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(54) Title: GRINDING RING WITH DUAL FUNCTION GRINDING SEGMENTS

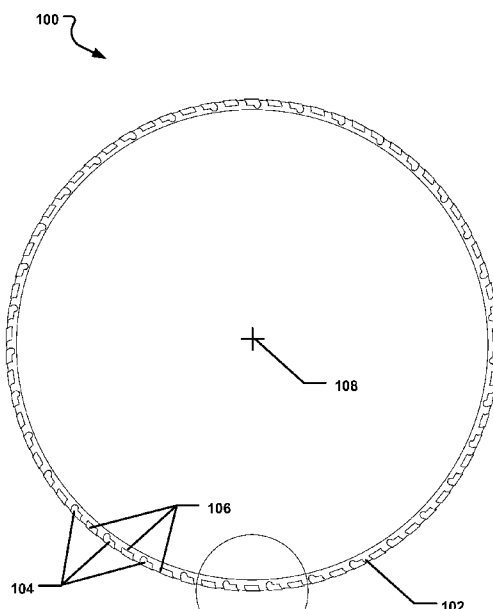


FIG. 1

(57) Abstract: An abrasive article is disclosed and can include a base. At least one dual function grinding segment can be mounted on the base. The dual function grinding segment can include a working surface having an average slope, S_{ws} , relative to a rotation plane and a finishing surface having an average slope relative to the plane rotation, S_{fs} , and wherein S_{ws} is greater than S_{fs} .

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GRINDING RING WITH DUAL FUNCTION GRINDING SEGMENTS

FIELD OF THE DISCLOSURE

The present disclosure is directed to a grinding ring comprising dual function
5 grinding segments, dual function grinding segments, and processes for grinding workpieces
using dual function grinding segments.

BACKGROUND

Certain construction materials, such as bricks, are formed with substantial
dimensional variations from brick-to-brick. In order to be properly assembled using modern
10 techniques that utilize adhesive foams and not mortar, each brick should undergo a grinding
operation in order to comply with dimensional tolerances. One grinding operation for
grinding the bricks includes passing the bricks through a grinding apparatus and grinding two
faces of the brick at the same time in order to reduce the size of the bricks. Typically, the
bricks are ground multiple times until the bricks are the appropriate size. A final grinding
15 operation can include including a finishing operation in which the faces of the brick are
lightly ground in order to make the faces of the bricks as smooth as possible.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments are illustrated by way of example and are not limited in the
accompanying figures.

20 FIG. 1 includes a plan view of a grinding ring that includes dual function abrasive
segments in accordance with a particular embodiment.

FIG. 2 includes a close up plan view of a grinding ring that includes dual function abrasive segments in accordance with a particular embodiment taken at Circle 2 of FIG. 1.

FIG. 3 includes a perspective view of a dual function abrasive segment in accordance with a particular embodiment.

5 FIG. 4 is a top plan view of a dual function abrasive segment in accordance with a particular embodiment.

FIG. 5 is a side plan view of a dual function abrasive segment in accordance with a particular embodiment.

FIG. 6 is a cross-sectional view of a grinding ring that includes dual function
10 abrasive segments in accordance with a particular embodiment take at Line 6-6 of FIG. 1.

FIG. 7 includes a perspective view of a dual function abrasive segment in accordance with a particular embodiment.

FIG. 8 is a top plan view of a dual function abrasive segment in accordance with a particular embodiment.

15 FIG. 9 is a side plan view of a dual function abrasive segment in accordance with a particular embodiment.

FIG. 10 is a plan view of a grinding apparatus in accordance with a particular embodiment.

FIG. 11 is an illustration of a prior art grinding operation using a prior art grinding
20 ring.

FIG. 12 is an illustration of a grinding operation using a grinding ring in accordance with a particular embodiment.

FIG. 13 is an illustration of a workpiece finished using prior art grinding rings.

FIG. 14 is an illustration of a workpiece finished using grinding rings 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 items.

DETAILED DESCRIPTION

The following description in combination with the figures is provided to assist in understanding the teachings disclosed herein. The following discussion will focus on specific implementations and embodiments of the teachings. This focus is provided to assist in describing the teachings and should not be interpreted as a limitation on the scope or applicability of the teachings.

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.

Referring initially to FIG. 1 and FIG. 2, an abrasive article, i.e., a grinding ring, is illustrated and is generally designated 100. As illustrated, the grinding ring 100 can include a base 102 and a plurality of grinding segments can be attached thereto. Specifically, the base 102 can include a ring having an annular shape that defines a central opening. A plurality of dual function grinding segments 104 and a plurality of single function grinding segments 106 are attached to the base 102. The ring-shaped base 102 can be made from a metal or metal allow. Further, the ring-shaped base 102 can be made from steel. The grinding segments 104, 106 can be brazed, or otherwise welded or affixed, to the ring. During use, the grinding ring 100 can rotate clockwise with respect to FIG. 1 around a rotation axis 108 extending perpendicular through FIG. 1. However, in another aspect, the grinding ring 100 can rotate counter-clockwise around the rotation axis 108.

In a particular aspect, the ring-shaped base 102 comprises an outer diameter of at least about 300 mm. Further, the outer diameter can be at least about 350 mm, at least about 400 mm, at least about 450 mm, at least about 550 mm, at least about 600 mm, at least about 650 mm, at least about 700 mm, or at least about 750 mm. In another aspect, the outer diameter may be no greater than about 1300 mm. For example, the outer diameter may be no greater than about 1250 mm, no greater than about 1200 mm, no greater than about 1150 mm, no greater than about 1100 mm, no greater than about 1050 mm, no greater than about 1000, no greater than about 950 mm, or no greater than 900 mm. The outer diameter can be within a range between and including any of the minimum and maximum diameter values described above.

In another aspect, the grinding ring 100 can include at least 30 grinding segments 104, 106 mounted on the base 102. Moreover, the grinding ring 100 can include 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 grinding segments 104, 106 mounted on the base 102. In another aspect, no greater than 120 grinding segments 104, 106 may be mounted on the base 102. Further, no greater than 115, no greater than 110, no greater than 105, no greater than 100, no greater than 95, no greater than 90, no greater than 85, no greater than 80, or no greater than 75 grinding segments 104, 106 may be mounted on the base 102. The number of grinding segments 104, 106 mounted on the base 102 can be within a range between and including any of the minimum and maximum numbers described above.

In another aspect, the grinding ring 102 can include a total number of grinding segments that is equal to a sum of the dual function grinding segments 104 and the single function grinding segments 106. Moreover, at least about 20% of the total can include the dual function grinding segments 104. In another aspect, at least about 25%, at least about

30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, at least about 80%, at least about 85%, at least about 90%, or at least about 95% of the total includes the dual function grinding segments 104. Further, about 100% of the total includes
5 the dual function grinding segments 104.

In a particular aspect, the dual function grinding segments 104 and the single function grinding segments 106 can be mounted on the base 102 in a repeated pattern. For example, a dual function grinding segment 104 can be mounted on the base 102 between each pair of adjacent single function grinding segments 106. Alternatively, a plurality of dual
10 function grinding segments 104 can be mounted on the base 102 between each pair of adjacent single function grinding segments 106. For example, two, three, four, or more dual function grinding segments 104 can be mounted on the base 102 between each pair of adjacent single function grinding segments 106.

In another aspect, a single function grinding segment 106 can be mounted on the
15 base 102 between each pair of adjacent dual function grinding segments 104. Moreover, a plurality of single function grinding segments 106 can be mounted on the base 102 between each pair of adjacent dual function grinding segments 104. For example, two, three, four, or more single function grinding segments 106 can be mounted on the base 102 between each pair of adjacent dual function grinding segments 104.

20 Referring to FIG. 3 through FIG. 5, details concerning the dual function grinding segment 104 are illustrated. FIG. 3 through FIG. 5 indicate that the dual function grinding segment 104 can include a body 302 that includes a working portion 304 and a finishing portion 306 (for clarity, the approximate boundary between the working portion 304 and the finishing portion 306 is indicated by the dashed line in FIG. 3).

In a particular embodiment, the working portion 304 and the finishing portion 306 may be formed integrally with each other, e.g., using a molding operation, an extrusion operation, a pressing operation, a stamping operation, or some other forming operation. However, in another aspect, the working portion 304 and the finishing portion 306 can be
5 formed separately and then, joined using a chemical adhesive, a mechanical adhesive, an arc welding operation, an oxyfuel gas welding operation, a resistance welding operation, a solid state welding operation, or some other welding operation.

In accordance with an embodiment, the body 302 of the grinding segment 104 can include abrasive grains contained within a matrix material. Notably, the grinding segment
10 104 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 about 4, such as at least about 5, at least about 6, or even at least about 7. In particular instances, the abrasive grains can include a superabrasive material, such as diamond, cubic boron nitride, or a combination thereof. In
15 one embodiment, the abrasive grains consist essentially of diamond.

In certain embodiments, 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.

20 The matrix material of the grinding 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.

In certain embodiments, the grinding segment 104 can be an infiltrated bonded abrasive article. In such instances, the grinding segment 104 can include abrasive grains contained within a metal matrix, wherein the grinding segment 104 further includes an interconnected network of pores, which can be filled with an infiltrant material. The metal
 5 matrix can include a metal element or metal alloy including a plurality of metal elements.

As noted above, the grinding segment 104 can be formed such that an infiltrant is present within the interconnected network of pores within the body 302 of the grinding segment 104. The infiltrant can partially fill, substantially fill, or even completely fill the volume of the pores extending through the volume of the grinding segment 104. In
 10 accordance with one particular design, the infiltrant can be a metal or metal alloy material.

As illustrated in FIG. 3 through FIG. 5, the working portion 304 of the body 302 of the dual function grinding segment 104 can include a working surface 308. The finishing portion 306 of the body 302 can include a finishing surface 310. The finishing surface 310 can be formed contiguously with the working surface 308 and the finishing surface 310 can
 15 extend from the working surface 308.

The working surface 308 can include an average slope, S_{ws} , relative to a rotation plane. The finishing surface 310 can include an average slope relative to the plane rotation, S_{FS} , and wherein S_{ws} can be greater than S_{FS} - S_{ws} can be at least greater than about $2 \times S_{FS}$ - Further, S_{ws} can be at least greater than about $3 \times S_{FS}$, at least greater than about $4 \times S_{FS}$, at
 20 least greater than about $5 \times S_{FS}$, or at least greater than about $10 \times S_{FS}$ - However, S_{ws} can be less than about $25 \times S_{FS}$, less than about $20 \times S_{FS}$, or less than about $15 \times S_{FS}$ -

Moreover, the finishing surface 310 can be formed at a reflect angle 312 with respect to the working surface 308. In a particular aspect, the reflex angle 312 can be at least

about 185°. Further, the angle can be at least about 186°, at least about 187°, at least about 188°, at least about 189°, at least about 190°, at least about 191°, at least about 191°, at least about 192°, at least about 192°, at least about 193°, or at least about 194°. Moreover, the angle 312 may not be not greater than about 210°, not greater than about 205°, not greater than about 200°, not greater than about 199°, not greater than about 198°, not greater than about 197°, not greater than about 196°, or not greater than about 195°. The angle 312 may be within a range between and including any of minimum and maximum angle values described above.

In another aspect, the working surface 308 can include a working surface area and the finishing surface 310 can include a finishing surface area. The finishing surface area can be less than the working surface area. For example, the finishing surface area can be less than about 60% of the working surface area. In another aspect, the finishing surface area can be less than about 55% of the working surface area, less than about 50% of the working surface area, less than about 45% of the working surface area, or less than about 40% of the working surface area. Further, the finishing surface area can be greater than about 20% of the working surface area, greater than about 25% of the working surface area, greater than about 30% of the working surface area, or greater than about 35% of the working surface area. The finishing surface area can be within a range between and including any of the minimum and maximum percentage values described above.

The working portion 308 of the body 302 of the dual function grinding segment 104 can include a working volume. Also, the finishing portion of the body 302 of the dual function grinding segment 104 can include a finishing volume. In one aspect, the finishing volume can be less than the working volume. For example, the finishing volume is less than about 60% of the working volume. In another aspect, the finishing volume can be less than

about 55% of the working volume, less than about 50% of the working volume, less than about 45% of the working volume, or less than about 40% of the working volume. Further, the finishing volume can be greater than about 20% of the working volume, greater than about 25% of the working volume, greater than about 30% of the working volume, or greater than about 35% of the working volume. The finishing volume can be within a range between and including any of the minimum and maximum percentage values described above.

In another aspect, the finishing volume can include a first plurality of abrasive grains that can include a first average grain size. The working volume can a second plurality of abrasive grains that can have a second average grain size. The first average grain size can be substantially the same as the second average grain size.

However, in yet another aspect, the first average grain size can be less than the second average grain size. For example, the first average grain size can be less than about 80% of the second average grain size, less than about 75% of the second average grain size, less than about 70% of the second average grain size, less than about 65% of the second average grain size, less than about 60% of the second average grain size, less than about 55% of the second average grain size, less than about 50% of the second average grain size, less than about 45% of the second average grain size, or less than about 40% of the second average grain size. Moreover, the first average grain size is greater than about 20% of the second average grain size, greater than about 25% of the second average grain size, greater than about 30% of the second average grain size, or greater than about 35% of the second average grain size. The first average grain size can be within a range between and including any of the minimum and maximum percentage values described above.

In another aspect, the finishing volume can include a first binder material that can include a first binder hardness. The working volume can include a second binder material

that can include a second binder hardness. In one embodiment, the first binder hardness can be substantially the same as the second binder hardness.

In another embodiment, the first binder hardness can be less than the second binder hardness. For example, the first binder hardness can be less than about 80%, less than about 75%, less than about 70%, less than about 65%, less than about 60%, less than about 55%, less than about 50%, less than about 45%, or less than about 40% of the second binder hardness. Also, the first binder hardness may be greater than about 20%, greater than about 25%, greater than about 30%, or greater than about 35% of the second binder hardness. The first binder hardness can be within a range between and including any of the minimum and maximum percentage values described above.

In yet another embodiment, the second binder hardness can be less than the first binder hardness. For example, the second binder hardness can be less than about 80%, less than about 75%, less than about 70%, less than about 65%, less than about 60%, less than about 55%, less than about 50%, less than about 45%, or less than about 40% of the first binder hardness. Moreover, the second binder hardness can be greater than about 20%, greater than about 25%, greater than about 30%, or greater than about 35% of the first binder hardness. The second binder hardness can be within a range between and including any of the minimum and maximum percentage values described above.

As indicated in FIG. 4, the working portion 304 of the dual function grinding segment 104 can include a leading face 320 and a trailing face 322 connected to each other by an external face 324 (with respect to placement on and rotation of the grinding ring 102). Each face 320, 322, can include a first portion 326 that forms a face angle 327 with respect to the external face 324 and a second portion 328 extending from the first portion 326 in a direction that is substantially perpendicular to the external face 324.

The angle 327 can be at least 55° degrees. For example, the face angle can be at least 56° degrees, at least 57° degrees, at least 58° degrees, at least 59° degrees, or at least 60° degrees. In another aspect, the face angle may be no greater than about 65°, no greater than about 64°, no greater than about 63°, no greater than about 62°, or no greater than about 61°.

- 5 The face angle can be within a range between and including any of the minimum and maximum angle values described above.

The finishing portion 306 can be generally semi-cylindrical in shape and can include a rounded face 330 that extends between the second portion 328 of the leading face 320 and an internal face 332 that is parallel to the external face 324.

- 10 The working portion 304 can include a width as measured from external face 324 to the internal face 332 of at least about 8 mm. For example, the width can be at least about 9 mm, at least about 10 mm, at least about 11 mm, or at least about 12 mm. Moreover, the width may be no greater than about 20 mm, no greater than about 19 mm, no greater than about 18 mm, no greater than about 17 mm, no greater than about 16 mm, or no greater than about 15 mm. The width can be within a range between and including any of the minimum and maximum width values described above.

- 20 The finishing portion 306 can have a radius of at least 3 mm. For example, the radius can be at least 3.5 mm, at least 4 mm, at least 4.5 mm, at least 5 mm, or at least 5.5 mm. In another aspect, the radius may be no greater than 7.5 mm, no greater than 7.0 mm, no greater than 6.5 mm, or no greater than 6.0 mm. The radius can be within a range between and including any of the minimum and maximum radius values described above.

The body 302 of the dual function grinding segment 104 can have an overall height of at least 15 mm as measured from a bottom surface to the working surface 308. For

example the overall height can be 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 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, or no greater than about 25 mm. The overall height can be within a range between and including any of the minimum and maximum overall height values described above.

In another aspect, the body 302 of the dual function grinding segment 104 can have an overall length of at least 15 mm. For example the overall length can be 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 length 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, or no greater than about 25 mm. The overall length can be within a range between and including any of the minimum and maximum overall length values described above.

FIG. 6 illustrates a cross-section view of the grinding ring 100 taken along line 6-6 in FIG. 1. As previously described, the grinding ring 100 may rotate around the rotation axis 108 (FIG. 1). With respect to FIG. 6, the grinding ring 100 would rotate such that the ring 102 and the dual function grinding segment 104 would move into (or out of) FIG. 6. A workpiece 602 can move in a direction along a working axis 604 so that the workpiece 602 is abraded by the grinding ring 100 as it rotates. In a particular aspect, the working axis 604 is substantially perpendicular to the rotation axis 108.

As depicted in FIG. 6, the working surface 308 can define a working angle 606 with respect to the working axis 604. The finishing surface 310 can define a finishing angle 608 with respect to the working axis 604. In a particular aspect, the finishing angle 608 can be less than the working angle 606. For example, the finishing angle 608 can be less than

about 10% of the working angle 606. Further, the finishing angle 608 can be less than about 9%, less than about 8%, less than about 7%, less than about 6%, or less than about 5% of the working angle 606. In another aspect, the finishing angle 608 can be greater than about 0.5% of the working angle 606. The finishing angle 608 can be greater than about 1.0%, greater
5 than about 1.5%, greater than about 2.0%, greater than about 2.5%, or greater than about 3.0% of the working angle 206. The finishing angle 608 can be within a range between and including any of the minimum and maximum percentage values described above.

In another aspect, the working angle 606 can be at least about 8°. Further, the working angle 606 can be at least about 9°, at least about 10°, at least about 11°, at least
10 about 12°, or at least about 13°. The working angle 606 may be no greater than 20°, no greater than 19°, no greater than 18°, no greater than 17°, no greater than 16°, or no 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.

The finishing angle 608 can be at least about 0.08°. Further, the finishing angle
15 608 can be at least about 0.1°, at least about 0.25°, or at least about 0.5°. In another aspect, the finishing angle 608 may be no greater than 2.0°, no greater than 1.75°, no greater than 1.5°, no greater than 1.0°, or no greater than 0.75°. The finishing angle 608 can be within a range between and including any of the minimum and maximum angle values described above.

20 As indicated in FIG. 6, during operation the working surface 308 can remove a first portion of material 610 from the workpiece 602 at a particular working grinding depth. Further, the finishing surface 310 can remove a second portion of material 612 from the workpiece 602 at a particular finishing grinding depth. As illustrated, the finishing grinding depth is less than the working grinding depth.

In particular, the finishing grinding depth is less than about 10% of the working grinding depth. Further, the finishing grinding depth is less than about 9%, less than about 8%, less than about 7%, less than about 6%, or less than about 5% of the working grinding depth. In another aspect, the finishing grinding depth is greater than about 1.0% of the working grinding depth. For example, finishing grinding depth is greater than about 1.5%, greater than about 2.0%, greater than about 2.5%, greater than about 3.0%, or greater than about 3.5% of the working grinding depth. The finishing grinding depth can be within a range between and including any of the minimum and maximum angle values described above.

In another aspect, the working grinding depth can be at least about 1.0 mm. Further, the working grinding depth can be at least about 1.5 mm, at least about 2.0 mm, at least about 2.5 mm, or at least about 3.0 mm. The working grinding depth may be no greater than about 5.0 mm, no greater than about 4.5 mm, no greater than about 4.0 mm, or no greater than about 3.5mm.

The finishing grinding depth can be at least about 0.01 mm. For example, the finishing grinding depth can be at least about 0.025 mm, at least about 0.05 mm, at least about 0.075 mm, or at least about 0.1 mm. Further, the finishing grinding depth may be no greater than about 0.5 mm, no greater than about 0.4 mm, no greater than about 0.3mm, or no greater than about 0.25 mm.

During operation, the finishing surface 310 can finish a surface of a workpiece, e.g., a brick, to a surface roughness of less than about 0.1 mm. Further, the surface roughness after the grinding operation using the dual function grinding segment 104 is performed can be less than about 0.09 mm, less than about 0.08 mm, less than about 0.07 mm, less than about 0.06 mm, or less than about 0.05 mm. The surface roughness may be greater than about 0.01

mm, greater than about 0.02 mm, or greater than about 0.03 mm. The surface roughness can be within a range between and including any of the surface roughness values described above.

Referring to FIG. 7 through FIG. 9, another embodiment of a dual function grinding segment is illustrated and is generally designated 700. FIG. 7 through FIG. 9 indicate that the dual function grinding segment 700 can include a body 702 that includes a working portion 704 and a finishing portion 706 (for clarity, the approximate boundary between the working portion 704 and the finishing portion 706 is indicated by the dashed line in FIG. 7).

As illustrated in FIG. 7 through FIG. 9, the working portion 704 of the body 702 of the dual function grinding segment 700 can include a working surface 708. The finishing portion 706 of the body 702 can include a finishing surface 710. The finishing surface 710 can be formed contiguously with the working surface 708 and the finishing surface 710 can extend from the working surface 708. Moreover, the finishing surface 710 can be formed at an angle 712 with respect to the working surface 708. The angle 712 can be essentially the same as the angle 312 described above.

In another aspect, the working surface 708 can include a working surface area and the finishing surface 710 can include a finishing surface area. The working portion 708 of the body 702 of the dual function grinding segment 104 can include a working volume. Also, the finishing portion of the body 702 of the dual function grinding segment 104 can include a finishing volume.

As indicated in FIG. 8, the working portion 704 of the dual function grinding segment 700 can include a leading face 720 and a trailing face 722 connected to each other

by an external face 724 (with respect to placement on and rotation of the grinding ring 102). Each face 720, 722, can include a first portion 726 that is angled with respect to the external face 724 at an angle 727. The angle 727 can be substantially the same as the angle 327 described above in conjunction with FIG. 3 through FIG. 5.

5 The trailing face 722 can a second portion 728 extending from the first portion 726 in a direction that is perpendicular to the external face 724. The leading face 720 can include a second portion 730 extending from the first portion 726 at an angle with respect the external face 724 to form a generally wedge shape having a wedge angle 731, as illustrated.

 The wedge angle can be at least about 130°. For example, the wedge angle can be
10 at least about 131°, at least about 132°, at least about 133°, at least about 134°, at least about 135°, at least about 136°, or at least about 137°. Moreover, the wedge angle may be no greater than about 145°. Further, the wedge angle may be no greater than about 144°, no greater than about 143°, no greater than about 142°, no greater than about 141°, or no greater than about 140°. The wedge angle can be within a range between and including any of the
15 minimum or maximum wedge angle values described above.

 The finishing portion 706 of the grinding segment 700 can have a truncated semi-cylindrical shape with a portion remove therefrom longitudinally. The finishing portion 706 can include a rounded face 732 that can extend from the second portion 730 of the leading face 720 to an internal face 734 that is parallel to the external face 724.

20 The grinding segment 700 can include the same characteristics as the grinding segment 104 described herein, e.g., matrix material, abrasive grains, overall dimensions (height, width, length), radius, percentage values, etc.

FIG. 10 illustrates a grinding apparatus 1000. The grinding apparatus 1000 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
5 grinding ring 1014 can include a grinding ring according to one or more embodiments described herein. As depicted in FIG. 10, the grinding rings 1014 are space apart from each other so that a working space 1016 is established there between. 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
10 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. The grinding rings 1014, with the aid of dual function grinding segments constructed in accordance with one or more embodiments described herein, can perform a working
15 operation to remove a first portion of the brick face at a working grinding depth, described herein, from each respective face in contact therewith.

Immediately thereafter, without moving to another set of grinders having another set of grinding rings, a finishing operation can be performed to remove a second portion of the brick face at a finishing grinding depth, as described herein. Accordingly, two faces of a
20 brick can be ground and finished in a single pass within a single grinding apparatus between two grinding rings 1014.

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,

wherein a working distance between the grinding rings varies as the construction block moves through the space. The working distance can be measured between the faces of the grinding segments and with the angled surfaces described herein, the working distance decreases from a periphery of the grinding rings toward an axis of rotation of the grinding rings. Further, 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. The grinding rings can be configured in accordance with an embodiment herein so that during operation a working distance between the first grinding ring and the second grinding varies, e.g., so that the working distance decreases from a periphery of the grinding rings toward an axis of rotation of the grinding rings.

In another particular aspect, other abrasive characteristics between the working portion and the finishing portion of each dual function segment can vary. For example, an amount of abrasive content can vary such that the working portion includes a higher concentration of abrasive content or a lower abrasive content than the finishing portion. Further, porosity can vary so that one portion or the other has a porosity that is more or less than the other.

EXAMPLES

Two test abrasive articles are constructed as a pair. Each test abrasive article includes 70 grinding segments disposed on a steel ring having a diameter of 750mm. 35 of the grinding segments are dual function grinding segments constructed in accordance with the first embodiment described herein. Specifically, each dual function grinding segment is 22 mm tall and has an overall length of 24 mm. Further, the working portion of the dual function grinding segment includes a working width of 10 mm (measured from external surface to internal surface of the working portion). The finishing portion of the dual function

grinding segment includes a radius of 5.5 mm. Further, the finishing surface is formed at an angle of 193° with respect to the working surface. The dual function grinding segment is mounted on the steel ring so that that the working surface forms a working angle with respect to a working axis of approximately 14° and the finishing surface forms a finishing angle with respect to the working axis of approximately 1° . 35 of the grinding segments are single function grinding segments and include the same shape and dimensions as the working portion of the dual function grinding segment described above.

Two comparison abrasive articles are provided as a matched pair and each includes 70 standard single function grinding segments having essentially the same dimensions as the single function grinding segments on each test abrasive article. Each grinding segment on the test abrasive articles and the comparison abrasive articles include the same size abrasive grains dispersed within the same binder at the same concentration.

Grinding is performed on similarly constructed bricks using similarly constructed grinding apparatuses. Bricks are fed at a rate of 10 m/min and 20 m/min.

FIG. 11 depicts a grinding operation being performed on a brick using the comparison abrasive articles (FIG. 11 illustrates one of the pair). FIG. 12 depicts a grinding operation being performed on a brick using the test abrasive articles (FIG. 12 illustrates one of the pair). The heat generated by the test abrasive article is only slightly higher than the heat generated by the comparison abrasive article (as indicated by the orange in the image captured by an endoscopic camera) while the amount of material removed by the test abrasive article is greater than the amount of brick material removed by the comparison abrasive article.

FIG. 13 depicts a first brick after being ground using the comparison abrasive articles. FIG. 14 depicts a second brick after being ground using the test abrasive articles. Clearly, as shown in the images, the first brick includes a surface roughness substantially greater than the surface roughness exhibited by the second brick. In fact, when measured, the
5 first brick includes a surface roughness of approximately 0.5 mm. The second brick includes a surface roughness of approximately 0.05 mm.

With the configuration described herein the abrasive article that includes the dual function grinding segments can be used to perform a working grinding operation and a finishing grinding operation within a single grinding apparatus using a single pair of abrasive
10 articles (e.g., grinding rings). As such, the need for additional equipment and tooling 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
15 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
20 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
5 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
10 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
15 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;
at least one dual function grinding segment mounted on the base, wherein the dual
function grinding segment includes a working surface having an average slope,
 S_{ws} , relative to a rotation plane and a finishing surface having an average slope
relative to the plane rotation, S_{FS} , and wherein S_{ws} is greater than S_{FS} -
2. The abrasive article of claim 1, wherein S_{ws} is at least greater than about $2 \times S_{FS}$ -
3. The abrasive article of claim 2, wherein S_{ws} is at least greater than about $3 \times S_{FS}$,
at least greater than about $4 \times S_{FS}$, at least greater than about $5 \times S_{FS}$, or at least greater
than about $10 \times S_{FS}$.
4. The abrasive article of claim 3, wherein S_{ws} is less than about $25 \times S_{FS}$, less than
about $20 \times S_{FS}$, or less than about $15 \times S_{FS}$.
5. The abrasive article of claim 1, wherein the working surface is formed at an angle
with the finishing surface at an angle of at least about 185° .
6. The abrasive article of claim 5, wherein the angle is at least about 186° , at least
about 187° , at least about 188° , at least about 189° , at least about 190° , at least about

191°, at least about 191°, at least about 192°, at least about 192°, at least about 193°, or at least about 194°.

7. The abrasive article of claim 6, wherein the angle is not greater than about 210°, not greater than about 205°, not greater than about 200°, not greater than about 199°, not greater than about 198°, not greater than about 197°, not greater than about 196°, or not greater than about 195°.

8. The abrasive article of claim 1, wherein the dual function grinding segment further comprises a working surface area and a finishing surface area and the finishing surface area is less than the working surface area.

9. The abrasive article of claim 8, wherein the finishing surface area is less than about 60% of the working surface area.

10. The abrasive article of claim 1, wherein the dual function grinding segment comprises a working volume and a finishing volume and the finishing volume is less than the working volume.

11. The abrasive article of claim 1, wherein the base comprises a metal or a metal alloy.

12. The abrasive article of claim 11, wherein the base comprises steel.

13. The abrasive article of claim 1, wherein the base comprises an outer diameter of at least about 500 mm.

14. The abrasive article of claim 13, wherein the outer diameter is at least about 550 mm, at least about 600 mm, at least about 650 mm, at least about 700 mm, or at least about 750 mm.

15. The abrasive article of claim 14, wherein the outer diameter is no greater than about 1200 mm, no greater than about 1150 mm, no greater than about 1100 mm, no greater than about 1050 mm, no greater than about 1000, no greater than about 950 mm, or no greater than 900 mm.

16. The abrasive article of claim 1, further comprising at least 50 grinding segments mounted on the base.

17. The abrasive article of claim 16, further comprising at least 60, at least 70, at least 80, at least 90, or at least 100 grinding segments mounted on the base.

18. The abrasive article of claim 17, further comprising no greater than 200 grinding segments mounted on the base.

19. The abrasive article of claim 17, further comprising no greater than 190, no greater than 180, no greater than 170, no greater than 160, or no greater than 150 grinding segments mounted on the base.

20. The abrasive article of claim 1, further comprising a plurality of dual function grinding segments mounted on the base and a plurality of single function grinding segments mounted on the base.

21. The abrasive article of claim 20, further comprising a total number of grinding segments equal to a sum of the dual function grinding segments and the single function grinding segments, wherein at least about 20% of the total includes the dual function grinding segments.

22. The abrasive article of claim 21, wherein at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, at least about 50%, at least about 55%, at least about 60%, at least about 65%, at least about 70%, at least about 75%, at least about 80%, at least about 85%, at least about 90%, or at least about 95% of the total includes the dual function grinding segments.

23. The abrasive article of claim 22, wherein about 100% of the total includes the dual function grinding segments.

24. The abrasive article of claim 20, wherein the dual function grinding segments and the single function grinding segments are mounted on the base in a repeated pattern.

25. The abrasive article of claim 24, wherein a dual function grinding segment is mounted on the base between each pair of adjacent single function grinding segments.

26. The abrasive article of claim 24, wherein a plurality of dual function grinding segments are mounted on the base between each pair of adjacent single function grinding segments.

27. The abrasive article of claim 24, wherein a single function grinding segment is mounted on the base between each pair of adjacent dual function grinding segments.

28. The abrasive article of claim 24, wherein a plurality of single function grinding segments are mounted on the base between each pair of adjacent dual function grinding segments.

29. The abrasive article of claim 1, further comprising:
a rotation axis around which the abrasive article rotates during use; and
a working axis along a direction in which a workpiece is moved relative to the abrasive article during use;
wherein the working axis is substantially perpendicular to the rotation axis;

wherein the working surface defines a working angle with respect to the working axis;

wherein the finishing surface defines a finishing angle with respect to the working axis; and

wherein the finishing angle is less than the working angle.

30. The abrasive article of claim 29, wherein the finishing angle is less than about 10% of the working angle.

31. The abrasive article of claim 30, wherein the finishing angle is less than about 9%, less than about 8%, less than about 7%, less than about 6%, or less than about 5% of the working angle.

32. The abrasive article of claim 31, wherein the finishing angle is greater than about 0.5% of the working angle.

33. The abrasive article of claim 32, wherein the finishing angle is greater than about 1.0%, greater than about 1.5%, greater than about 2.0%, greater than about 2.5%, or greater than about 3.0% of the working angle.

34. The abrasive article of claim 1, wherein the finishing surface comprises a finishing grinding depth and the working surface comprises a working grinding depth and wherein the finishing grinding depth is less than the working grinding depth.

35. The abrasive article of claim 34, wherein the finishing grinding depth is less than about 10% of the working grinding depth.

36. The abrasive article of claim 35, wherein the finishing grinding depth is less than about 9%, less than about 8%, less than about 7%, less than about 6%, or less than about 5% of the working grinding depth.

37. The abrasive article of claim 35, wherein the finishing grinding depth is greater than about 1.0% of the working grinding depth.

38. The abrasive article of claim 37, wherein the finishing grinding depth is greater than about 1.5%, greater than about 2.0%, greater than about 2.5%, greater than about 3.0%, or greater than about 3.5% of the working grinding depth.

39. A dual function grinding segment, comprising:
a body, wherein the body comprises:
a working surface;
a finishing surface adjacent to the working surface, wherein a first line tangential to the finishing surface is formed at a reflex angle with respect to a second line tangential the working surface.

40. The grinding segment of claim 39, wherein the angle is at least about 185°.

41. The grinding segment of claim 40, wherein the angle is at least about 186°, at least about 187°, at least about 188°, at least about 189°, at least about 190°, at least about 191°, at least about 191°, at least about 192°, at least about 192°, at least about 193°, or at least about 194°.

42. The grinding segment of claim 41, wherein the angle is not greater than about 210°, not greater than about 205°, not greater than about 200°, not greater than about 199°, not greater than about 198°, not greater than about 197°, not greater than about 196°, or not greater than about 195°.

43. The grinding segment of claim 39, wherein the body further comprises a working surface area and a finishing surface area and the finishing surface area is less than the working surface area.

44. The grinding segment of claim 34, wherein the finishing surface area is less than about 60% of the working surface area.

45. The grinding segment of claim 9 or claim 44, wherein the finishing surface area is less than about 55% of the working surface area, less than about 50% of the working surface area, less than about 45% of the working surface area, or less than about 40% of the working surface area.

46. The grinding segment of claim 45, wherein the finishing surface area is greater than about 20% of the working surface area, greater than about 25% of the working surface area, greater than about 30% of the working surface area, or greater than about 35% of the working surface area.

47. The grinding segment of claim 39, wherein the body further comprises a working volume and a finishing volume and the finishing volume is less than the working volume.

48. The grinding segment of claim 10 or claim 47, wherein the finishing volume is less than about 60% of the working volume.

49. The grinding segment of claim 48, wherein the finishing volume is less than about 55% of the working volume, less than about 50% of the working volume, less than about 45% of the working volume, or less than about 40% of the working volume.

50. The grinding segment of claim 49, wherein the finishing volume is greater than about 20% of the working volume, greater than about 25% of the working volume, greater than about 30% of the working volume, or greater than about 35% of the working volume.

51. The grinding segment of claim 10 or claim 47, wherein the finishing volume comprises a first plurality of abrasive grains having a first average grain size and the working volume comprises a second plurality of abrasive grains having a second average

grain size and the first average grain size is substantially the same as the second average grain size.

52. The grinding segment of claim 51, wherein the first average grain size is less than the second average grain size.

53. The grinding segment of claim 52, wherein the first average grain size is less than about 80% of the second average grain size, less than about 75% of the second average grain size, less than about 70% of the second average grain size, less than about 65% of the second average grain size, less than about 60% of the second average grain size, less than about 55% of the second average grain size, less than about 50% of the second average grain size, less than about 45% of the second average grain size, or less than about 40% of the second average grain size.

54. The grinding segment of claim 53, wherein the first average grain size is greater than about 20% of the second average grain size, greater than about 25% of the second average grain size, greater than about 30% of the second average grain size, or greater than about 35% of the second average grain size.

55. The grinding segment of claim 10 or claim 47, wherein the finishing volume comprises a first binder material having a first binder hardness and the working volume comprises a second binder material having a second binder hardness and the first binder hardness is substantially the same as the second binder hardness.

56. The grinding segment of claim 55, wherein the first binder hardness is less than the second binder hardness.

57. The grinding segment of claim 56, wherein the first binder hardness is less than about 80%, less than about 75%, less than about 70%, less than about 65%, less than about 60%, less than about 55%, less than about 50%, less than about 45%, or less than about 40% of the second binder hardness.

58. The grinding segment of claim 57, wherein the first binder hardness is greater than about 20%, greater than about 25%, greater than about 30%, or greater than about 35% of the second binder hardness.

59. The grinding segment of claim 55, wherein the second binder hardness is less than the first binder hardness.

60. The grinding segment of claim 59, wherein the second binder hardness is less than about 80%, less than about 75%, less than about 70%, less than about 65%, less than about 60%, less than about 55%, less than about 50%, less than about 45%, or less than about 40% of the first binder hardness.

61. The grinding segment of claim 60, wherein the second binder hardness is greater than about 20%, greater than about 25%, greater than about 30%, or greater than about 35% of the first binder hardness.

62. The grinding segment of claim 39, further comprising:
a rotation axis around which the grinding segment rotates during use; and
a working axis along a direction in which a workpiece is moved relative to the grinding segment during use;
wherein the working axis is substantially perpendicular to the rotation axis;
wherein the working surface defines a working angle with respect to the working axis;
wherein the finishing surface defines a finishing angle with respect to the working axis; and
wherein the finishing angle is less than the working angle.

63. The grinding segment of claim 62, wherein the finishing angle is less than about 10% of the working angle.

64. The grinding segment of claim 63, wherein the finishing angle is less than about 9%, less than about 8%, less than about 7%, less than about 6%, or less than about 5% of the working angle.

65. The grinding segment of claim 64, wherein the finishing angle is greater than about 0.5% of the working angle.

66. The grinding segment of claim 65, wherein the finishing angle is greater than about 1.0%, greater than about 1.5%, greater than about 2.0%, greater than about 2.5%, or greater than about 3.0% of the working angle.

67. The grinding segment of claim 39, wherein the finishing surface comprises a finishing grinding depth and the working surface comprises a working grinding depth and wherein the finishing grinding depth is less than the working grinding depth.

68. The grinding segment of claim 67, wherein the finishing grinding depth is less than about 10% of the working grinding depth.

69. The grinding segment of claim 68, wherein the finishing grinding depth is less than about 9%, less than about 8%, less than about 7%, less than about 6%, or less than about 5% of the working grinding depth.

70. The grinding segment of claim 68, wherein the finishing grinding depth is greater than about 1.0% of the working grinding depth.

71. The grinding segment of claim 69, wherein the finishing grinding depth is greater than about 1.5%, greater than about 2.0%, greater than about 2.5%, greater than about 3.0%, or greater than about 3.5% of the working grinding depth.

72. A method for changing an overall size of a construction block, the method comprising:

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, wherein a working distance between the grinding rings varies as the construction block moves through the space.

73. The method of claim 72, wherein the working distance decreases from a periphery of the grinding rings toward an axis of rotation of the grinding rings.

74. A grinding system, the system comprising:

a first grinding ring; and

a second grinding ring parallel to the first grinding ring, wherein during operation a working distance between the first grinding ring and the second grinding varies.

75. The system of claim 74, wherein the working distance decreases from a periphery of the grinding rings toward an axis of rotation of the grinding rings.

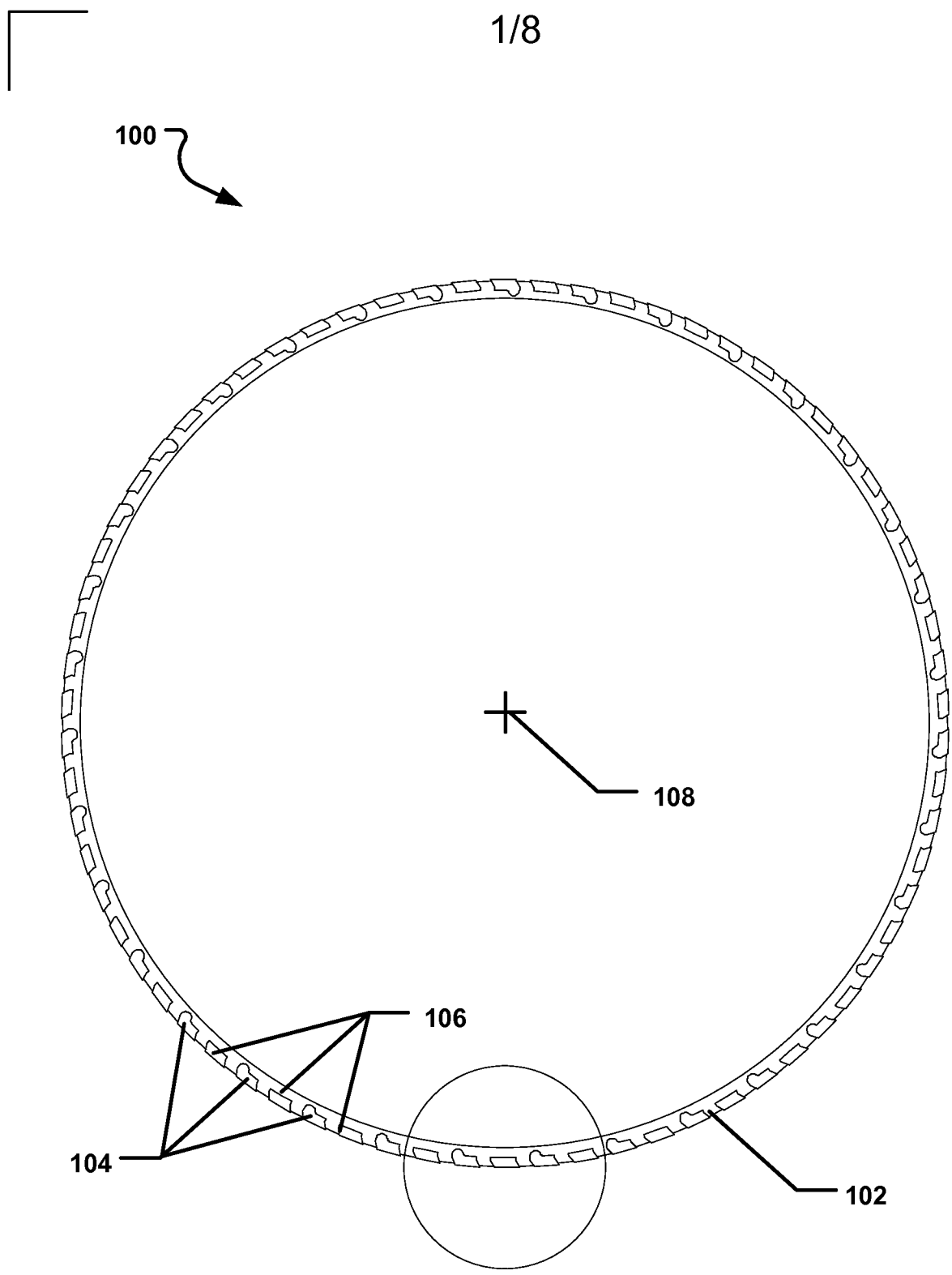


FIG. 1

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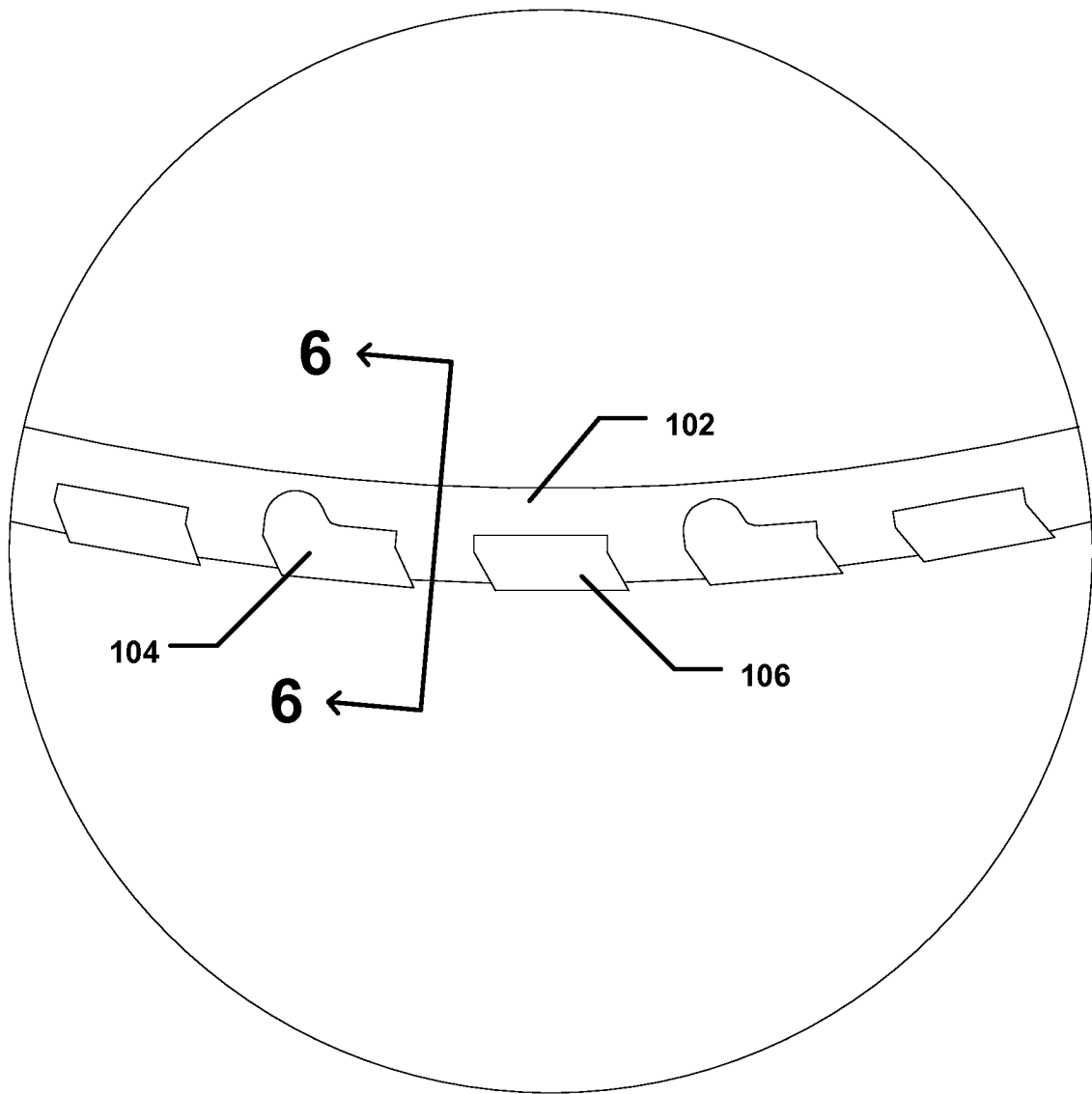
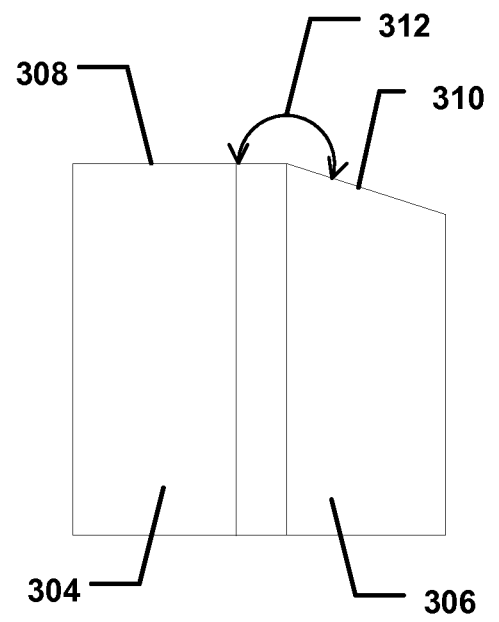
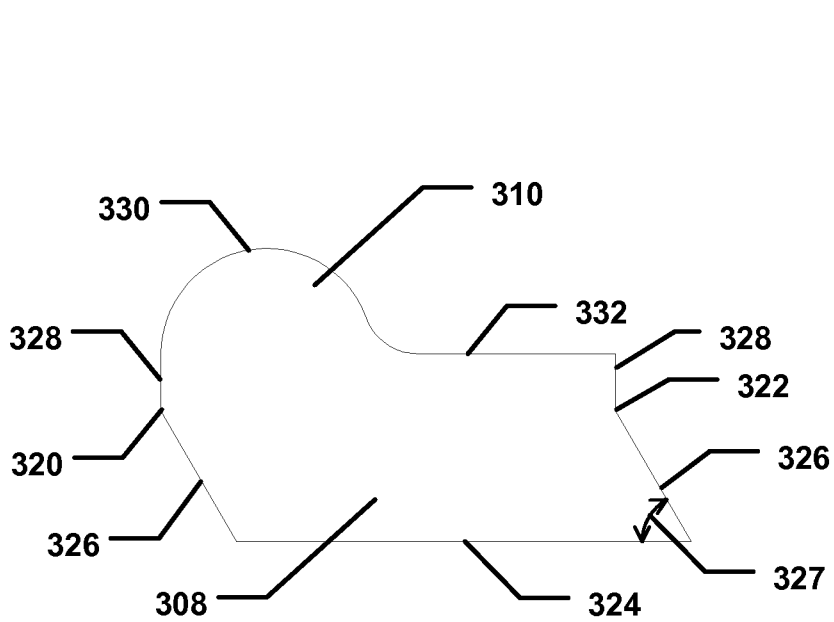
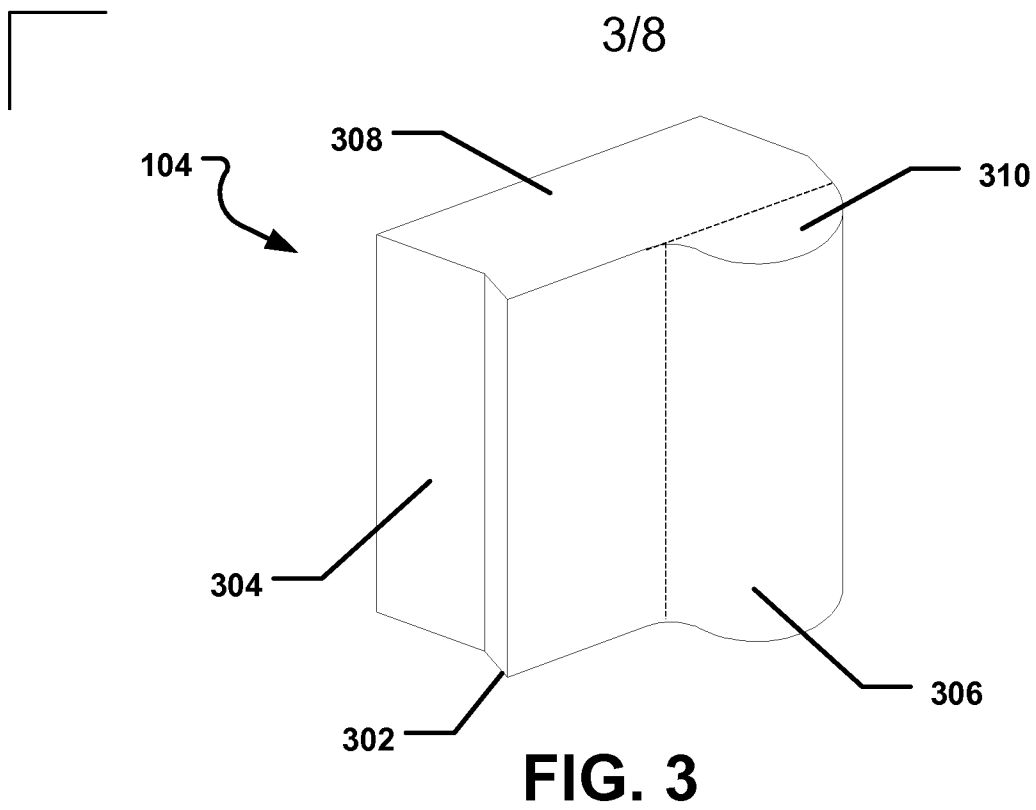


FIG. 2



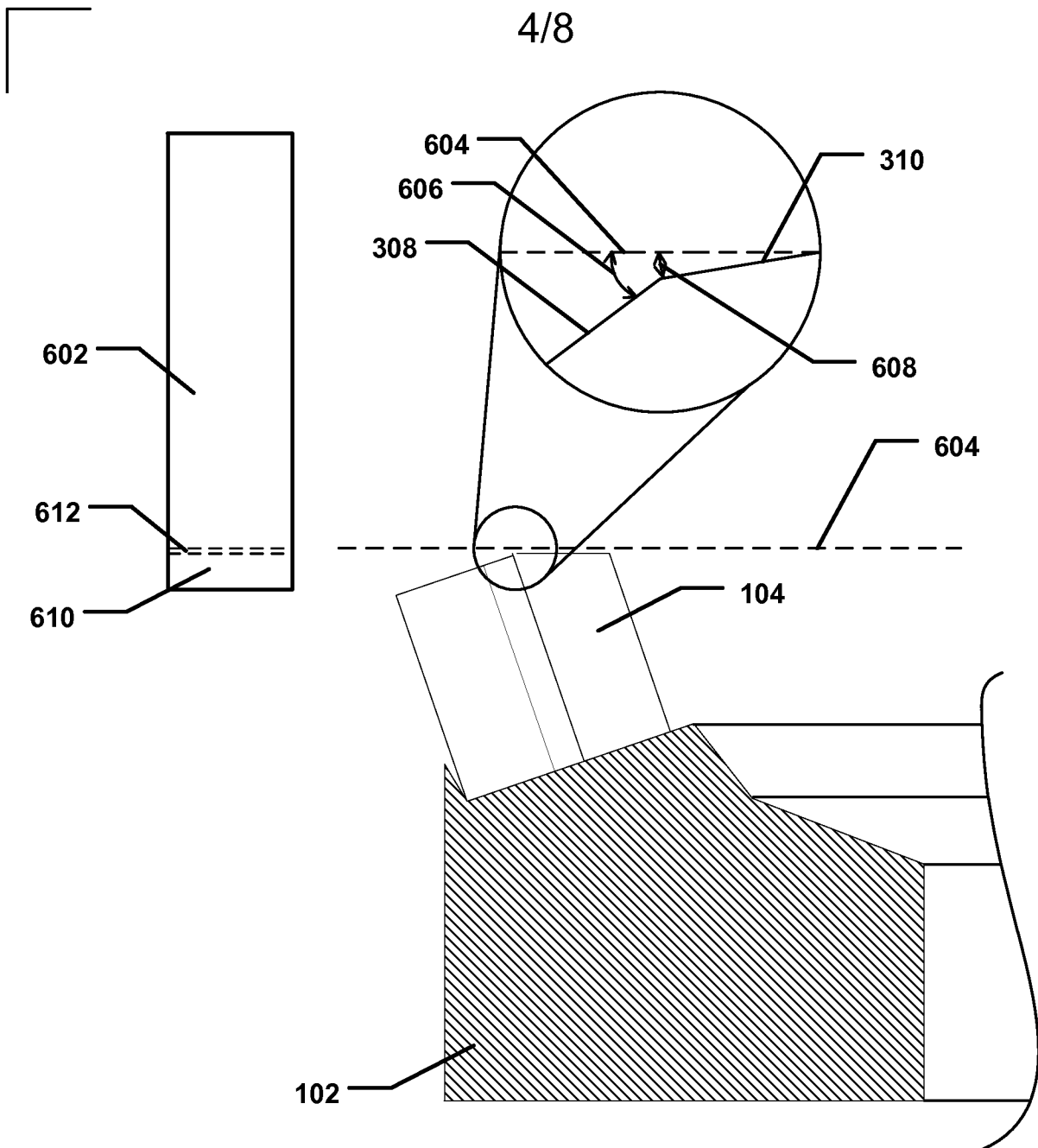


FIG. 6

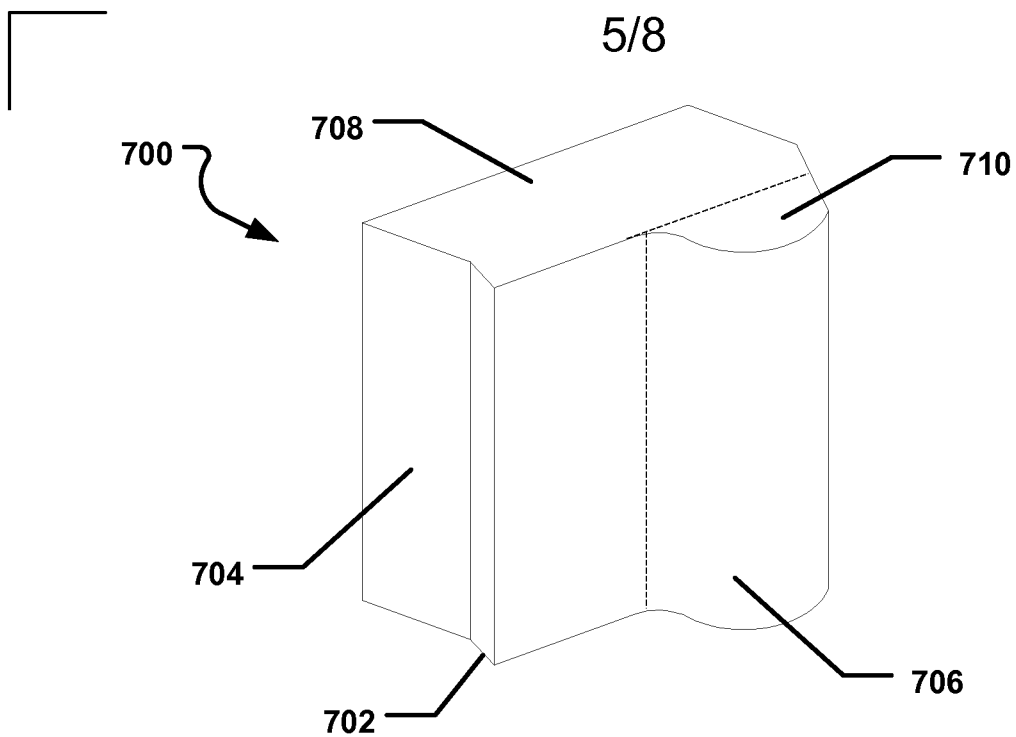


FIG. 7

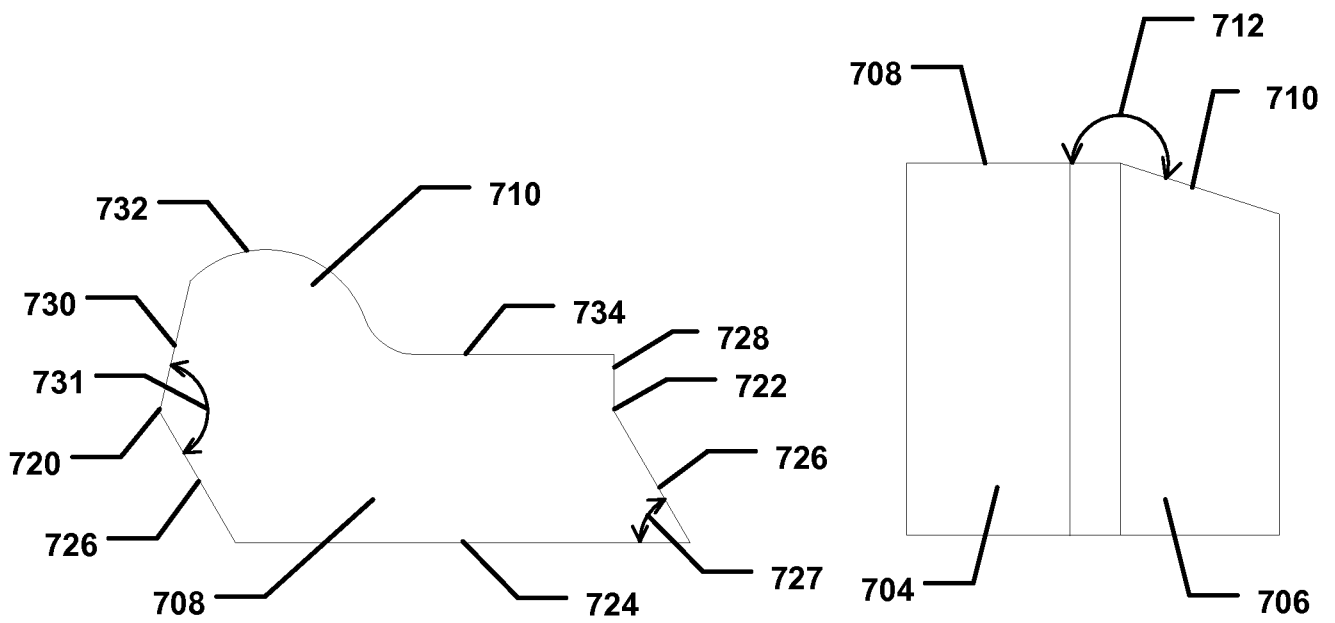
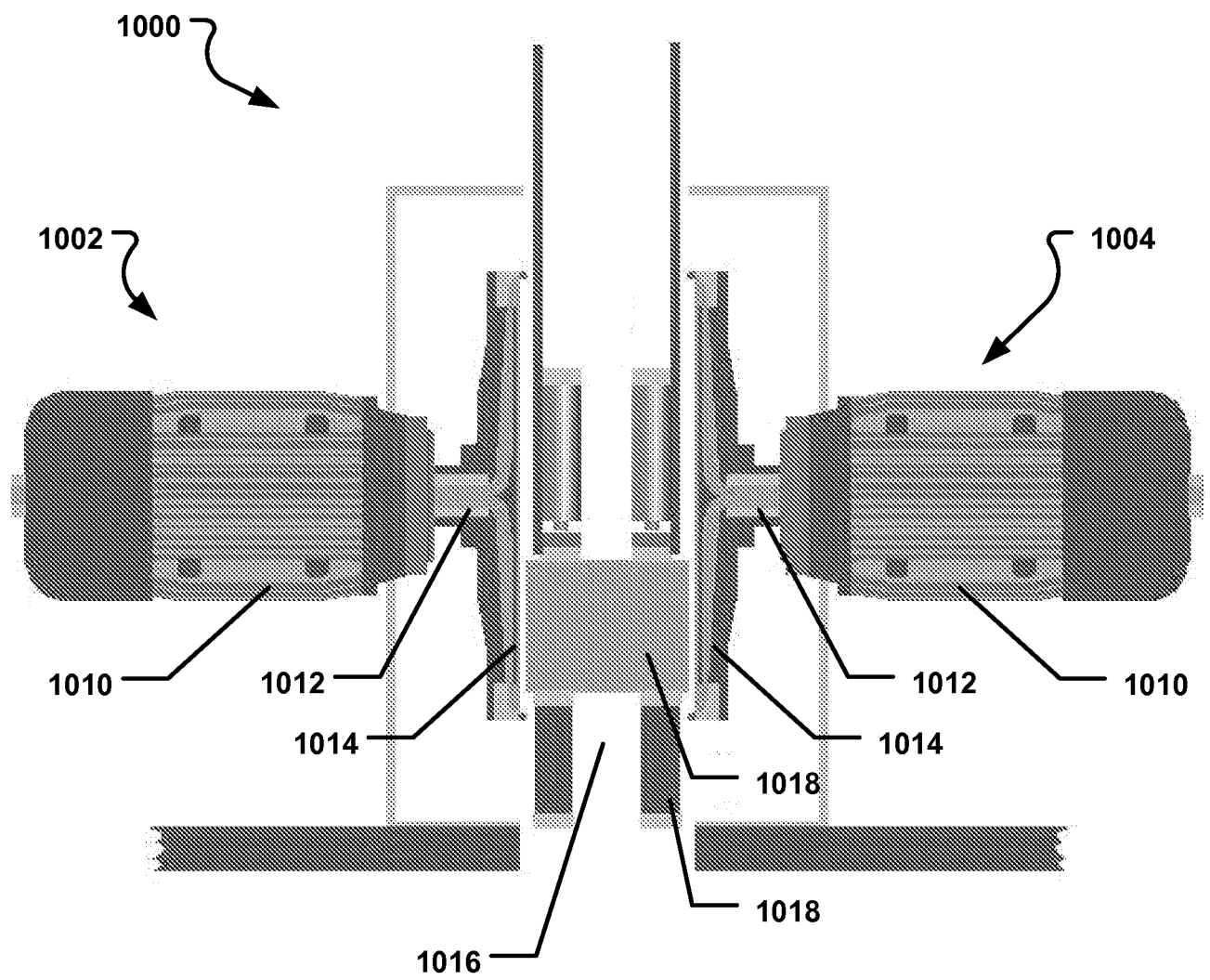


FIG. 8

FIG. 9

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**FIG. 10**

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FIG. 11
(Prior Art)



FIG. 12

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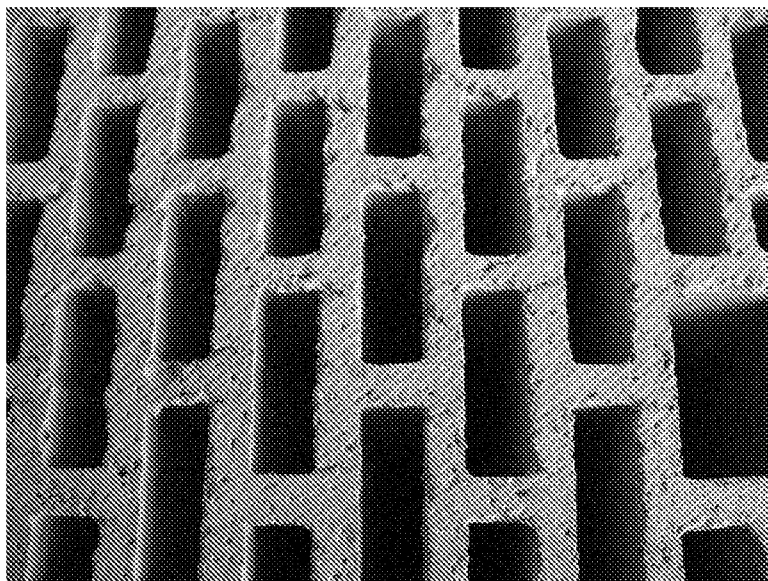


FIG. 13

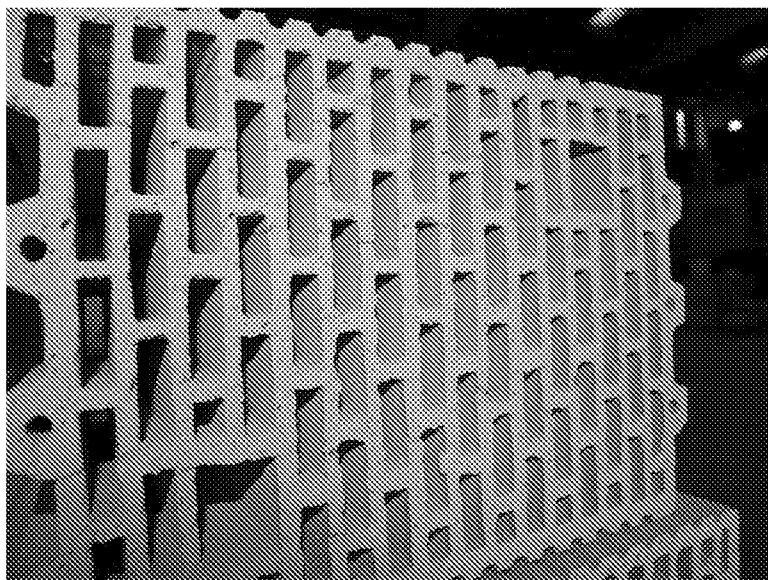


FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/072237**A. CLASSIFICATION OF SUBJECT MATTER****B24D 5/06(2006.01)i, B24D 3/20(2006.01)1, C09K 3/14(2006.01)1, C09C 1/68(2006.01)1, C09G 1/02(2006.01)1**

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)

IPC: B24D 5/06; B24B 27/00; H01L 21/304; B24D 13/14; B24B 7/04; B24B 55/02; A46B 7/08; B24B 7/17

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, article, annular shape, grinding, segment, slope, rotation, block, and ring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 0575296 A1 (OFFICINE MECCANICHE VIOTTÒ S.R.L.) 22 December 1993 See abstract, column 3, line 12-column 5, line 31, and figures 1-5.	72, 74 1-71, 73, 75
A	US 7497212 B2 (CHOI, JONG SUK et al.) 03 March 2009 See abstract, column 3-column 4, and figures 2,3.	1-75
A	EP 2087965 A1 (WENDT GMBH) 12 August 2009 See abstract, paragraphs [0028]-[0032], and figures 1,2.	1-75
A	JP 2009-078055 A (KOWA CO., LTD.) 16 April 2009 See abstract, paragraphs [0005]-[0020], and figure 1.	1-75
A	KR 10-2011-0007087 A (SHINETSU HANDOTAI K.K.) 21 January 2011 See abstract, paragraphs [0052]-[0065], and figure 1.	1-75



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 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

08 April 2013 (08.04.2013)

Date of mailing of the international search report

10 April 2013 (10.04.2013)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan
City, 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KIM, Jin Ho

Telephone No. 82-42-481-8699



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2012/072237

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