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(71) **Demandeur/Applicant:**
ALCOA INC., US

(72) **Inventeurs/Inventors:**
PINHEIRO, RODRIGO, US;
HAYLOCK, LUKE, US

(74) **Agent:** BERESKIN & PARR LLP/S.E.N.C.R.L.,S.R.L.

(54) **Titre : CREUX ET CLEF DE DISPOSITIF DE FIXATION ASYMETRIQUE**
(54) **Title: ASYMMETRIC FASTENER RECESS AND KEY**

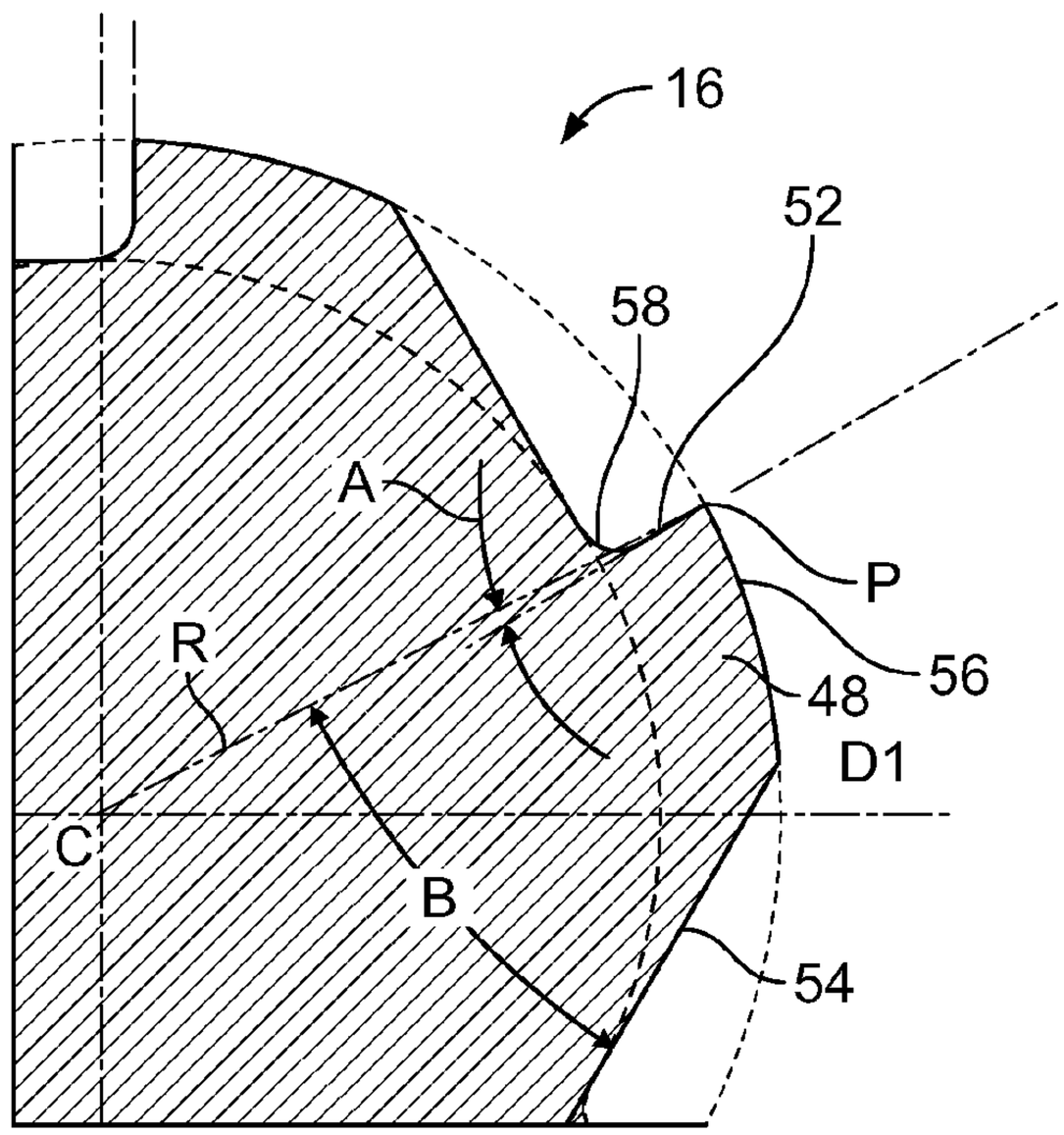

FIG. 6B

(57) **Abrégé/Abstract:**
A fastening system (10) including a pin member (12) and a key (16) for engaging the pin member (12). The pin member (12) includes a shank portion (18) and a recess (28) formed within an end face (30) of the shank portion (18). The recess (28) includes

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(57) **Abrégé(suite)/Abstract(continued):**
a plurality of splines (32) and recesses (34) that form first and second bearing surfaces (36, 38) oriented at angles (A, B). The key (16) includes a key head (46) having a plurality of splines and grooves (48, 50) that form first and second bearing surfaces (52, 54) oriented at angles (A, B). The plurality of splines and recesses (52, 54) of the pin member (12) and the plurality of splines and recesses (52, 54) of the key (16) are adapted to communicate with each other when tightening and loosening the pin member (12).

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(71) Applicant: **ALCOA INC.** [US/US]; 201 Isabella Street, Pittsburgh, PA 15212-5858 (US).

(72) Inventors: **PINHEIRO, Rodrigo**; 11232 Streamfield Court, Riverside, CA 90505 (US). **HAYLOCK, Luke**; 4522 Huntley Avenue, Culver City, CA 90230 (US).

(74) Agent: **AGOSTINO, Joseph**; c/o Greenberg Traurig, LLP, Alcoa Inc., 100 Technical Drive, Alcoa Center, PA 15069 (US).

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(54) Title: ASYMMETRIC FASTENER RECESS AND KEY

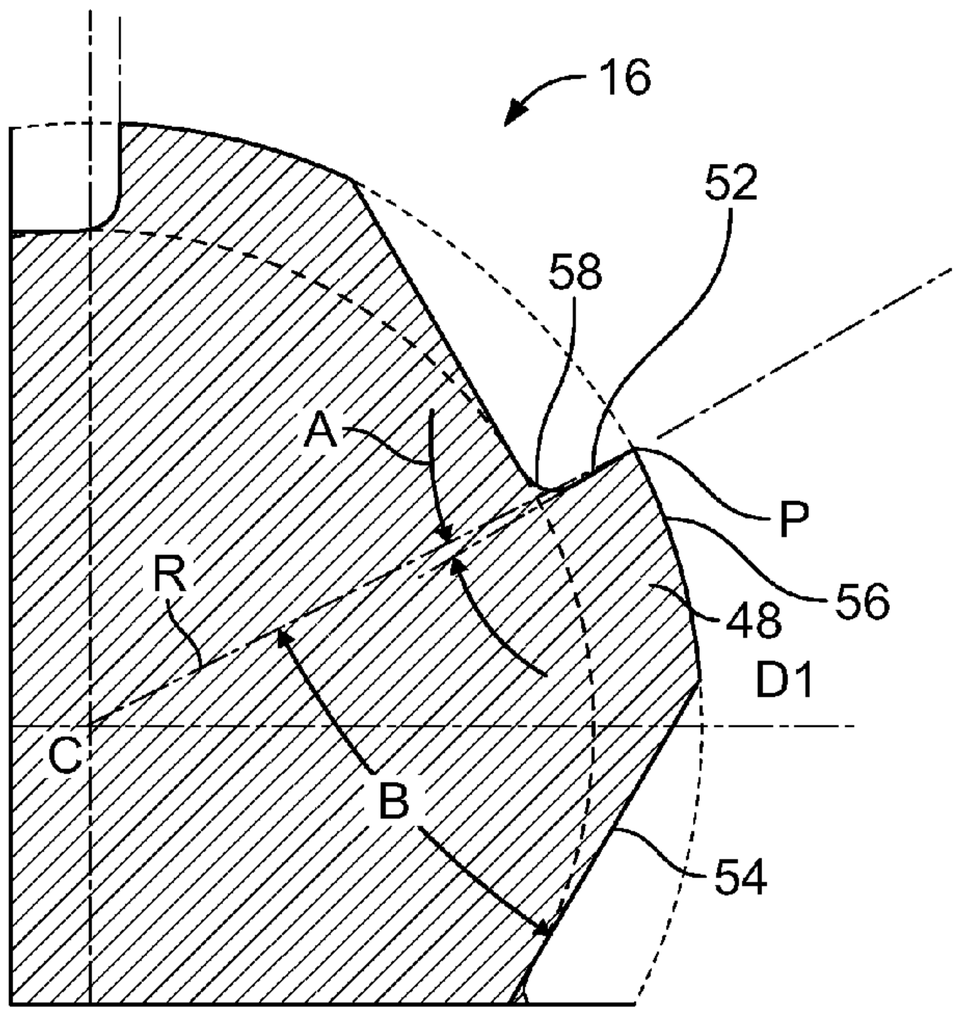

FIG. 6B

(57) Abstract: A fastening system (10) including a pin member (12) and a key (16) for engaging the pin member (12). The pin member (12) includes a shank portion (18) and a recess (28) formed within an end face (30) of the shank portion (18). The recess (28) includes a plurality of splines (32) and recesses (34) that form first and second bearing surfaces (36, 38) oriented at angles (A, B). The key (16) includes a key head (46) having a plurality of splines and grooves (48, 50) that form first and second bearing surfaces (52, 54) oriented at angles (A, B). The plurality of splines and recesses (52, 54) of the pin member (12) and the plurality of splines and recesses (52, 54) of the key (16) are adapted to communicate with each other when tightening and loosening the pin member (12).

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ASYMMETRIC FASTENER RECESS AND KEY

Cross-Reference to Related Application

This application relates to and claims the benefit of commonly owned, co-pending U.S. Provisional Patent Application No. 61/885,227, filed on October 1, 2013, entitled ASYMMETRIC FASTENER RECESS AND KEY, which is incorporated by reference herein in its entirety.

Technical Field of the Invention

The present invention relates to fastener systems, and, more particularly, to a fastener system having a pin member with a spline-drive asymmetric recess for receiving a mating key or tool.

Background of the Prior Art

Fasteners come in a variety of types, such as threaded pins or bolts, which threadedly receive a nut, or which threadedly engage a bore. Asymmetric fasteners and tools utilize a first set of bearing surfaces for loosening the fastener and a second set of bearing surfaces for tightening the fastener. Problems with existing asymmetric fasteners are high hoop stresses, dilation of the pin member, low bearing strength and shorter life, low torque capabilities, and bearing distortion on the recesses of the fastener.

Disclosure of the Invention

In an embodiment, a fastening system includes a pin member including an elongated shank portion having a first end, a second end opposite the first end, a smooth cylindrical shank portion, a threaded portion located at the second end and having a plurality of external threads, and an end face located at the second end and having a recess formed therein, and a head located at the first end, wherein the recess includes a plurality of splines extending axially and positioned circumferentially and equally spaced about a periphery thereof and extending inwardly, each of the plurality of splines includes a first bearing surface and a second bearing surface, wherein the recess includes a plurality of recesses extending axially and formed circumferentially and equally spaced about the periphery, each of the plurality of recesses being located between a corresponding pair of the plurality of splines, wherein each of the first bearing surfaces of each of the plurality of splines of the is oriented at a first angle extending and measured from a radial line that extends from a center point of the elongated shank portion of the pin member to a first point on such first bearing surface located proximate to minor inner diameter of such spline of the pin member in a rotational direction towards the second bearing surface of such spline, wherein each of the second bearing surfaces of each of the plurality of splines is oriented at a second angle extending and measured from the radial line in a rotational direction towards such second bearing surface of such spline; and a key including an elongated shaft having a first end, and a second end opposite the first end of the elongated shaft, and a key head located at the second end of the elongated shaft, wherein the key head includes a plurality of splines extending axially thereon and being equally spaced around a circumference thereof,

each of the plurality of splines of the key head having a first bearing surface and a second bearing surface, and wherein the key head includes a plurality of grooves extending axially thereon and being equally spaced around the circumference, each of the plurality of grooves being located between a corresponding pair of the plurality of splines of the key head, wherein each of the first bearing surfaces of each of the plurality of splines of the key head is oriented at a third angle extending and measured from a radial line that extends from a center point of the key to a first point on such first bearing surface of such spline of the key head located proximate to a major outer diameter of such spline of the key head in a rotational direction towards the second bearing surface of such spline of the key head, wherein each of the second bearing surfaces of each of the plurality of splines of the key head is oriented at a fourth angle extending and measured from the radial line of the key head in a rotational direction towards such second bearing surface of such spline of the key head, and wherein the key head of the key is adapted to mate with the recess of the pin member such that each of the first bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the first bearing surface of a corresponding one of each of the plurality of splines of the pin member, and each of the second bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the second bearing surface of a corresponding one of each of the plurality of splines of the pin member.

In an embodiment, the plurality of splines of the pin member includes six of the splines and wherein the plurality of recesses of the pin member includes six of the recesses, and wherein the plurality of splines of the key includes six of the splines and

the plurality of grooves of the key includes six of the grooves. In an embodiment, the first angle and the third angle are each within a range of about 1° to about 5°. In an embodiment, the second angle and the fourth angle are each within a range of about 30° to about 35°.

In an embodiment, the plurality of splines of the pin member includes eight of the splines and wherein the plurality of recesses of the pin member includes eight of the recesses, and wherein the plurality of splines of the key includes eight of the splines and the plurality of grooves of the key includes eight of the grooves. In an embodiment, the first angle and the third angle are each within a range of about 1° to about 5°. In an embodiment, the second angle and the fourth angle are each within a range of about 40° to about 50°. In an embodiment, a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines of the pin member are perpendicular to one another, and wherein a corresponding pair of the first bearing and the second bearing surface of each of the plurality of splines of the key are perpendicular to one another.

In an embodiment, the fastening system includes a nut adapted to engage threadedly the threaded portion of the pin member. In an embodiment, the nut includes a centrally-located bore that is sized and shaped to receive the key therethrough.

Brief Description of the Drawings

FIG. 1 is a perspective view of a fastening system in accordance with an embodiment;

FIG. 2 is a bottom plan view of a pin member employed by the fastener system shown in **FIG. 1**;

FIGS. 3 and **4** are side elevational and perspective views, respectively, of a fastener key employed by the fastener system shown in **FIG. 1**;

FIG. 5 is a perspective view of Detail B of **FIG. 4**;

FIG. 6A is a cross-sectional view, taken along line A-A and looking in the direction of the arrows, of the fastener key shown in **FIG. 3**;

FIG. 6B is an enlarged view of a portion of the fastener key shown in **FIG. 6A**;

FIG. 7 is a bottom plan view of the pin member shown in **FIG. 2** with a cross-section of the key shown in **FIGS. 3** through **6B** engaging the pin member;

FIG. 8 is a cross-sectional view of the fastening system shown in **FIG. 1** with the pin member and the nut engaging a work piece;

FIG. 9 is a standard hex configuration superimposed over a asymmetric recess configuration;

FIG. 10 is a bottom plan view of another embodiment of a pin member;

FIG. 11 is a side elevational view of another embodiment of a fastener key;

FIG. 12 is a cross-sectional view, taken along line A-A and looking in the direction of the arrows, of the fastener key shown in **FIG. 11**; and

FIG. 13 is a bottom plan view of the pin member shown in **FIG. 10** with a cross-section of the fastener key shown in **FIGS. 11** and **12** engaging the pin member.

Best Mode for Carrying Out the Invention

Referring to **FIG. 1**, in an embodiment, a fastening system **10** includes a bolt or pin member **12** (hereinafter, "pin member **12**"), a nut **14**, and a fastener installation tool or fastener key **16** (hereinafter, "key **16**"). In an embodiment, the pin member **12** is a shear pin. In an embodiment, the pin member **12** includes an elongated shank portion **18** having a smooth cylindrical shank portion **20** and a threaded portion **22** having a plurality of external threads **24**. In an embodiment, the pin member **12** includes a head **26** at one end and a centrally located internal wrench cavity or recess **28** formed axially within an end face **30** of the threaded portion **22** at an opposite end. In an embodiment, the nut **14** includes a centrally-located bore **15** that is sized and shaped to receive the key **16** therein. In an embodiment, the nut **14** includes a plurality of internal threads that threadedly engages the external threads **24** of the pin member **12**. In an embodiment, the fastening system **10** is adapted to secure a plurality of work pieces to one another by compressive engagement between the nut **14** on one side of one of the work pieces and the head **26** of the pin member **12** on an opposite side of another of the work pieces when the nut **14** is torqued onto the pin member **12**. As will be discussed in further detail below, the recess **28** of the pin member **12** is sized, shaped, and adapted to mate with and receive the key **16**, which holds the pin member **12** stationary while a driver turns the nut **14**. In an embodiment, the recess **28** reacts to the torque translated onto the pin member **12** when tightening the nut **14**. In another embodiment, the recess **28** may be formed within the top of the head **26** of the pin member **12** (not shown in the Figures).

Referring to **FIG. 2**, the recess **28** includes a plurality of splines **32** positioned circumferentially and equally spaced about a periphery thereof and extending inwardly, and a plurality of recesses **34** formed circumferentially and equally spaced about the periphery thereof. In an embodiment, the plurality of splines **32** includes six (6) of the splines, while the plurality of recesses **34** includes six (6) of the recesses. In an embodiment, each of the splines **32** includes a first bearing surface **36** (sometimes referred to as a "contact flank" or a "contact area") and a second bearing surface **38**. In an embodiment, the first bearing surface **36** and the second bearing surface **38** on each of the splines **32** are substantially perpendicular to one another. In an embodiment, each of the first bearing surfaces **36** is parallel to a plane that contains the diametrical centerline of the recess **28**, and the first bearing surface **36** is offset from such plane. In an embodiment, the recess **28** is sized and shaped to match that of the geometry of a fastener engagement end of the key **16**, which will be described in detail below.

Referring to **FIGS. 3** through **5**, in an embodiment, the key **16** includes an elongated shaft **40** having a first end **42**, a second end **44** opposite the first end **42**, and a frusto-conical shaped key head **46** located at the second end **44** of the shaft **40**. In an embodiment, referring to **FIG. 5,** the key head **46** includes a plurality of splines **48** extending axially thereon and equally spaced around the circumference thereof, and a plurality of grooves **50** extending axially thereon and equally spaced around the circumference thereof, each of which is located intermediate two of the splines **48**. In an embodiment, the splines **48** and the grooves **50** are parallel to the longitudinal axis **A-A** of the shaft **40**. In an embodiment, the plurality of splines **48** includes six (6) of the splines, while the plurality of grooves **50** includes six (6) of the grooves **50**.

Referring to **FIGS. 6A** and **6B**, in an embodiment, each of the splines **48** of the key **16** includes a first bearing surface **52** (or contact flank), a second bearing surface **54**, and an outer face **56** which forms a portion of the major outer diameter of the key **16.** In an embodiment, the first bearing surface **52** includes a length **L** (see **FIG. 6A**). In an embodiment, each of the first bearing surfaces **52** is parallel to a plane that contains the diametrical centerline of the key **16**, and the first bearing surface **52** is offset from such plane. In an embodiment, the first bearing surface **52** of one of the splines **48** and the second bearing surface **54** of another of the splines **48** that is positioned proximate and counterclockwise thereto (as shown in **FIGS. 6A** and **6B**) are perpendicular to one another. In an embodiment, the first bearing surface **52** of one of the splines **48** and the second bearing surface **54** of another of the splines **48** positioned proximate and counterclockwise thereto (as shown in **FIGS. 6A** and **6B**) are contiguous by a radiused portion **58.**

In an embodiment, and as especially shown in greater detail in **FIG. 6B,** the first bearing surface **52** of each of the splines **48** is oriented at an Angle **A.** That is, Angle **A** is measured from a radial line **R** that extends from a center point **C** to a point **P** on the first bearing surface **52** located proximate to a major outer diameter **D1** of such spline **48**. In an embodiment, Angle **A** of the first bearing surface **52** of each of the splines **48** extends and is measured from the radial line **R** in a rotational direction towards the second bearing surface **54** of such spline **48**. Angle **A** is sometimes referred to as a negative undercut. That is, Angle **A** of the first bearing surface **52** extends in a direction as that of the preferential direction (e.g., the direction in which the load is applied to the pin member **12** during tightening of the nut **14** thereon). In an embodiment, Angle **A** is

within a range of about 1° to about 5°. In another embodiment, Angle **A** is about 1°. In another embodiment, Angle **A** is about 1.5°. In another embodiment, Angle **A** is about 1.6°. In another embodiment, Angle **A** is about 1.7°. In another embodiment, Angle **A** is about 1.8°. In another embodiment, Angle **A** is about 1.9°. In another embodiment, Angle **A** is about 2.0°. In another embodiment, Angle **A** is about 2.1°. In another embodiment, Angle **A** is about 2.2°. In another embodiment, Angle **A** is about 2.3°. In another embodiment, Angle **A** is about 2.4°. In another embodiment, Angle **A** is about 2.5°. In another embodiment, Angle **A** is about 2.6°. In another embodiment, Angle **A** is about 2.7°. In another embodiment, Angle **A** is about 2.8°. In another embodiment, Angle **A** is about 2.9°. In another embodiment, Angle **A** is about 3.0°.

Still referring to **FIG. 6B**, the second bearing surface **54** of each of the splines **48** is oriented at an Angle **B.** In an embodiment, Angle **B** is measured from the radial line **R** in a rotational direction towards the second bearing surface **54** of such spline **48**. In an embodiment, Angle **B** is within a range of about 30° to about 35°. In another embodiment, Angle **B** is about 30°. In another embodiment, Angle **B** is about 30.5°. In another embodiment, Angle **B** is about 31°. In another embodiment, Angle **B** is about 31.5°. In another embodiment, Angle **B** is about 32°. In another embodiment, Angle **B** is about 32.5°. In another embodiment, Angle **B** is about 33°. In another embodiment, Angle **B** is about 33.5°. In another embodiment, Angle **B** is about 34°. In another embodiment, Angle **B** is about 34.5°. In another embodiment, Angle **B** is about 35°.

In an embodiment, as mentioned above, the recess **28** of the pin member **12** (i.e., the splines **32** and the recesses **34**) includes a geometry that is the same as (or is substantially similar to) the geometry of the key head **46** at the second end **44,** as

described above. In an embodiment, the recess **28** of the pin member **12** is sized and shaped to mate with and accommodate receipt of the key head **46** of the key **16** with necessary clearances and tolerances in order for the key **16** to engage the pin member **12**.

Referring to **FIGS. 7** and **8**, in an embodiment, when the pin member **12** and the nut **14** are set on a work piece **60** (**FIG. 8** showing the nut **14** and the work piece **60**), the key head **46** of the key **16** mates with and engages the recess **28** of the pin member **12** to prevent rotation of the pin member **12** as the nut **14** is torqued on by a driver (not shown in the Figures). In an embodiment, the key **16** may be attached to a power tool, or may be used for manual installation. In an embodiment, the splines **48** and grooves **50** of the key **16** engage the corresponding recesses **34** and splines **32** of the recess **28** of the pin member **12**, respectively. In an embodiment, when the key **16** engages the recess **28** and is turned/torqued, each of the first bearing surfaces **52** of the splines **48** of the key **16** contacts a corresponding one of the first bearing surfaces **36** of the splines **32** of the recess **28** of the pin member **12** (see **FIG. 7**). In an embodiment, the length **L** of each of the first bearing surfaces **36** is of a sufficient length to maintain such contact. In an embodiment, the contact between each of the first bearing surfaces **52** of the splines **48** of the key **16** and the corresponding one of the first bearing surfaces **36** of the splines **32** of the recesses **28** of the pin member **12** is always face-to-face in the preferential (tightening direction), independent of any clearances between the pin member **12** and the key **16** (see **FIG. 7**). When engaged in this manner, there is a negative angle of contact (angle of attack in the preferential direction), due to Angle **A** of each of the first bearing surfaces **52** of each of the splines **48**. Furthermore, when the

key **16** engages the recess **28** and torque is applied, the radial component of the contact force is directed inwardly (the key **16** pulls the recess **28** inwardly), thereby reducing the hoop stresses applied to the recess **28** and eliminating dilation on the pin member **12.** This enables the pin member **12** to be made with a thinner wall, as well as accommodate higher torques. Also, the bearing strength of the key **16** is increased, which promotes a higher useful life thereof. In addition, bearing distortion on the recess **28** is alleviated, thereby improving torque capability.

When torque is applied in the non-preferential direction (loosening or reverse direction), each of the second bearing surfaces **54** of the splines **48** of the key **16** contact and engage a corresponding one of the second bearing surfaces **38** of the splines **32** of the recess **28** of the pin member **12.** In an embodiment, such contact can be configured to match polygonal configurations, such as a hex for a six lobe key, as shown in **FIG. 9,** or as a double square for an eight lobe key.

In other embodiments, the recess **28** of the pin member **12** and the key **16** can each include other numbers of asymmetric splines **32, 48**, respectively, such as 5, 7, 8 (to be described below), 12, etc.

FIGS. 10 through **13** show an embodiment of a pin member **112** and an embodiment of a key **116**. Elements shown in **FIGS. 10** through **13** which correspond, either identically or substantially, to the elements described above with respect to the embodiment shown in **FIGS. 1** through **9** have been designated by corresponding reference numerals increased by one hundred, respectively. Unless otherwise stated, the embodiment shown in **FIGS. 10** through **13** is structured and functions in the same manner as the embodiment shown in **FIGS. 1** through **9**.

Referring to **FIG. 10**, in an embodiment, the pin member **112** includes a recess **128** on an end face **130** and is defined by a plurality of splines **132** positioned circumferentially and equally spaced about a periphery thereof and extending inwardly, and a plurality of recesses **134** formed circumferentially and equally spaced about the periphery thereof. In an embodiment, the plurality of splines **132** includes eight (8) of the splines, while the plurality of recesses **134** includes eight (8) of the recesses. In an embodiment, each of the splines **132** includes a first bearing surface **136** (sometimes referred to as a "contact flank" or "contact area") and a second bearing surface **138**. In an embodiment, the first bearing surface **136** and the second bearing surface **138** of each of the splines **132** are substantially perpendicular to one another. In an embodiment, the recess **128** is sized and shaped to match that of the geometry of an end of the key **116**, which will be described in detail below.

Referring to **FIG. 11**, in an embodiment, the key **116** includes an elongated shaft **140** having a first end **142**, a second end **144** opposite the first end **142**, and a frusto-conical-shaped key head **146** located at the second end **144** of the shaft **140**. In an embodiment, the key head **146** includes a plurality of splines **148** extending axially thereon and equally spaced around the circumference thereof, and a plurality of grooves **150** extending axially thereon and equally spaced around the circumference thereof, each of which is positioned intermediate two of the splines **148**. In an embodiment, the splines **148** and the grooves **150** are parallel to the longitudinal axis **A-A** of the shaft **140**. In an embodiment, the plurality of splines **148** includes eight (8) of the splines **148**, while the plurality of grooves includes eight (8) of the grooves **150**.

Referring to **FIG. 12**, in an embodiment, each of the splines **148** includes a first bearing surface **152** (or contact flank), a second bearing surface **154**, and an outer face **156** which forms a portion of the major outer diameter of the key **116.** In an embodiment, the first bearing surface **152** includes a length **L**. In an embodiment, the first bearing surface **152** of one of the splines **148** and the second bearing surface **154** of another of the splines **148** positioned proximate and counterclockwise thereto (as shown in **FIG. 12**) are perpendicular to one another. In an embodiment, the first bearing surface **152** of one of the splines **148** and the second bearing surface **154** of another of the splines **148** positioned proximate and counterclockwise thereto (as shown in **FIG. 12**) are contiguous by a radiused portion **158.**

In an embodiment, the first bearing surface **152** of each of the splines **148** is oriented at an Angle **A.** Angle **A** of each of the first bearing surfaces **152** is measured as that of Angle **A** of the first bearing surfaces **152** of the key **116**, as described above. In an embodiment, Angle **A** of each of the first bearing surfaces **152** is within a range of about 1° to about 5°. In another embodiment, Angle **A** is about 1°. In another embodiment, Angle **A** is about 1.5°. In another embodiment, Angle **A** is about 1.6°. In another embodiment, Angle **A** is about 1.7°. In another embodiment, Angle **A** is about 1.8°. In another embodiment, Angle **A** is about 1.9°. In another embodiment, Angle **A** is about 2.0°. In another embodiment, Angle **A** is about 2.1°. In another embodiment, Angle **A** is about 2.2°. In another embodiment, Angle **A** is about 2.3°. In another embodiment, Angle **A** is about 2.4°. In another embodiment, Angle **A** is about 2.5°. In another embodiment, Angle **A** is about 2.6°. In another embodiment, Angle **A** is about

2.7°. In another embodiment, Angle **A** is about 2.8°. In another embodiment, Angle **A** is about 2.9°. In another embodiment, Angle **A** is about 3.0°.

In an embodiment, the second bearing surfaces **154** of each of the splines **148** is oriented at an Angle **B,** and is measured in the same manner as that of Angle **B** of the each of the second bearing surfaces **54** of the key **16**, as described above. In an embodiment, Angle **B** is within a range of about 40° to about 50°. In another embodiment, Angle **B** is about 40°. In another embodiment, Angle **B** is about 40.5°. In another embodiment, Angle **B** is about 41°. In another embodiment, Angle **B** is about 41.5°. In another embodiment, Angle **B** is about 42°. In another embodiment, Angle **B** is about 42.5°. In another embodiment, Angle **B** is about 43°. In another embodiment, Angle **B** is about 43.5°. In another embodiment, Angle **B** is about 44°. In another embodiment, Angle **B** is about 44.5°. In another embodiment, Angle **B** is about 45°. In another embodiment, Angle **B** is about 45.5°. In another embodiment, Angle **B** is about 46°. In another embodiment, Angle **B** is about 46.5°. In another embodiment, Angle **B** is about 47°. In another embodiment, Angle **B** is about 47.5°. In another embodiment, Angle **B** is about 48°. In another embodiment, Angle **B** is about 48.5°. In another embodiment, Angle **B** is about 49°. In another embodiment, Angle **B** is about 49.5°. In another embodiment, Angle **B** is about 50°.

Referring to **FIG. 13**, in an embodiment, when the pin member **112** is set (the nut not being shown), the recess **128** of the pin member **112** receives and engages the key **116** to prevent rotation of the pin member **112** as a nut is torqued on by a driver (not shown in **FIG. 13**). In an embodiment, the key **116** may be attached to a power tool, or may be used for manual installation. In an embodiment, the splines **148** and grooves

150 of the key **116** engage the corresponding recesses **134** and splines **132** of the recess **128** of the pin member **112**. In an embodiment, when the key **116** engages the recess **128** and is turned/torqued, each of the first bearing surfaces **152** of the splines **148** of the key **116** contact a corresponding one of the first bearing surfaces **136** of the splines **132** of the recess **128** of the pin member **112.** In an embodiment, the length **L** of each of the first bearing surfaces **136** is of a sufficient length to maintain such contact. In an embodiment, the contact between each of the first bearing surfaces **152** of the splines **148** of the key **116** and the corresponding one of the first bearing surfaces **136** of the splines **132** of the recesses **128** of the pin member **112** is always face-to-face in the preferential direction (tightening direction), independent of any clearances between the pin member **112** and the key **116**. When engaged in this manner, there is a negative angle of contact (angle of attack in the preferential direction). Furthermore, when the key **116** engages the recess **128** and torque is applied, the radial component of the contact force is directed inwardly (the key **116** pulls the recess **128** inwardly), thereby reducing the hoop stresses applied to the recess **128** and eliminating dilation on the pin member **112.**

When torque is applied in the non-preferential direction (loosening or reverse direction), each of the second bearing surfaces **154** of the splines **148** of the key **116** contact and engage a corresponding one of the second bearing surfaces **138** of the splines **132** of the recess **128** of the pin member **112.** In an embodiment, such contact can be configured to match polygonal configurations, such as a hex for a six lobe key or as a double square for an eight lobe key.

It should be understood that the embodiments described herein are merely exemplary and that a person skilled in the art may make many variations and modifications without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention as defined in the appended claims.

CLAIMS

What is claimed is:

1. A fastening system, comprising:

a pin member including an elongated shank portion having a first end, a second end opposite the first end, a smooth cylindrical shank portion, a threaded portion located at the second end and having a plurality of external threads, and an end face located at the second end and having a recess formed therein, and a head located at the first end,

wherein the recess includes a plurality of splines extending axially and positioned circumferentially and equally spaced about a periphery thereof and extending inwardly, each of the plurality of splines includes a first bearing surface and a second bearing surface,

wherein the recess includes a plurality of recesses extending axially and formed circumferentially and equally spaced about the periphery, each of the plurality of recesses being located between a corresponding pair of the plurality of splines,

wherein each of the first bearing surfaces of each of the plurality of splines of the is oriented at a first angle extending and measured from a radial line that extends from a center point of the elongated shank portion of the pin member to a first point on such first bearing surface located proximate to minor inner diameter of such spline of the pin member in a rotational direction towards the second bearing surface of such spline,

wherein each of the second bearing surfaces of each of the plurality of splines is oriented at a second angle extending and measured from the radial line in a rotational direction towards such second bearing surface of such spline; and

a key including an elongated shaft having a first end, and a second end opposite the first end of the elongated shaft, and a key head located at the second end of the elongated shaft,

wherein the key head includes a plurality of splines extending axially thereon and being equally spaced around a circumference thereof, each of the plurality of splines of the key head having a first bearing surface and a second bearing surface, and wherein the key head includes a plurality of grooves extending axially thereon and being equally spaced around the circumference, each of the plurality of grooves being located between a corresponding pair of the plurality of splines of the key head,

wherein each of the first bearing surfaces of each of the plurality of splines of the key head is oriented at a third angle extending and measured from a radial line that extends from a center point of the key to a first point on such first bearing surface of such spline of the key head located proximate to a major outer diameter of such spline of the key head in a rotational direction towards the second bearing surface of such spline of the key head,

wherein each of the second bearing surfaces of each of the plurality of splines of the key head is oriented at a fourth angle extending and measured from the radial line of the key head in a rotational direction towards such second bearing surface of such spline of the key head, and

wherein the key head of the key is adapted to mate with the recess of the pin member such that each of the first bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the first bearing surface of a corresponding one of each of the plurality of splines of the pin member, and each of the second

bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the second bearing surface of a corresponding one of each of the plurality of splines of the pin member.

2. The fastening system of Claim 1, wherein the plurality of splines of the pin member includes six of the splines and wherein the plurality of recesses of the pin member includes six of the recesses, and wherein the plurality of splines of the key includes six of the splines and the plurality of grooves of the key includes six of the grooves.

3. The fastening system of Claim 2, wherein the first angle and the third angle are each within a range of about 1° to about 5°.

4. The fastening system of Claim 3, wherein the second angle and the fourth angle are each within a range of about 30° to about 35°.

5. The fastening system of Claim 1, wherein the plurality of splines of the pin member includes eight of the splines and wherein the plurality of recesses of the pin member includes eight of the recesses, and wherein the plurality of splines of the key includes eight of the splines and the plurality of grooves of the key includes eight of the grooves.

6. The fastening system of Claim 5, wherein the first angle and the third angle are each within a range of about 1° to about 5°.

7. The fastening system of Claim 6, wherein the second angle and the fourth angle are each within a range of about 40° to about 50°.

8. The fastening system of Claim 1, wherein a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines of the pin member are perpendicular to one another, and wherein a corresponding pair of the first bearing and the second bearing surface of each of the plurality of splines of the key are perpendicular to one another.

9. The fastening system of Claim 1, further comprising a nut adapted to engage threadedly the threaded portion of the pin member.

10. The fastening system of Claim 9, wherein the nut includes a centrally-located bore that is sized and shaped to receive the key therethrough.

11. A fastening system, comprising:

a pin member including an elongated shank portion having a first end, a second end opposite the first end, a smooth cylindrical shank portion, a threaded portion located at the second end and having a plurality of external threads, and a head located at the first end and having a recess formed therein,

wherein the recess includes a plurality of splines extending axially and positioned circumferentially and equally spaced about a periphery thereof and extending inwardly, each of the plurality of splines includes a first bearing surface and a second bearing surface,

wherein the recess includes a plurality of recesses extending axially and formed circumferentially and equally spaced about the periphery, each of the plurality of recesses being located between a corresponding pair of the plurality of splines,

wherein each of the first bearing surfaces of each of the plurality of splines of the key is oriented at a first angle extending and measured from a radial line that extends from a center point of the elongated shank portion of the pin member to a first point on such first bearing surface located proximate to minor inner diameter of such spline of the pin member in a rotational direction towards the second bearing surface of such spline,

wherein each of the second bearing surfaces of each of the plurality of splines is oriented at a second angle extending and measured from the radial line in a rotational direction towards such second bearing surface of such spline; and

a key including an elongated shaft having a first end, and a second end opposite the first end of the elongated shaft, and a key head located at the second end of the elongated shaft,

wherein the key head includes a plurality of splines extending axially thereon and being equally spaced around a circumference thereof, each of the plurality of splines of the key head having a first bearing surface and a second bearing surface, and wherein the key head includes a plurality of grooves extending axially thereon and being equally spaced around the circumference, each of the plurality of grooves being located between a corresponding pair of the plurality of splines of the key head,

wherein each of the first bearing surfaces of each of the plurality of splines of the key head is oriented at a third angle extending and measured from a radial line that extends from a center point of the key to a first point on such first bearing surface of

such spline of the key head located proximate to a major outer diameter of such spline of the key head in a rotational direction towards the second bearing surface of such spline of the key head,

wherein each of the second bearing surfaces of each of the plurality of splines of the key head is oriented at a fourth angle extending and measured from the radial line of the key head in a rotational direction towards such second bearing surface of such spline of the key head, and

wherein the key head of the key is adapted to mate with the recess of the head if the pin member such that each of the first bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the first bearing surface of a corresponding one of each of the plurality of splines of the pin member, and each of the second bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the second bearing surface of a corresponding one of each of the plurality of splines of the pin member.

12. The fastening system of Claim 11, wherein the plurality of splines of the pin member includes six of the splines and wherein the plurality of recesses of the pin member includes six of the recesses, and wherein the plurality of splines of the key includes six of the splines and the plurality of grooves of the key includes six of the grooves.

13. The fastening system of Claim 12, wherein the first angle and the third angle are each within a range of about 1° to about 5°.

14. The fastening system of Claim 13, wherein the second angle and the fourth angle are each within a range of about 30° to about 35°.

15. The fastening system of Claim 14, wherein the plurality of splines of the pin member includes eight of the splines and wherein the plurality of recesses of the pin member includes eight of the recesses, and wherein the plurality of splines of the key includes eight of the splines and the plurality of grooves of the key includes eight of the grooves.

16. The fastening system of Claim 15, wherein the first angle and the third angle are each within a range of about 1° to about 5°.

17. The fastening system of Claim 16, wherein the second angle and the fourth angle are each within a range of about 40° to about 50°.

18. The fastening system of Claim 11, further comprising a nut adapted to engage threadedly the threaded portion of the pin member.

19. The fastening system of Claim 18, wherein the nut includes a centrally-located bore that is sized and shaped to receive the key therethrough.

20. The fastening system of Claim 11, wherein a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines of the pin member are perpendicular to one another, and wherein a corresponding pair of the first bearing and the second bearing surface of each of the plurality of splines of the key are perpendicular to one another.

21. A fastening system, comprising:

a pin member including an elongated shank portion having a first end, a second end opposite the first end, and an end face located at the second end and having a recess formed therein,

wherein the recess includes a plurality of splines extending axially and positioned circumferentially about a periphery thereof and extending inwardly, wherein each of the plurality of splines includes a first bearing surface and a second bearing surface,

wherein the recess includes a plurality of recesses extending axially and formed circumferentially about the periphery, each of the plurality of recesses being located between a corresponding pair of the plurality of splines,

wherein each of the first bearing surfaces of each of the plurality of splines of the recess is oriented at a first angle extending and measured from a radial line that extends from a center point of the elongated shank portion of the pin member to a first point on such first bearing surface located proximate to a minor inner diameter of such spline of the pin member in a rotational direction towards the second bearing surface of such spline,

wherein each of the second bearing surfaces of each of the plurality of splines is oriented at a second angle extending and measured from the radial line in a rotational direction towards such second bearing surface of such spline; and

a key including an elongated shaft having a first end and a second end opposite the first end of the elongated shaft, and a key head located at the second end of the elongated shaft,

wherein the key head includes a plurality of splines extending axially thereon, each of the plurality of splines of the key head having a first bearing surface and a second bearing surface, and wherein the key head includes a plurality of grooves extending axially thereon, each of the plurality of grooves being located between a corresponding pair of the plurality of splines of the key head,

wherein each of the first bearing surfaces of each of the plurality of splines of the key head is oriented at a third angle extending and measured from a radial line that extends from a center point of the key to a first point on such first bearing surface of such spline of the key head located proximate to a major outer diameter of such spline of the key head in a rotational direction towards the second bearing surface of such spline of the key head,

wherein each of the second bearing surfaces of each of the plurality of splines of the key head is oriented at a fourth angle extending and measured from the radial line of the key head in a rotational direction towards such second bearing surface of such spline of the key head, and

wherein the key head of the key is adapted to mate with the recess of the pin member such that each of the first bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the first bearing surface of a corresponding one of the plurality of splines of the pin member, and each of the second bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the second bearing surface of a corresponding one of the plurality of splines of the pin member.

22. The fastening system of Claim 21, wherein the plurality of splines of the pin member includes six of the splines and wherein the plurality of recesses of the pin member includes six of the recesses, and wherein the plurality of splines of the key includes six of the splines and the plurality of grooves of the key includes six of the grooves.

23. The fastening system of Claim 22, wherein the first angle and the third angle are each within a range of about 1° to about 5°.

24. The fastening system of Claim 23, wherein the second angle and the fourth angle are each within a range of about 30° to about 35°.

25. The fastening system of Claim 21, wherein the plurality of splines of the pin member includes eight of the splines and wherein the plurality of recesses of the pin member includes eight of the recesses, and wherein the plurality of splines of the key includes eight of the splines and the plurality of grooves of the key includes eight of the grooves.

26. The fastening system of Claim 25, wherein the first angle and the third angle are each within a range of about 1° to about 5°.

27. The fastening system of Claim 26, wherein the second angle and the fourth angle are each within a range of about 40° to about 50°.

28. The fastening system of Claim 21, wherein a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines of the pin member are perpendicular to one another, and wherein a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines of the key are perpendicular to one another.

29. The fastening system of Claim 21, further comprising a nut, and wherein the elongated shank portion of the pin member includes a threaded portion located at the second end thereof and having a plurality of external threads, and wherein the nut is adapted to engage threadedly the threaded portion of the pin member.

30. The fastening system of Claim 29, wherein the nut includes a centrally-located bore that is sized and shaped to receive the key therethrough.

31. A fastening system, comprising:

a pin member including an elongated shank portion having a first end, a second end opposite the first end, and a head located at the first end and having a recess formed therein,

wherein the recess includes a plurality of splines extending axially and positioned circumferentially about a periphery thereof and extending inwardly, wherein each of the plurality of splines includes a first bearing surface and a second bearing surface,

wherein the recess includes a plurality of recesses extending axially and formed circumferentially about the periphery, each of the plurality of recesses being located between a corresponding pair of the plurality of splines,

wherein each of the first bearing surfaces of each of the plurality of splines of the recess is oriented at a first angle extending and measured from a radial line that extends from a center point of the elongated shank portion of the pin member to a first point on such first bearing surface located proximate to a minor inner diameter of such spline of the pin member in a rotational direction towards the second bearing surface of such spline,

wherein each of the second bearing surfaces of each of the plurality of splines is oriented at a second angle extending and measured from the radial line in a rotational direction towards such second bearing surface of such spline; and

a key including an elongated shaft having a first end, and a second end opposite the first end of the elongated shaft, and a key head located at the second end of the elongated shaft,

wherein the key head includes a plurality of splines extending axially thereon, each of the plurality of splines of the key head having a first bearing surface and a second bearing surface, and wherein the key head includes a plurality of grooves extending axially thereon, each of the plurality of grooves being located between a corresponding pair of the plurality of splines of the key head,

wherein each of the first bearing surfaces of each of the plurality of splines of the key head is oriented at a third angle extending and measured from a radial line that extends from a center point of the key to a first point on such first bearing surface of such spline of the key head located proximate to a major outer diameter of such spline

of the key head in a rotational direction towards the second bearing surface of such spline of the key head,

wherein each of the second bearing surfaces of each of the plurality of splines of the key head is oriented at a fourth angle extending and measured from the radial line of the key head in a rotational direction towards such second bearing surface of such spline of the key head, and

wherein the key head of the key is adapted to mate with the recess of the head of the pin member such that each of the first bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the first bearing surface of a corresponding one of the plurality of splines of the pin member, and each of the second bearing surfaces of each of the plurality of splines of the key head is sized and shaped to engage the second bearing surface of a corresponding one of the plurality of splines of the pin member.

32. The fastening system of Claim 31, wherein the plurality of splines of the pin member includes six of the splines and wherein the plurality of recesses of the pin member includes six of the recesses, and wherein the plurality of splines of the key includes six of the splines and the plurality of grooves of the key includes six of the grooves.

33. The fastening system of Claim 32, wherein the first angle and the third angle are each within a range of about 1° to about 5°.

34. The fastening system of Claim 33, wherein the second angle and the fourth angle are each within a range of about 30° to about 35°.

35. The fastening system of Claim 34, wherein the plurality of splines of the pin member includes eight of the splines and wherein the plurality of recesses of the pin member includes eight of the recesses, and wherein the plurality of splines of the key includes eight of the splines and the plurality of grooves of the key includes eight of the grooves.

36. The fastening system of Claim 35, wherein the first angle and the third angle are each within a range of about 1° to about 5°.

37. The fastening system of Claim 36, wherein the second angle and the fourth angle are each within a range of about 40° to about 50°.

38. The fastening system of Claim 31, further comprising a nut, and wherein the elongated shank portion of the pin member includes a threaded portion located at the second end thereof and having a plurality of external threads, and wherein the nut is adapted to engage threadedly the threaded portion of the pin member.

39. The fastening system of Claim 38, wherein the nut includes a centrally-located bore that is sized and shaped to receive the key therethrough.

40. The fastening system of Claim 31, wherein a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines of the pin member are perpendicular to one another, and wherein a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines of the key are perpendicular to one another.

41. A pin member, comprising:

an elongated shank portion having a first end, a second end opposite the first end, and an end face located at the second end and having a recess formed therein,

wherein the recess includes a plurality of splines extending axially and positioned circumferentially about a periphery thereof and extending inwardly, wherein each of the plurality of splines includes a first bearing surface and a second bearing surface,

wherein the recess includes a plurality of recesses extending axially and formed circumferentially about the periphery, each of the plurality of recesses being located between a corresponding pair of the plurality of splines,

wherein each of the first bearing surfaces of each of the plurality of splines of the recess is oriented at a first angle extending and measured from a radial line that extends from a center point of the elongated shank portion to a first point on such first bearing surface located proximate to a minor inner diameter of such spline in a rotational direction towards the second bearing surface of such spline, and

wherein each of the second bearing surfaces of each of the plurality of splines is oriented at a second angle extending and measured from the radial line in a rotational direction towards such second bearing surface of such spline.

42. The pin member of Claim 41, wherein the plurality of splines includes six of the splines and wherein the plurality of recesses includes six of the recesses.

43. The pin member of Claim 42, wherein the first angle is within a range of about 1° to about 5°.

44. The pin member of Claim 43, wherein the second angle is within a range of about 30° to about 35°.

45. The pin member of Claim 41, wherein the plurality of splines includes eight of the splines and wherein the plurality of recesses includes eight of the recesses.

46. The pin member of Claim 45, wherein the first angle is within a range of about 1° to about 5°.

47. The pin member of Claim 46, wherein the second angle is within a range of about 40° to about 50°.

48. The pin member of Claim 41, wherein a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines are perpendicular to one another.

49. The pin member of Claim 41, wherein the elongated shank portion includes a threaded portion located at the second end thereof and having a plurality of

external threads, and wherein a nut is adapted to engage threadedly the threaded portion.

50. A key, comprising:

an elongated shaft having a first end and a second end opposite the first end, and a key head located at the second end,

wherein the key head includes a plurality of splines extending axially thereon, each of the plurality of splines of the key head having a first bearing surface and a second bearing surface, and wherein the key head includes a plurality of grooves extending axially thereon, each of the plurality of grooves being located between a corresponding pair of the plurality of splines,

wherein each of the first bearing surfaces of each of the plurality of splines is oriented at a first angle extending and measured from a radial line that extends from a center point of the key to a first point on such first bearing surface of such spline located proximate to a major outer diameter of such spline in a rotational direction towards the second bearing surface of such spline,

wherein each of the second bearing surfaces of each of the plurality of splines is oriented at a second angle extending and measured from the radial line of the key head in a rotational direction towards such second bearing surface of such spline.

51. The key of Claim 50, wherein the plurality of splines includes six of the splines and the plurality of grooves includes six of the grooves.

52. The key of Claim 51, wherein the first angle is within a range of about 1° to about 5°.

53. The key of Claim 52, wherein the second angle is within a range of about 30° to about 35°.

54. The key of Claim 51, wherein the plurality of splines includes eight of the splines and the plurality of grooves includes eight of the grooves.

55. The key of Claim 54, wherein the first angle is within a range of about 1° to about 5°.

56. The key of Claim 55, wherein the second angle is within a range of about 40° to about 50°.

57. The key of Claim 51, wherein a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines are perpendicular to one another.

58. A pin member, comprising:

an elongated shank portion having a first end, a second end opposite the first end, and a head located at the first end and having a recess formed therein,

wherein the recess includes a plurality of splines extending axially and positioned circumferentially about a periphery thereof and extending inwardly, wherein

each of the plurality of splines includes a first bearing surface and a second bearing surface,

wherein the recess includes a plurality of recesses extending axially and formed circumferentially about the periphery, each of the plurality of recesses being located between a corresponding pair of the plurality of splines,

wherein each of the first bearing surfaces of each of the plurality of splines of the recess is oriented at a first angle extending and measured from a radial line that extends from a center point of the elongated shank portion to a first point on such first bearing surface located proximate to a minor inner diameter of such spline in a rotational direction towards the second bearing surface of such spline, and

wherein each of the second bearing surfaces of each of the plurality of splines is oriented at a second angle extending and measured from the radial line in a rotational direction towards such second bearing surface of such spline.

59. The pin member of Claim 58, wherein the plurality of splines includes six of the splines and wherein the plurality of recesses includes six of the recesses.

60. The pin member of Claim 59, wherein the first angle is within a range of about 1° to about 5°.

61. The pin member of Claim 60, wherein the second angle is within a range of about 30° to about 35°.

62. The pin member of Claim 58, wherein the plurality of splines includes eight of the splines and wherein the plurality of recesses includes eight of the recesses.

63. The pin member of Claim 62, wherein the first angle is within a range of about 1° to about 5°.

64. The pin member of Claim 63, wherein the second angle is within a range of about 40° to about 50°.

65. The pin member of Claim 58, wherein a corresponding pair of the first bearing surface and the second bearing surface of each of the plurality of splines are perpendicular to one another.

66. The pin member of Claim 58, wherein the elongated shank portion includes a threaded portion located at the second end thereof and having a plurality of external threads, and wherein a nut is adapted to engage threadedly the threaded portion.

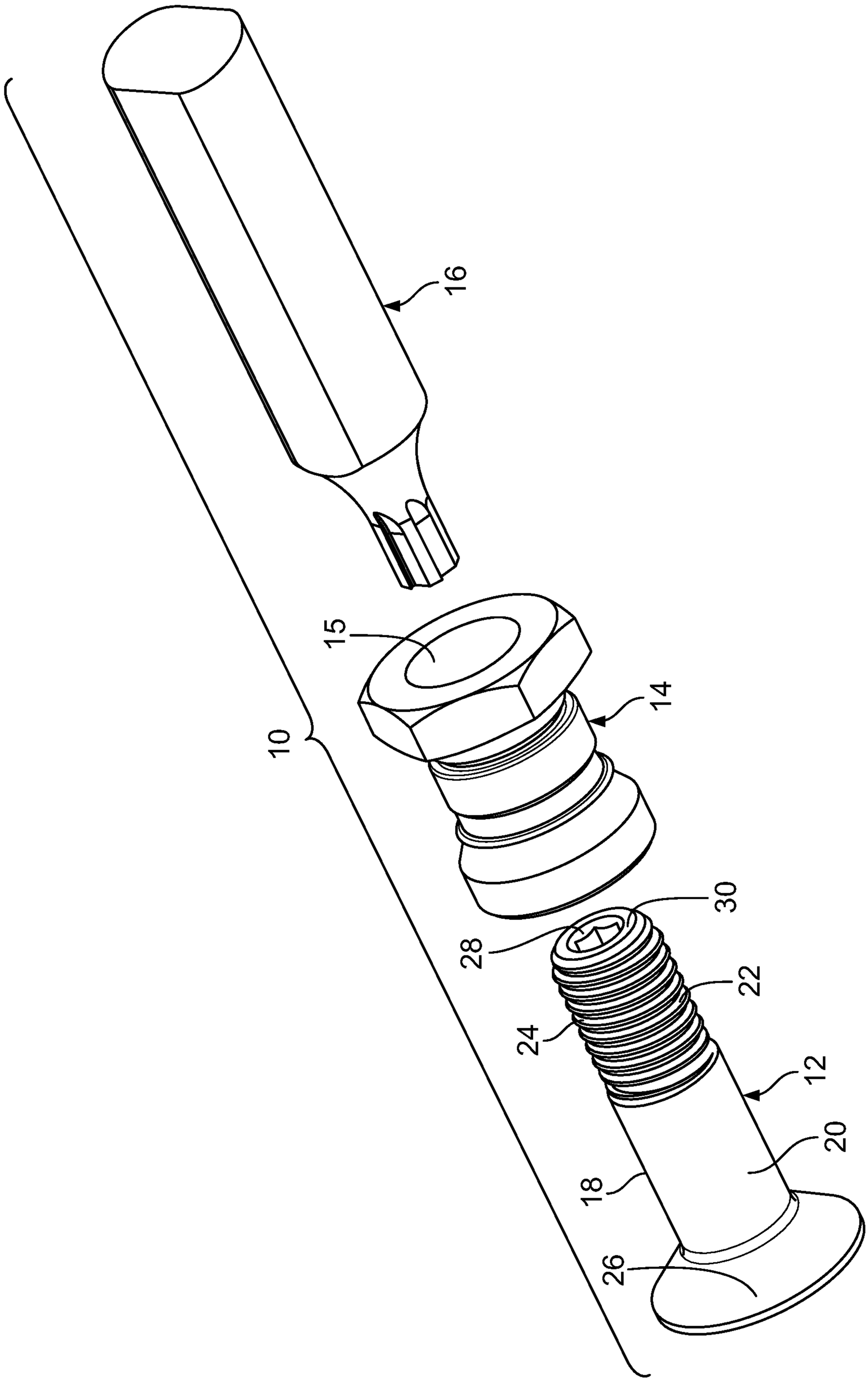

FIG. 1

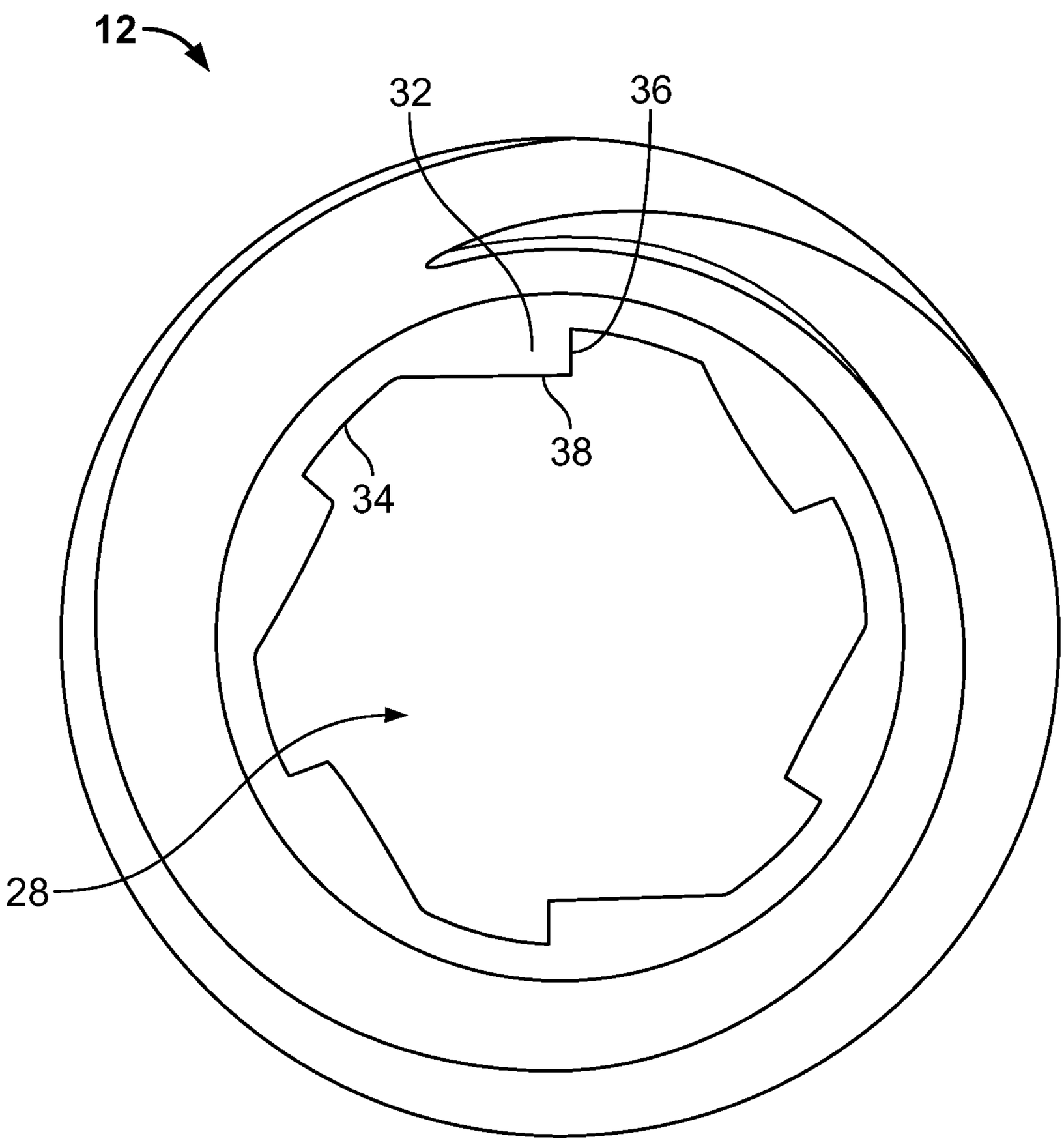

FIG. 2

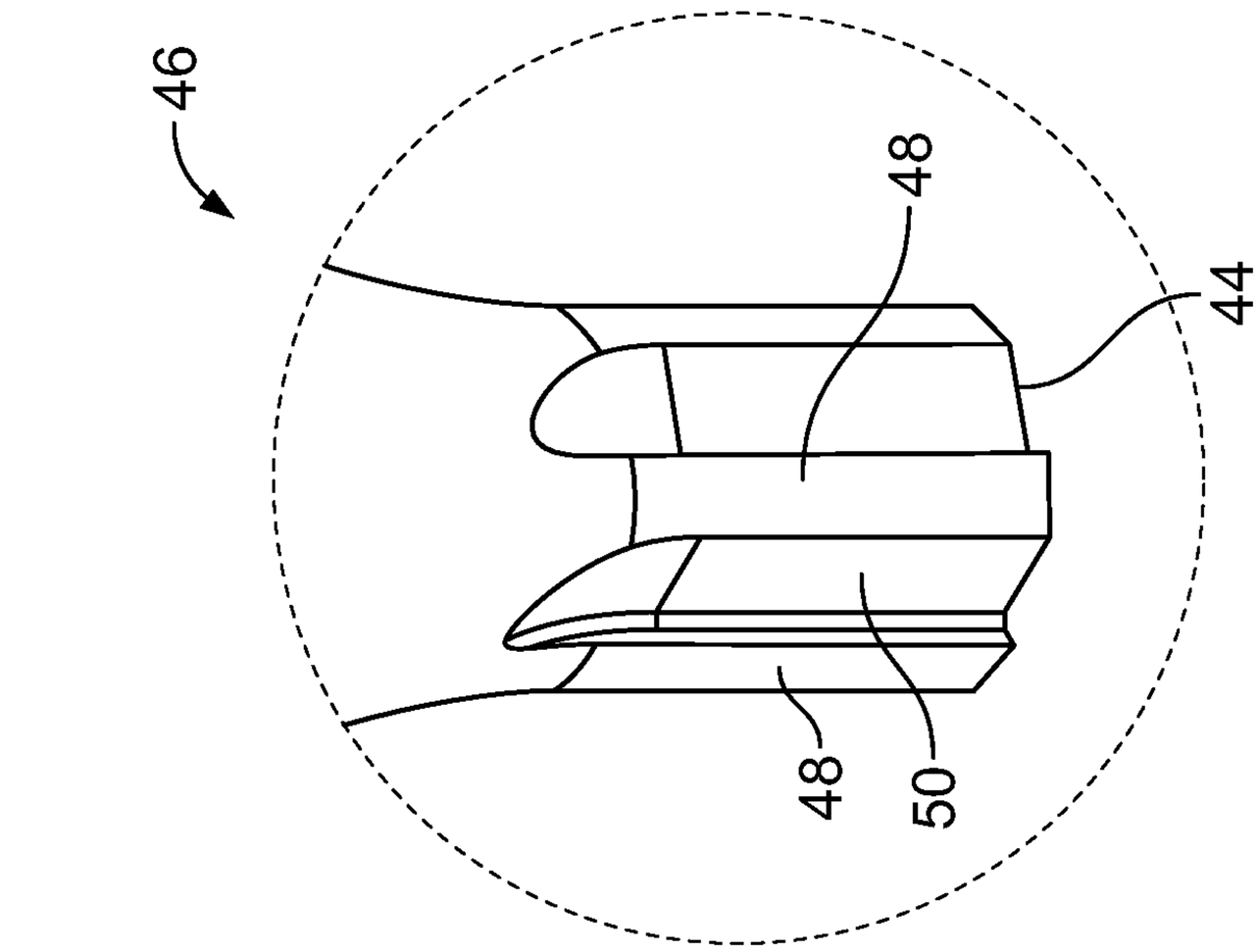

FIG. 5

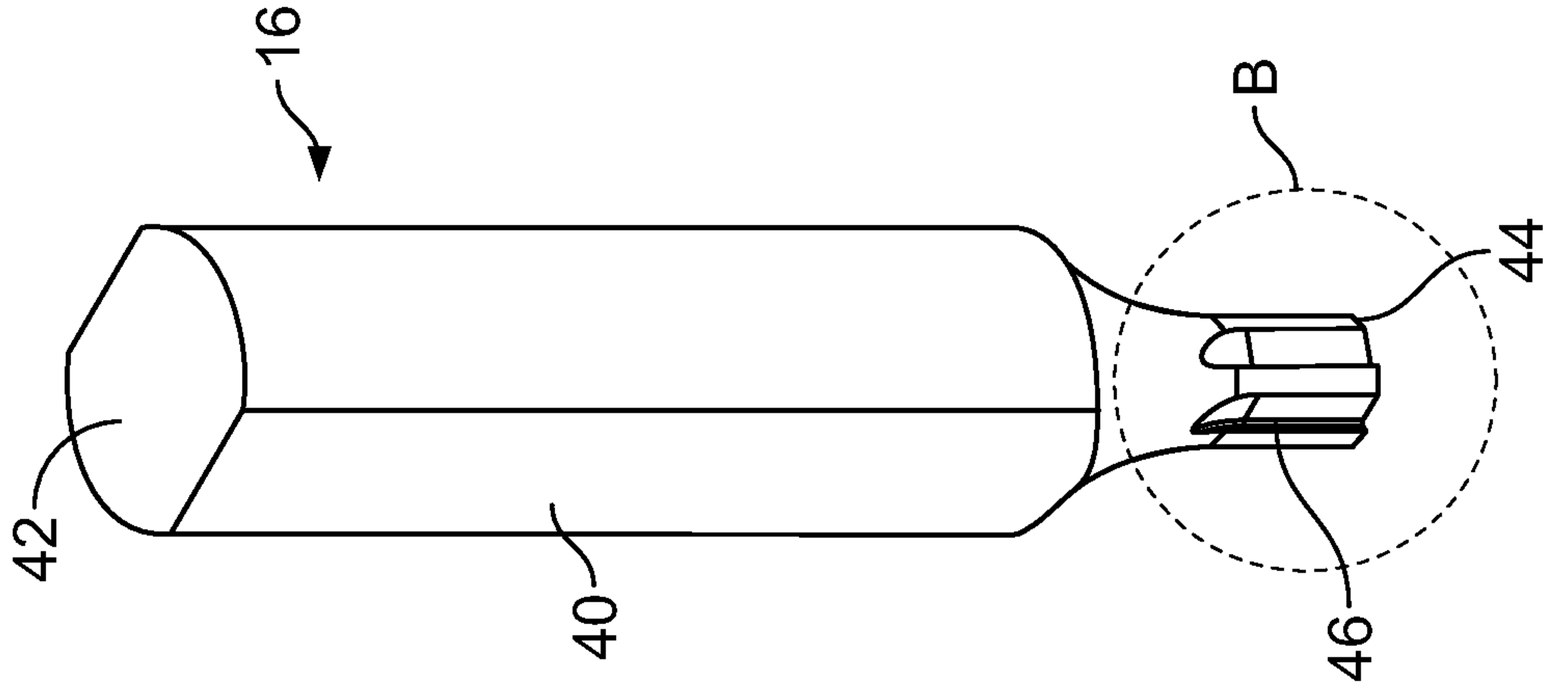

FIG. 4

FIG. 3

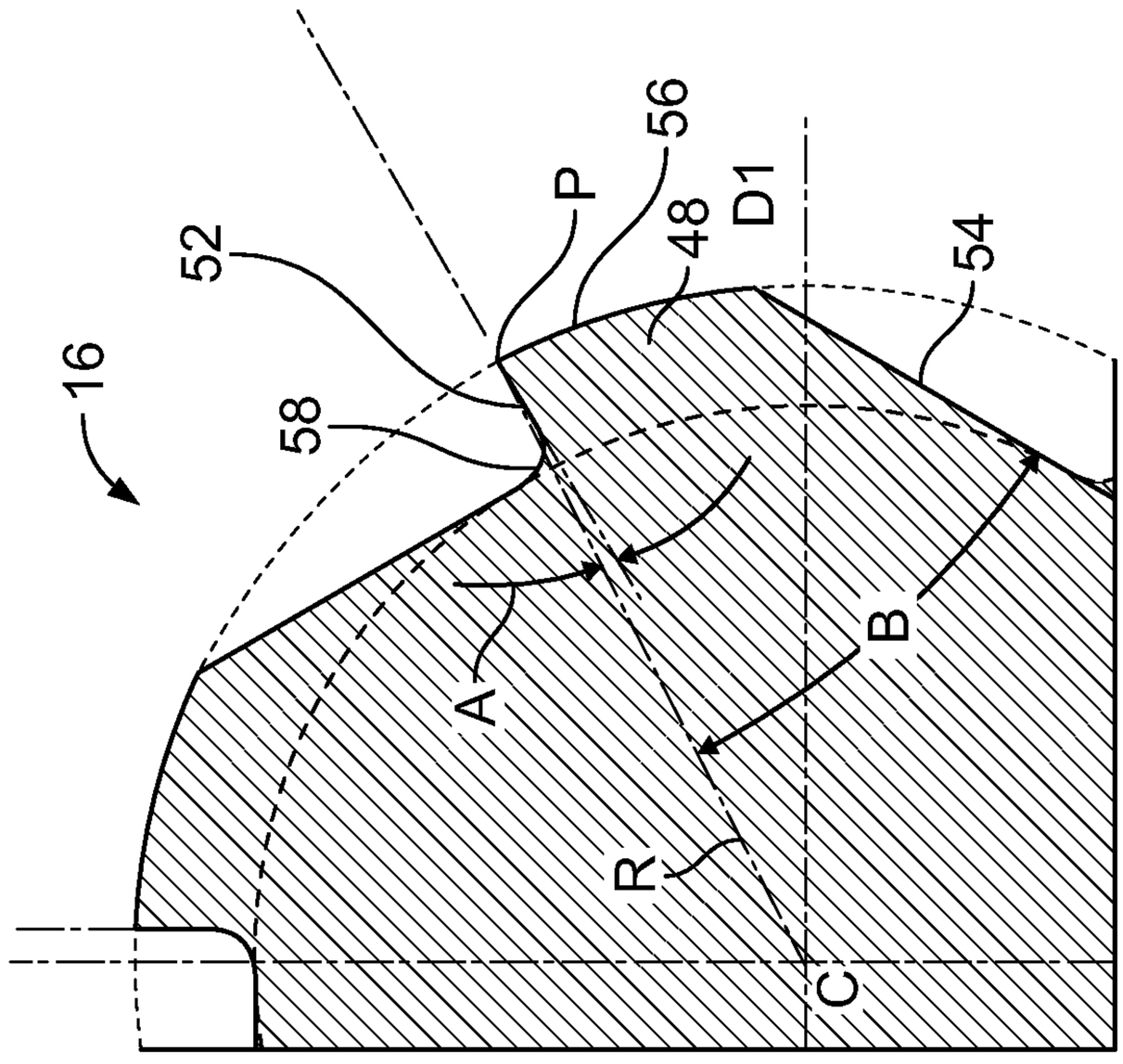

FIG. 6B

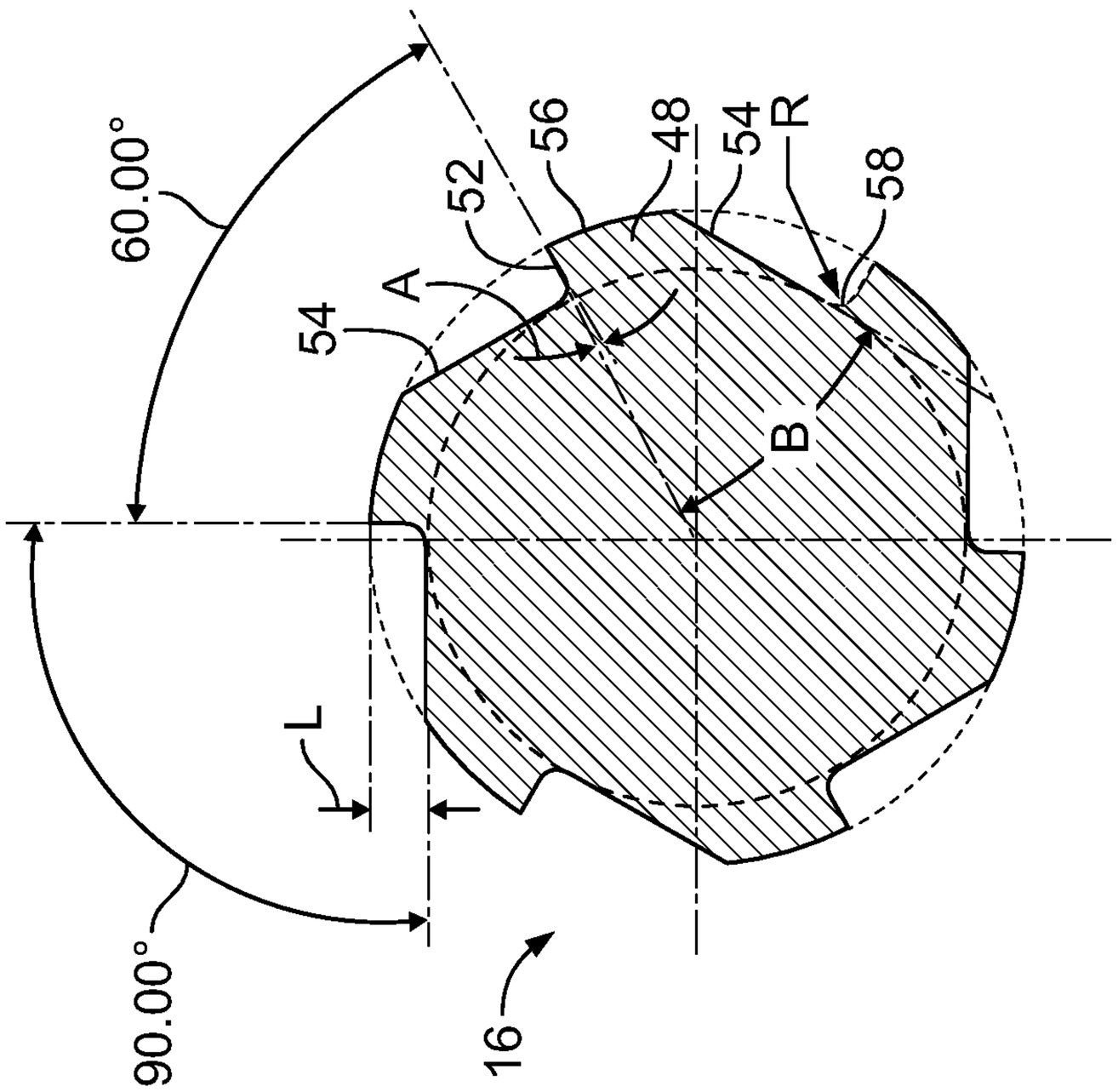

FIG. 6A

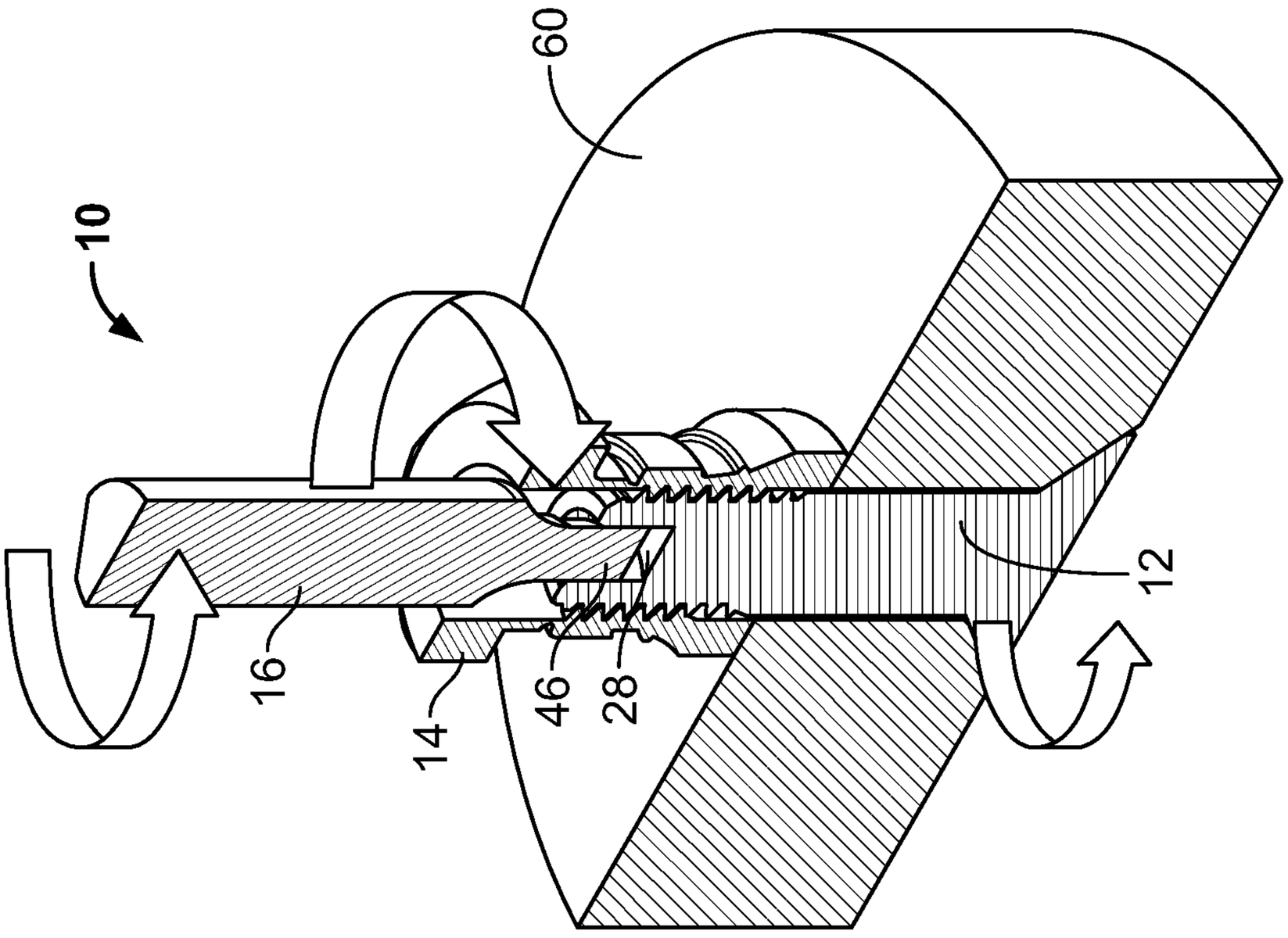

FIG. 8

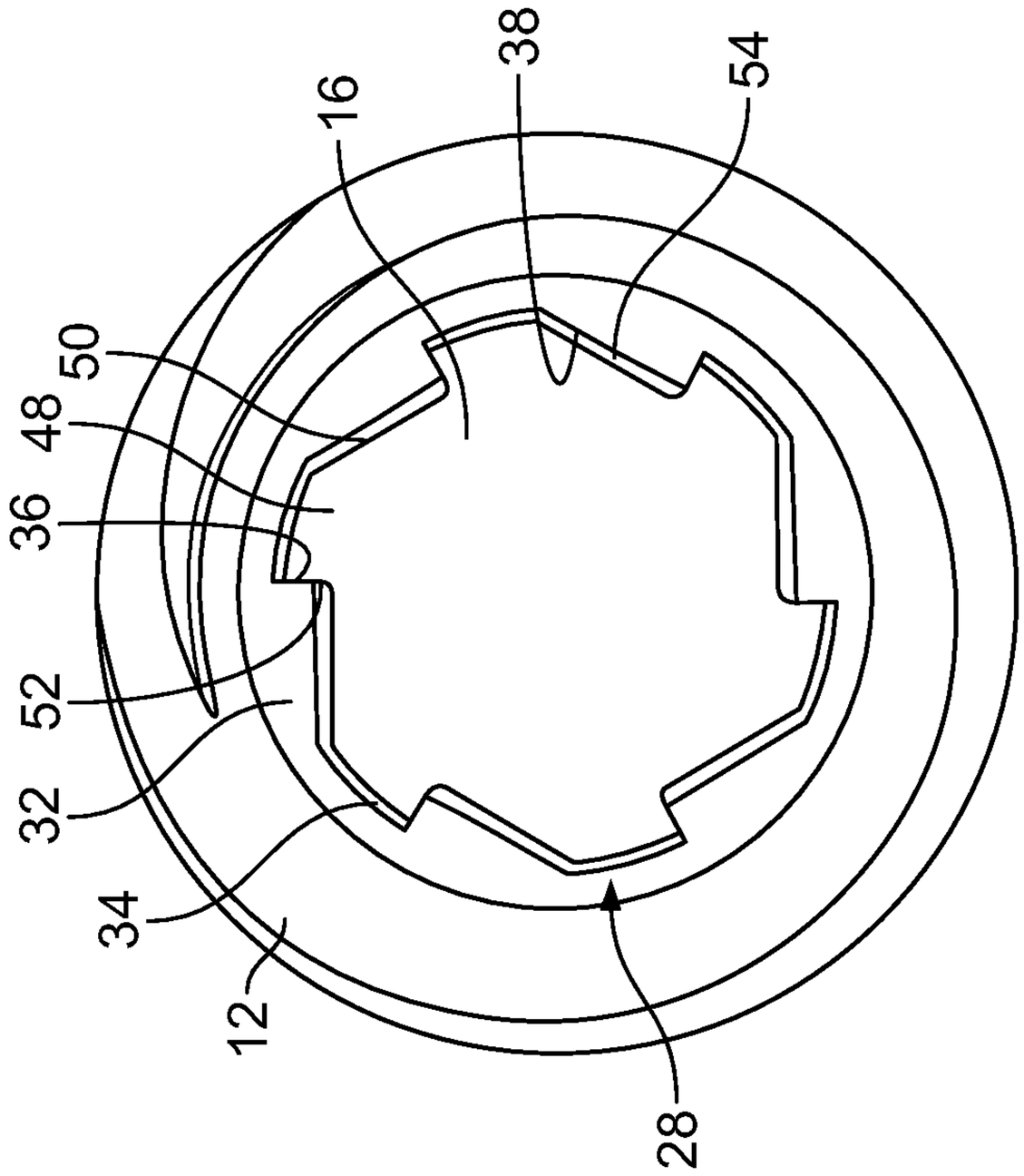

FIG. 7

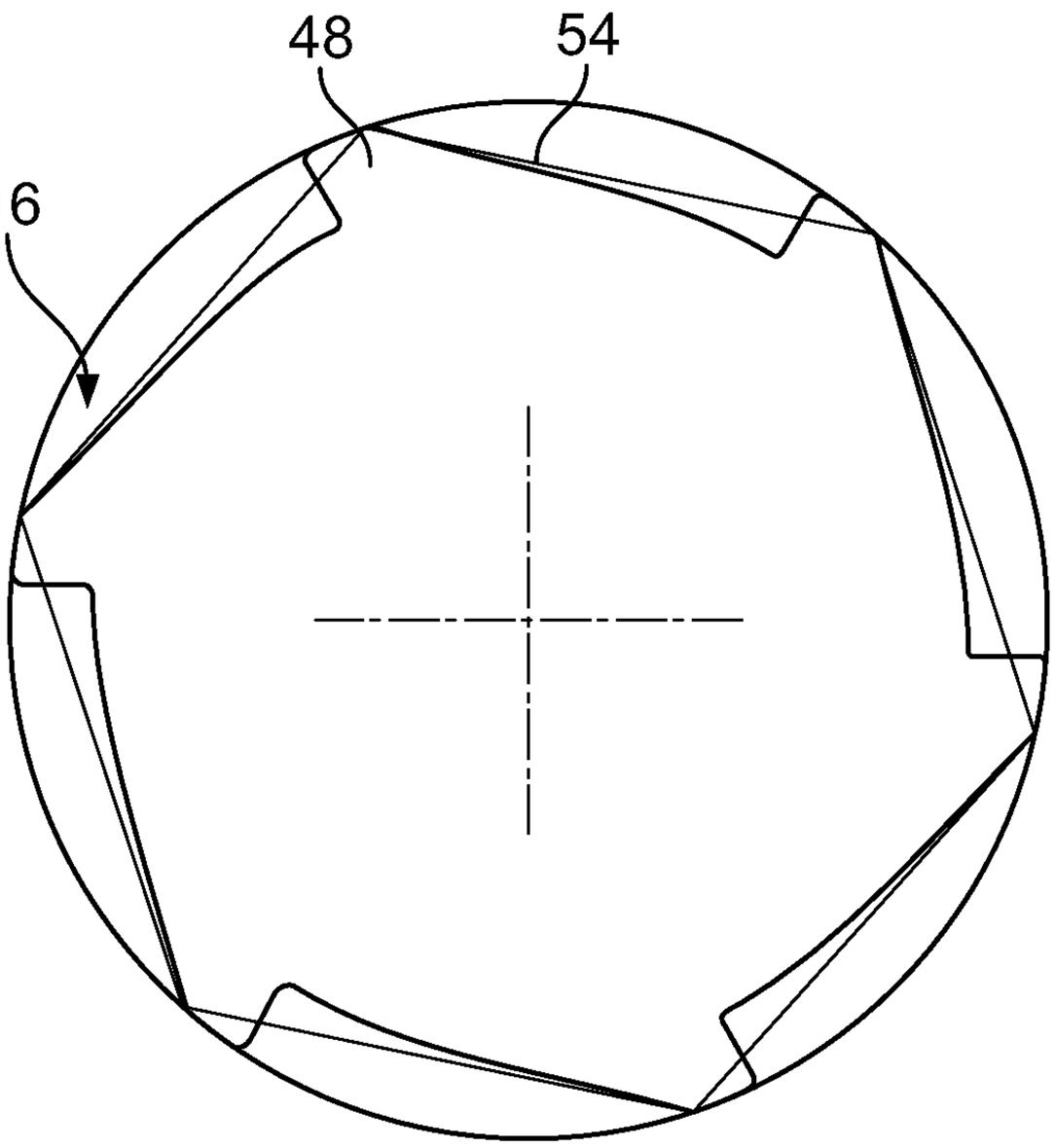

FIG. 9

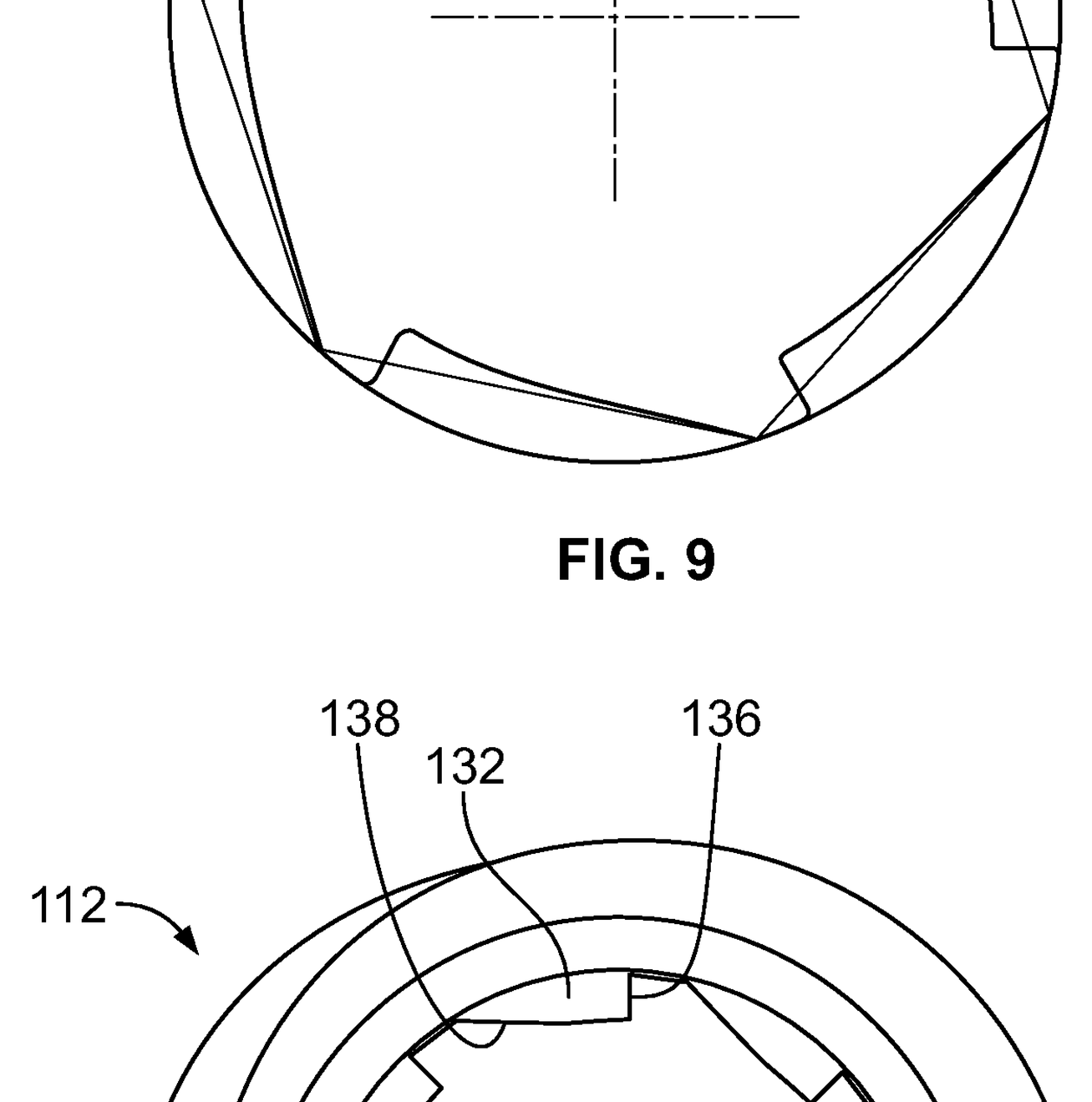

FIG. 10

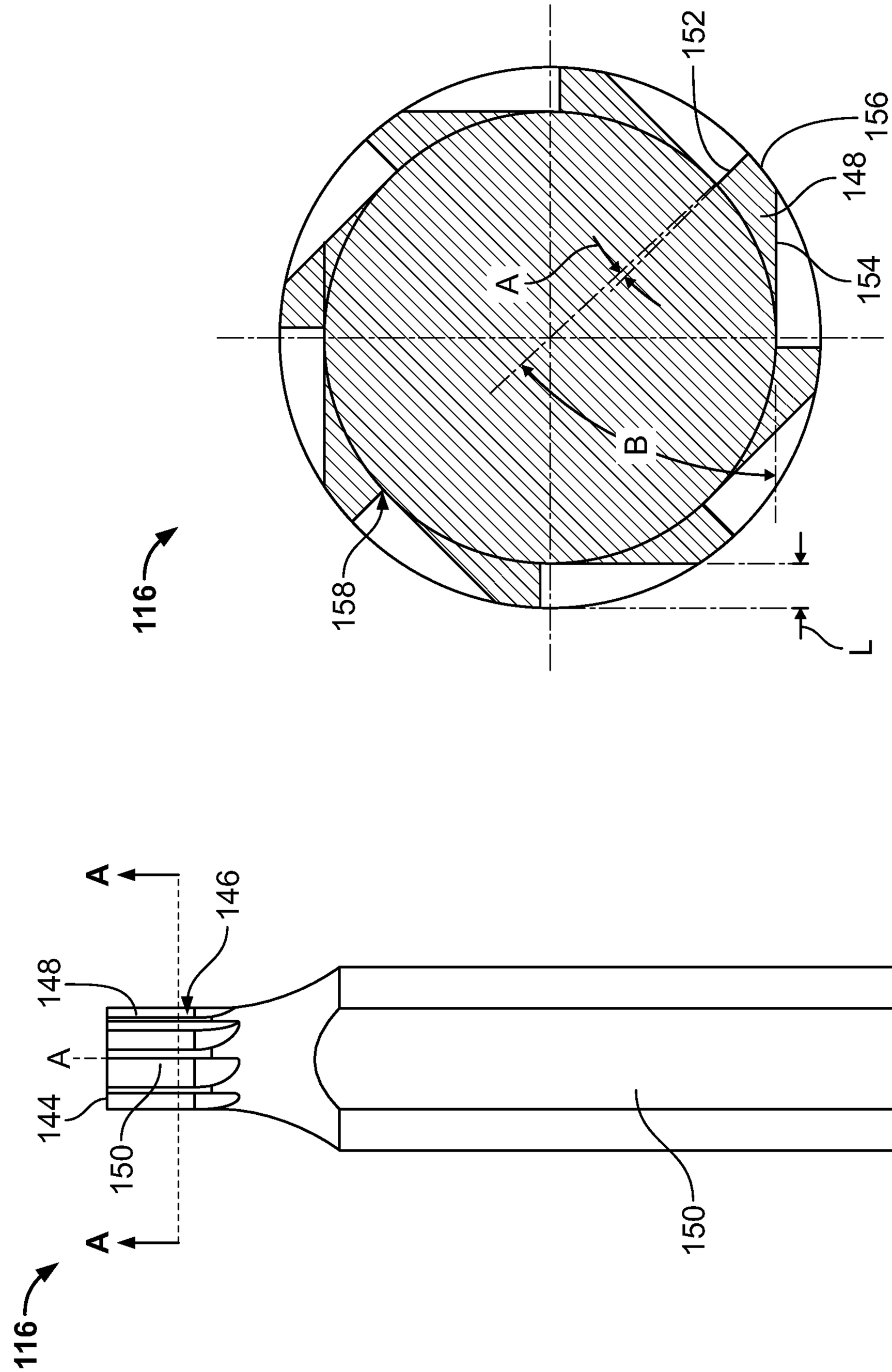

FIG. 12

FIG. 11

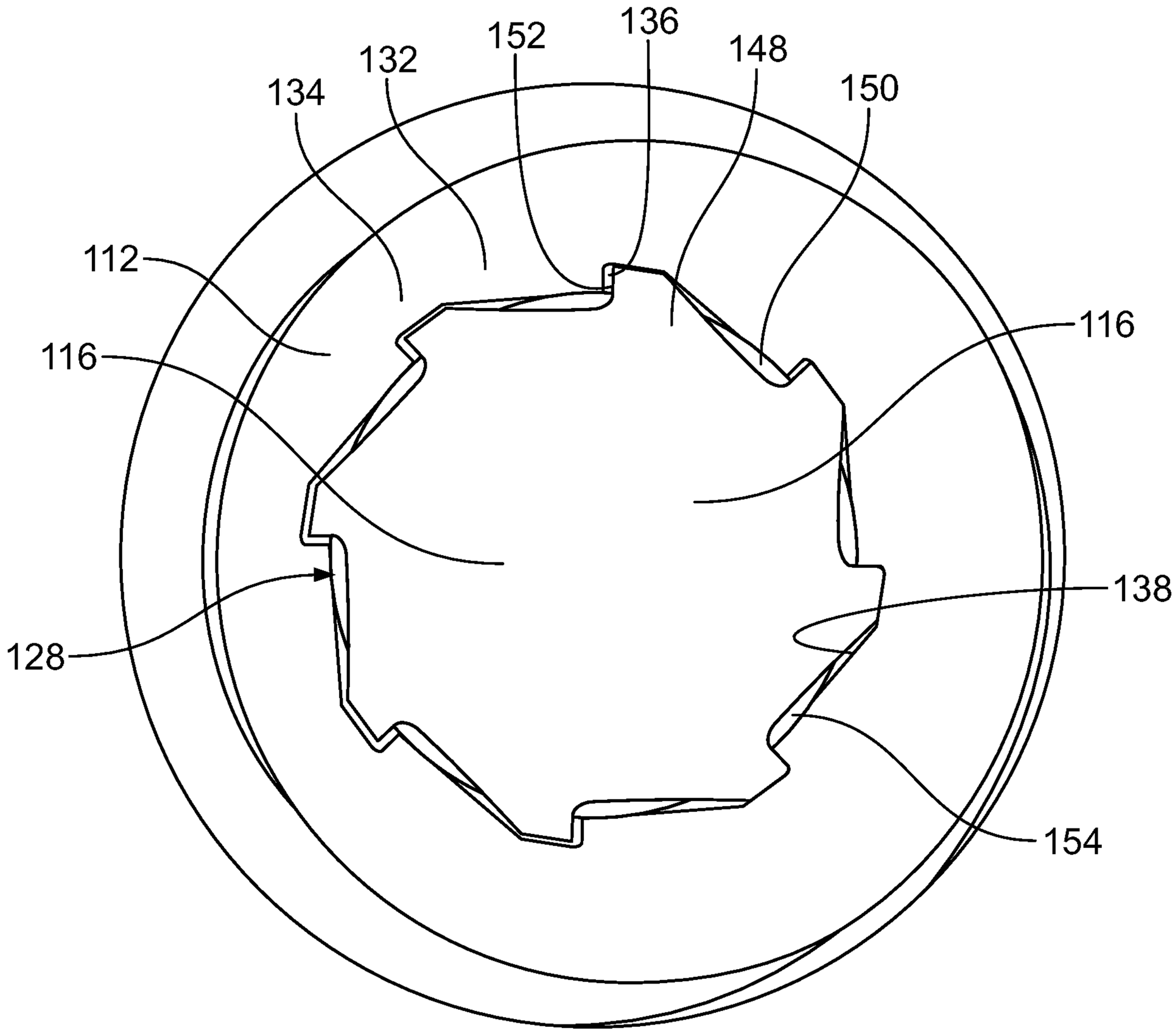

FIG. 13

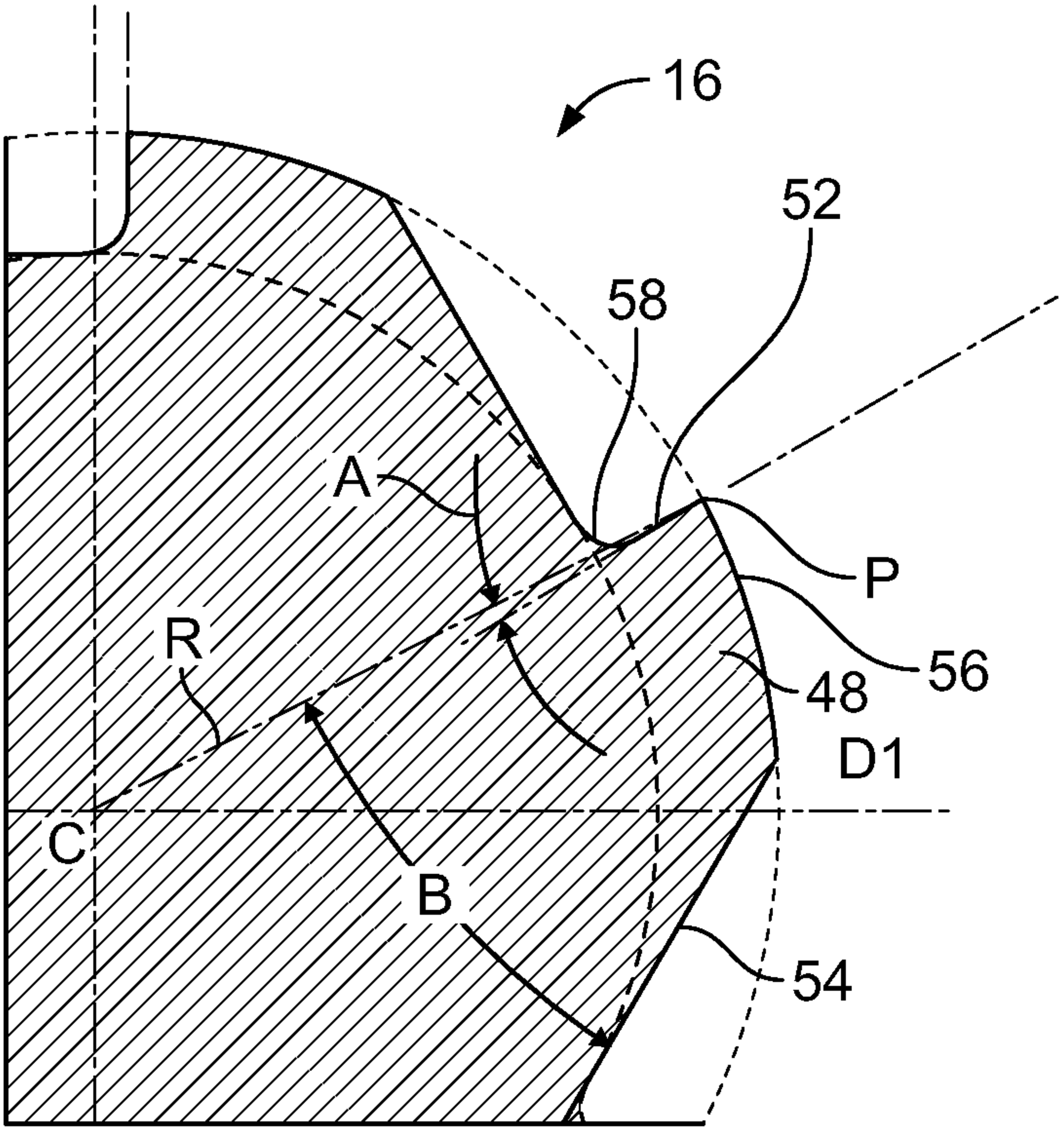

FIG. 6B