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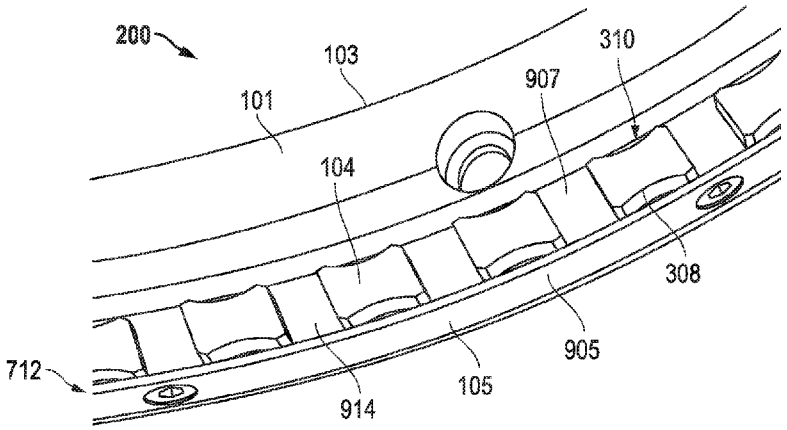

FIG. 9

(57) Abstract: An abrasive article including a base having an annular shape defining a central opening, and an abrasive segment coupled to the base, the abrasive segment having at least one side surface with a non-linear shape. In particular, the abrasive segment can have a first and a second side surface, each having a non-linear shape. More particularly, the abrasive segment can have a biconcave shape.

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GRINDING RING WITH CONCAVE ABRASIVE SEGMENTS

TECHNICAL FIELD

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

Certain construction materials, such as clay bricks, can be formed with substantial dimensional variations from brick-to-brick. Modern techniques for assembly 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. Such a grinding operation can introduce surface imperfections on the brick and can also cause wear on the grinding ring, particularly the abrasive segments of the grinding ring. Imperfections in the brick and wear on the abrasive segment can be manifested in the form of cracks or fractures. Improvements to abrasive segments of grinding rings are needed to reduce imperfections in construction materials having undergone a grinding operation and wear of abrasive segments performing the grinding operation.

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 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. 1.

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 third side surface portion.

FIG. 6 includes a side plane view of an abrasive segment in accordance with an embodiment illustrating a first side surface portion.

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

FIG. 9 includes a perspective view of a portion of an abrasive article having abrasive segments in accordance with an embodiment.

FIG. 10 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. 11 includes a plan view of a grinding ring in accordance with an embodiment.

FIG. 12 includes a cross-sectional view of an abrasive article in accordance with an embodiment that includes an abrasive segment in accordance with a an embodiment taken at Line 12-12 of FIG. 11.

FIG. 13 includes a cross-sectional view of an abrasive article in accordance with an embodiment that includes an abrasive segment in accordance with an embodiment taken at Line 12-12 of FIG. 11.

FIG. 14 includes a perspective view of a portion of an abrasive article in accordance with an embodiment having abrasive segments in accordance with an embodiment.

FIG. 15 includes a cross-sectional view of an abrasive article in accordance with an embodiment that includes an abrasive segment in accordance with an embodiment taken at Line 15-15 of FIG. 11.

FIG. 16 includes a cross-sectional view of a portion of a mounting assembly including an axial flange in accordance with an embodiment taken at Circle 16 of FIG. 15.

FIG. 17 includes a cross-sectional view of a portion of a mounting assembly including an axial flange in accordance with an embodiment taken at Circle 17 of FIG. 16.

FIG. 18 includes a photo of an abrasive article in accordance with an embodiment.

FIG. 19 includes a photo of the abrasive article of FIG. 18.

FIG. 20 includes a photo of a clay brick having been processed by a grinding operation using an abrasive article formed according to an embodiment herein.

FIG. 21 includes a photo of a clay brick having been processed by a grinding operation using a comparative abrasive article not formed according to an embodiment herein.

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 EMBODIMENTS

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 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 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 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 than 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 200 mm, such as at least 250 mm, at least 300 mm, 350 mm, at least 400 mm, 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 1600 mm, such as not greater than 1500 mm, not greater than 1400 mm, not greater than

1300 mm, not greater than 1200 mm, 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 200 and 1600 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 a mounting assembly, which in turn can be attached to 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 third side surface portion 312 of the abrasive segment 104; and FIG. 6 includes a side plane view illustrating a first side surface portion 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.

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, a first side surface portion 308 and a second side surface portion 310

opposite the first side surface portion 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 second side surface portion 310 faces the rotation axis 108 and the first side surface portion 308 faces away from the rotation axis 108. The first side surface portion 308 and the second side surface portion 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 third side surface portion 312 and a fourth side surface portion 314 opposite the third side surface portion 312. The third side surface portion 312 and the fourth side surface portion 314 can also each extend between the top surface 304 and the bottom surface 306. The body 302 of the abrasive segment 104 can also include bevel side surface portions 316 extending between top surface 304 and the bottom surface 306.

The body 302 of the abrasive segment 104 can also include bevel side surface portions 316 extending between the first side surface portion 308 and the third side surface portion 312, between the third side surface portion 312 and the second side surface portion 310, between the second side surface portion 310 and the fourth side surface portion 314, and between the fourth side surface portion 314 and the first side surface portion 308. In accordance with an embodiment, the first side surface portion 308, second side surface portion 310, third side surface portion 312 and fourth side surface portion 314, in combination with the bevel side surface portions 316 therebetween, 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 first side surface portion 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 first side surface portion 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, W_m, defined as the minimum distance between the first side surface portion 308 and the second surface portion 310. In a particular instance, the minimum width, W_m, can be located at center, C, of the length, L, of the body 302, equidistant between the third side surface portion 312 and fourth side surface portion 314, as illustrated in FIG. 3 and FIG. 4. In an embodiment, the minimum width, W_m, 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, W_m, 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, W_m, 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 15 mm, such as at least 16 mm, at least 17 mm, at least 18 mm, at least 19 mm, at least 20 mm, at least 21 mm, or at least 22 mm. The overall height, H, may be no greater than about 30 mm, no greater than about 29 mm, no greater than about 28 mm, no greater than about 27 mm, no greater than about 26 mm, no 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, 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 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 first side surface portion 308 can be different that the height as measured at the second side surface portion 310. The difference between a height at the first side surface portion 308 and the second side surface portion 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 first side surface portion 308 and the second side surface portion 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 first side surface portion 308 and the second side surface portion 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 third side surface portion 312 and the fourth 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 15 mm, such as at least 16 mm, at least 17 mm, at least 18 mm, at least 19 mm, at least 20 mm, at least 21 mm, at least 22 mm, at least 23 mm, or at least 24 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 accordance with an embodiment, the first side surface portion 308 can extend between adjacent bevel side surface portions 316, as illustrated in FIG. 3, FIG. 4 and FIG. 6. In a non-limiting embodiment, the first side surface portion 308 can have a length that extends between adjacent bevel side surface portions 316.

The first side surface portion 308 of the abrasive segment 104 can have a certain shape. In accordance with an embodiment, the shape of the first side surface portion 308 can be defined along a plane intersecting the width, W, of the abrasive segment 104 at a normal angle. In an embodiment, the first side surface portion 308 can have a non-linear shape, as briefly noted above. A non-linear shape can be defined by a changing slope between two different lines drawn tangent to two different points on the first side surface portion 308. For example, the non-linear shape can be defined by a curve drawn between any two points on the first side surface portion 308. In accordance with a particular, the non-linear shape of the first side surface portion 308 can define an arcuate portion. In another particular

embodiment, the non-linear shape of the first side surface portion 308 can define a monotonic curve.

In accordance with an embodiment, the non-linear shape of the first side surface portion 308 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 non-linear shape of the first side surface portion 308 can be a concave shape.

In an embodiment, the non-linear shape of the first side surface portion 308 can extend for a full length of the first side surface portion 308. In a non-limiting embodiment, the non-linear shape can extend for not greater than the full length or 100% of the length of the first side surface portion 308, such as not greater than 90%, not greater than 80%, not greater than 70%, not greater than 60%, or not greater than 50% of the length of the first side surface portion 308. In a non-limiting embodiment, the non-linear shape can extend for at least 50% of the full length of the first side surface portion 308, such as at least 60%, at least 70%, at least 80%, or at least 90% of the full length of the first side surface portion 308. It will be appreciated that the non-linear shape can extend for a length of the first side surface portion 308 within a range of any minimum and maximum value noted above.

In accordance with an embodiment, the full length of the non-linear shape of the first side surface portion 308 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 accordance with an embodiment, the radius of curvature of the first side surface portion 308 can be smaller than the outer radius of curvature of the base 101. In accordance with another embodiment, the radius of curvature of the first side surface portion 308 can be smaller than the outer diameter (OD) of the base 101. In a non-limiting embodiment, the radius of curvature of the first side surface portion 308 can be smaller than an inner radius of curvature of the base 101. In accordance with another embodiment, the radius of curvature of the first side surface portion 308 can be smaller than the inner diameter (ID) of the base 101. In an embodiment, the radius of curvature of the non-linear shape of the first side surface portion 308 can be at least 300 mm, such as at least 350 mm, at least 400 mm, at least 450 mm, at least 500 mm, at least 550 mm, or at least 600 mm. In a non-limiting embodiment, the radius of curvature of the non-linear shape of the first side surface portion 308 can be not greater than 1000 mm, such as 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 radius of curvature of the non-linear shape of the first side surface portion 308 can be within any minimum and maximum value noted above. In a certain instance, the radius of curvature of the non-linear shape of the first side surface portion 308 can be within a range of at least 600 mm and not greater than 700 mm.

The second side surface portion 310 of the abrasive segment 104 can include features that are similar or different to those of the first side surface portion 308. In particular embodiments, the second side surface portion 310 can include features that are similar or substantially identical to those of the first side surface portion 308 noted above. In an embodiment, the second side surface portion 310 can extend between adjacent bevel side surface portions 316, as illustrated in FIG. 3and FIG. 6. In a non-limiting embodiment, the second side surface portion 310 can have a length that extends between adjacent bevel side surface portions 316.

The second side surface portion 310 can have a certain shape. In accordance with an embodiment, the shape of the second side surface portion 310 can be defined along a plane intersecting a width, W, of the abrasive segment 104 at a normal angle. In an embodiment, the second side surface portion 310 can have a non-linear shape as defined above with respect to the first side surface portion 308. In particular embodiments, the non-linear shape of the second side surface portion 310 can be a concave shape. In yet another particular embodiment, both the non-linear shape of the first side surface portion 308 and the non-linear shape of the second side surface portion 310 can be concave shapes. The concave shapes of the first side surface portion 308 and the second side surface portion 310 can be different or similar, and in a particular embodiment, the concave shape of the first side surface portion 308 and the concave shape of the second side surface portion 310 can be substantially similar such that they are identical and mirror each other.

In accordance with an embodiment, the abrasive segment 104 can have a bi-concave shape defined by the first side surface portion 308 and the second side surface portion 310, such that each of the first side surface portion 308 and the second side surface portion 310 have a concave shape and are substantially similar such that they are identical and mirror each other, as generally illustrated in FIG. 3 and FIG. 4. As also illustrated, the bi-concave shape of the abrasive segment 104 can be further defined by an hourglass shape, such that each of the first side surface portion 308 and

the second side surface portion 310 have a concave shape, and each of the third side surface portion 312 and the fourth side surface portion 314 have a linear shape. In an embodiment of the bi-concave shape, the linear shapes of the third side surface portion 312 can include a flat surface that is parallel and substantially identical to a flat surface of the fourth side surface portion 314.

The shape of the abrasive segment 104 can also be defined by one or more shapes of the edges that join adjacent side surface portions or features of the abrasive segment 104. In accordance with an embodiment, the abrasive segment 104 can have a first non-linear edge 320 joining the first side surface portion 308 and the top surface 304, as generally illustrated in FIG. 3 and FIG. 4. In an embodiment, the first non-linear edge 320 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 shape of the first non-linear edge 320 can be a concave shape. In an embodiment, the shape of the first non-linear edge can be defined by a changing slope between two different lines drawn tangent to two different points on the first non-linear edge 320. In an embodiment, the shape of the first non-linear edge can be defined by a curve drawn between any two points on the first non-linear edge. In accordance with an embodiment, the shape of the first non-linear edge 320 can define an arcuate portion, and in a certain embodiment, the arcuate portion can define a monotonic curve.

In an embodiment, the first non-linear edge 320 can extend for a full length of the first side surface portion 308. In another embodiment, the first non-linear edge 320 can extend for not greater than the full length of the first side surface portion 308, such as not greater than 100%, not greater than 90%, not greater than 80%, not greater than 70%, not greater than 60%, or not greater than 50% of the length of the first side surface portion 308. In a non-limiting embodiment, the first non-linear edge 320 can extend for at least 50% of the full length of the first side surface portion 308, such as at least 60%, at least 70%, at least 80%, or at least 90% of the full length of the first side surface portion 308. It will be appreciated that the first non-linear edge 320 can extend for a length of the first side surface portion 308 within a range of any minimum and maximum value noted above. In accordance with an embodiment, the full length of the non-linear edge 320 can be defined by a certain radius of curvature. In an embodiment, the radius of curvature of the first non-linear edge 320 can be at least 300 mm, such as at least 350 mm, at least 400 mm, at least

450 mm, at least 500 mm, at least 550 mm, or at least 600 mm. In a non-limiting embodiment, the radius of curvature of the first non-linear edge 320 can be not greater than 1000 mm, such as 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 radius of curvature of the first non-linear edge 320 can be within any minimum and maximum value noted above. In a certain instance, the radius of curvature of the first non-linear edge 320 can be within a range of at least 600 mm and not greater than 700 mm.

In accordance with an embodiment, the abrasive segment 104 can have a second non-linear edge 321 joining the first side surface portion 308 and the bottom surface 306, as generally illustrated in FIG. 3 and FIG. 6. The second non-linear edge 321 can include features that are similar or different to those of the first non-linear edge 320. In particular embodiments, the second non-linear edge 321 can include features that are similar or substantially identical to those of the first non-linear edge 320 noted above.

In accordance with an embodiment, the abrasive segment 104 can have a third non-linear edge 322 joining the second side surface portion 310 and the top surface 304, as generally illustrated in FIG. 3 and FIG. 4. The third non-linear edge 322 can include features that are similar or different to those of the first non-linear edge 320. In particular embodiments, the third non-linear edge 322 can include features that are similar or substantially identical to those of the first non-linear edge 320 noted above.

In accordance with an embodiment, the abrasive segment 104 can have a fourth non-linear edge 323 joining the second side surface portion 310 and the bottom surface 306. The fourth non-linear edge 323 can include features that are similar or different to those of the first non-linear edge 320, or even the third non-linear edge 322. In particular embodiments, the fourth non-linear edge 323 can include features that are similar or substantially identical to those of the third non-linear edge 322.

In a particular embodiment, a curvature of the first non-linear edge 320 and a curvature of the second non-linear edge 321 can be the same. In a non-limiting embodiment, a curvature of the first non-linear edge 320 and a curvature of the third non-linear edge 322 can be the same. In accordance with a particular embodiment, the curvature of the first non-linear edge 320, second non-linear edge 321, third non-

linear edge 322 and fourth non-linear edge 324 can be the same, defining a bi-concave shape of the abrasive segment 104.

As illustrated in FIG. 4, the bevel side surface portions 316 can be formed at a bevel angle 317 with respect to a linear portion of the adjacent third side surface portion 312 or fourth side surface portion 314, respectively. In a particular aspect, the bevel angle 317 can be at least 90°, such as at least 95°, at least about 100°, at least 110°, at least 120°, or at least 130°. In a non-limiting embodiment, the bevel angle 317 can be not greater than 180°, not greater than 170°, not greater than 160°, not greater than 150°, or not greater than 140°. It will be appreciated that the bevel angle 317 may be within a range between and including any of minimum and maximum angle values described above.

In another aspect, the third side surface portion 312 can include a surface area defined with respect to a surface area of first side surface portion 308. In accordance with an embodiment, the surface area of the third side surface portion 312 can be less than the surface area of the first side surface portion 308. For example, the surface area of the third side surface portion 312 can be less than 90% the surface area of the first side surface portion 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 third side surface portion 312 can be at least 20% the surface area of the first side surface portion 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 third side surface portion 312 with respect to the surface area of the first side surface portion 308 can be within a range of any minimum and maximum value of noted above.

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

portion 310 can have the same relationship as noted above with respect to the relationship of the surface area of the third side surface portion 312 with respect to the surface area of the first side surface portion 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 first side surface portion 308 can be substantially the same as the height as measured at the second side surface portion 310, thereby defining a certain working angle 606. In another instance, the height as measured at the first side surface portion 308 can be different that the height as measured at the second side surface portion 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 first side surface portion 308 can be less than that the height as measured at the second side surface portion 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°, such as at least about 9°, at least about 10°, at least about 11°, at least about 12°, or at least about 13°. In a non-limiting embodiment, the working angle 606 may be not greater than 20°, not greater than 19°, not greater than 18°, not greater than 17°, not greater than 16°, or not greater than 15°. 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.

FIG. 9 includes a perspective view of a portion of an abrasive article 200 having abrasive segments 104 in accordance with an embodiment, and FIG. 10 includes a cross-sectional view of an abrasive article 200 of FIG. 9 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 a mounting assembly 914 mounted on the base 101. In accordance with an embodiment, the mounting 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 mounting 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 mounting assembly, and can define an outer peripheral surface of the abrasive article 200 (e.g., grinding ring). As further illustrated, the abrasive segment 104 can be mounted on the receiving surface 907 of the mounting assembly 914. In a particular embodiment, the abrasive segment 104 can be mounted on the receiving surface 907 of the mounting assembly in direct contact with the axial flange 712. The first side surface portion 308 of the abrasive segment 104 can be adjacent to the outer annular surface 105 of the base 101. In a particular embodiment, the first side surface portion 308 can be adjacent to the outer annular surface 205 of the mounting assembly 914.

FIG. 11 includes a plan view of a grinding ring in accordance with an embodiment. FIG. 12 illustrates a cross-section view of the grinding ring 200 taken along line 12-12 in FIG. 11. As illustrated in FIG. 12, the base 101 can have an axial flange 412. The axial flange 412 can be formed integrally with the base 101 or can be a discrete body mounted on the base 101. In another embodiment, the axial flange 412 can be part of a mounting assembly that can be mounted to the base 101, as discussed further herein. As further illustrated in FIG. 12, 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 412.

As depicted in FIG. 12, 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 the height of the abrasive segment. In particular, the height as measured at the first side surface portion 308 can be substantially the same as the height as measured at the second side surface portion 310, thereby defining a certain working angle 606. In another instance, as depicted in FIG. 13, the height as measured at the first side surface portion 308 can be different that the height as measured at the second side surface portion 310, thereby defining a working angle 606 that may be different or even less than the working angle 606 depicted in FIG. 12. In any instance, the working angle 606 can be at least about 8° in accordance with an embodiment, such as at least about 9°, at least about 10°, at least about 11°, at least about 12°, or at least about 13°. In a non-limiting embodiment, the working angle 606 may be not greater than 20°, not greater than 19°, not greater than 18°, not greater than 17°, not greater than 16°, or not greater than 15°. The working angle 606 can be within a range between and including any of the minimum and maximum angle values described above.

FIG. 14 includes a perspective view of a portion of an abrasive article having abrasive segments in accordance with an embodiment, and FIG. 15 includes a cross-sectional view of an abrasive article taken at Line 15-15 of FIG. 11. As generally illustrated, the base 101 can have an axial flange 412 extending axially from grinding ring 200. As further illustrated, the axial flange 412 can be a portion of a mounting assembly 1414 mounted on the base 101. In accordance with an

embodiment, the mounting assembly 1414 can have a receiving surface 1407 for receiving an abrasive segment 104 and a rear surface 1409 opposite the receiving surface 1407, both of which can extend generally perpendicular to the rotation axis 108. The mounting assembly 1414 can have an outer annular surface 1405 extending generally axially between the receiving surface 1407 and rear surface 1409, and an inner radial surface 1403 opposite the outer annular surface 1405. The outer annular surface 1405 can also extend circumferentially around the body of the mounting assembly, and can define an outer peripheral surface of the grinding ring 200. As further illustrated, the abrasive segment 104 can be mounted on the receiving surface 1407 of the mounting assembly 1414. In a particular embodiment, the abrasive segment 104 can be mounted on the receiving surface 1407 of the mounting assembly 1414 in direct contact with the axial flange 412. The first side surface portion 308 of the abrasive segment 104 can be adjacent to the outer annular surface 1405 of the base 101. In a particular embodiment, the first side surface portion 308 can be adjacent to the outer annular surface 1405 of the mounting assembly 1414.

FIG. 16 includes a cross-sectional view of a portion of a mounting assembly including an axial flange in accordance with an embodiment taken at Circle 16 of FIG. 15. FIG. 17 includes a cross-sectional view of a portion of a mounting assembly including an axial flange in accordance with an embodiment taken at Circle 17 of FIG. 16. As generally illustrated in FIG. 16 and FIG. 17, the base 101 of the abrasive article 200 can include an inner annular surface 103, an outer annular surface 105 opposite the inner annular surface 103, and a receiving surface 107 extending between the inner annular surface 103 and the outer annular surface 105. The base 101 can include a top annular surface 112 extending from the inner annular surface 103 to the outer annular surface 105. As illustrated, the receiving surface 107 of the base 101 can define a channel region comprising an intermediate radial surface 110 and a radial flange 111 extending radially from the intermediate radial surface 110. According to an embodiment, the receiving surface 107 of the base 101 can be configured to include a complementary shape for accepting a mounting assembly 1414. In a particular embodiment, the base 101 can be configured to receive a fastener for coupling the mounting assembly 1414 to the receiving surface 107 of the base 101. In a particular embodiment, the base 101 can be configured to receive a radial fastening member 1601 In accordance with an embodiment, the base 101 cab be configured to receive a plurality of mounting assemblies 1414.

In accordance with an embodiment, the mounting assembly 1414 can have a complementary shape for inserting into the base 101 of the abrasive article 200. In a particular aspect, the mounting assembly can have a complementary shape for inserting into the receiving surface 107 of the base 101. In one aspect, the mounting assembly 1414 can be coupled to the base 101. In another aspect, the mounting assembly 1414 can be coupled to the receiving surface 107 of the base 101. In a particular aspect, the mounting assembly 1414 can be removably attached to the base 101. In another aspect, the mounting assembly 1414 can be coupled to and in direct contact with the receiving surface 107 of the base 101. In a particular aspect, a portion of the mounting assembly 1414 can be under a compressive force with coupled to the base 101. In a particular aspect, the mounting assembly 1414 can be coupled to the receiving surface 107 by one or more fasteners. In accordance with an embodiment, the mounting assembly 1414 can have a fastener receiving portion 1602 configured to receive a fastener. In accordance with an embodiment, the fastener can be a radial fastening member 1601. In a particular aspect, the receiving portion 1602 can be a countersunk portion such that, when installed, the radial fastening member1601 can be countersunk with respect to the outer annular surface 1405 of the mounting assembly 1414. In a particular embodiment, the mounting assembly 1414 can be engaged and fastened to the base 101, and more particularly the channel region of the base 101 with at least one radial fastening member 1601.

In accordance with an embodiment, the abrasive article 200 can include at least one abrasive segment 104 coupled to the base 101. In a certain aspect, the abrasive segment 104 can be coupled to the receiving surface 107 of the base 101. In another aspect, the abrasive segment 104 can be attached to the mounting assembly 1414. In yet another aspect, the abrasive segment 104 can be coupled to the receiving surface 107 of the base 101 via the mounting assembly 1414.

According to an embodiment, the abrasive segment 104 can be attached to and in direct contact with a receiving surface 1407 of the mounting assembly 1414. In particular embodiments, the abrasive segment 104 can be coupled to the receiving surface 107 of the base 101 via the mounting assembly 1414, which itself can be coupled to and in direct contact with the receiving surface 107 of the base 101. In an embodiment, a plurality of abrasive segments 104 can be attached to a single mounting assembly 1414.

In accordance with an embodiment, the mounting assembly 1414 can further include an axial flange 412. The axial flange 412 can be disposed between the abrasive segment 104 and the central opening 102 of the base 101. In another aspect, the axial flange 412 can be disposed between the abrasive segment 104 and the inner annular surface 103 of the base 101.

In accordance with an embodiment, the axial flange 412 can include an inner radial surface 1701, an outer radial surface 1702 opposite the inner radial surface 1701, and an upper surface 1703 extending between the inner radial surface 1701 and the outer radial surface 1702 of the axial flange 412. In an embodiment, the outer radial surface 1702 of the axial flange 412 can be in direct contact with a side surface portion of the abrasive segment 104. In a particular aspect, the outer radial surface 1702 of the axial flange 412 can be in direct contact with the second side surface portion 310 of the abrasive segment 104.

In accordance with an embodiment, the axial flange 412 can include a height, H_{af}, defined as a portion of the axial flange 412 extending above a receiving surface 1407 of the mounting assembly 1414, and wherein H_{af} is at least 1% the overall height, H, of the abrasive segment 104, such as at least 2%, at least 4%, at least 6%, at least 8%, at least 8%, at least 10%, at least 12%, at least 14%, at least 16%, at least 18%, or even at least 20%. In a non-limiting embodiment, the height, H_{af}, of the axial flange 412 can be not greater than 25% the overall height, H, of the abrasive segment 104, such as not greater than 24%, not greater than 22%, not greater than 20%, not greater than 18%, not greater than 16%, not greater than 14%, not greater than 12%, not greater than 10%, not greater than 8%, not greater than 6%, not greater than 4%, or even not greater than 2%. It will be appreciated that the height, H_{af}, as a function of the overall height, H, of the abrasive segment 104 can be within any minimum or maximum value noted above. In a particular embodiment, the portion of the axial flange 412 extending above the receiving surface 1407 of the mounting assembly 1414 can include the outer radial surface 1702 of the axial flange 412.

In accordance with an embodiment, the axial flange includes 412 can include a thickness, T_{af}, defined as the distance between the outer radial surface 1702 of the axial flange 412 and the inner radial surface 1701 of the axial flange 412. In an embodiment, the thickness, T_{af}, can include the top surface 1701 of the axial flange 412. In an embodiment, the thickness, T_{af}, can be at least 50% the height, H_{af}, of the

axial flange 412, such as at least 75%, at least 100%, at least 125%, at least 150%, at least 175%, at least 200%, at least 225%, at least 250%, or even at least 375%. In a non-limiting embodiment, the thickness, T_{af}, can be not greater than 300% the height, H_{af}, of the axial flange 412, such as not greater than 275%, not greater than 250%, not greater than 225%, not greater than 200%, not greater than 175%, not greater than 150%, not greater than 125%, not greater than 100%, or even not greater than 75%. It will be appreciated that the thickness, T_{af}, as a function of the height, H_{af}, of the axial flange 412 can be within any minimum or maximum value noted above.

In accordance with an embodiment, the mounting assembly 1414 can be formed of any material disclosed herein with respect to the abrasive article according to embodiments herein. In a particular aspect, the mounting assembly 1414 can include a metal or metal alloy.

In accordance with an embodiment, the axial flange 412 can form a continuous member mounted along the top annular surface 112 of the base 101. In another embodiment, the abrasive article 200 can include a plurality of axial flanges 412 separated from each other.

Embodiment 1. An abrasive article, comprising: a base having an annular shape defining a central opening; and an abrasive segment coupled to the base, the abrasive segment having a biconcave shape.

Embodiment 2. An abrasive article, comprising: a base having a body comprising an annular shape including an inner annular surface, an outer annular surface, and a receiving surface extending between the inner annular surface and the outer annular surface; an abrasive segment comprising a body and coupled to the receiving surface of the base, wherein the abrasive segment comprises a first side surface portion having a non-linear shape, and wherein the first side surface portion is adjacent to the outer annular surface of the base.

Embodiment 3. The abrasive article of embodiment 2, wherein the non-linear shape of the first side surface portion is defined by a changing slope between two different lines drawn tangent to two different points on the first side surface portion.

Embodiment 4. The abrasive article of embodiment 2, wherein the non-linear shape of the first side surface portion defines an arcuate portion.

Embodiment 5. The abrasive article of embodiment 4, wherein the arcuate portion defines a monotonic curve.

Embodiment 6. The abrasive article of embodiment 4, wherein the non-linear shape extends for a full length of the first side surface portion.

Embodiment 7. The abrasive article of embodiment 2, wherein the non-linear shape is defined by a curve drawn between any two points on the first side surface portion along a plane intersecting a thickness of the abrasive segment at a normal angle.

Embodiment 8. The abrasive article of embodiment 6, wherein the full length of the non-linear shape is defined by a radius of curvature.

Embodiment 9. The abrasive article of embodiment 8, wherein the radius of curvature of at least 300 mm, at least 350 mm, at least 400 mm, at least 450 mm, at least 500 mm, at least 550 mm, at least 600 mm.

Embodiment 10. The abrasive article of embodiment 8, wherein the radius of curvature is 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, not greater than 700 mm; wherein the radius of curvature of the first surface of the abrasive segment is at least 600 mm and not greater than 700 mm.

Embodiment 11. The abrasive article of embodiment 2, wherein the non-linear shape is a concave shape.

Embodiment 12. The abrasive article of embodiment 2, wherein the abrasive segment comprises: a top surface; a bottom surface; and a second side surface portion opposite the first side surface portion, wherein the second side surface portion and the first side surface portion extend between the top surface and the bottom surface, and wherein the second side surface portion comprises a non-linear shape.

Embodiment 13. The abrasive article of embodiment 12, further comprising: a first non-linear edge joining the top surface and first side surface portion; and a second non-linear edge joining the bottom surface and the first side surface portion, wherein the first non-linear edge has a curvature and the second non-linear edge has a curvature.

Embodiment 14. The abrasive article of embodiment 13, wherein the curvature of the first non-linear edge and the curvature of the second non-linear edge are the same.

Embodiment 15. The abrasive article of embodiment 13, wherein the curvature of the first non-linear edge and the curvature of the second non-linear edge are different.

Embodiment 16. The abrasive article of embodiment 12, wherein the non-linear shape of the second side surface portion is defined by a changing slope between two different lines drawn tangent to two different points on the second surface portion.

Embodiment 17. The abrasive article of embodiment 12, wherein the non-linear shape of the second side surface portion defines an arcuate portion.

Embodiment 18. The abrasive article of embodiment 17, wherein the arcuate portion defines a monotonic curve.

Embodiment 19. The abrasive article of embodiment 17, wherein the non-linear shape extends for a full length of the second side surface portion.

Embodiment 20. The abrasive article of embodiment 12, wherein the non-linear shape of the second side surface portion is defined by a curve drawn between any two points on the second surface portion along a plane intersecting a thickness of the abrasive segment at a normal angle,

Embodiment 21. The abrasive article of embodiment 19, wherein the full length of the non-linear shape is defined by a radius of curvature.

Embodiment 22. The abrasive article of embodiment 21, wherein the radius of curvature of at least 300 mm, at least 350 mm, at least 400 mm, at least 450 mm, at least 500 mm, at least 550 mm, at least 600 mm.

Embodiment 23. The abrasive article of embodiment 21, wherein the radius of curvature is 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, not greater than 700 mm; wherein the radius of curvature of the first surface of the abrasive segment is at least 600 mm and not greater than 700 mm.

Embodiment 24. The abrasive article of embodiment 12, wherein the non-linear shape of the second side surface portion is a concave shape.

Embodiment 25. The abrasive article of embodiment 12, further comprising a third side surface portion extending between the first and second side surface portions; a fourth side portion opposite the third side surface portion and extending between the first and second side surface portions, wherein the third and fourth side surface portions are linear.

Embodiment 26. The abrasive article of embodiment 25, wherein the abrasive segment comprises a minimum width defined as the minimum distance between the first side surface portion and the second side surface portion,

Embodiment 27. The abrasive article of embodiment 26, wherein the minimum width is located equidistant between the third and fourth surface portions.

Embodiment 28. The abrasive article of embodiment 8, wherein the first side surface of the abrasive segment comprises a concave shape having a curvature, and the second side surface of the abrasive segment comprises a concave shape having a curvature.

Embodiment 29. The abrasive article of embodiment 28, wherein the curvature of the concave shape of the first side surface portion is substantially the same as the curvature of the concave shape of the second side surface portion.

Embodiment 30. The abrasive article of embodiment 2, wherein the abrasive segment comprises a biconcave shape

Embodiment 31. The abrasive article of any one of embodiments 1 or 30, wherein the biconcave shape of the abrasive segment comprises a principle axis, wherein the principle axis is defined as a line joining a center of curvature of the concave curvature of the first surface and the center of curvature of the concave curvature of the second surface, and passing through the center of the body of the abrasive segment.

Embodiment 32. The abrasive article of embodiment 31, wherein the principle axis intersects the rotation axis of the abrasive article.

Embodiment 33. The abrasive article of any one of the above embodiments, wherein the annular shape of the base includes an inner annular surface and an outer annular surface opposite the inner annular surface.

Embodiment 34. The abrasive article of embodiment 33, wherein the inner annular surface of the base defines the central opening.

Embodiment 35. The abrasive article of any one of the above embodiments, wherein the annular shape of the base comprises an inner diameter defined by an inner radius of curvature, and an outer diameter defined by an outer radius of curvature, wherein the outer diameter is greater than the inner diameter, and wherein the outer radius of curvature is greater than the inner radius of curvature.

Embodiment 36. The abrasive article of embodiment 35, wherein an outer diameter of the base is at least 500 mm, at least 550 mm, at least 600 mm, at least 650

mm, at least 700 mm, at least 750 mm, at least 800 mm, at least 850 mm; wherein the outer diameter of the base is not greater than 1300 mm, not greater than 1250 mm, not greater than 1200 mm, not greater than 1150 mm, not greater than 1100 mm, not greater than 1050 mm, not greater than 1000 mm, not greater than 950 mm; wherein the outer diameter of the base is at least 850 mm and not greater than 950 mm.

Embodiment 37. The abrasive article of embodiment 8, wherein the radius of curvature of the first surface of the abrasive segment is smaller than an outer radius of curvature of the base.

Embodiment 38. The abrasive article of embodiment 8, wherein the radius of curvature of the first surface of the abrasive segment is smaller than an inner radius of curvature of the base.

Embodiment 39. The abrasive article of any one of the above embodiments, further comprising a rotation axis around with the abrasive article is configured to rotate during use, and wherein the abrasive segment is mounted on the base such that a second surface of the abrasive segment faces the rotation axis, and the first surface of the abrasive segment faces opposite the second surface of the abrasive segment.

Embodiment 40. An abrasive article, comprising: a base having an annular shape defining a central opening; a mounting assembly coupled to the base; an abrasive segment attached to the mounting assembly; wherein the mounting assembly comprises an axial flange disposed between the abrasive segment and the central opening of the base.

Embodiment 41. An abrasive article, comprising: a base comprising an inner annular surface, an outer annular surface opposite the inner annular surface, and a receiving surface extending between the inner annular surface and the outer annular surface; an abrasive segment coupled to the receiving surface of the base; and an axial flange disposed between the abrasive segment and the inner annular surface of the base.

Embodiment 42. The abrasive article of embodiment 41, wherein the abrasive segment is coupled to the receiving surface of the base via a mounting assembly coupled to and in direct contact with the receiving surface of the base.

Embodiment 43. The abrasive article of embodiment 40, wherein the base further comprises an inner annular surface, an outer annular surface, and a receiving surface extending between the inner annular surface and the outer annular surface.

Embodiment 44. The abrasive article of embodiment 43, wherein the mounting assembly is coupled to and in direct contact with the receiving surface of the base.

Embodiment 45. The abrasive article of embodiment 44, wherein the abrasive segment is coupled to the receiving surface of the base via the mounting assembly.

Embodiment 46. The abrasive article of any one of the above embodiments, wherein the abrasive segment is attached to and in direct contact with a receiving surface of the mounting assembly.

Embodiment 47. The abrasive article of any one of the above embodiments, wherein an inner radial surface, an outer radial surface opposite the inner radial surface of the axial flange, and an upper surface extending between the inner radial surface and the outer radial surface of the axial flange; and wherein the outer radial surface of the axial flange is in direct contact with a side surface portion of the abrasive segment.

Embodiment 48. The abrasive article of any one of the above embodiments, wherein the axial flange includes a height, H_{af}, defined as a portion of the axial flange extending above a receiving surface of the mounting assembly, and wherein H_{af} is at least 1% an overall height, H, of the abrasive segment, such as at least 2%, at least 4%, at least 6%, at least 8%, at least 8%, at least 10%, at least 12%, at least 14%, at least 16%, at least 18%, or even at least 20%.

Embodiment 49. The abrasive article of any one of the above embodiments, wherein the axial flange includes a height, H_{af}, defined as a portion of the axial flange extending above a receiving surface of the mounting assembly, and wherein H_{af} is not greater than 25% an overall height, H, of the abrasive segment, such as not greater than 24%, not greater than 22%, not greater than 20%, not greater than 18%, not greater than 16%, not greater than 14%, not greater than 12%, not greater than 10%, not greater than 8%, not greater than 6%, not greater than 4%, or even not greater than 2%.

Embodiment 50. The abrasive article of embodiment 48, wherein the portion of the axial flange extending above the receiving surface of the mounting assembly comprises the outer radial surface of the axial flange.

Embodiment 51. The abrasive article of any one of the above embodiments, wherein the axial flange includes a thickness, T_{af}, defined as the

distance between the outer radial surface of the axial flange and the inner radial surface of the axial flange; wherein the thickness, T_{af}, comprises the top surface of the axial flange; and wherein T_{af} is at least 50% the height, H_{af}, of the axial flange, such as at least 75%, at least 100%, at least 125%, at least 150%, at least 175%, at least 200%, at least 225%, at least 250%, or even at least 375%.

Embodiment 52. The abrasive article of any one of the above embodiments, wherein the axial flange includes a thickness, T_{af}, defined as the distance between the outer radial surface of the axial flange and the inner radial surface of the axial flange; wherein the thickness comprises the top portion of the axial flange; and wherein T_{af} is not greater than 300% the height, H_{af}, of the axial flange, such as not greater than 275%, not greater than 250%, not greater than 225%, not greater than 200%, not greater than 175%, not greater than 150%, not greater than 125%, not greater than 100%, or even not greater than 75%.

Embodiment 53. The abrasive article of embodiment 51, wherein the receiving surface of the base defines a channel region comprising an intermediate radial surface and a radial flange extending radially from the intermediate radial surface.

Embodiment 54. The abrasive article of any one of the above embodiments, wherein a portion of the mounting assembly is under a compressive force.

Embodiment 55. The abrasive article of any one of the above embodiments, wherein the mounting assembly is engaged and fastened to the base with at least one radial fastening member.

Embodiment 56. The abrasive article of embodiment 55, wherein the mounting assembly is engaged and fastened to the channel region of the base with at least one radial fastening member.

Embodiment 57. The abrasive article of embodiment 55, wherein the mounting assembly has a complementary shape for inserting into base, wherein the mounting assembly has a complementary shape for inserting into the channel region of the base.

Embodiment 58. The abrasive article of any one of the above embodiments, wherein the base comprises an inner annular surface and an outer annular surface opposite the inner annular surface, and a top annular surface

extending from the inner annular surface to the outer annular surface, and wherein the flange forms a continuous member mounted along the top annular surface of the base.

Embodiment 59. The abrasive article of any one of the above embodiments, wherein the abrasive article comprises a plurality of axial flanges separated from each other.

Embodiment 60. The abrasive article of any one of the above embodiments, wherein a plurality of abrasive segments are attached to the mounting assembly.

Embodiment 61 The abrasive article of any one of the above embodiments, wherein a plurality of mounting assemblies are removably attached to the base.

Embodiment 62. The abrasive article of any one of the above embodiments, wherein the mounting assembly comprises a metal or metal alloy.

EXAMPLE

A sample grinding wheel SN1 was formed to include a plurality of abrasive segments with a biconcave shape according to an embodiment described herein, and as shown in FIG 18 and FIG. 19. A comparative sample grinding wheel CS1 was formed identical to sample SN1, but instead including abrasive segments without a non-linear shape. A grinding operation was performed on a clay brick using sample SN1, and on a substantially identical clay brick using sample CS1. The resulting brick of the grinding operation using sample SN1 is shown in FIG. 20, while the resulting brick of the grinding operation using CS1 is shown in FIG. 21. As illustrated, sample SN1 provided a brick with fewer cracks (see FIG. 20) than was provided by sample CS1 (see FIG. 21).

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 including an abrasive segment as described herein can be used to perform a grinding operation while experiencing less wear than a comparative abrasive segment not having shape as described herein (e.g., non-linear, curved, or concave). Further, an abrasive article including an abrasive segment 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 segment not having shape as described herein (e.g., non-linear, curved, or concave). The shape of the abrasive segment according to the embodiments herein provide increased longevity and effectiveness by reducing wear that can manifest during a grinding operation in the form of cracks or fractures in the workpiece or in the body of the abrasive segment or. 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 defining a central opening; and

an abrasive segment coupled to the base, the abrasive segment having a biconcave shape.

2. An abrasive article, comprising:

a base having a body comprising an annular shape including an inner annular surface, an outer annular surface, and a receiving surface extending between the inner annular surface and the outer annular surface;

an abrasive segment comprising a body and coupled to the receiving surface of the base, wherein the abrasive segment comprises a first side surface portion having a non-linear shape, and wherein the first side surface portion is adjacent to the outer annular surface of the base.

3. The abrasive article of claim 2, wherein the non-linear shape of the first side surface portion is defined by a changing slope between two different lines drawn tangent to two different points on the first side surface portion.

4. The abrasive article of claim 2, wherein the non-linear shape of the first side surface portion defines an arcuate portion.

5. The abrasive article of claim 4, wherein the arcuate portion defines a monotonic curve.

6. The abrasive article of claim 4, wherein the non-linear shape extends for a full length of the first side surface portion.

7. The abrasive article of claim 6, wherein the full length of the non-linear shape is defined by a radius of curvature.

8. The abrasive article of claim 7, wherein the radius of curvature of at least 300 mm and not greater than 1000 mm.

9. The abrasive article of claim 7, wherein the radius of curvature of the first surface of the abrasive segment is smaller than an outer radius of curvature of the base.

10. The abrasive article of claim 2, wherein the abrasive segment comprises:

a top surface;

a bottom surface; and

a second side surface portion opposite the first side surface portion, wherein the second side surface portion and the first side surface portion extend

between the top surface and the bottom surface, and wherein the second side surface portion comprises a non-linear shape.

11. The abrasive article of claim 10, wherein the non-linear shape of the second side surface portion is a concave shape.

12. The abrasive article of claim 2, wherein the abrasive segment comprises a biconcave shape.

13. The abrasive article of claim 2, wherein the abrasive article comprises an axial flange disposed between the abrasive segment and the outer annular surface of the base.

14. The abrasive article of claim 2, wherein the abrasive article comprises an axial flange disposed between the abrasive segment and the inner annular surface of the base.

15. An abrasive article, comprising:

a base comprising an inner annular surface, an outer annular surface opposite the inner annular surface, and a receiving surface extending between the inner annular surface and the outer annular surface;

an abrasive segment coupled to the receiving surface of the base; and

an axial flange disposed between the abrasive segment and the inner annular surface of the base.

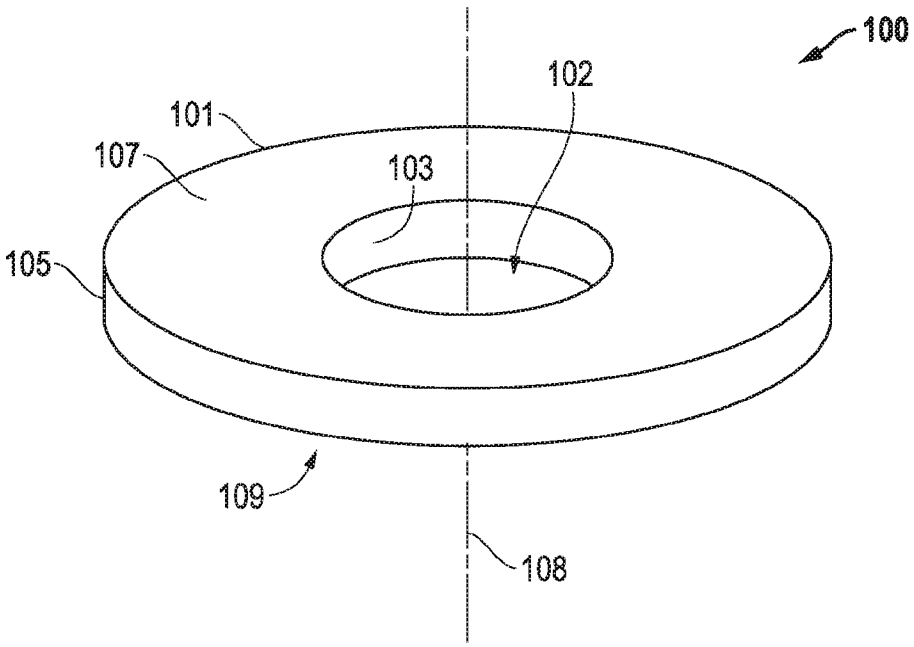

FIG. 1A

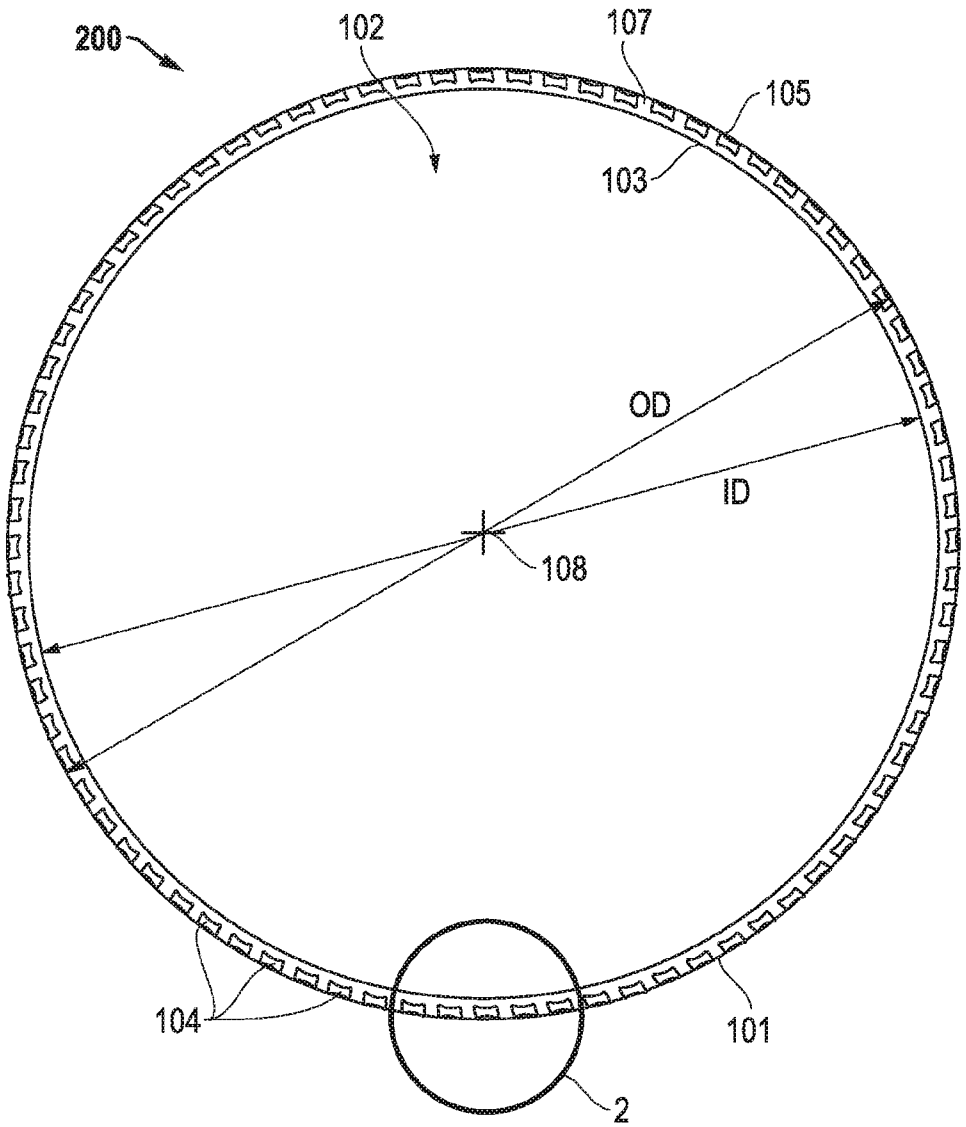

FIG. 1B

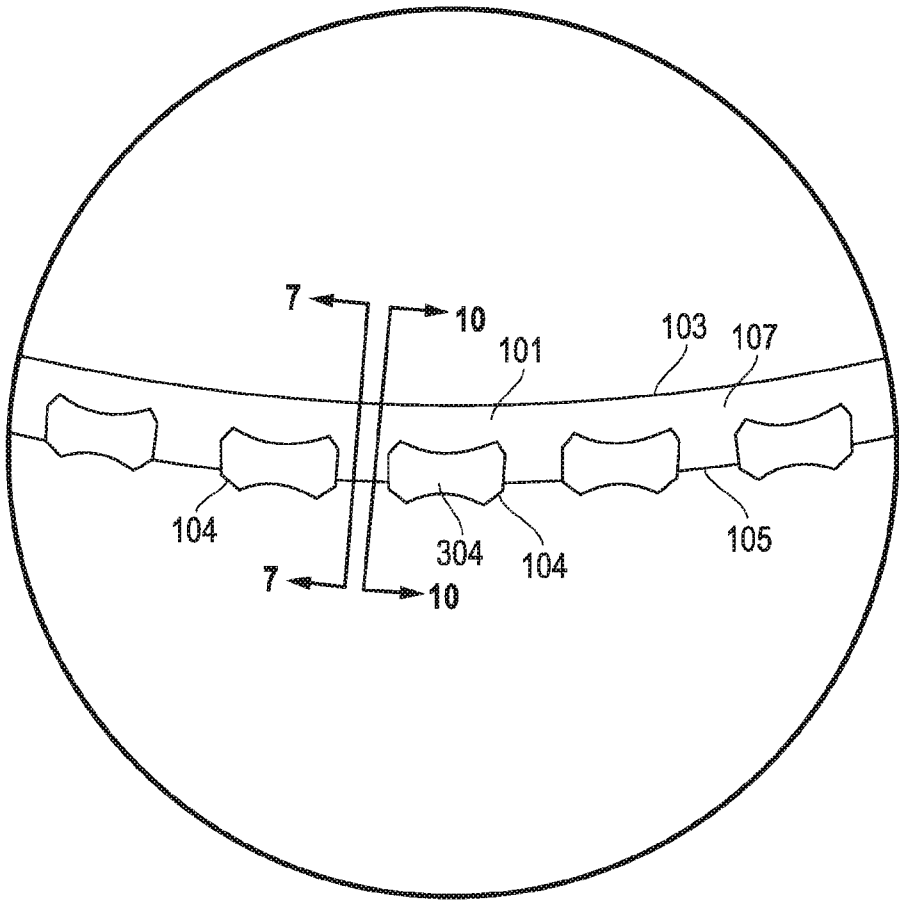

FIG. 2

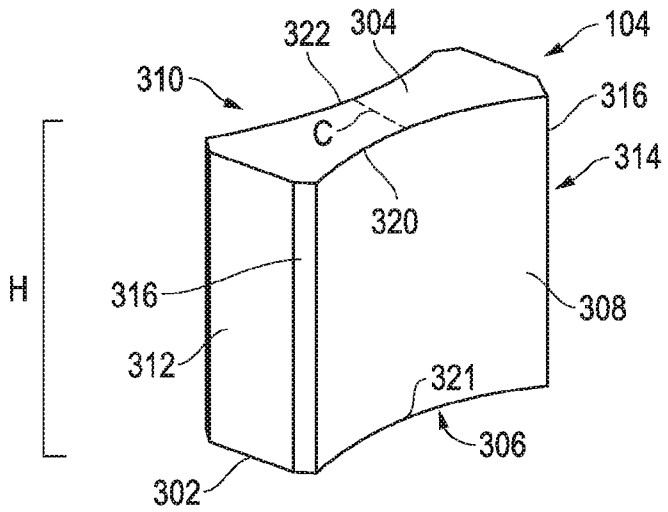

FIG. 3

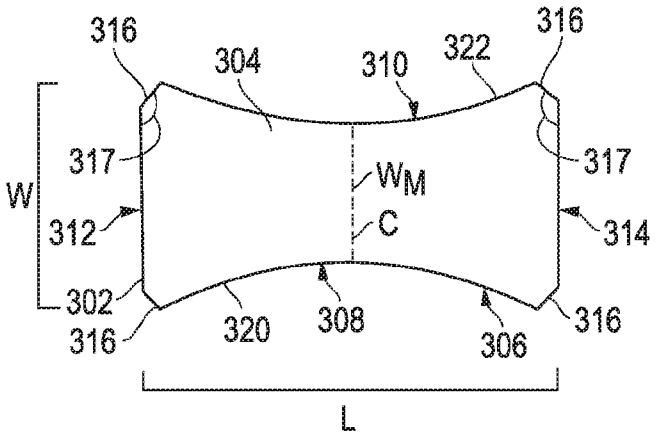

FIG. 4

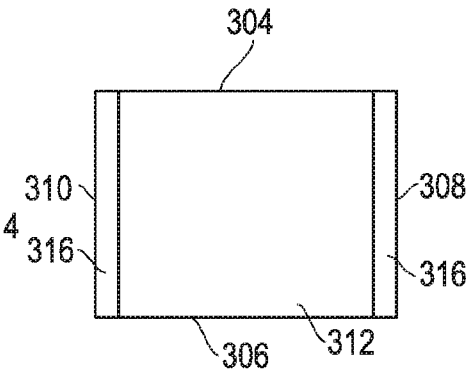

FIG. 5

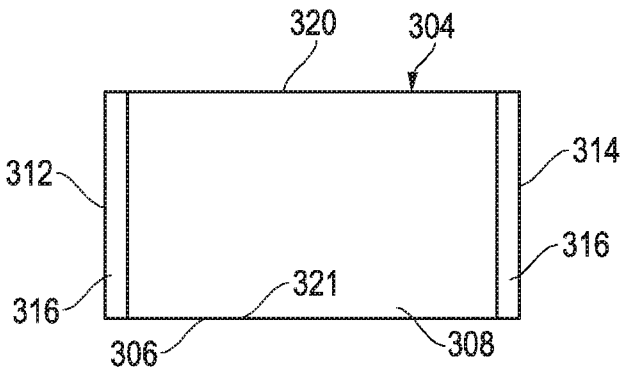

FIG. 6

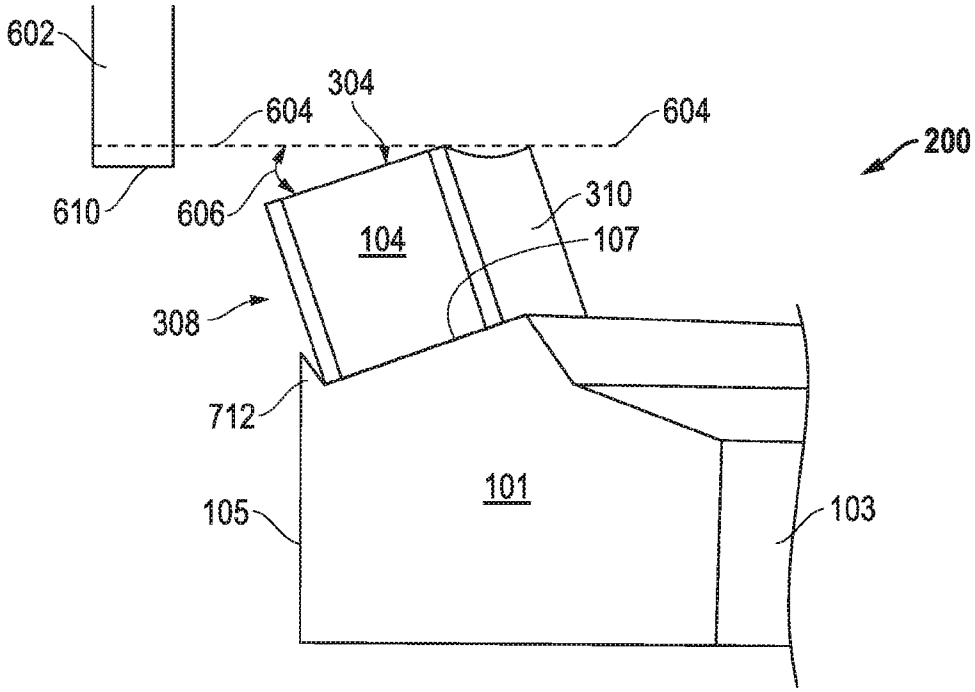
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FIG. 7

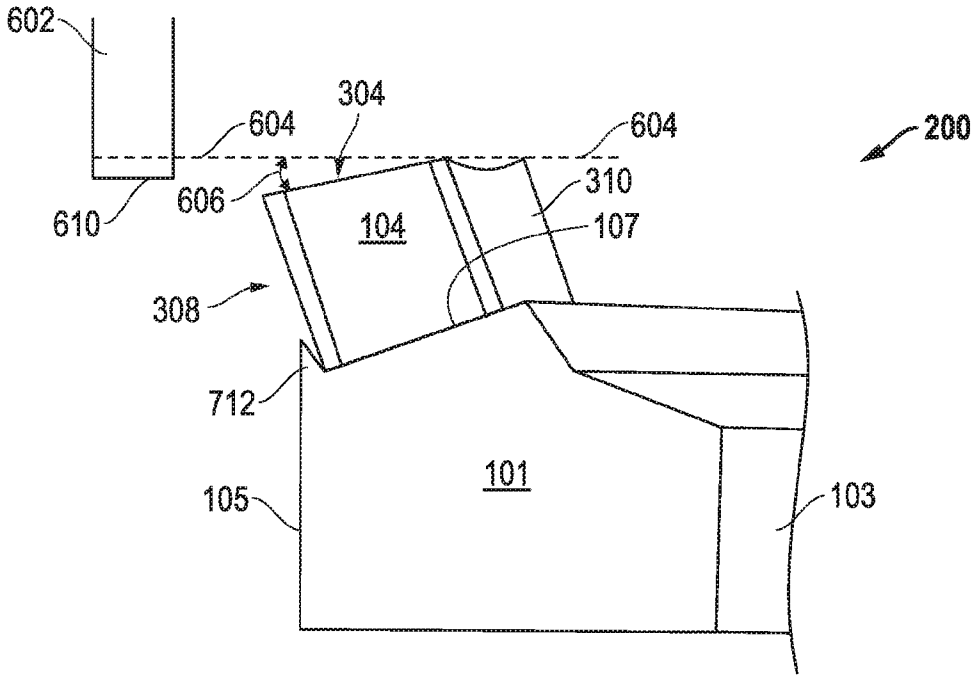
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FIG. 8

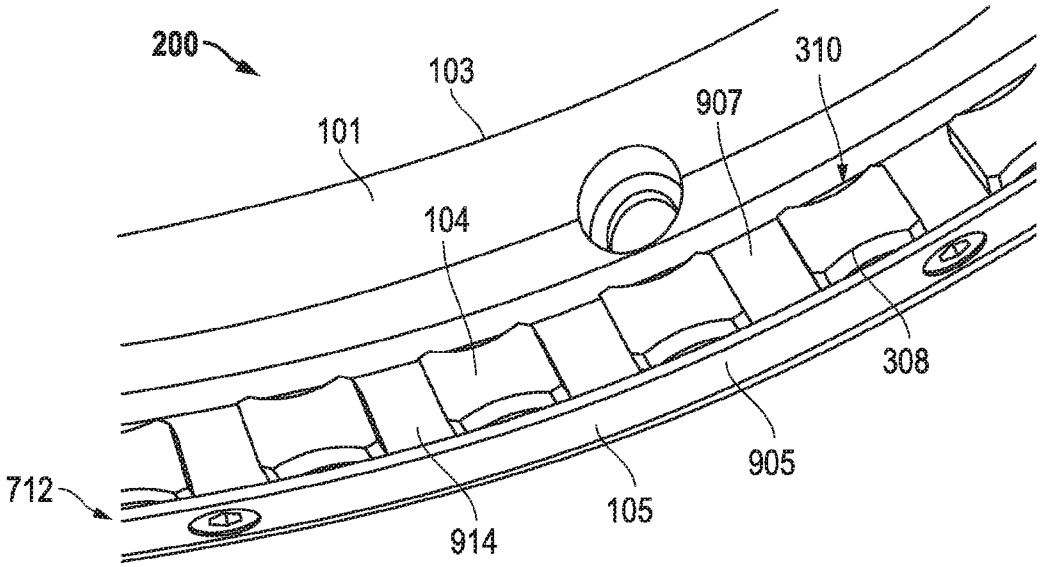
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FIG. 9

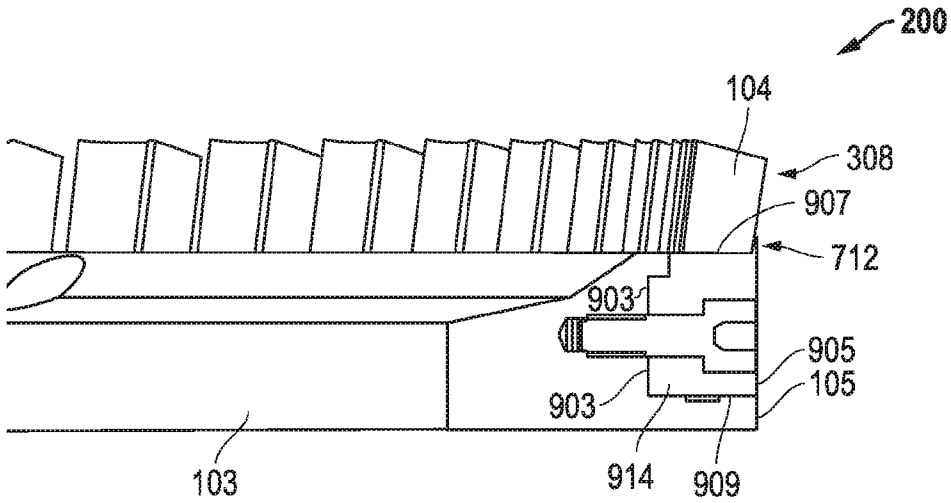
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FIG. 10

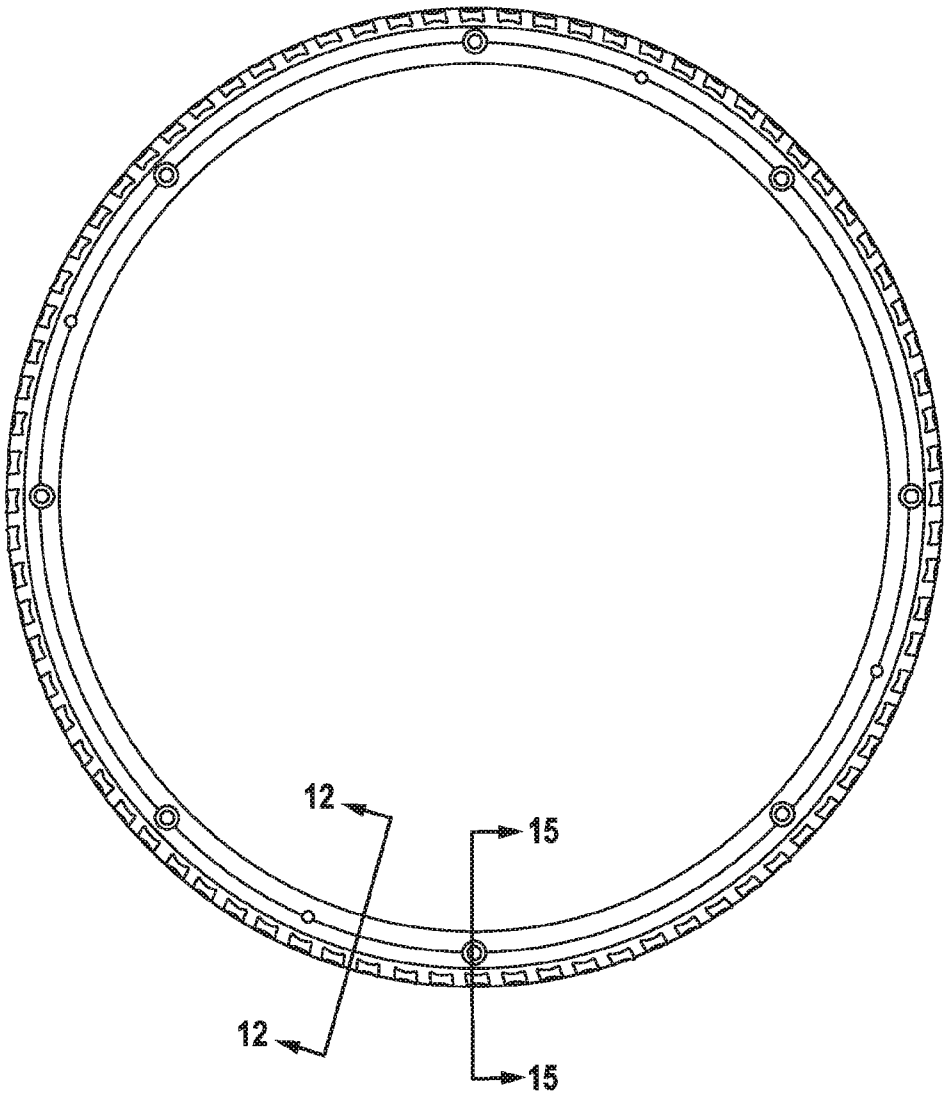

FIG. 11

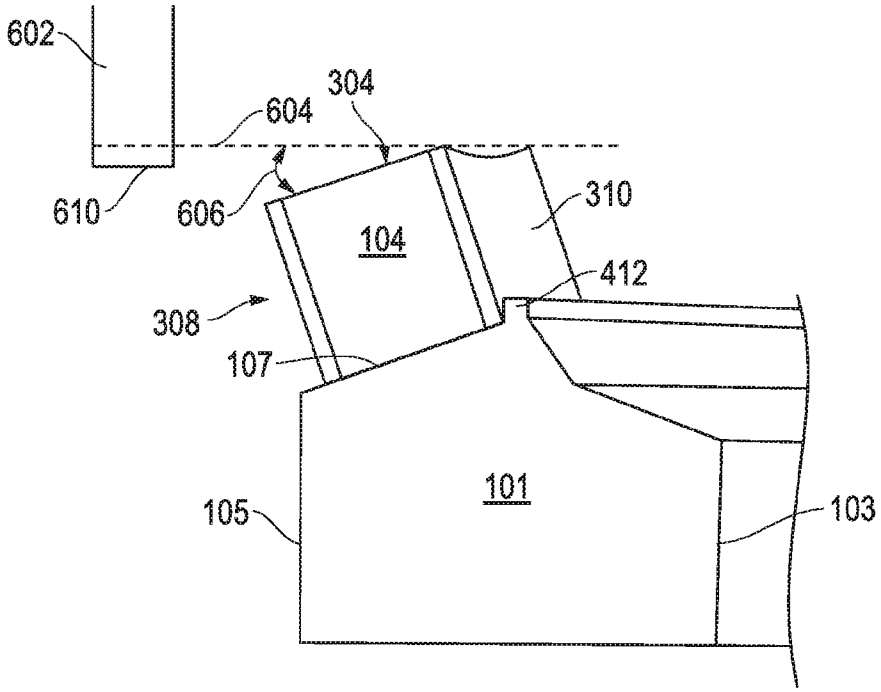
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FIG. 12

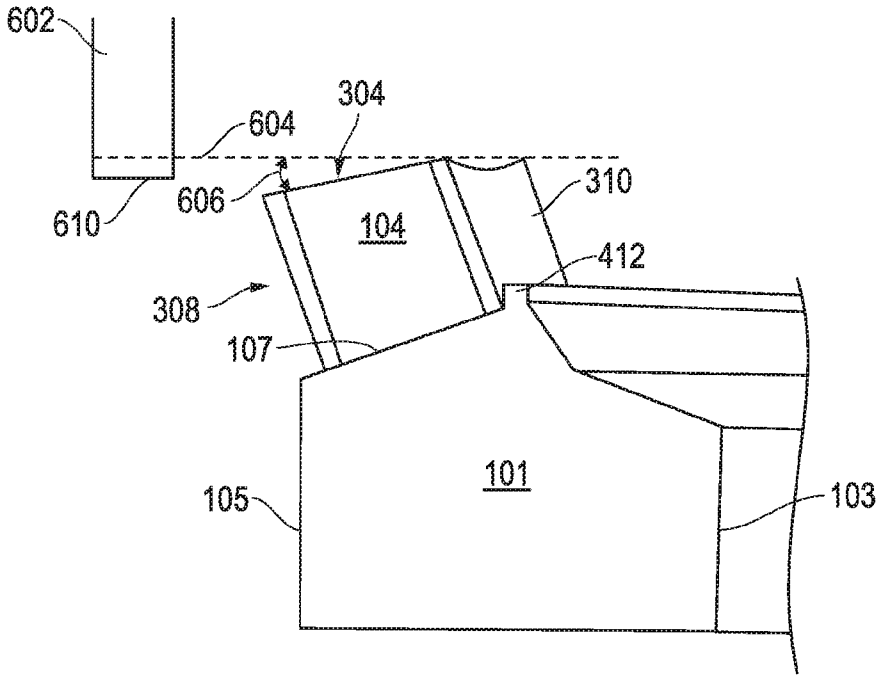
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FIG. 13

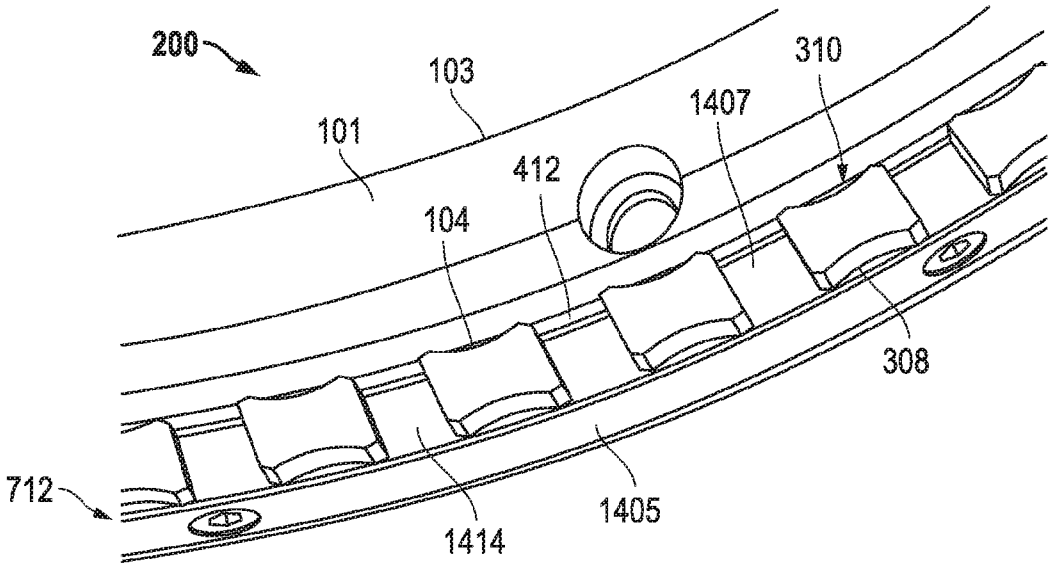
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FIG. 14

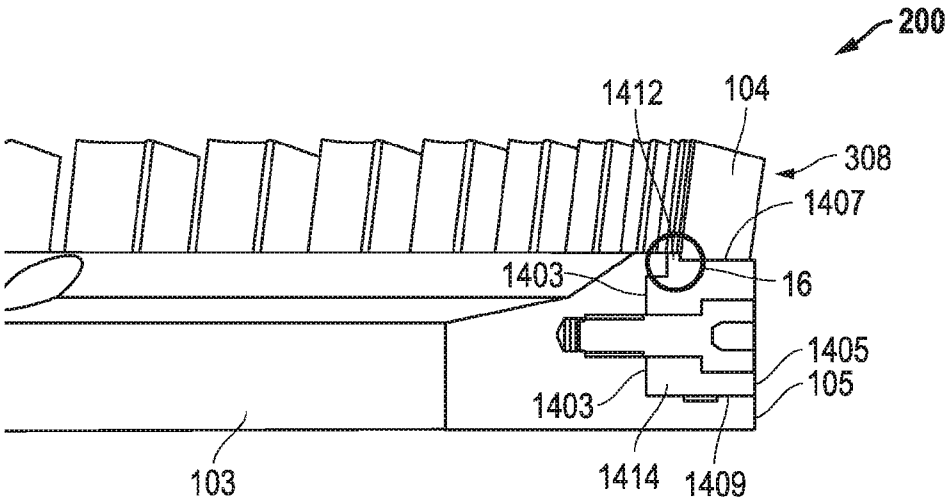
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FIG. 15

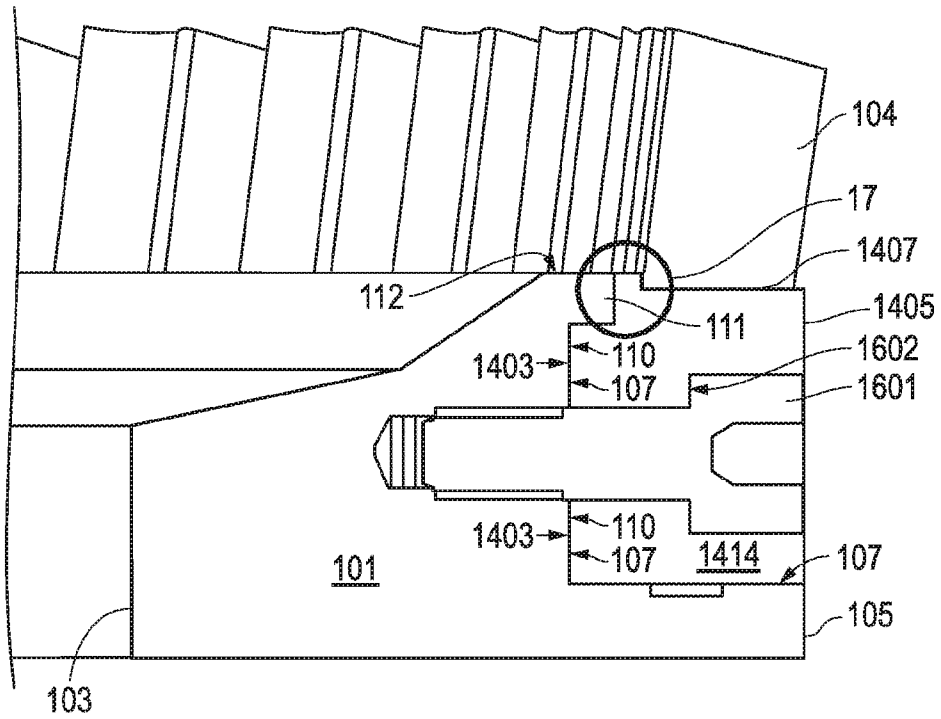
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FIG. 16

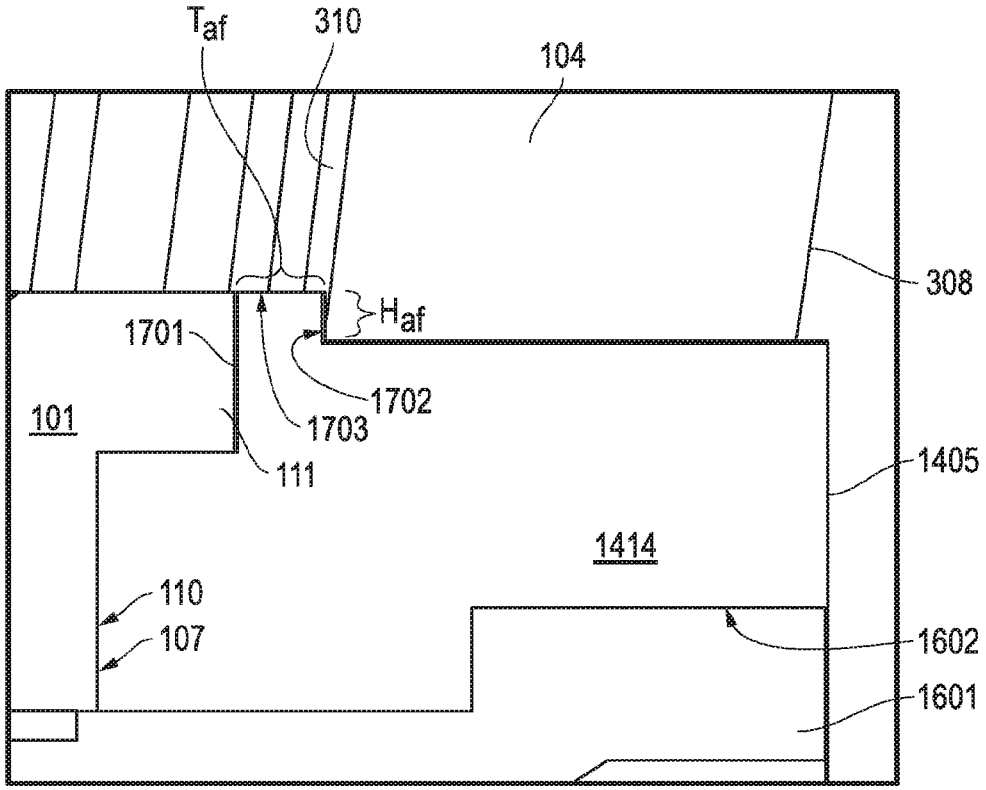
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FIG. 17

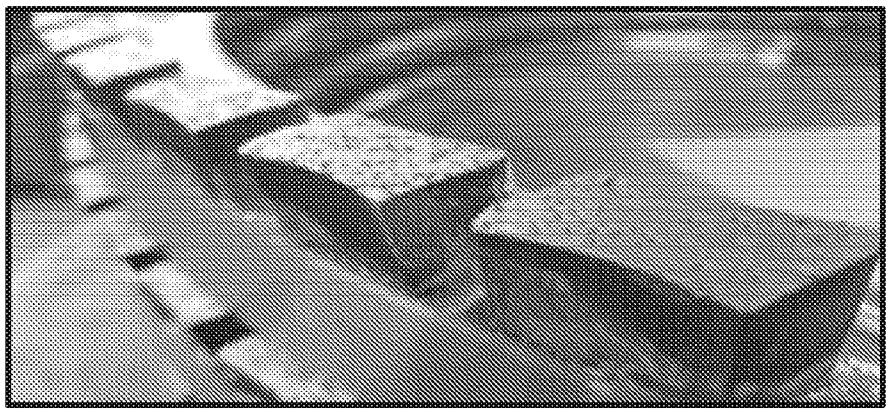

FIG. 18

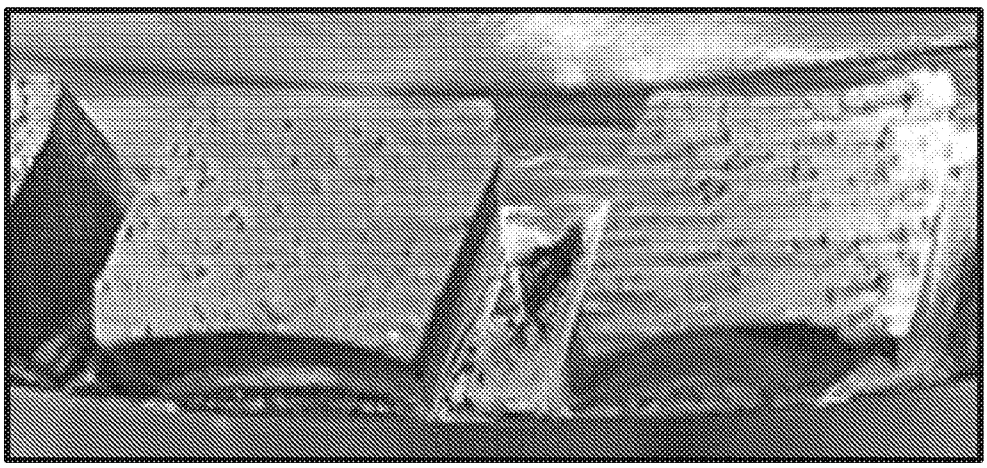

FIG. 19

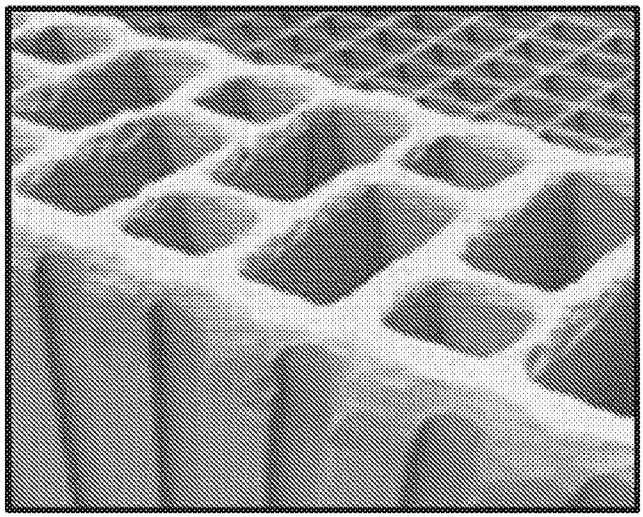

FIG. 20

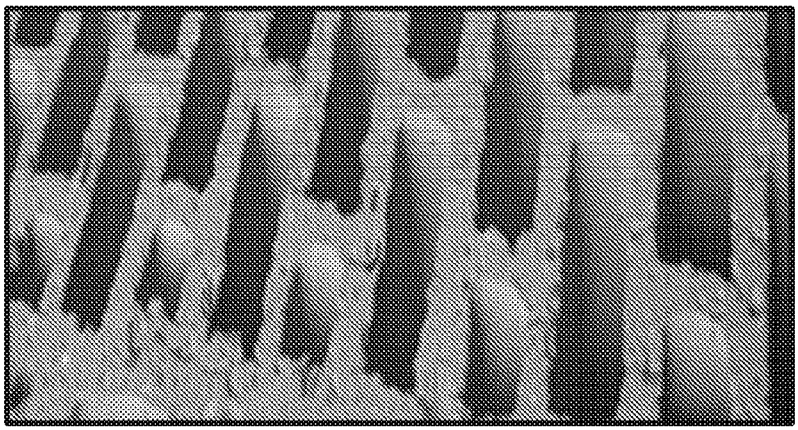

FIG. 21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/036386

A. CLASSIFICATION OF SUBJECT MATTER

B24D 7/06(2006.01)i, B24B 7/22(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 7/06; B24B 11/02; B24B 11/10; B24D 3/00; B24D 3/18; B24D 7/00; B24D 7/18; B24B 7/22

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, grinding, concave, annular, arcuate, shape, segment, non-linear

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6402600 B1 (BESCH, OTHMAR C.) 11 June 2002 See column 5, lines 1-55, claim 1 and figures 2-5.	15
Y		1-14
Y	US 2016-0362589 A1 (SAINT-GOBAIN CERAMICS & PLASTICS, INC.) 15 December 2016 See paragraph [0309] and figure 6.	1-14
A	JP 2006-224201 A (DISCO ABRASIVE SYSTEMS LTD.) 31 August 2006 See paragraphs [0019]-[0021] and figures 3, 4.	1-15
A	EP 2047949 B1 (LAI, CHUN-CHEN) 21 March 2012 See paragraph [0016] and figures 4, 5.	1-15
A	US 2015-0259587 A1 (ROBERT BOSCH GMBH) 17 September 2015 See paragraphs [0326]-[0330] and figures A2a, A2b.	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2018 (28.09.2018)	**28 September 2018 (28.09.2018)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
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Facsimile No. +82-42-481-8578

Authorized officer
LEE, Se Gyoung
Telephone No. +82-42-481-8740

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2018/036386

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