



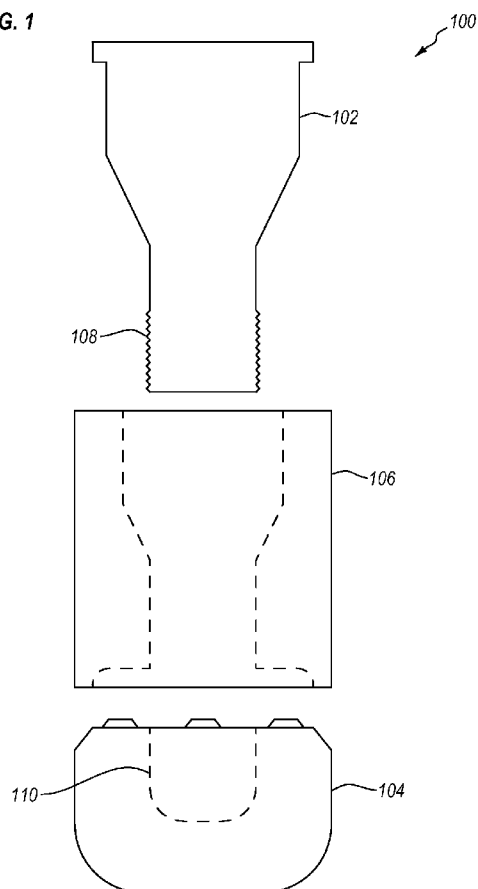
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[Continued on next page]

(54) Title: LOCKING RING WITH STABILIZING BLADES

FIG. 1



(57) Abstract: A locking ring may be adapted to be positioned between first and second components. The locking ring may include a body having a bore formed axially therethrough. A blade may be disposed on an outer radial surface of the body. At least a portion of a centerline through the blade may be oriented at an angle from about 1 to about 60 with respect to a centerline through the body. A recess, a protrusion, or both may be formed in an outer axial surface of the body.



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TITLE

LOCKING RING WITH STABILIZING BLADES

CROSS-REFERENCE TO RELATED APPLICATIONS

5 **[0001]** The present application claims priority to and the benefit of United States Patent Application No. 14/459,965, entitled “LOCKING RING WITH STABILIZING BLADES,” and filed August 14, 2014, which claims priority to and the benefit of United States Provisional Patent Application No. 61/866,370, entitled “LOCKING RING WITH STABILIZING BLADES,” and filed August 15, 2013, the disclosures of which are
10 incorporated herein by reference in their entireties.

BACKGROUND

[0002] In downhole tools, two components that have a similar composition may be connected by the fusing or addition of material. For example, two components made of
15 steel may be connected to one another through welding and/or brazing. The two components may be positioned near or adjacent one another and heated metal or additional steel may be applied to an interface between the two components to bind the two components together. However, the application additional material may result in a poor connection between components made of or including dissimilar compositions.

20 **[0003]** A connection pin may be used to couple a drill string to a bit. In such bits, the connection pin has threads formed on the outer surface thereof, and the bit has corresponding threads formed on the inner surface thereof. The threaded engagement, by itself, may not be sufficient to hold the connection pin and the bit together downhole due to high loads and/or vibration while drilling. Further, it may be difficult to weld the
25 connection pin and the bit together to fortify the engagement if they are made from different materials with different melting points. For example, the connection pin may be made of steel, and the bit may be made of a tungsten carbide matrix. As such, a locking ring may be positioned between the connection pin and the bit to facilitate a secure connection between the connection pin and the bit.

30 **[0004]** During some drilling operations, such as rotary steerable drilling operations, a locking ring may be used that is integral with the drill bit. As such, the drill bit may be inseparable from the locking ring and may not be coupled to other components for use in other drilling operations.

SUMMARY

[0005] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid
5 in limiting the scope of the claimed subject matter.

[0006] In accordance with some embodiments of the present disclosure, embodiments of a locking ring are described. One embodiment of a locking ring includes a body having a bore formed axially therethrough. A blade is located on an outer radial surface of the body. At least a portion of a centerline through the blade is oriented at an angle
10 from 1° to 60° with respect to a centerline through the body. A locking feature including a recess, a protrusion, or both is formed on an outer axial surface of the body.

[0007] Embodiments of a downhole tool are also disclosed. In one embodiment, the downhole tool includes a first component, a second component, and a locking ring. The second component has a plurality of engagement features formed on an outer axial
15 surface thereof that are circumferentially spaced apart from one another. The locking ring is positioned at least partially between the first and second components. The locking ring includes a body having a bore formed axially therethrough. The first component extends at least partially through the bore. A plurality of blades is located on an outer radial surface of the body and circumferentially spaced apart from one another. A plurality of
20 engagement features is formed on an outer axial surface of the body and circumferentially spaced apart from one another. The engagement features on the second component may engage the engagement features on the body to prevent relative movement therebetween.

[0008] In another embodiment, a downhole tool includes a non-weldable component and a locking ring. The non-weldable component includes an axial protrusion and a first
25 blade located adjacent a radial surface of the non-weldable component. The first blade has a first centerline and at least a portion of the first centerline forms a first angle relative to a longitudinal centerline of the downhole tool. The locking ring is positioned adjacent to and abutting the non-weldable component. The locking ring includes an annular body having first and second opposing axial surfaces and an axial bore formed therethrough.
30 The locking ring includes an axial recess formed into the second axial surface, and the axial recess is configured to receive the axial protrusion. The locking ring includes a second blade having a second centerline, and the second centerline forms a second angle relative to the longitudinal centerline of the downhole tool.

[0009] Embodiments of methods of assembling a downhole tool are also disclosed. In one embodiment, a method may include inserting a shaft of a first component through a bore formed axially through a locking ring, where the locking ring includes an annular body having first and second opposing axial surfaces and aligning an axial protrusion
5 extending from a second component in an axial recess formed in the second axial surface of the locking ring and at least one blade of the second component with at least one corresponding blade of the locking ring. The method also includes engaging one or more threads formed on an outer surface of the shaft with one or more threads formed on an inner surface of the second component and applying a force to a circumferentially offset
10 surface of the axial recess to compress the circumferentially offset surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] In order to describe the manner in which embodiments of the present disclosure may be used, a more particular description will be rendered by reference to
15 specific embodiments as illustrated in the appended drawings. While some of the drawings are schematic representations of systems, assemblies, features, methods, or the like, at least some of the drawings may be drawn to scale. Understanding that these drawings depict example embodiments of the disclosure and are not therefore to be considered to be limiting of the scope of the present disclosure or to scale for each
20 embodiment contemplated herein, the embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[0011] FIG. 1 is a schematic exploded view of an embodiment of a downhole tool having a first component, a second component, and a locking ring disposed therebetween;

[0012] FIG. 2 is a side view of an embodiment of a first component, according to the
25 present disclosure;

[0013] FIG. 3 is a cross-sectional view of an embodiment of a first component, according to the present disclosure;

[0014] FIG. 4 is a side view of an embodiment of a second component, according to the present disclosure;

30 [0015] FIG. 5 is a cross-sectional view of an embodiment of a second component, according to the present disclosure;

[0016] FIG. 6 is a side view of an embodiment of a locking ring, according to the present disclosure;

[0017] FIG. 7 is a cross-sectional view of an embodiment of a locking ring, according to the present disclosure;

[0018] FIG. 8 is a side view of an embodiment of a downhole tool including a first component, a second component, and a locking ring, according to the present disclosure;

5 [0019] FIG. 9 is a cross-sectional view of an embodiment of a downhole tool including a first component, a second component, and a locking ring, according to the present disclosure;

[0020] FIG. 10 is a cross-sectional view in a circumferential or tangential direction of an illustrative engagement between an embodiment of a protrusion and a corresponding
10 recess, according to the present disclosure;

[0021] FIG. 11 is a cross-sectional view in a circumferential or tangential direction of an illustrative engagement between an embodiment of an axial protrusion and a corresponding axial recess having tapered radial surfaces, according to the present disclosure;

15 [0022] FIG. 12 is a cross-sectional view in a circumferential or tangential direction of an illustrative engagement between an embodiment of an axial protrusion and a corresponding axial recess having an inner radial recess surface, according to the present disclosure;

[0023] FIG. 13 is a cross-sectional view radially-inward of an engagement between
20 an embodiment of an axial protrusion and a corresponding axial recess, according to the present disclosure;

[0024] FIG. 14 is another cross-sectional view radially-inward of an engagement between an embodiment of an axial protrusion and a corresponding axial recess having a tip recess, according to the present disclosure;

25 [0025] FIG. 15 is yet another cross-sectional view radially-inward of an engagement between an embodiment of an axial protrusion and a corresponding axial recess having planar axial surfaces, according to the present disclosure; and

[0026] FIG. 16 is an embodiment of a method for assembling a downhole tool, according to the present disclosure.

30

DETAILED DESCRIPTION

[0027] As generally shown in the figures, a locking ring configured to aid in connecting a first downhole tool component to a second downhole tool component (e.g., a bit to a connection pin) is disclosed. The locking ring may include a body having a bore

formed axially therethrough. One or more blades may be disposed on an outer radial surface of the body. A centerline through each of the blades may be oriented at an angle from 1° to 60° with respect to a longitudinal centerline through the body. The centerline through each of the blades may substantially align with a centerline through a blade on the second downhole tool component. A recess and/or a protrusion may be formed on an outer axial surface of the body. The recess and/or protrusion may aid in mechanically securing the locking ring and downhole tool components relative to one another.

[0028] FIG. 1 is a side exploded view of a schematic representation of a downhole tool 100 having a first component 102 and a second component 104 that may be coupled together using a locking ring 106. The first component 102 may include a first engagement feature 108. The second component 104 may include a second engagement feature 110 configured to engage with the first engagement feature 108 of the first component 102. The first and second engagement features 108, 110 may include threads, a quick lock configuration, another engaging feature, or combinations thereof. The first engagement feature 108 may be located on an exterior of the first component 102. The second engagement feature 110 may be located on an interior of the second component 104.

[0029] The first component 102 and second component 104 may be made of different materials such that the first component 102 and second component may not be welded together. The locking ring 106 may be made of or include a weldable material that may allow the locking ring 106 to be welded to the first component 102 and/or second component 104. In an embodiment, the locking ring 106 and first component 102 may be made of or include a weldable material and the second component 104 may be made of or include a non-weldable material, such that the locking ring 106 and first component 102 may be welded together and the second component 104 may not be welded to either the locking ring 106 or first component 102. While the present disclosure may describe a downhole tool 100 with reference to a weldable first component 102 and a non-weldable second component 104, it should be understood that either component may be a weldable material. For example, the first and second components 102, 104 may be made of the same or different materials. The first and second components 102, 104 may be made of one or more metals or metal alloys. Suitable metals may include steel, including carbon steel (e.g., AISI 10XX, AISI 11XX, AISI 12XX, or AISI 15XX), manganese steel (e.g., AISI 13XX), nickel steel (e.g., AISI 23XX, or AISI 25XX), nickel-chromium steel (e.g., AISI 31XX, AISI 32XX, AISI 33XX, or AISI 34XX), molybdenum steel (e.g., AISI

40XX, or AISI 44XX), chromium-molybdenum steel (e.g., AISI 41XX), nickel-chromium-molybdenum steel (e.g., AISI 43XX, or AISI 47XX), nickel-molybdenum steel (e.g., AISI 46XX, or AISI 48XX), chromium steel (e.g., AISI 50XX, or AISI 51XX), combinations thereof, and the like, where “XX” may range from 1 to 99 and
5 represents the carbon content, superalloys, titanium, other weldable materials, or combinations thereof.

[0030] The first component 102 and/or the second component 104 may also be made of or include one or more matrix materials. For example, the first component 102 and/or the second component 104 may be made of or include a matrix material including a
10 carbide material, such as tungsten carbide, titanium carbide, calcium carbide, silicon carbide, aluminum carbide, chromium carbide, molybdenum carbide, combinations thereof, and the like disposed in a metal binder, such as a metal or metal alloy. The first component 102 may be made of or include a steel (e.g., AISI 4340 steel), and the second component 104 may be made of or include a tungsten carbide matrix material. The first
15 component 102 and the second component 104 may also be made of other different materials.

[0031] The locking ring 106 may be made of or include the same material as the first component and/or the second component, or the locking ring 106 may be made of or include a different material. In some embodiments, the locking ring 106 may be made of
20 steel. For example, the locking ring 106 may be made from any of the steel materials described with respect to the first or second component. For example, the locking ring 106 may be made of or include a nickel-chromium-molybdenum alloy steel such as AISI 43XX steel (e.g., 4340 steel).

[0032] FIG. 2 shows a side view of an embodiment of an illustrative first component 202, and FIG. 3 shows a cross-sectional view of another embodiment of a first component 302. Like reference characters may reference similar elements. The first component 202 is shown as a connection pin that may be adapted to couple to a drill string (not shown). It may be appreciated, however, that although the first component 202 is shown as a connection pin, other components are also contemplated. For example, the first
25 component 202 may be or include a drill pipe, a drill string, a coiled tube, a wireline, a drill collar, a stabilizer sleeve, an internal in a larger tool, or the like.

[0033] As shown in the embodiment of a first component 202 in FIG. 2, the first component 202 may include a head 212 having a shaft 214 extending therefrom. The shaft 214 may include a first portion 216, a second portion 218, and a third portion 220.

The first portion 216 of the shaft 214 may have a first outer diameter. The third portion 220 of the shaft 214 may have a second outer diameter. The second portion 218 of the shaft 214 may be positioned between the first and third portions 216, 220. The second portion 218 may taper from the first diameter to the second diameter. A diameter of the second portion 218 of the shaft 214 may have a rate of change of a diameter that is constant (i.e., the taper is linear). The diameter of the second portion 218 of the shaft 214 may have a rate of change that is non-constant (i.e., the taper is curved). A ratio of the first outer diameter to the second outer diameter may range from 1.01:1.00 to 2.00:1.00. For example, the ratio may be from 1.01:1.00 to 1.10:1.00, 1.10:1.00 to 1.20:1.00, or 1.20:1.00 to 1.50:1.00.

[0034] A first engagement feature 208 may be disposed on an outer radial surface of the shaft 214. As shown, the first engagement feature 208 may be or include a plurality of threads disposed on an outer surface of the third portion 220 of the shaft 214. The first engagement feature 208 may be adapted to couple the first component 202 to a second component, as discussed in more detail in relation to the embodiments described in FIGS. 7 and 8. In various embodiments, threads, corresponding splines, a quick lock configuration, other suitable mechanical connections, or combinations thereof may be used.

[0035] As shown in the embodiment of a first component 302 in FIG. 3, an axial bore 322 may extend at least partially through the first component 302. The diameter of the bore 322 may vary along the length of the first component 302. As shown, a first portion 316 of a shaft 314 may have a first inner diameter. The first inner diameter may taper to a second inner diameter within a second portion 318 of the shaft 314. A ratio of the first inner diameter to the second inner diameter may range from 1.01:1.00 to 3.00:1.00. For example, the ratio may be from 1.05:1.00 to 1.20:1.00, 1.20:1.00 to 1.50:1.00, or 1.50:1.00 to 2.00:1.00. The second inner diameter may expand to a third inner diameter within a third portion 320 of the shaft 314. A ratio of the second inner diameter to the third inner diameter may range from 1.00:1.01 to 1.00:3.00. For example, the ratio may be from 1.00:1.05 to 1.00:1.20, 1.00:1.20 to 1.00:1.50, or 1.00:1.50 to 1.00:2.00.

[0036] FIG. 4 is a side view of an embodiment of an illustrative second component 404, and FIG. 5 is a cross-sectional side view another embodiment of a second component 504. FIG. 4 depicts the second component 404 as a drill bit (e.g., a polycrystalline diamond compact drill bit) that may be used to drill a wellbore into a subterranean formation. It may be appreciated, however, that although the second

component 404 is shown as a drill bit, other components are also contemplated. For example, the second component 404 may be or include an underreamer, a stabilizer (e.g., a stabilizer sleeve), a logging-while-drilling (“LWD”) tool, a measurement-while-drilling (“MWD”) tool, a concentric hole opener, a bi-center bit, a roller-cone bit, a housing on a motor, and the like.

[0037] The second component 404 may have one or more blades 424 disposed on the outer surface thereof. The blades 424 may be circumferentially spaced apart from one another. The blades 424 may each have a plurality of cutting elements 426 coupled thereto. In at least one embodiment, the cutting elements 426 may include polycrystalline diamond compact (“PDC”) cutters. The blades 424 may also include a plurality of diamond impregnated bits and/or grit hot pressed inserts (“GHIs”) coupled thereto or embedded therein. The cutting elements 426 may cut, grind, impact, and/or scrape the subterranean formation to drill the wellbore.

[0038] The second component 404 may also have a plurality of gage pads 428 disposed on the outer surface thereof. As shown, the gage pads 428 may be a radial surface of the blades 424. At least a portion of a centerline 431 through the outer radial surface of the gage pads 428 and/or blades 424 may be oriented at an angle 430 with respect to a longitudinal centerline 432 through the second component 404. The angle 430 may be within a range having upper and lower values including any of 1°, 5°, 10°, 20°, 30°, 40°, 50°, 60°, more than 60°, or any value therebetween. For example, the angle 430 may be from 1° to 10°, 10° to 20°, or 20° to 45°. It should be understood that the angle 430 may define at least a portion of the centerline 431 of the gage pads 428 and/or blades 424. For example, while the gage pads 428 and/or blades 424 in FIG. 4 are depicted as having a substantially straight centerline 431, in other embodiments, the gage pads 428 and/or blades 424 may be curved such that a centerline 431 includes one or more curves. For a centerline 431 that is completely curved, a tangent line (not shown) through the centerline 431 may be oriented at an angle 430. In yet other embodiments, the gage pads 428 and/or blades 424 may include a centerline 431 including one or more portions having different angles. For example, the gage pads 428 and/or blades 424 may have a centerline 431 including at least a portion that is oriented at an angle 430 and at least a portion that is oriented at a different angle.

[0039] A groove 434 may be formed between each adjacent pair of blades 424 and/or gage pads 428. One or more of the grooves 434 may be oriented at the same angle 430 as the gage pads 428. One or more of the grooves 434 may be curved or include one or

more angle such that at least a portion of the groove 434 is oriented at an angle 430 to the longitudinal centerline 432 of the second component 404.

[0040] One or more inserts 436 may be disposed on the gage pads 428. The inserts 436 may include tungsten carbide, thermally stable polycrystalline (“TSP”) diamond, other suitable superhard materials, or combinations thereof. The inserts 436 may increase the hardness and/or toughness of the gage pads 428 and thereby improve the wear resistance of the gage pads 428. The combination of the gage pads 428 and the inserts 436 may provide stability to the second component 404 and dampen shock and/or vibrations generated by contact with a surrounding formation and/or well casing material.

[0041] The second component 404 may have one or more locking features such as axial protrusions 438 or “castellations” formed on an outer axial surface 440 thereof. In another embodiment, the locking features may be or include axial recesses formed in the outer axial surface 440. In a further embodiment, the locking features may be or include both axial protrusions 438 and axial recesses. The number of axial protrusions 438 may be within a range having upper and lower values including any of 1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, or more, or any value therebetween. The axial protrusions 438 may be positioned in a variety of patterns on the second component 404. As shown, the axial protrusions 438 are circumferentially spaced apart from one another and extend axially-outward from the outer axial surface 440 of the second component 404. In at least one embodiment, if an even number of axial protrusions 438 are employed, each axial protrusion 438 may be directly across from another corresponding axial protrusion 438. In some embodiments, the axial protrusions 438 may be distributed equally about the circumference of the axial surface of the second component 404. In other embodiments, the axial protrusions 438 may be distributed at non-equal intervals about the circumference of the axial surface of the second component 404. In some embodiments, the axial protrusions 438 may axially extend equidistantly from the outer axial surface 440 of the second component 404. In other embodiments, the axial protrusions 438 may axially extend in non-uniform distances from the outer axial surface 440 of the second component 404.

[0042] As depicted in FIG. 5, an axial bore 542 may be formed at least partially (or completely) through the second component 504. One or more openings or nozzles 544 may provide a path of fluid communication from the bore 542 through the second component 504. A fluid (e.g., drilling fluid) may flow through the nozzles 544 to cool the

cutting elements 526 and/or blades 524 and/or to flush away cuttings from the formation during drilling operations.

[0043] The second component 504 may have one or more second engagement features 510 formed on an inner radial surface thereof. The second engagement features 510 may be configured to complementarily engage one or more corresponding first engagement features (108 in FIG. 1). As shown, the second engagement features 510 may be or include a plurality of threads.

[0044] FIG. 6 is a side view of an embodiment of an illustrative locking ring 606, and FIG. 7 is a cross-sectional view of another embodiment of a locking ring 706. As shown in FIG. 6, a locking ring 606 may include a body 646. An axial length 648 of the locking ring 606 may be within a range having upper and lower values including any of 1 cm, 5 cm, 10 cm, 20 cm, 40 cm, 60 cm, 80 cm, 100 cm, more than 100 cm, or any value therebetween. For example, the axial length 648 may be from 5 cm to 20 cm, 20 cm to 40 cm, or 40 cm to 60 cm. A ratio of the axial length 648 of the locking ring 606 to an outer diameter 650 of the locking ring 606 (at the widest point) may range from 0.5:1.0 to 3.0:1.0. In some embodiments, the ratio may be from 0.5:1.0 to 1.0:1.0. In other embodiments, the ratio may range from 1.0:1.0 to 1.5:1.0. In further embodiments, the ratio may range from 1.5:1.0 to 3.0:1.0.

[0045] The locking ring 606 may have one or more stabilizing pads or blades 652 disposed on the outer surface thereof. The blades 652 may be circumferentially spaced apart from one another. A centerline 655 through the outer surface of each of the blades 652 may be oriented at an angle 654 with respect to a longitudinal centerline 656 through the locking ring 606. The angle 654 may be within a range having upper and lower values including any of 1°, 5°, 10°, 20°, 30°, 40°, 50°, 60°, more than 60°, or any value therebetween. In some embodiments, the angle 654 may be from 1° to 10°. In other embodiments, the angle 654 may be from 10° to 20°. In further embodiments, the angle 654 may be from 20° to 45°. It should be understood that the angle 654 may define at least a portion of the centerline 655 of the blades 652. For example, while the blades 652 in FIG. 6 are depicted as having a substantially straight centerline 655, in other embodiments, the blades 652 may be curved such that a centerline 655 includes one or more curves. For a centerline 655 that is completely curved, a tangent line (not shown) through the centerline 655 may be oriented at an angle 654. In yet other embodiments, the blades 652 may include a centerline 655 including one or more portions having different angles. For example, the blades 652 may have a centerline 655 including at

least a portion that is oriented at an angle 654 and at least a portion that is oriented at a different angle.

[0046] A groove 658 may be formed between each adjacent pair of blades 652. One or more of the grooves 658 may be oriented at the same angle 654 as the blades 652. In some embodiments, each of the blades 652 may be oriented at an angle 654 having the same value with respect to the longitudinal centerline 656. In other embodiments, the blades 652 may be oriented at angles 654 having different values with respect to the longitudinal centerline 656. For example, a first blade may be oriented at a 45° angle with respect to the longitudinal centerline 656 and a second blade may be oriented at a 55° angle with respect to the longitudinal centerline 656. One or more of the grooves 658 may be curved or include one or more angle such that at least a portion of the groove 658 is oriented at an angle 654 to the longitudinal centerline 656 of the locking ring 606.

[0047] The blades 652 may each extend radially outward a distance 660 (i.e., height) within a range having upper and lower values including any of 0.5 cm, 1 cm, 2 cm, 4 cm, 6 cm, 8 cm, 10 cm, more than 10cm, or any value therebetween. In some embodiments, a ratio of the height 660 of the blades 652 (measured in a radial direction) to the outer diameter 650 of the body 646 (at the widest point including blades 652) may be from 0.01:1.00 to 0.05:1.00. In other embodiments, the ratio may range from 0.05:1.00 to 0.10:1.00. In further embodiments, the ratio may range from 0.10:1.00 to 0.20:1.00. The blades 652 may each have a width 662 (measured in a direction perpendicular to the longitudinal centerline 656) within a range having upper and lower values including any of 0.5 cm, 1 cm, 2 cm, 5 cm, 10 cm, 15 cm, 20 cm, more than 20 cm, or any value therebetween. In some embodiments, a ratio of the width 662 of one of the blades 652 to a circumference of the body 646 may range from a low of 0.01:1.00 to 0.05:1.00. In other embodiments, the ratio may range from 0.05:1.00 to 0.10:1.00. In further embodiments, the ratio may range from 0.10:1.00 to 0.20:1.00.

[0048] The blades 652 may have a plurality of inserts 664 disposed on the outer radial surfaces thereof. At least a portion of the inserts 664 may be oriented along the centerline 655 of the blades 652 and/or may be otherwise oriented. The inserts 664 may be made from tungsten carbide, thermally stable polycrystalline ("TSP") diamond, or the like. The inserts 664 may improve the hardness and/or toughness the blades 652 and thereby improve wear resistance of the blades 652. The combination of the blades 652 and the inserts 664 may provide stability to the locking ring 606 and/or dampen shock and/or vibrations generated by contact with a surrounding formation and/or well casing material.

[0049] One or more lateral grooves 666-1, 666-2 may also be formed about at least a portion of the circumference of the body 646. As shown, the lateral grooves 666-1, 666-2 may be formed around a portion of the circumference and may be circumferentially spaced apart from one another. In at least one embodiment, the lateral grooves may facilitate connection of the downhole tool to a drill string, another downhole tool, tubular component, or other component of a bottomhole assembly.

[0050] FIG. 7 is a cross-sectional view of an embodiment of a locking ring 706 having an axial bore 768 formed therethrough. The inner surface of the locking ring 706 defining the bore 768 may be shaped and/or sized to receive the outer surface of a first component, as shown in and described with reference to FIGS. 8 and 9. A first axial surface 770 of the locking ring 706 may be substantially flat. An opposing second axial surface 772 of the locking ring 706 may have one or more locking features such as axial recesses 774 or indentations formed thereon or therein. Although not shown, in another embodiment, the locking features may be axial protrusions or both axial protrusions and axial recesses 774. At least one axial recess 774 may be configured to receive a corresponding axial protrusion of a second component at least partially therein to prevent or limit relative movement and/or rotation between the second component and the locking ring 706, as will be described in relation to FIGS. 8 and 9. As such, the axial recesses 774 may be circumferentially spaced apart from one another around the second axial surface 772 of the locking ring 706.

[0051] FIGS. 8 and 9 illustrate the assembly of an embodiment of a first component, a second component, and a locking ring to form an illustrative downhole tool. FIG. 8 is a side view of an embodiment of an illustrative downhole tool 800 including a first component 802, a second component 804, and a locking ring 806. FIG. 9 is a cross-sectional view of another embodiment of a downhole tool 900. In some embodiments, the downhole tool may be a long sleeve bit or a long gage bit. In other embodiments, the downhole tool may be used as part of a rotary steerable system.

[0052] As shown in FIG. 8, the blades 852 of the locking ring 806 may be aligned with blades 824 of the second component 804 when the locking ring 806 and the second component 804 are coupled together. Similarly, the grooves 858 of the locking ring 806 may be aligned with the grooves 834 of the second component 804 when the locking ring 806 and the second component 804 are coupled together. The locking ring 806 (and/or the blades 852 thereon) may serve as a stabilizer for the downhole tool 800 during drilling operations.

[0053] The alignment of the second component 804 and the locking ring 806 may be effected by the locations of the axial recesses and/or the axial protrusions in the second component 804 and the locking ring 806 (visible in FIG. 9). The locations of the axial recesses and axial protrusions may align the second component 804 and the locking ring 806 in relative orientations such that the blades 852 of the locking ring 806 may be aligned with the blades 824 of the second component 804 and the grooves 858 of the locking ring 806 may be aligned with the grooves 834 of the second component 804 when the locking ring 806 and the second component 804 are coupled together. An alignment of the blades 852, 824 and grooves 858, 834 may therefore be provided during assembly of the downhole tool 800 without additional machining or grinding of material. The alignment of the blades 852, 824 and grooves 858, 834 by the alignment of the axial recesses and axial protrusions may also facilitate interchangeability of parts between downhole tools.

[0054] As shown in FIG. 9, a first axial surface 970 of a locking ring 906 (i.e., the flat surface) may abut a first component 902, and the locking ring 906 and the first component 902 may be attached to one another using any suitable attachment mechanism, for example, welding or brazing. The locking ring 906 and the first component 902 may be attached together via electronic welding with a suitable weld material. It may be appreciated that the order of assembly described is merely illustrative, and the first component 902, the second component 904, and the locking ring 906 may be assembled in a different order.

[0055] The outer axial surface 940 of the second component 904 may be placed in contact with the second axial surface 972 of the locking ring 906. The axial protrusions 938 on the second component 904 may be aligned with and/or inserted into the corresponding axial recesses 974 in the second axial surface 972 of the locking ring 906. The engagement between the axial protrusions 938 and the recesses 974 may prevent or limit rotational movement between the second component 904 and the locking ring 906 during operation. The second axial surface 972 may be configured to mate complementarily to an outer axial surface 940 of the second component 904. The interface of the second axial surface 972 and the outer axial surface 940 of the second component 904 may be configured that foreign objects, such as drill cuttings, may be prevented from entering the interface.

[0056] The first component 902 may be inserted through the locking ring 906 until the head 912 of the first component 902 abuts the first axial surface 970 of the locking

ring 906. The shaft 914 of the first component 902 may be at least partially disposed within the second component 904. A first engagement feature 908 on the outer surface of the shaft 914 may engage a complimentary second engagement feature 910 on the inner surface of the second component 904, thereby securing the first component 902, the second component 904, and the locking ring 906 together. The engagement features 908, 910 may include, for example, a threaded connection, corresponding splines, a quick lock configuration, other suitable mechanical connections, or combinations thereof. The engagement features 908, 910 may enable the first component 902, the second component 904, and the locking ring 906 to be easily disassembled so that the second component 904 may be coupled to or used with another tool.

[0057] The shaft 914 may provide an axial preload or tension in the connection with the second component 904. However, in other embodiments, the first component 902 may be coupled to the second component 904 by one or more different features on the shaft 914 and/or the second component 904 to prevent relative rotation and provide a similar preload. For example, corresponding splines or a quick lock configuration may be used.

[0058] FIG. 10 is a cross-sectional view in a circumferential or tangential direction of an illustrative interface between an embodiment of a second component 1004 and a locking ring 1006. The interface shows an engagement between an axial protrusion 1038 and a corresponding recess 1074, according to at least one embodiment. The axial protrusions 1038 on the second component 1004 each include opposing inner and outer radial protrusion surfaces 1076, 1078 and an outer axial protrusion surface 1080. The axial recesses 1074 in the locking ring 1006 may be defined by an outer radial recess surface 1082 and an inner axial recess surface 1084.

[0059] The outer radial protrusion surface 1078 of the axial protrusion 1038 may be configured to abut, mate with, or otherwise contact the outer radial recess surface 1082 defining the axial recess 1074. In another embodiment, a gap or clearance may exist between the outer radial protrusion surface 1078 and the outer radial recess surface 1082. The clearance may be from about 0.1 mm to about 0.5 mm, about 0.5 mm to about 1 mm, about 1 mm to about 2 mm, about 2 mm to about 5 mm, about 5 mm to about 10 mm, or more.

[0060] The outer radial protrusion surface 1078 of the axial protrusion 1038 may be oriented at an angle α with respect to a plane 1086 that is perpendicular to a longitudinal axis or centerline (656 in FIG. 6) extending through the second component 1004 and/or

the locking ring 1006. As shown in FIG. 10, the angle α may be about 90° . The outer radial recess surface 1082 defining the axial recess 1074 may be oriented at an angle β with respect to the plane 1086. As shown in FIG. 10, the angle β may also be about 90° .

[0061] FIG. 11 is a cross-sectional view in a circumferential or tangential direction of an illustrative engagement between an embodiment of an axial protrusion 1138 and a corresponding axial recess 1174, according to one or more embodiments. An outer radial protrusion surface 1178 of the axial protrusion 1138 may be oriented at an angle α with respect to a plane 1186 that is not perpendicular to a longitudinal axis or centerline (656 in FIG. 5) extending through the second component 1104 and/or the locking ring 1106. As shown in FIG. 11, the angle α may be within a range having upper and lower values including any of 10° , 20° , 30° , 40° , 50° , 60° , 70° , 80° , 90° , or any value therebetween. The angle α may be between 30° and 60° , between 40° and 70° , between 50° and 80° , between 60° and 90° , or between 30° and 85° . The outer radial recess surface 1182 defining the axial recess 1174 may be oriented at an angle β with respect to the plane 1186. The angle β may be within a range having upper and lower values including any of 10° , 20° , 30° , 40° , 50° , 60° , 70° , 80° , 90° , or any value therebetween. The angle β may be between 30° and 60° , between 40° and 70° , between 50° and 80° , between 60° and 90° , or between 30° and 85° . Although the angles α and β are shown as being the same in FIGS. 10 and 11, it may be appreciated that in other embodiments, the angles α and β may be different.

[0062] An outer radial protrusion surface 1178 may be a curved or otherwise non-planar surface that includes at least a portion of the outer radial protrusion surface 1178 oriented at an angle α with respect to a plane 1186. For example, for an outer radial protrusion surface 1178 that is completely curved, a tangent line (not shown) through the outer radial protrusion surface 1178 may be oriented at an angle α . In some embodiments, the outer radial protrusion surface 1178 may be a curved surface that includes a portion having a tangent line (not shown) through the outer radial protrusion surface 1178 at an angle α with the plane 1186.

[0063] In other embodiments, the outer radial protrusion surface 1178 may include a portion of the outer radial protrusion surface 1178, whether planar or curved, that is oriented at an angle α and another portion, whether planar or curved, that is angled at a second angle that may be greater than or less than the angle α . For example, a first portion of the outer radial protrusion surface 1178 may be planar and have an angle α or may be curved such that a tangent line (not shown) through the outer radial protrusion

surface 1178 is angled at an angle α and a second portion of the outer radial protrusion surface 1178 may be planar and have a second angle or may be curved such that a tangent line (not shown) through the outer radial protrusion surface 1178 is angled at a second angle. Furthermore, the outer radial protrusion surface 1178 may include more or fewer
5 portions that are oriented at varying angles and/or the same angles (whether all portions include planar surfaces and/or or a tangent lines of curved surfaces) with respect to each other.

[0064] The outer radial recess surface 1182 may be configured to mate complementarily with substantially all of the outer radial protrusion surface 1178. The
10 outer radial recess surface 1182 may be configured such that a portion of the outer radial recess surface 1182 mates complementarily with the outer radial protrusion surface 1178. For example, the outer radial protrusion surface 1178 depicted in FIG. 11 includes a portion at an angle α that mates complementarily with the outer radial recess surface 1182. Other portions of the outer radial protrusion surface 1178 may not complementarily mate
15 with the outer radial recess surface 1182.

[0065] FIG. 12 is a cross-sectional view in a circumferential or tangential direction of another illustrative engagement between an embodiment of an axial protrusion 1238 from a second component 1204 and a corresponding axial recess 1274 of a locking ring 1206. In at least one embodiment, the axial recess 1274 may be at least partially defined by an
20 inner radial recess surface 1288 of the locking ring 1206. The inner radial recess surface 1288 at least partially defining each axial recess 1274 may be configured to abut, mate with, or otherwise contact the inner radial protrusion surface 1276 of the corresponding axial protrusion 1238. In another embodiment, a gap or clearance may exist between the inner radial recess surface 1288 and the inner radial protrusion surface 1276. The
25 clearance may be from about 0.1 mm to about 0.5 mm, about 0.5 mm to about 1 mm, about 1 mm to about 2 mm, about 2 mm to about 5 mm, about 5 mm to about 10 mm, or more.

[0066] As shown, the inner radial recess surface 1288 at least partially defining the axial recess 1274 may be generally normal to plane 1286 through the second component
30 1204 and/or the locking ring 1206. In another embodiment, the inner radial recess surface 1288 at least partially defining the axial recess 1274 may be oriented at an angle (not shown) with respect to the plane 1286. The angle may be within a range having upper and lower values including any of 20°, 30°, 40°, 50°, 60°, 70°, 80°, 85°, 90°, or any value therebetween.

[0067] FIG. 13 is a cross-sectional view looking radially-inward of an illustrative engagement between an embodiment of an axial protrusion 1338 and a corresponding axial recess 1374, according to one or more embodiments. The axial protrusion 1338 may include opposing circumferentially offset protrusion surfaces 1392, 1394. The axial recess 1374 in may be defined by opposing circumferentially offset recess surfaces 1396, 1398.

[0068] Although embodiments of axial protrusions are shown as including radial protrusion surfaces 1076, 1078 (see FIG. 10) and circumferentially offset protrusion surfaces 1392, 1394 that are substantially planar, it may be appreciated that an axial protrusion may include curved surfaces. An axial protrusion according to the present disclosure may have a cross-sectional shape that is substantially a circle, oval, or ellipse; as well as a square, rectangle, triangle, other regular polygon; an irregular polygon; or a combination thereof. Similarly, embodiments of axial recesses are shown as being defined by radial recess surfaces 1182, 1288 (see FIGS. 11 and 12) and circumferentially offset recess surfaces 1396, 1398 that are substantially planar. However, it may be appreciated that an axial recess according to the present disclosure may be defined by one or more surfaces that are curved. An axial recess may be defined by one or more surfaces that form a cross-sectional shape that is a circle, oval, or ellipse; as well as a square, rectangle, triangle, other regular polygon; an irregular polygon; or a combination thereof. In some embodiments, an axial protrusion and corresponding axial recess may have a substantially similar cross-sectional shape. In other embodiments, an axial protrusion and corresponding axial recess substantially sharing a cross-sectional shape may promote a particular alignment of a locking ring and a second component. In yet other embodiments, at least one pair of axial protrusion and corresponding axial recess among a plurality of pairs of axial protrusions and corresponding axial recesses may have a substantially different cross-sectional shape than the remainder of the plurality to promote a particular alignment of a locking ring and a second component.

[0069] The circumferentially offset protrusion surfaces 1392, 1394 of the axial protrusion 1338 may be arranged and designed to abut, mate with, or otherwise contact the circumferentially offset recess surfaces 1396, 1398 defining the recess 1374. In another embodiment, a gap or clearance may exist between the circumferentially offset protrusion surfaces 1392, 1394 and the corresponding circumferentially offset recess surfaces 1396, 1398. The clearance may be from about 0.1 mm to about 0.5 mm, about

0.5 mm to about 1 mm, about 1 mm to about 2 mm, about 2 mm to about 5 mm, about 5 mm to about 10 mm, or more.

[0070] The circumferentially offset protrusion surfaces 1392, 1394 of each axial protrusion 1338 may be oriented at angles Γ , Δ , respectively, with respect to the plane 1386. As shown in FIG. 13, the angles Γ , Δ may each be 90°. The opposing circumferentially offset recess surfaces 1396, 1398 defining the recess 1374 may be oriented at angles E, Z, respectively, with respect to the plane 1386. As shown in FIG. 13, the angles E, Z may each be 90°.

[0071] FIG. 14 is a cross-sectional view radially-inward of an engagement between an embodiment of an axial protrusion 1438 and a corresponding axial recess 1474. As shown in FIG. 14, the angles Γ and/or Δ may be similar to those described in relation to FIG. 13. The angles Γ and/or Δ may describe angles between circumferentially offset recess surfaces 1496, 1498 and a plane 1486. The angles Γ and/or Δ may be within a range having upper and lower values including any of 20°, 30°, 40°, 50°, 60°, 70°, 80°, 90°, or any value therebetween. The angles Γ and/or Δ may be between 30° and 60°, between 40° and 70°, between 50° and 80°, between 60° and 90°, or between 30° and 85°. Although the angles Γ and Δ are shown as being the same in FIGS. 13 through 15, it may be appreciated that in other embodiments, the angles Γ and Δ may be different.

[0072] As shown in FIG. 14, the angles E and/or Z may be similar to those described in relation to FIG. 13. The angles E and/or Z may describe angles between circumferentially offset protrusion surfaces 1492, 1494 and a plane 1486. The angles E and/or Z may be within a range having upper and lower values including any of 20°, 30°, 40°, 50°, 60°, 70°, 80°, 90°, or any value therebetween. The angles E and/or Z may be between 30° and 60°, between 40° and 70°, between 50° and 80°, between 60° and 90°, or between 30° and 85°. Although the angles E and Z are shown as being the same in FIGS. 13 through 15, it may be appreciated that in other embodiments, the angles E and Z may be different. The angles Γ and E may be the same, and the angles Δ and Z may be the same.

[0073] The opposing circumferentially offset protrusion surfaces 1492, 1494 may be planar surfaces oriented at the angles Γ and Δ with respect to the plane 1486, such as the circumferentially offset protrusion surface 1492 depicted in FIG. 14. As depicted by the opposing circumferentially offset protrusion surface 1492, one or more of the circumferentially offset protrusion surfaces 1492, 1494 may be a curved or otherwise non-planar surface that includes at least a portion of the circumferentially offset

protrusion surface 1492 oriented at an angle Γ or Δ with respect to a plane 1486. In some embodiments, one or more of the circumferentially offset protrusion surfaces 1492, 1494 may be a curved surface that includes a portion having an angle Δ with the plane 1486. In other embodiments, one or more of the circumferentially offset protrusion surfaces 1492, 1494 may include a portion of the outer radial surface that is oriented at an angle Δ and another portion that is angled at a second angle that may be greater than or less than the angle Δ . For example, for a circumferentially offset protrusion surface that is completely curved, a tangent line (not shown) through the circumferentially offset protrusion surface may be oriented at an angle α . In some embodiments, the circumferentially offset protrusion surface may be a curved surface that includes a portion having a tangent line (not shown) through the circumferentially offset protrusion surface at an angle Δ with the plane 1486. One or more of the circumferentially offset recess surfaces 1496, 1498 may be configured to mate complementarily with substantially all of one or more of the circumferentially offset protrusion surfaces 1492, 1494. One or more of the circumferentially offset recess surfaces 1496, 1498 may be configured such that a portion of one or more of the circumferentially offset recess surfaces 1496, 1498 may mate complementarily with one or more of the circumferentially offset protrusion surfaces 1492, 1494. For example, the circumferentially offset protrusion surface 1492 depicted in FIG. 14 includes a portion at an angle Δ that mates complementarily with a portion of the circumferentially offset recess surface 1496 at an angle Z . Other portions of one or more of the circumferentially offset recess surfaces 1496, 1498 may not complementarily mate with one or more of the circumferentially offset protrusion surfaces 1492, 1494.

[0074] The inner axial recess surface 1484 of each recess 1474 may be substantially planar such that the inner axial recess surface 1484 is substantially parallel to the plane 1486. In at least one embodiment, the inner axial recess surface 1484 may be non-planar, for example, the inner axial recess surface 1484 may include a tip recess 14100 that is adapted to receive a (conical or frustoconical) tip portion 14102 of a corresponding axial protrusion 1438. The tip recess 14100 may be larger than the corresponding tip portion 14102. The tip recess 14100 may extend inward from the inner axial recess surface 1484. The tip recess 14100 may prevent the tip portion 14102 from contacting the locking ring 1406. This may facilitate engagement of the other surfaces of the axial protrusion 1438 and axial recess 1474. The tip portion 14102 may be remnants from the inlets in the casting process during manufacture of the second component 1404. In another

embodiment, the tip recess 14100 may be omitted, and the inner axial recess surface 1484 may be substantially planar, as shown in FIG. 15.

[0075] FIG. 15 illustrates an embodiment of an interface between an axial protrusion 1538 and an axial recess 1574 having tapered lateral surfaces. In some embodiments, an inner axial recess surface 1584 may not contact an outer axial protrusion surface 1580. In such embodiments, the tapered lateral surfaces (i.e., defined by angles Γ , E, Δ , and Z) may apply a force to one another during assembly of a downhole tool as described herein. The force may compress material adjacent to the interface between the axial protrusion 1538 and axial recess 1574. The compression of material adjacent to the interface between the axial protrusion 1538 and axial recess 1574 may assist in compensating for variations in surfaces during manufacturing and provide a tighter interface.

[0076] Various elements have been described herein in relation to various embodiments of first and second components and locking rings. The elements described in connection with FIGS. 1-15 may be used interchangeably.

[0077] An embodiment of a method of assembly of a downhole tool according to the present disclosure is depicted in FIG. 16. The method 1601 may include inserting 1603 a shaft of a first component through a bore formed axially through a locking ring. The locking ring may include a body having first and second opposing axial surfaces. An axial protrusion extending from a second component may be aligned 1605 in an axial recess formed in the second axial surface of the locking ring. At least one blade and/or groove of the second component may be aligned 1605 with at least one corresponding blade and/or groove of the locking ring. One or more engagement features formed on an outer surface of the shaft may be engaged 1607 with one or more engagement features formed on an inner surface of the second component. A force may be applied 1609 to a circumferentially offset surface of the axial recess to compress the circumferentially offset surface. The method 1601 may also include welding 1611 the locking ring to the first component.

[0078] As used herein, the terms “inner” and “outer”; “up” and “down”; “upper” and “lower”; “upward” and “downward”; “above” and “below”; “inward” and “outward”; and other like terms as used herein refer to relative positions to one another and are not intended to denote a particular direction or spatial orientation. The terms “couple,” “coupled,” “connect,” “connection,” “connected,” “in connection with,” and “connecting” refer to “in direct connection with” or “in connection with via another element or member.” The terms “hot” and “cold” refer to relative temperatures to one another.

[0079] Although only a few example embodiments have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the example embodiments without materially departing from “Locking Ring with Stabilizing Blades Formed Thereon.” Accordingly, all such modifications are intended to be included within the scope of this disclosure. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment of fastening wooden parts, a nail and a screw may be equivalent structures. It is the express intention of the applicant not to invoke 35 U.S.C. § 120, paragraph 6 for any limitations of any of the claims herein, except for those in which the claim expressly uses the words 'means for' together with an associated function.

[0080] Certain embodiments and features have been described using a set of values which may form an upper and/or lower limit of a range. Certain lower limits, upper limits and ranges appear in one or more claims below. All numbers, percentages, ratios, or other values stated herein are intended to include not only that value, but also other values that are about or approximately the stated value, as would be appreciated by one of ordinary skill in the art encompassed by embodiments of the present disclosure. A stated value should therefore be interpreted broadly enough to encompass values that are at least close enough to the stated value to perform a desired function or achieve a desired result. The stated values include at least the variation to be expected in a suitable manufacturing or production process, and may include values that are within 5%, within 1%, within 0.1%, or within 0.01% of a stated value.

[0081] Various terms have been defined above. To the extent a term used in a claim is not defined above, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Furthermore, all patents, test procedures, and other documents cited in this application are fully incorporated by reference to the extent such disclosure is not inconsistent with this application and for all jurisdictions in which such incorporation is permitted.

[0082] The present disclosure may be embodied in other specific forms without departing from its spirit or characteristics. The described embodiments are to be considered as illustrative and not restrictive. The scope of the disclosure is, therefore, indicated by the appended claims rather than by the foregoing description. Changes that

come within the meaning and range of equivalency of the claims are to be embraced within their scope.

CLAIMS

What is claimed is:

- 5 1. A locking ring adapted to be positioned between first and second components, comprising:
- a body having a bore formed axially therethrough;
- a blade disposed on an outer radial surface of the body, wherein at least a portion of a centerline through the blade is oriented at an angle from 1° to 60° with respect to a
- 10 longitudinal centerline through the body; and
- at least one locking feature including a recess, a protrusion, or both formed on an outer axial surface of the body.
- 15 2. The locking ring of claim 1, wherein the body includes at least two blades that are circumferentially spaced apart from one another.
3. The locking ring of claim 2, wherein a groove is formed between each adjacent pair of blades, and wherein at least a portion of a centerline through the groove is oriented at an angle from 1° to 60° with respect to the centerline through the body.
- 20 4. The locking ring of claims 1-3, wherein the blade includes an insert on an outer surface thereof that comprises tungsten carbide, thermally stable polycrystalline diamond, or combinations thereof.
- 25 5. The locking ring of claims 1-4, wherein the at least one locking feature includes at least two recesses are formed in the outer axial surface of the body, and wherein the at least two recesses are circumferentially spaced apart from one another.
- 30 6. The locking ring of claims 1-5, wherein the at least one locking feature includes at least two protrusions are formed in the outer axial surface of the body, and wherein the at least two protrusions are circumferentially spaced apart from one another.

7. The locking ring of claims 1-6, wherein the at least one locking feature includes a recess, the recess being defined by:
- an outer radial surface;
 - first and second opposing circumferentially offset surfaces, wherein at least a portion of the first circumferentially offset surface is oriented at an angle between from 85° to 90° with respect to a plane that is perpendicular to the longitudinal centerline through the body; and
 - an inner axial surface.
8. The locking ring of claims 1-7, wherein the at least one locking feature includes a recess, the recess being defined by:
- an outer radial surface;
 - first and second opposing circumferentially offset surfaces, wherein at least a portion of the first circumferentially offset surface is oriented at an angle between 30° and 85° with respect to a plane that is perpendicular to the longitudinal centerline through the body; and
 - an inner axial surface.
9. The locking ring of claims 1-8, wherein the body comprises a steel.
10. The locking ring of claims 1-9, wherein the body comprises a nickel-chromium-molybdenum alloy steel.
11. A downhole tool, comprising:
- a first component;
 - a second component having a first plurality of locking features formed on an axial surface thereof, the locking features being circumferentially spaced apart from one another; and
 - a locking ring positioned at least partially between the first and second components, the locking ring including:
 - a body having a bore formed axially therethrough, wherein the first component extends at least partially through the bore;
 - a plurality of blades disposed on an outer radial surface of the body, the

blades being circumferentially spaced apart from one another; and

a second plurality of locking features formed on an outer axial surface of the body, the locking features being circumferentially spaced apart from one another, wherein the second plurality of locking features are configured to engage the first plurality of locking features to limit relative movement therebetween.

12. The downhole tool of claim 11, wherein the first plurality of locking features include axial protrusions, and the second plurality of locking features include corresponding recesses.

13. The downhole tool of claims 11-12, wherein the first plurality of locking features include recesses, and the second plurality of locking features include corresponding axial protrusions.

14. The downhole tool of claims 11-13, wherein the first component comprises a steel, the second component comprises tungsten carbide, and the locking ring comprises a steel.

15. The downhole tool of claims 11-14, wherein the first component is a connection pin, and the second component is a drill bit.

16. The downhole tool of claims 11-15, wherein a ratio of an axial length of the locking ring to an outer diameter of the locking ring at a widest point is from 0.5:1 to 3:1.

17. The downhole tool of claims 11-16, wherein the second component includes a plurality of blades disposed on an outer surface thereof, the blades being circumferentially spaced apart from one another and wherein the blades on the second component are aligned with the blades on the locking ring.

18. A downhole tool, comprising:

a non-weldable component having an axial protrusion extending therefrom and a first blade located adjacent an outer surface of the non-weldable component, the first blade having a first centerline, at least a portion of the first centerline forming a first angle relative to a longitudinal centerline of the downhole tool; and

a locking ring positioned adjacent to and abutting the non-weldable component, the locking ring including an annular body having first and second opposing axial surfaces and an axial bore formed therethrough, wherein an axial recess is formed into the second axial surface, and the axial recess is configured to receive the axial protrusion,

5 wherein the locking ring includes a second blade having a second centerline, at least a portion of the second centerline forming an second angle relative to the longitudinal centerline of the downhole tool, the second centerline.

19. The downhole tool of claim 18, further comprising a weldable component
10 positioned adjacent the locking ring and opposite the non-weldable component.

20. The downhole tool of claim 19, wherein the locking ring is welded or brazed to the weldable component.

15 21. The downhole tool of claims 18-20, wherein the first and second angles are between 10° and 30°.

22. The downhole tool of claims 18-21, wherein the axial protrusion comprises an outer axial surface, the outer axial surface of the axial protrusion and the second axial
20 surface of the axial recess not contacting when the locking ring and the non-weldable component abut one another.

23. A method of assembling a downhole tool, comprising:

inserting a shaft of a first component through a bore formed axially through a
25 locking ring, wherein the locking ring includes an annular body having first and second opposing axial surfaces;

aligning an axial protrusion extending from a second component in an axial recess formed in the second axial surface of the locking ring and at least one blade of the second component with at least one corresponding blade of the locking ring,

30 engaging one or more threads formed on an outer surface of the shaft with one or more threads formed on an inner surface of the second component; and

applying a force to a circumferentially offset surface of the axial recess to compress the circumferentially offset surface.

24. The method of claim 23, wherein the first component and the locking ring are made of steel, and wherein the second component is made of tungsten carbide.
25. The method of claims 23-24, further comprising welding the first component and
5 the locking ring together.
26. The method of claims 23-25, further comprising aligning at least one blade of the second component with at least one corresponding blade of the locking ring.

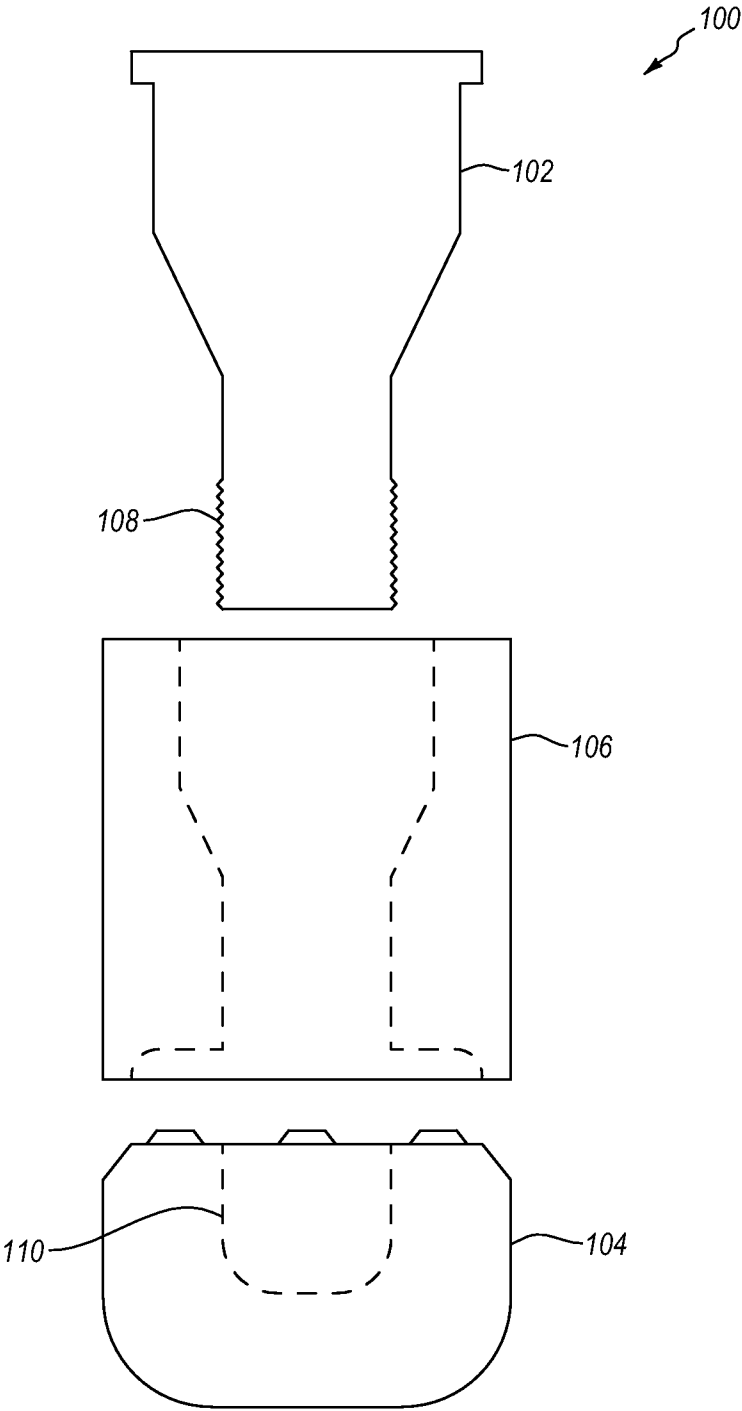


FIG. 1

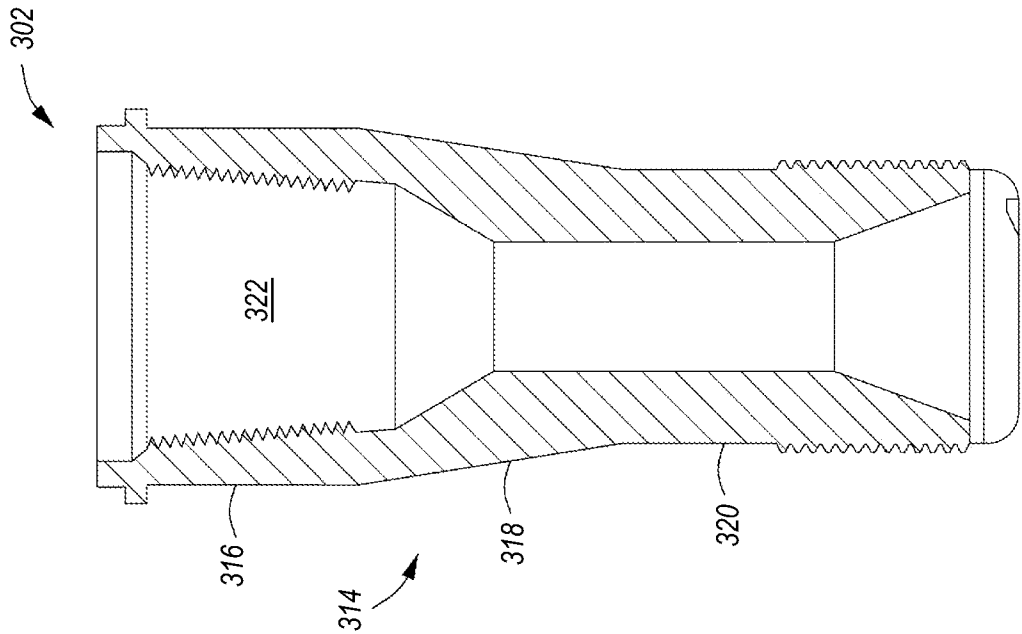


FIG. 3

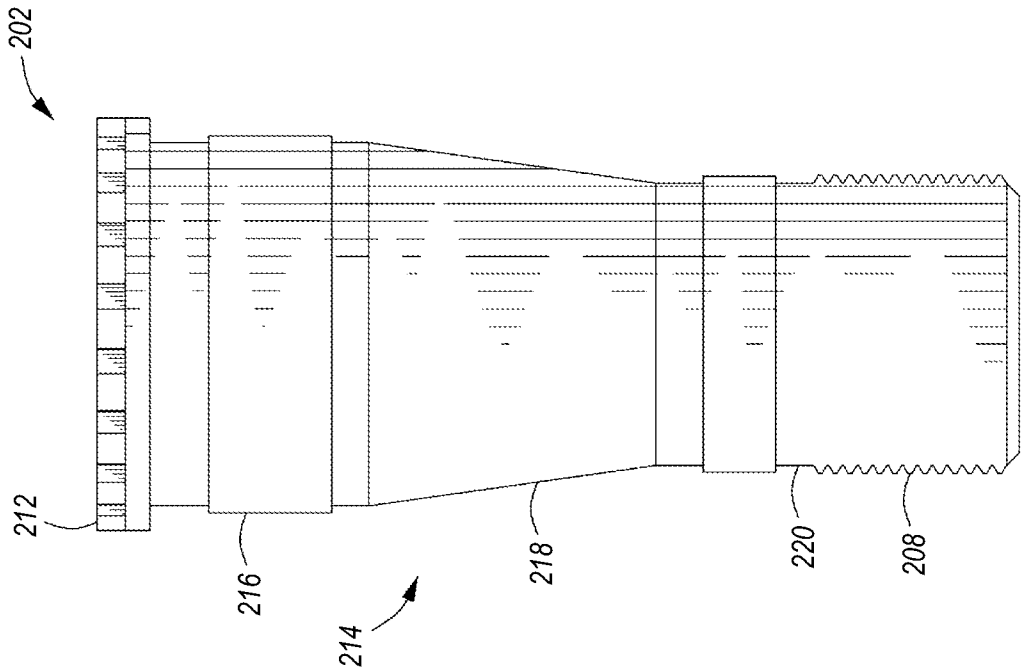


FIG. 2

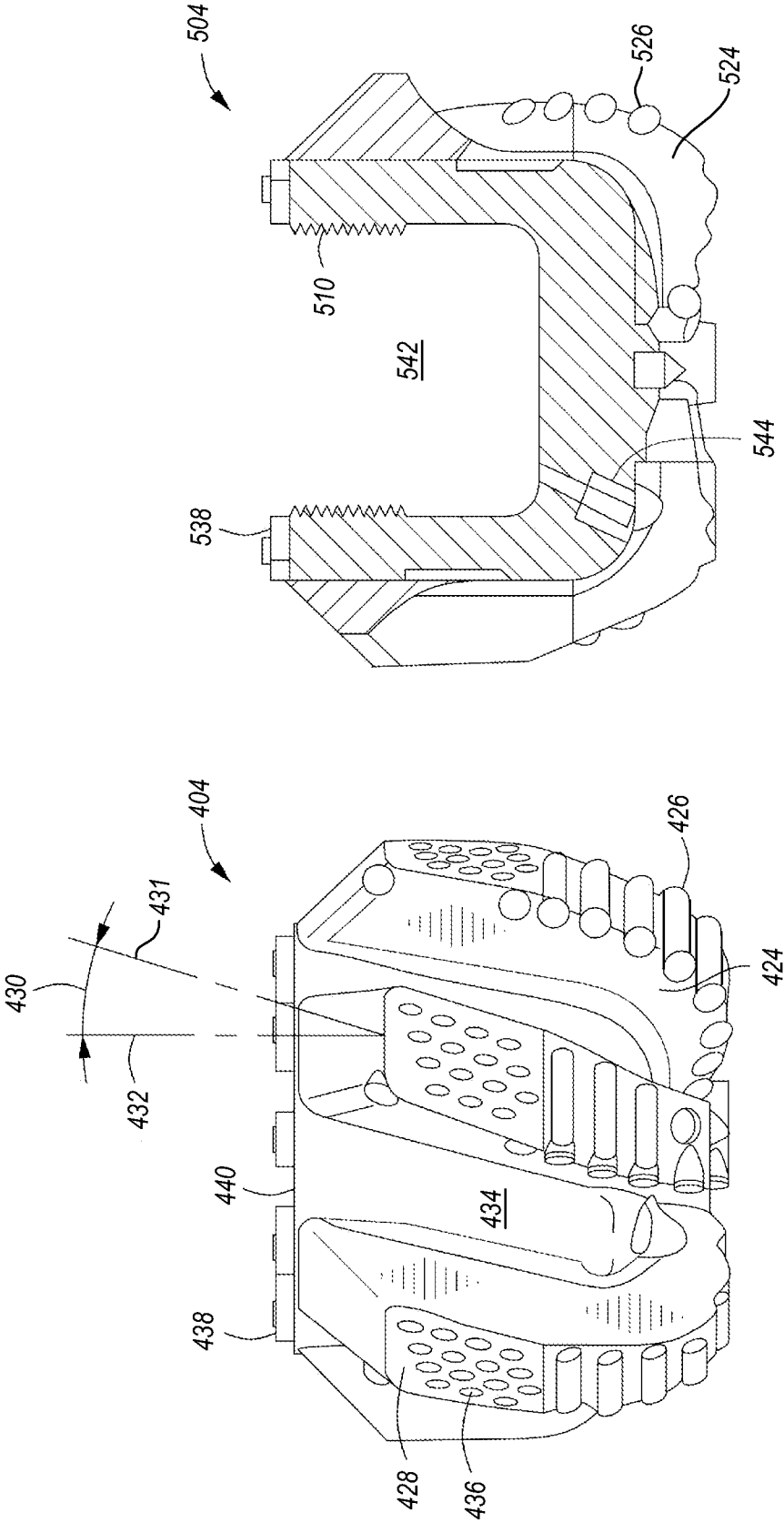


FIG. 5

FIG. 4

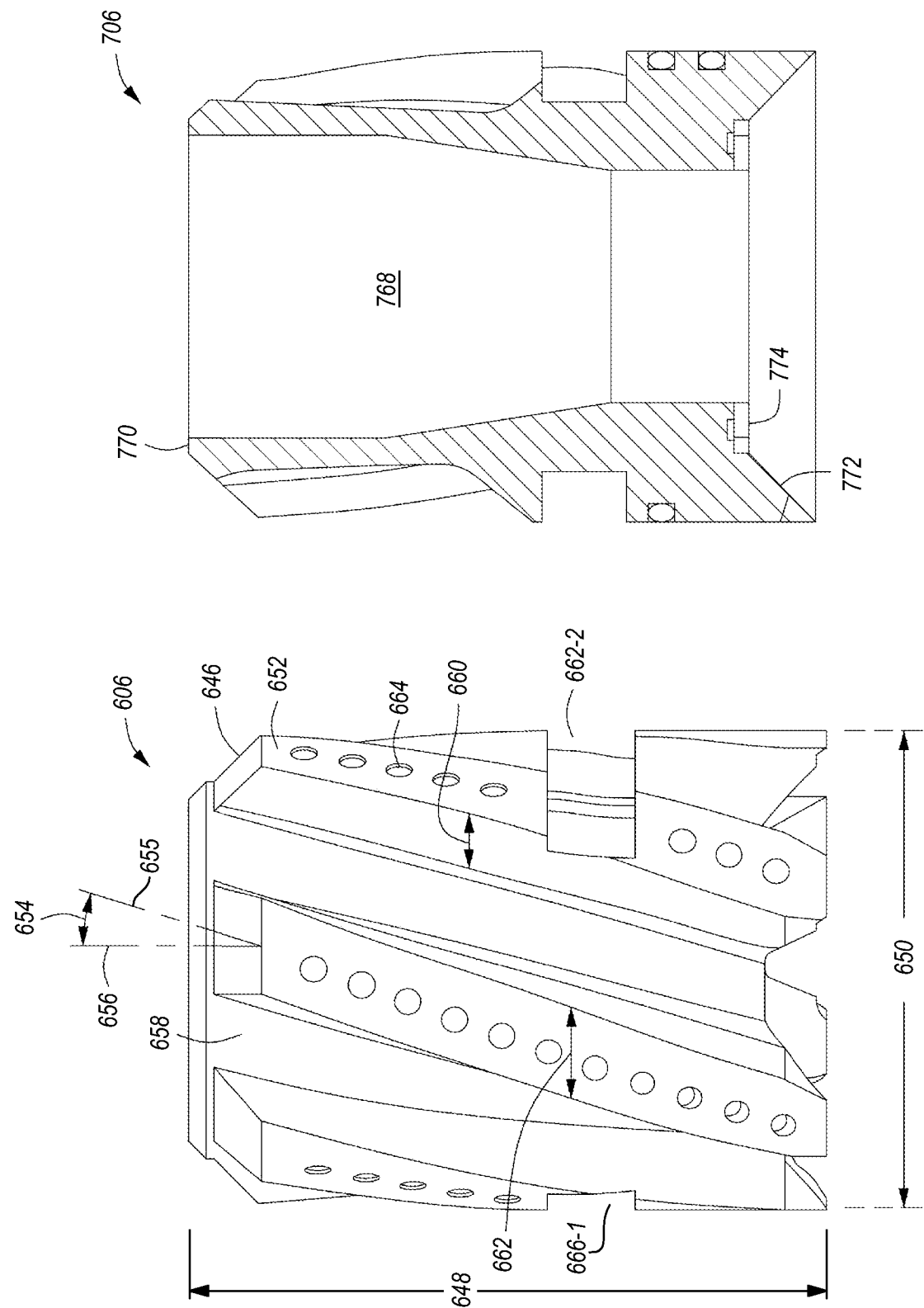


FIG. 7

FIG. 6

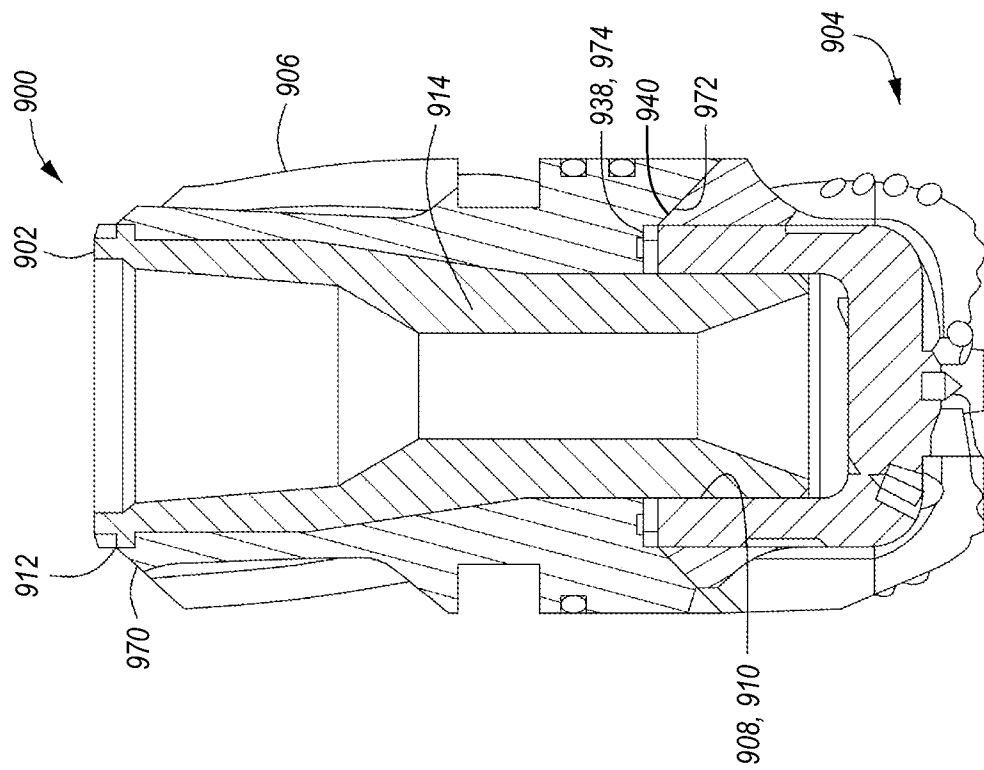


FIG. 9

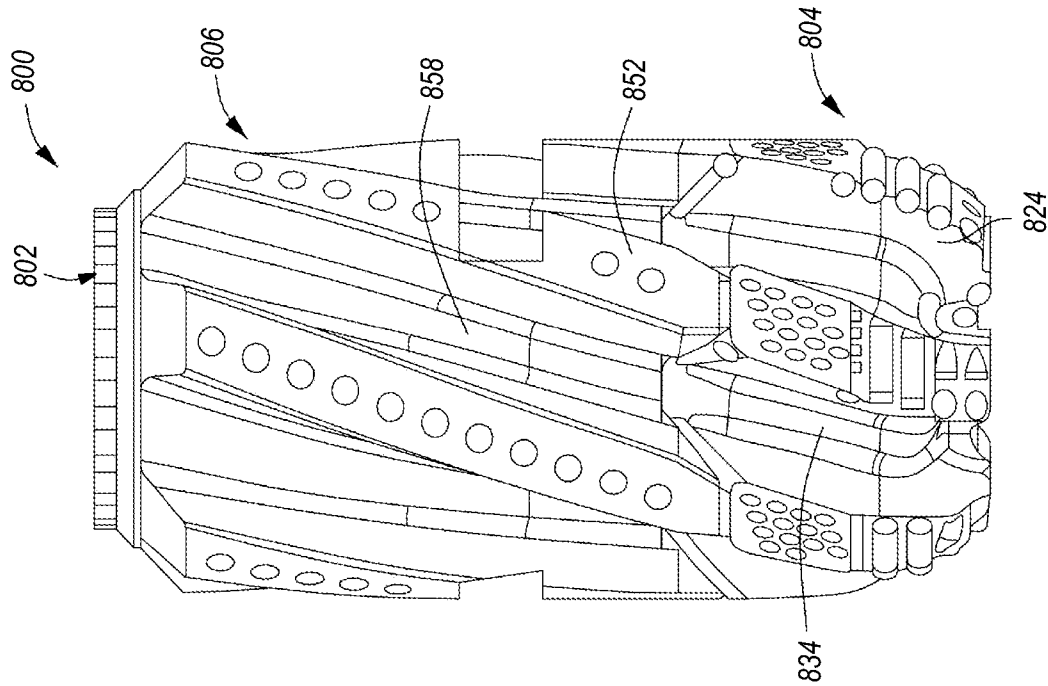


FIG. 8

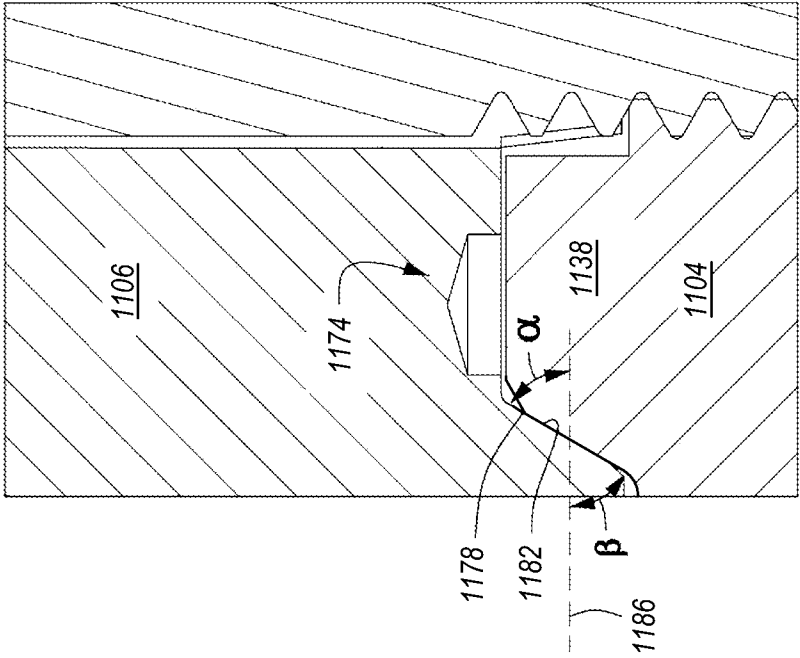


FIG. 11

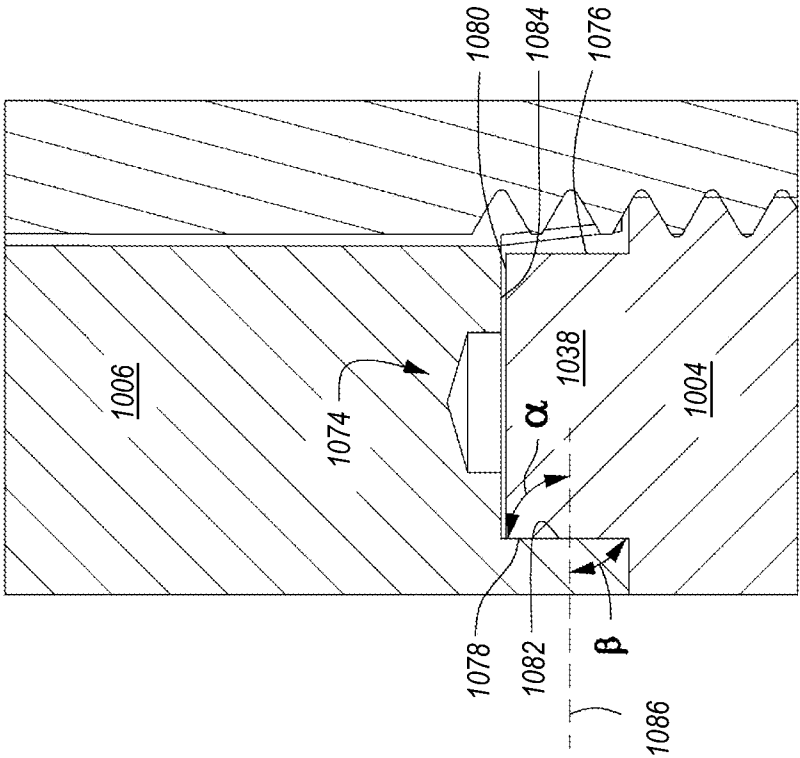


FIG. 10

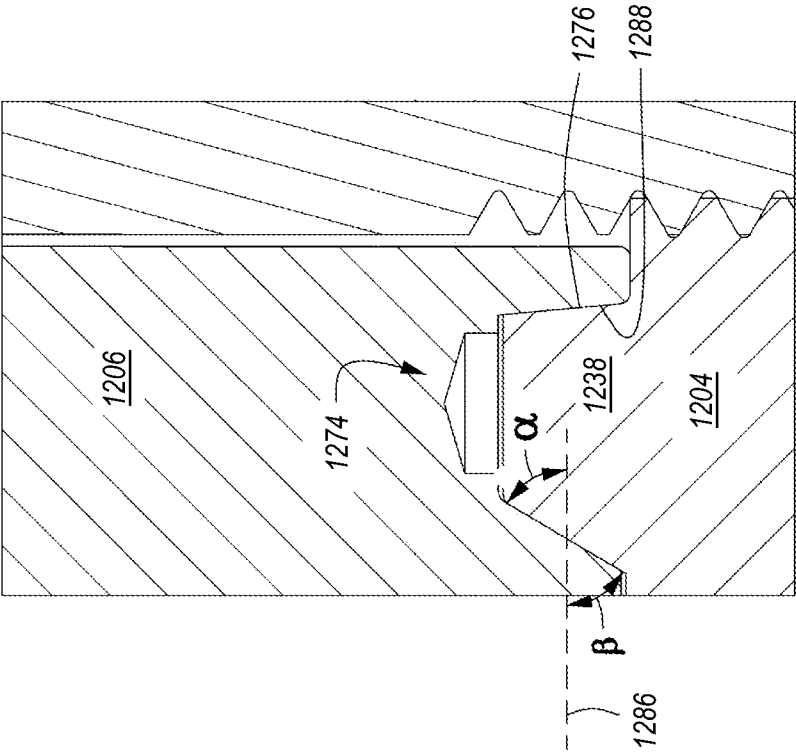


FIG. 12

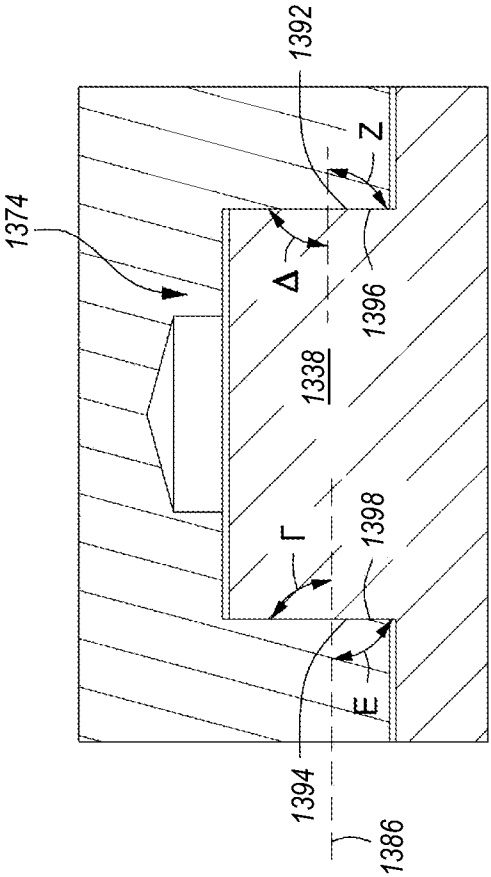


FIG. 13

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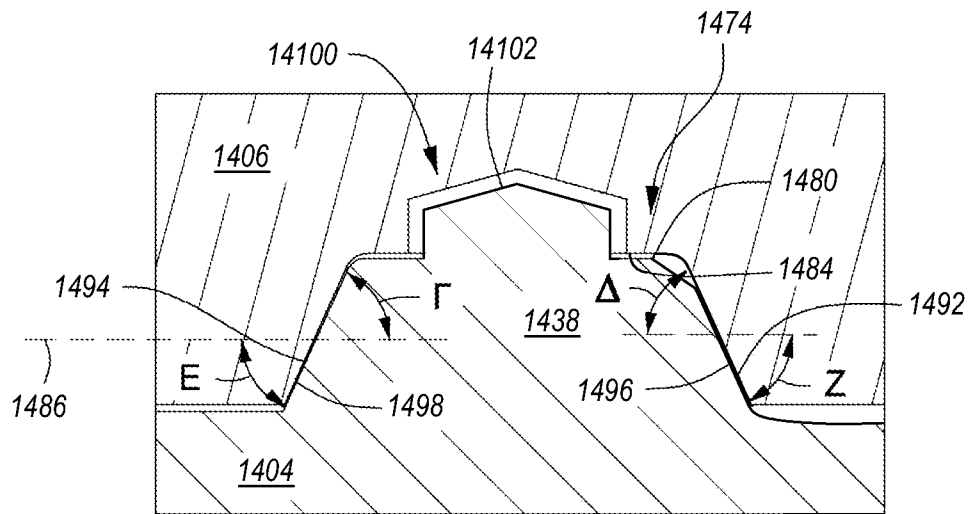


FIG. 14

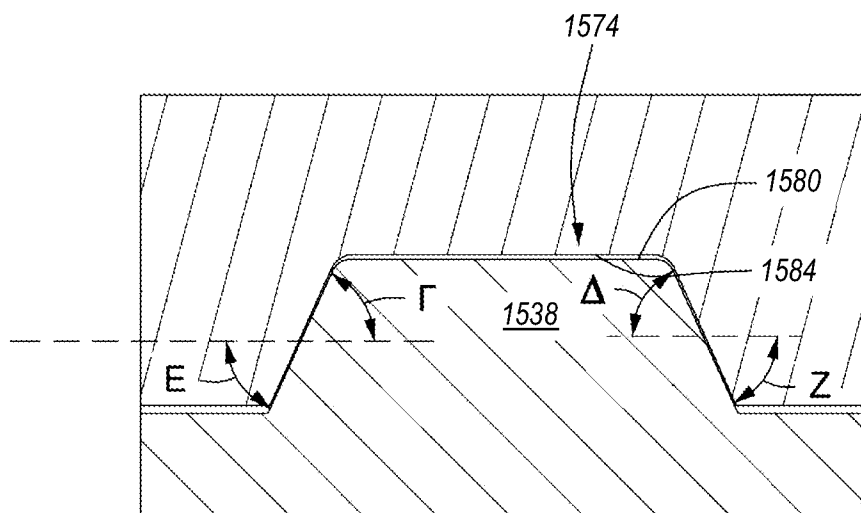
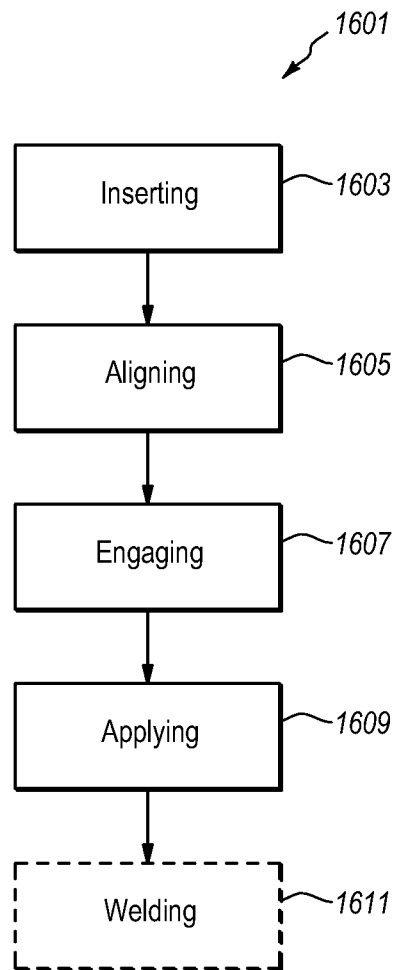


FIG. 15

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**FIG. 16**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/051242**A. CLASSIFICATION OF SUBJECT MATTER****E21B 10/42(2006.01)i, E21B 10/62(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)

E21B 10/42; E21B 10/18; E21B 3/02; E21B 17/10; E21B 10/36; E21B 47/02; E21B 10/32; E21B 37/00; B21K 5/04; E21B 10/62

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: locking ring, blade, recess, protrusion, non-weldable component

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009-0032309 A1 (THORSTEN SCHWEFE et al.) 05 February 2009 See paragraphs 9, 17, 21-30; and figures 2-5.	11
Y		1-3, 12, 18-20, 23-24
Y	US 2012-0273281 A1 (YURI BURHAN et al.) 01 November 2012 See paragraphs 32-34; and figures 2A-2B.	1-3, 12, 18-20, 23-24
A	US 2007-0029113 A1 (SHILIN CHEN) 08 February 2007 See paragraphs 151-166; and figures 5A-5D.	1-3, 11-12, 18-20 , 23-24
A	US 2012-0043087 A1 (CARLOS TORRES) 23 February 2012 See paragraphs 40-51; and figures 2A-2D.	1-3, 11-12, 18-20 , 23-24
A	KR 10-2012-0108707 A (INDUSTRY-ACADEMIC COOPERATION FOUNDATION, YONSEI UNIVERSITY) 05 October 2012 See paragraphs 26-40; and figures 1-4.	1-3, 11-12, 18-20 , 23-24



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

24 November 2014 (24.11.2014)

Date of mailing of the international search report

25 November 2014 (25.11.2014)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/051242**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 4-10,13-17,21-22,25-26
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/051242

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/051242

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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