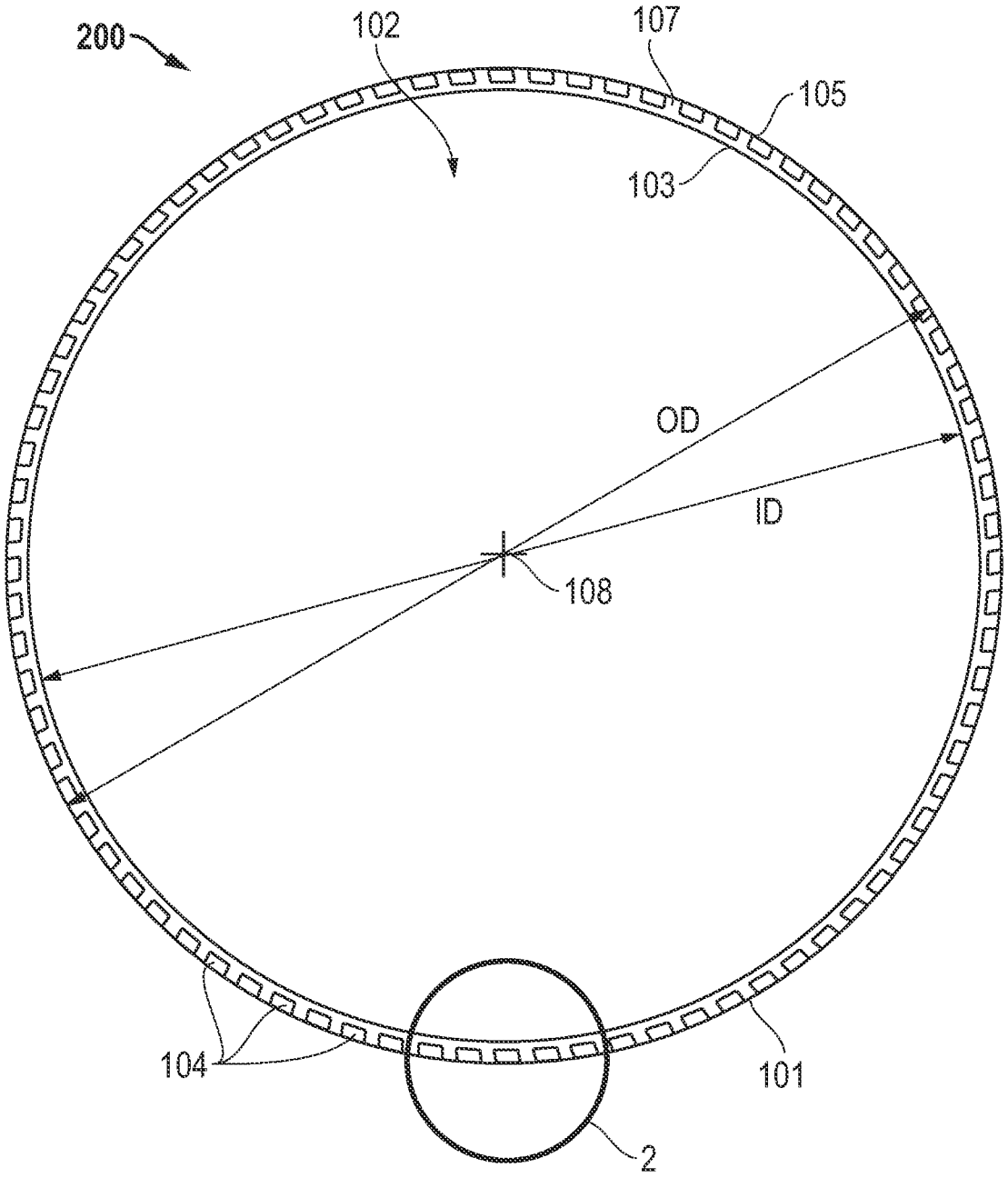

FIG. 1B

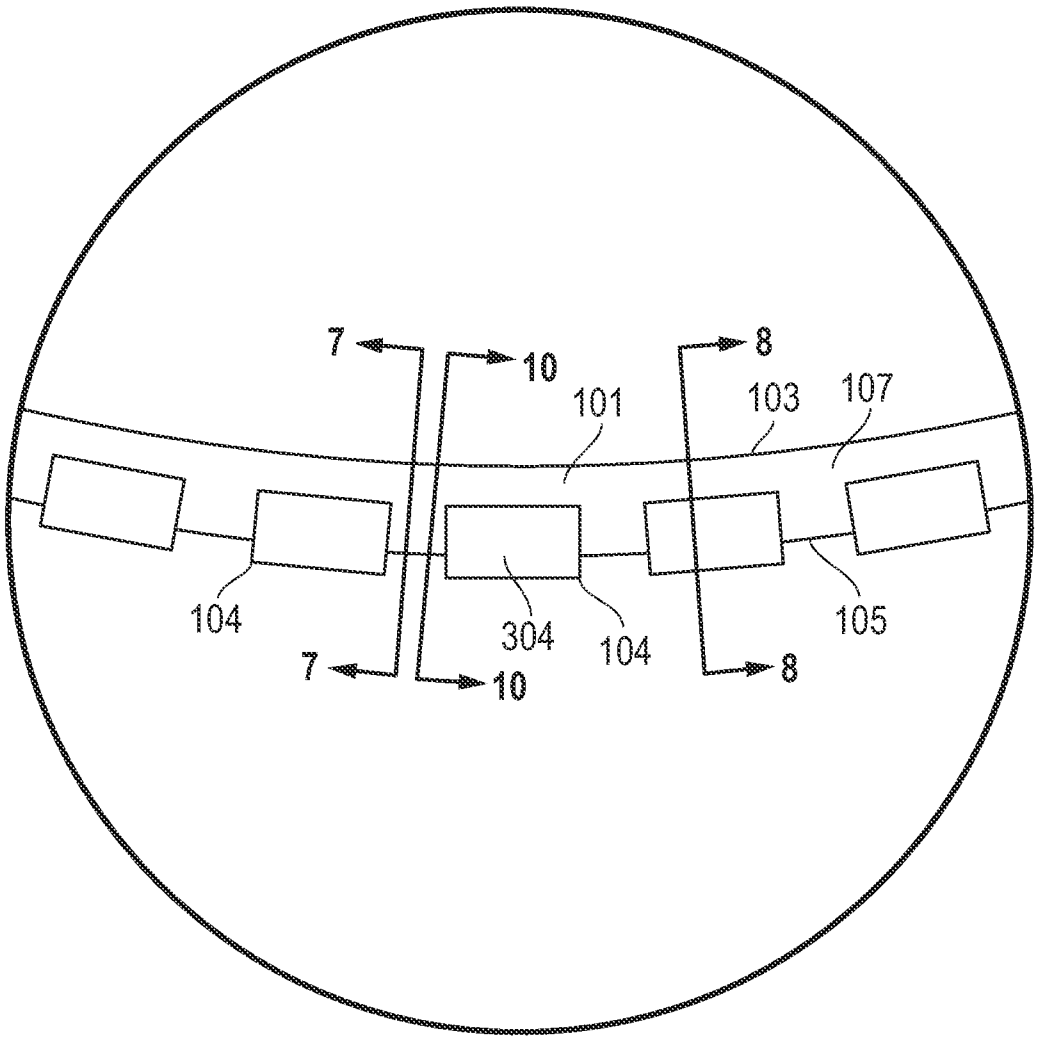

FIG. 2

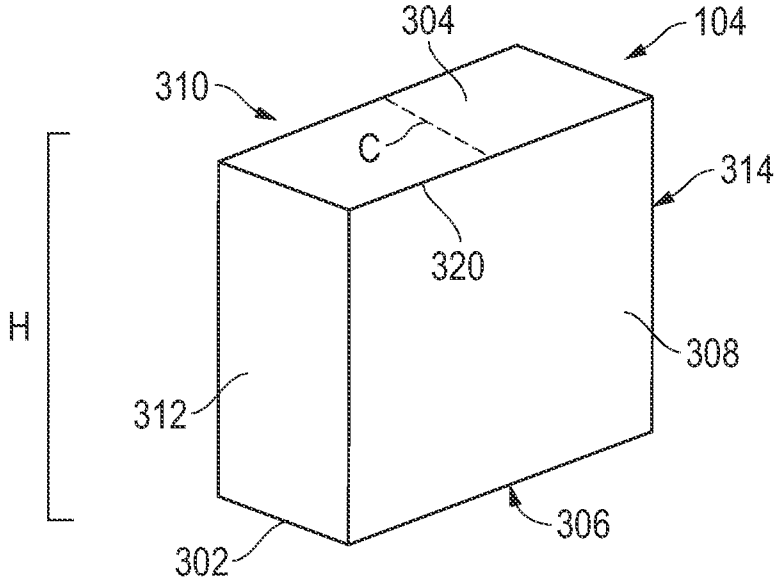

FIG. 3

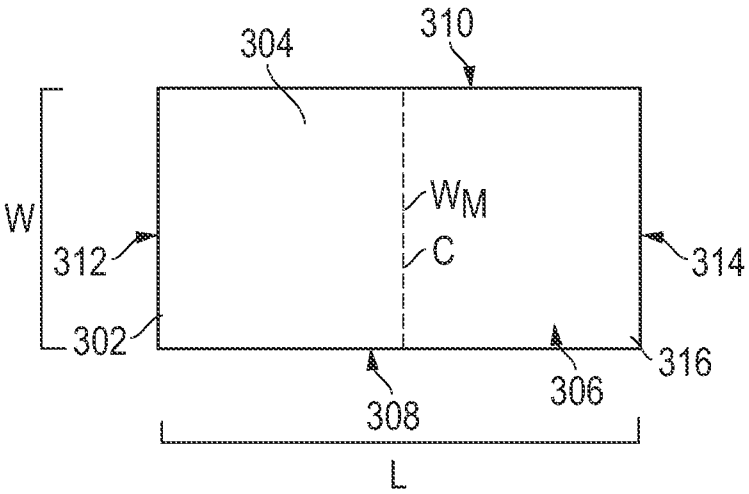

FIG. 4

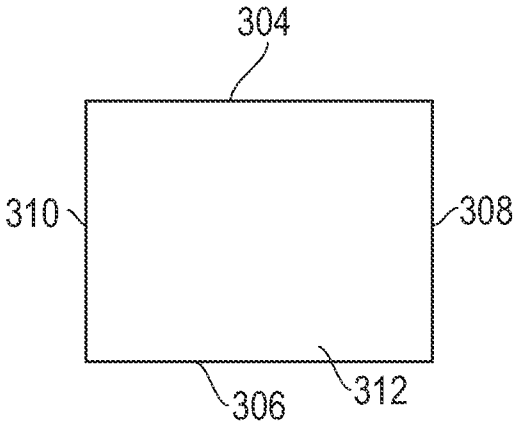

FIG. 5

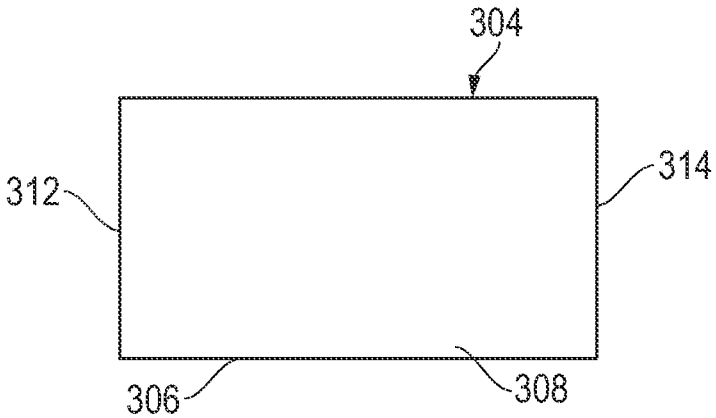

FIG. 6

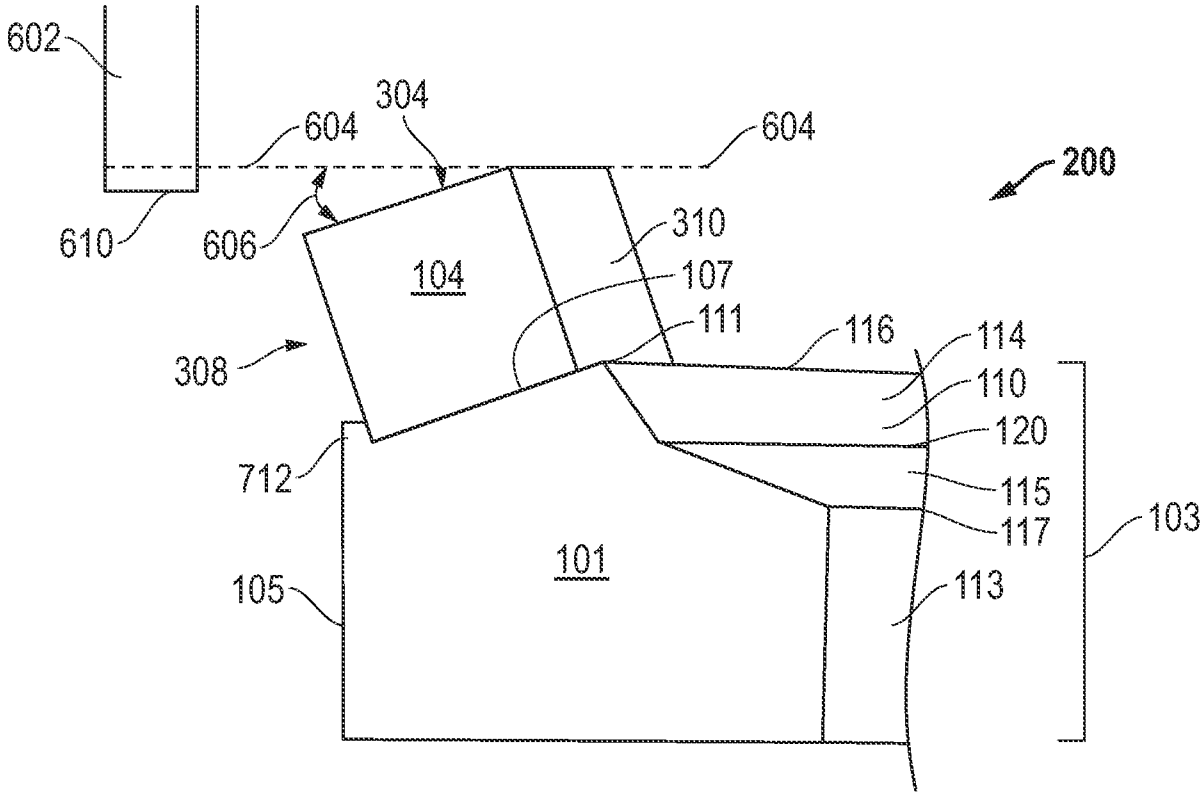
602
304
604
604
200
610
606
104
310
107
111
116
114
308
110
120
712
115
117
103
101
105
113

FIG. 7

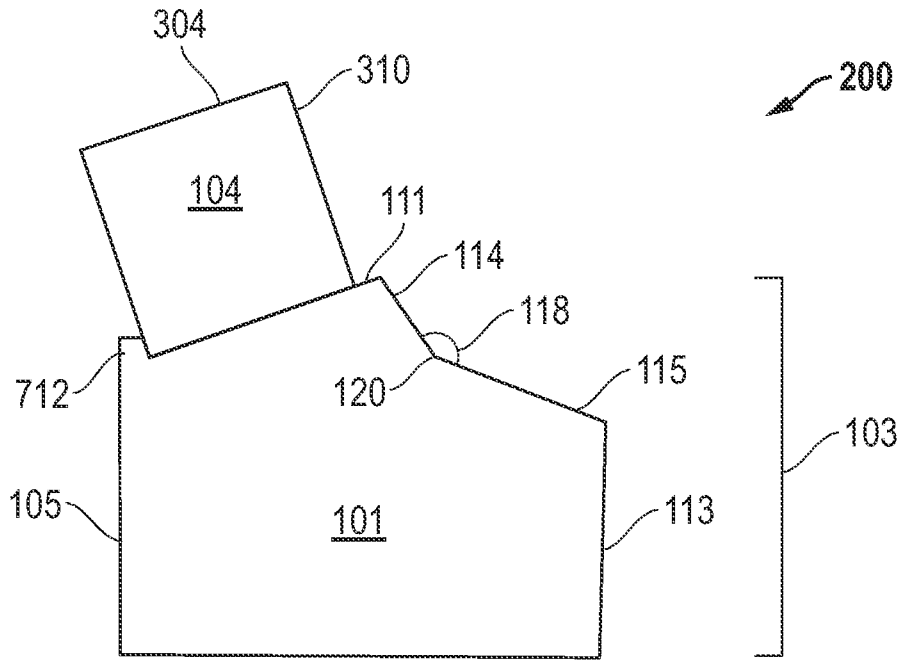
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FIG. 7A

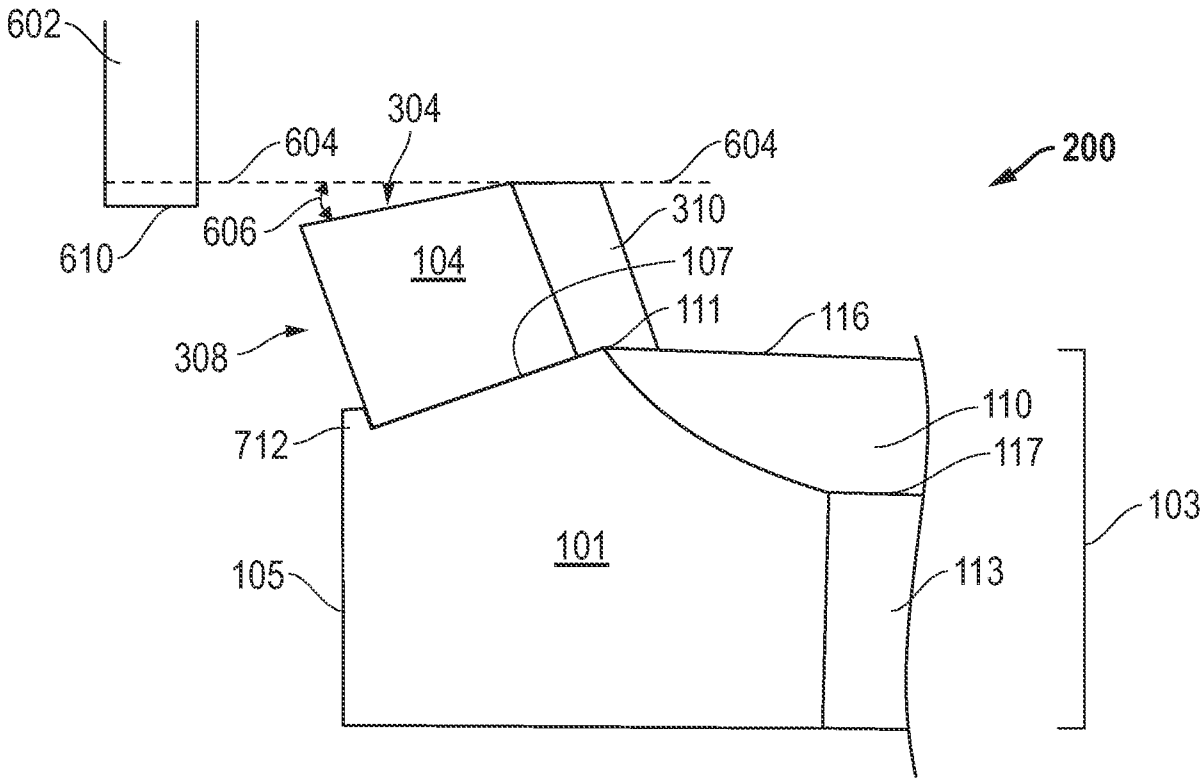
602
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FIG. 8

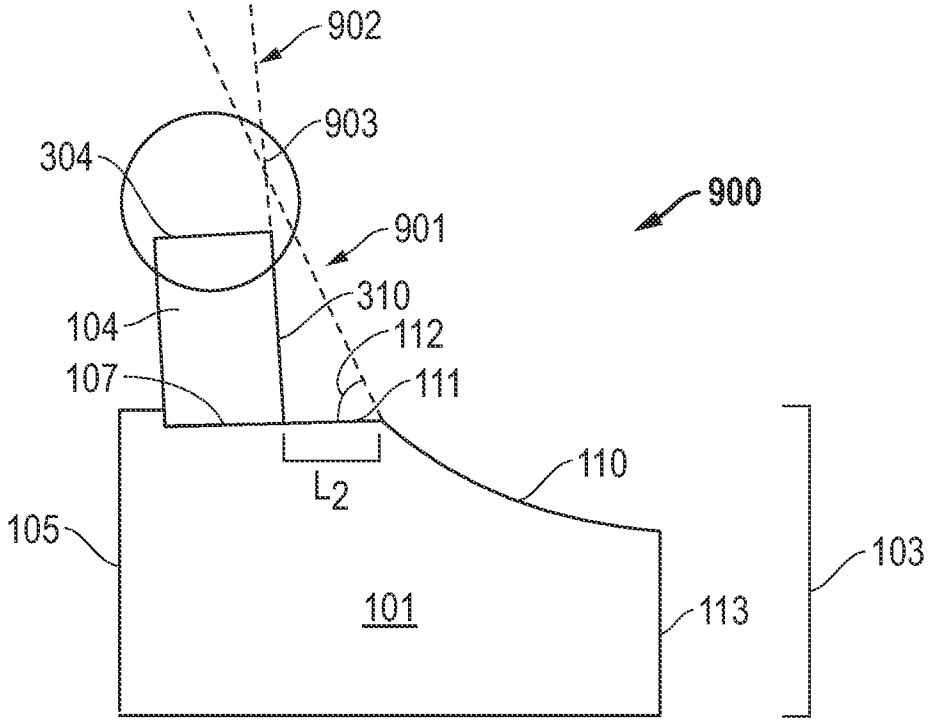

902
903
304
900
901
310
104
112
107
111
110
L_2
105
103
101
113

FIG. 9

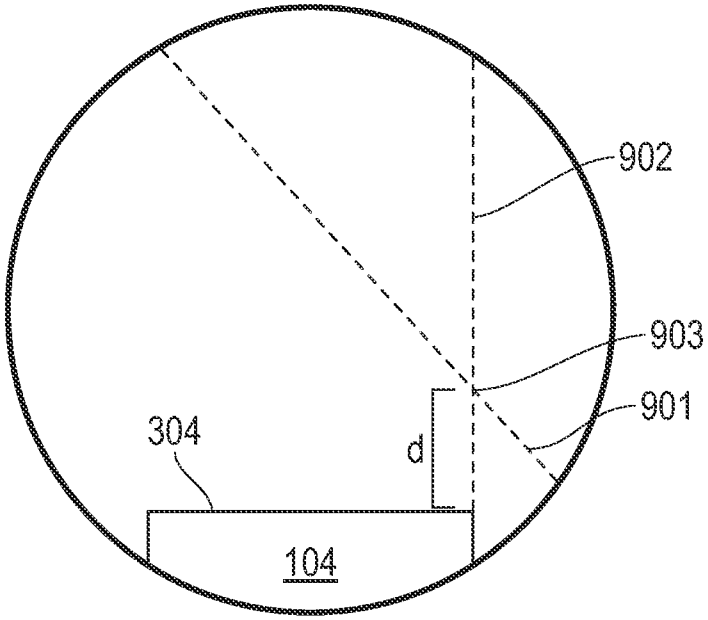
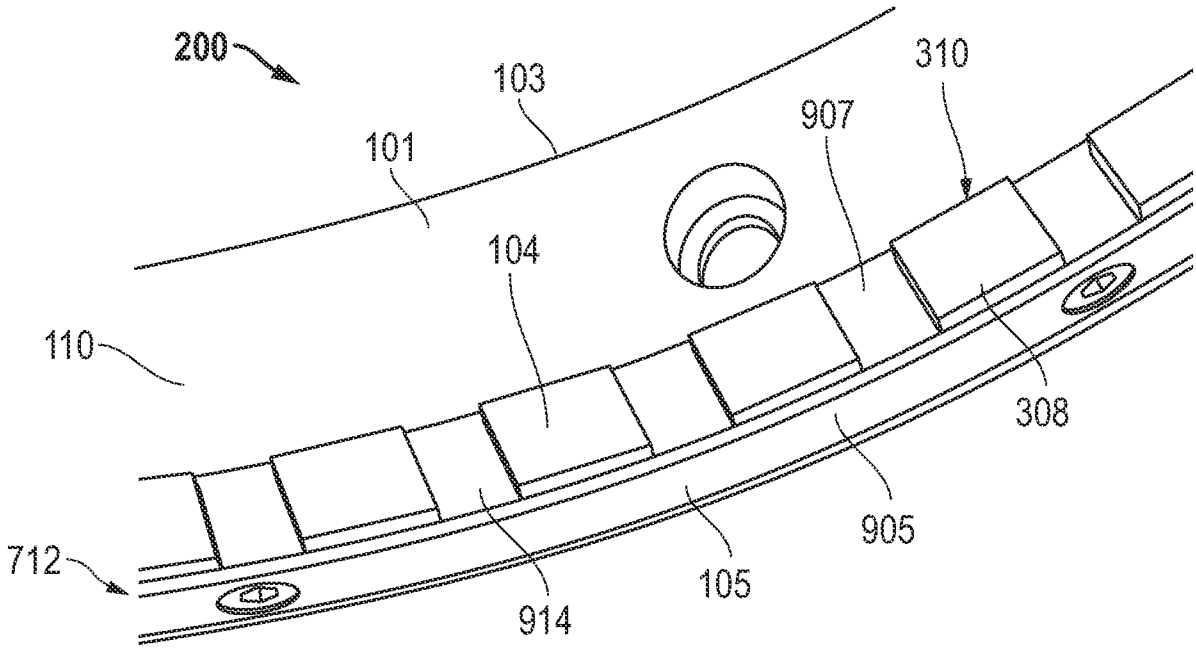


FIG. 10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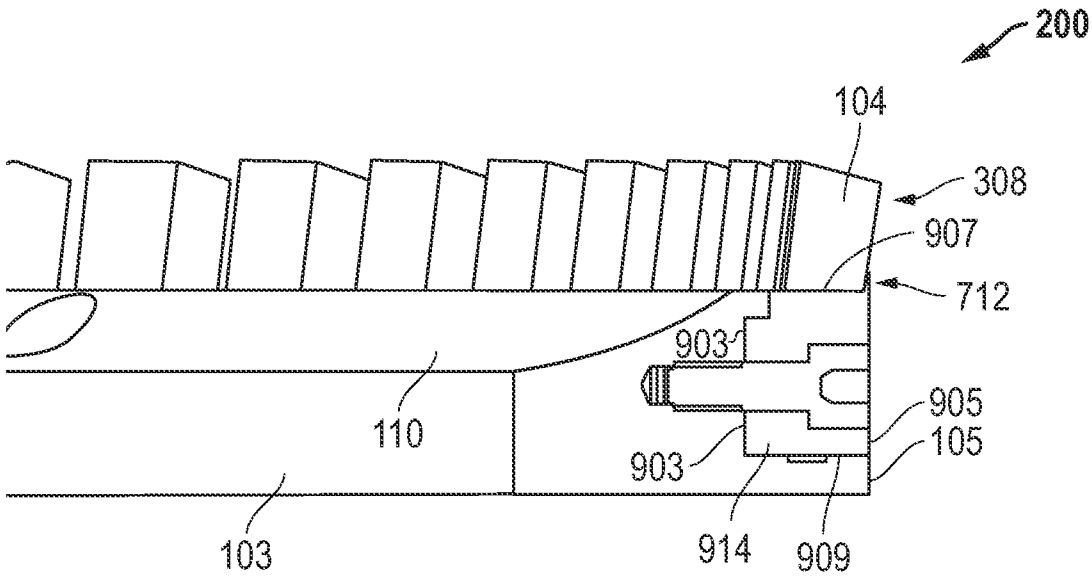
101
310
907
104
110
308
905
712
105
914

FIG. 11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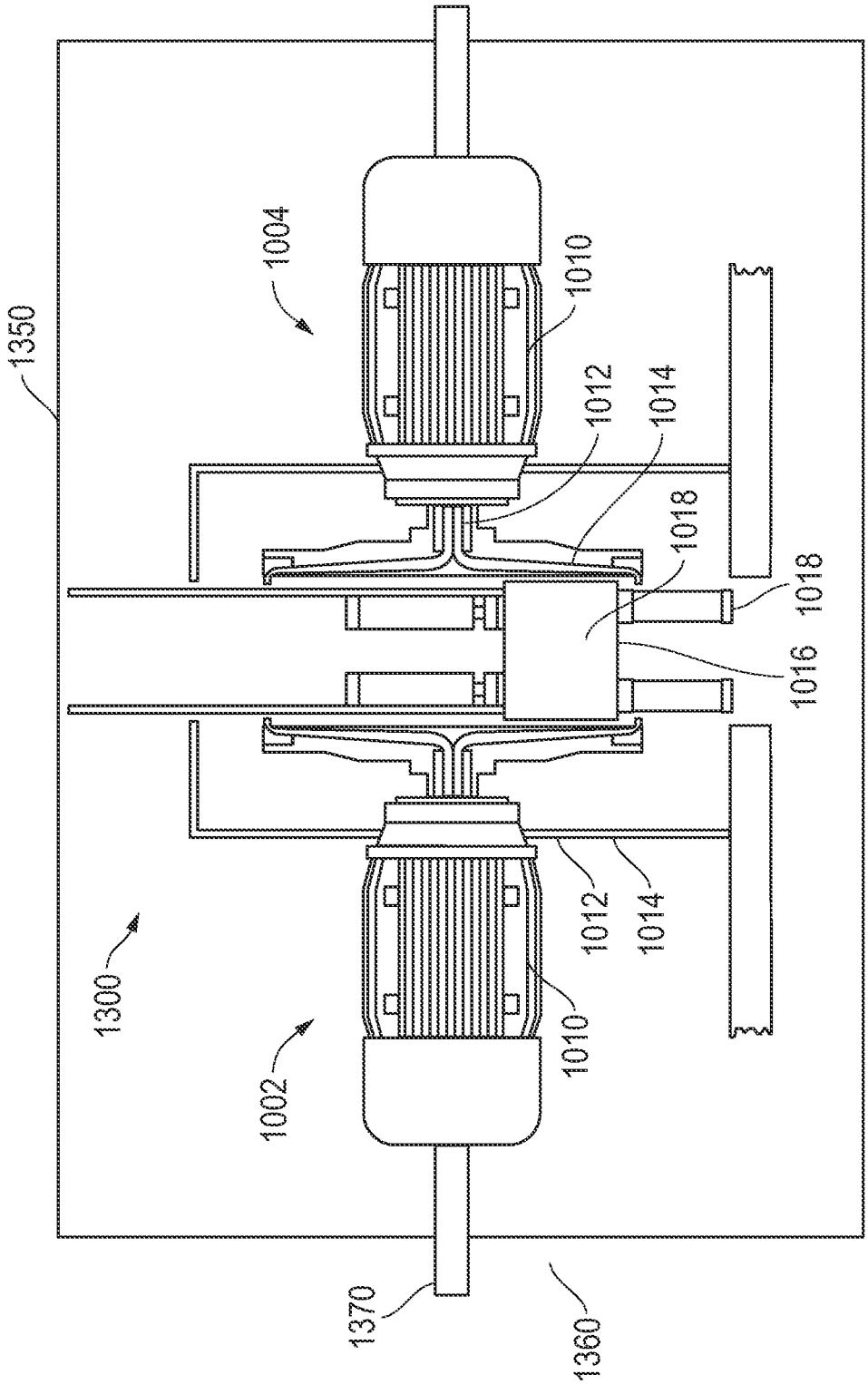
308
907
712
903
110
905
105
903
103
914
909

FIG. 12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1018
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1010
1002
1370
1360

FIG. 13

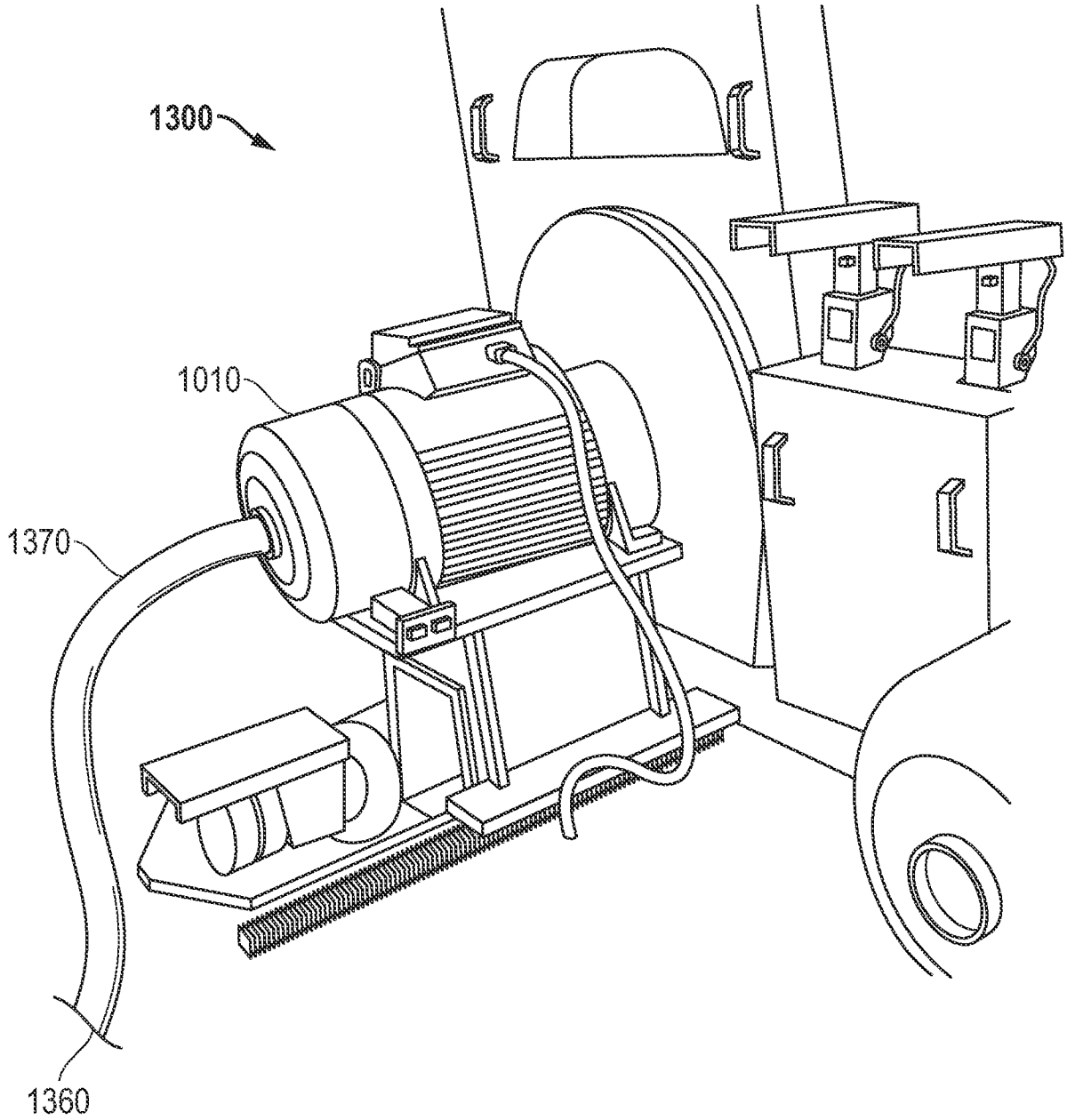

FIG. 14

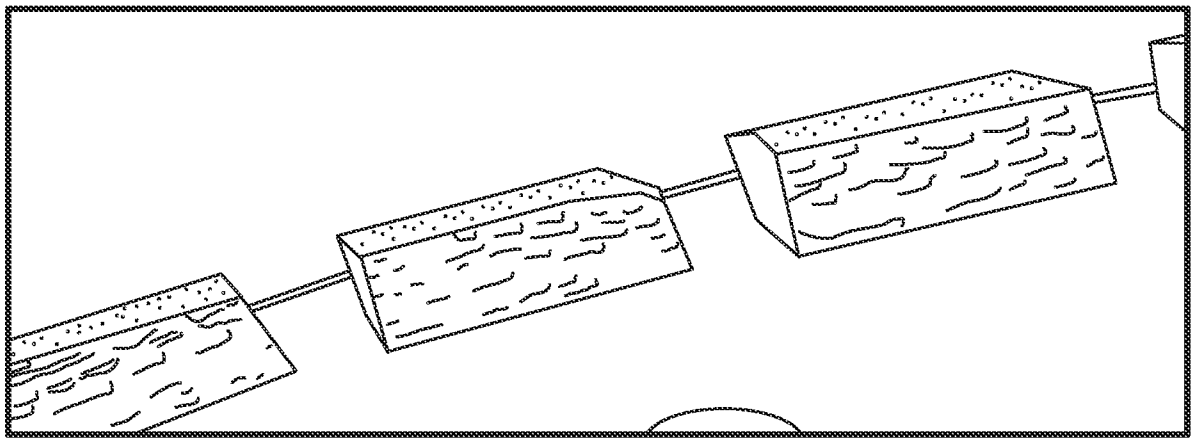

FIG. 15

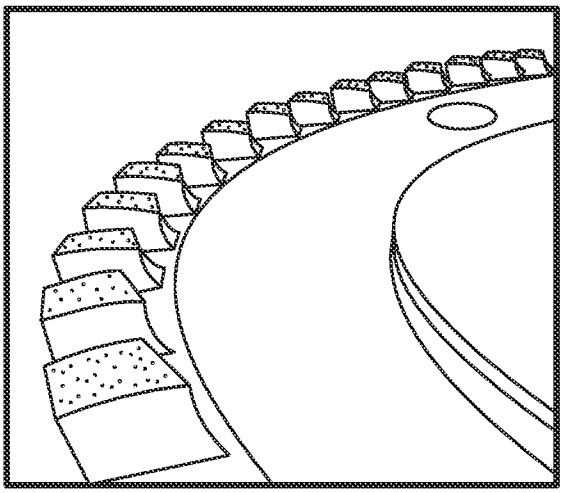

FIG. 16

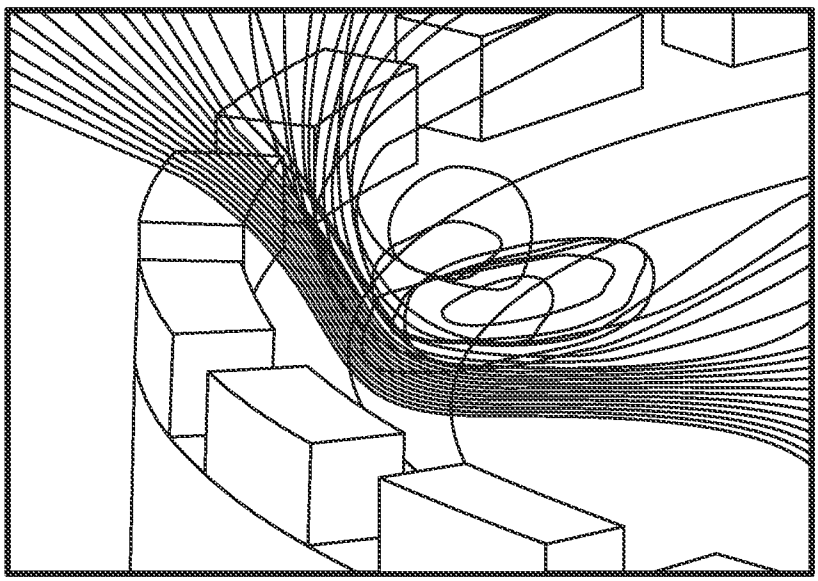

FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2021/039756

A. CLASSIFICATION OF SUBJECT MATTER

B24D 7/18(2006.01)i; **B24B 55/10**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B24D 7/18(2006.01); B23F 21/03(2006.01); B24B 7/24(2006.01); B24D 3/34(2006.01); B24D 7/06(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: abrasive, ring, inner, outer, segment, angle, swarf, remove, exit vectors

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014-0051340 A1 (GOSAMO et al.) 20 February 2014 (2014-02-20) paragraphs [0050], [0063]; and figures 1A-1B, 4A, 5	1-15
X	US 2003-0232586 A1 (RAMANATH et al.) 18 December 2003 (2003-12-18) paragraph [0039]; and figures 2A-2C	1-15
A	US 6093092 A (RAMANATH et al.) 25 July 2000 (2000-07-25) claims 1, 9; and figure 2	1-15
A	WO 99-42250 A1 (MINNESOTA MINING AND MANUFACTURING COMPANY) 26 August 1999 (1999-08-26) claims 1-4; and figure 1	1-15
A	US 2005-0048879 A1 (SKEEM et al.) 03 March 2005 (2005-03-03) paragraph [0041]; and figure 3	1-15

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 October 2021	**18 October 2021**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office **189 Cheongsa-ro, Seo-gu, Daejeon** **35208, Republic of Korea**	**BAHNG, Seung Hoon**
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2021/039756

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Information on patent family members

International application No.
PCT/US2021/039756

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