Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 2891297 C 2018/02/13

(11)(21) 2 891 297

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2013/11/28
(87) Date publication PCT/PCT Publication Date: 2014/06/19
(45) Date de délivrance/Issue Date: 2018/02/13
(85) Entrée phase nationale/National Entry: 2015/05/12
(86) N° demande PCT/PCT Application No.: IL 2013/050983
(87) N° publication PCT/PCT Publication No.: 2014/091477
(30) Priorité/Priority: 2012/12/13 (US13/714,024)

(51) Cl.Int./Int.Cl. *B23C 5/10* (2006.01), *B23B 31/113* (2006.01), *B23B 31/117* (2006.01)

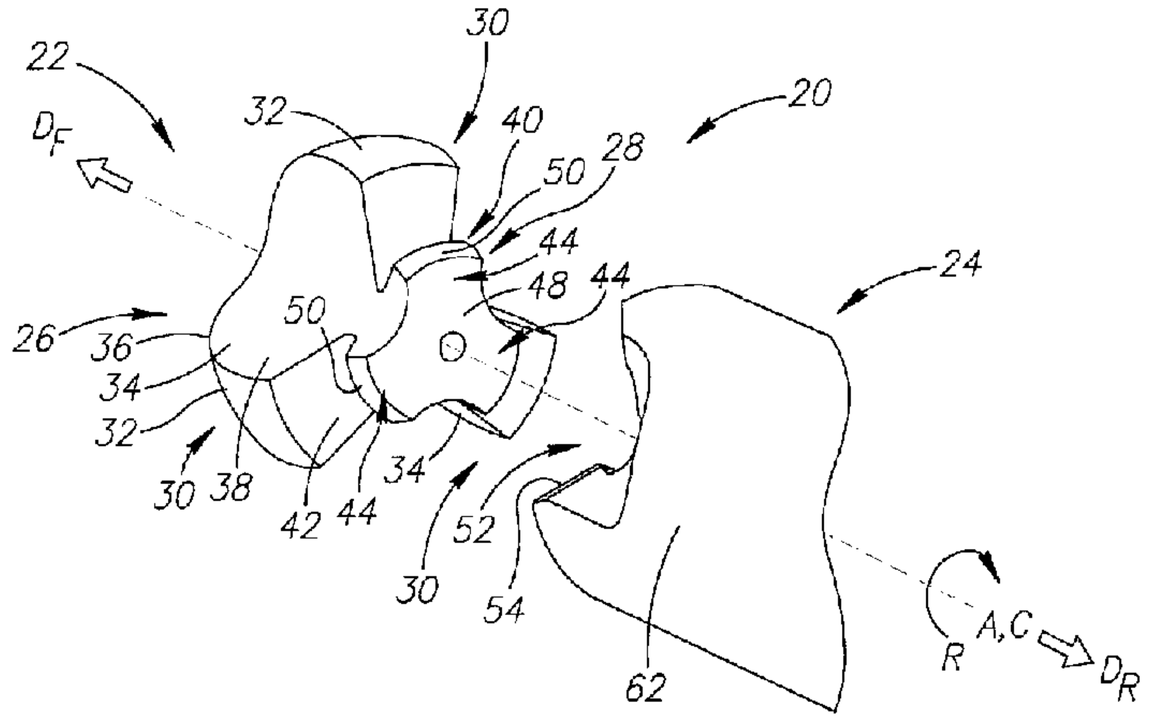
(72) Inventeur/Inventor:
HECHT, GIL, IL

(73) Propriétaire/Owner:
ISCAR LTD., IL

(74) Agent: WILSON LUE LLP

(54) Titre : OUTIL DE COUPE ET TETE DE COUPE REMPLACABLE AYANT DES SURFACES ENTRAINEES EN SPIRALE

(54) Title: CUTTING TOOL AND REPLACEABLE CUTTING HEAD HAVING SPIRAL DRIVEN SURFACES THEREFOR



(57) Abrégé/Abstract:
A replaceable cutting head (22) includes a forward cutting portion (26) and a rearward mounting portion (28). The mounting portion includes a male coupling member (40) that protrudes rearwardly from a base surface (42). The male coupling member includes three circumferentially spaced apart head fixation members (44), where each head fixation member has a head peripheral surface (46) that spirals inwardly in a direction against the direction of rotation (R) and diverges. A tool holder (24) includes a female coupling member (52) extends rearwardly from; a holder forward surface (54). The female coupling member includes three circumferentially spaced apart holder fixation members (56), where each holder fixation member has a holder peripheral surface (58) that diverges rearwardly. When a cutting tool (20), which includes said cutting head and tool holder, is in a locked position, the male coupling member of the replaceable cutting head is removably retained within the female coupling member of the tool holder by means of a self-lock mechanism.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 June 2014 (19.06.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/091477 A1

(51) International Patent Classification:
B23C 5/10 (2006.01) *B23B 31/117* (2006.01)
B23B 31/113 (2006.01)

(21) International Application Number:
PCT/IL2013/050983

(22) International Filing Date:
28 November 2013 (28.11.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13/714,024 13 December 2012 (13.12.2012) US

(71) Applicant: **ISCAR LTD.** [IL/IL]; P.O. Box 11, 24959 Tefen (IL).

(72) Inventor: **HECHT, Gil**; 30/18 Ahad Ha'am Street, 22443 Nahariya (IL).

(74) Agent: **ISCAR PATENT DEPARTMENT**; P.O. Box 11, 24959 Tefen (IL).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: CUTTING TOOL AND REPLACEABLE CUTTING HEAD HAVING SPIRAL DRIVEN SURFACES THEREFOR

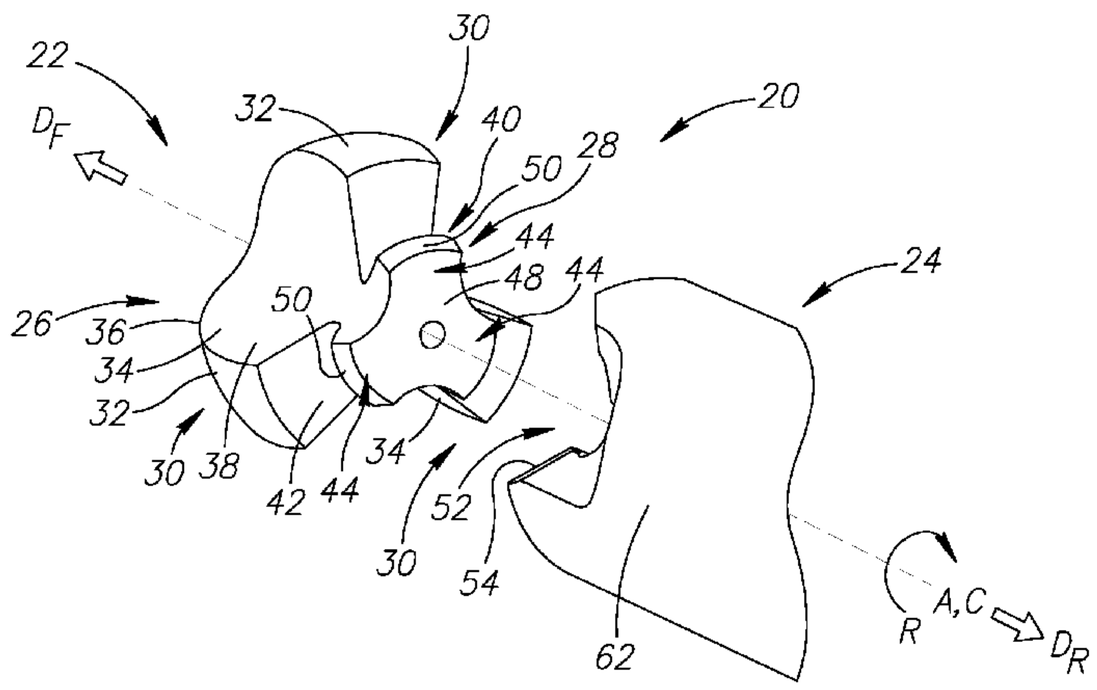


FIG.2

(57) Abstract: A replaceable cutting head (22) includes a forward cutting portion (26) and a rearward mounting portion (28). The mounting portion includes a male coupling member (40) that protrudes rearwardly from a base surface (42). The male coupling member includes three circumferentially spaced apart head fixation members (44), where each head fixation member has a head peripheral surface (46) that spirals inwardly in a direction against the direction of rotation (R) and diverges. A tool holder (24) includes a female coupling member (52) extends rearwardly from; a holder forward surface (54). The female coupling member includes three circumferentially spaced apart holder fixation members (56), where each holder fixation member has a holder peripheral surface (58) that diverges rearwardly. When a cutting tool (20), which includes said cutting head and tool holder, is in a locked position, the male coupling member of the replaceable cutting head is removably retained within the female coupling member of the tool holder by means of a self-lock mechanism.

WO 2014/091477 A1

CUTTING TOOL AND REPLACEABLE CUTTING HEAD HAVING SPIRAL DRIVEN SURFACES THEREFOR

FIELD OF THE INVENTION

[001] The subject matter of the present application relates to cutting tools of the type in which a cutting head, having a male coupling member, is removably retained in a female coupling member, of a tool holder, by means of a self-locking mechanism.

BACKGROUND OF THE INVENTION

[002] Cutting tools can be provided with a coupling mechanism for securely retaining a replaceable cutting head within a tool holder.

[003] The replaceable cutting head can include a male coupling member and the tool holder can include a female coupling member.

[004] In some such cutting tools, the male coupling member is an external thread and the female coupling member is an internal thread. An example of such a cutting tool is disclosed in, for example, US 6,494,648.

[005] In other such cutting tools the cutting tool can include matching radially extending surfaces on the replaceable cutting head and the tool holder for applying a torque force from the tool holder to the replaceable cutting head. Examples of such cutting tools are disclosed in US 7,407,350, WO 2011/021275 and US 2012/0155978.

[006] In still other such cutting tools the cutting tool can be devoid of said matching radially extending surfaces on the replaceable cutting head and the tool holder. An Example of such a cutting tool is disclosed in, for example, US 6,276,879.

[007] It is an object of the subject matter of the present application to provide a cutting tool having an improved means of coupling a replaceable cutting head in a tool holder.

[008] It is a further object of the subject matter of the present application to provide a cutting tool having coupling mechanism between a replaceable cutting head and a tool holder with an improved positioning of the replaceable cutting head with respect to the tool holder when in a locked position.

SUMMARY OF THE INVENTION

[009] In accordance with a first aspect of the subject matter of the present application there is provided a replaceable cutting head, for rotary cutting operations, having a head longitudinal axis around which the replaceable cutting head rotates in a direction of rotation, the head longitudinal axis extending in a forward to rearward direction, comprising:

a forward portion forming a cutting portion and a rearward portion forming a mounting portion;

the cutting portion comprising:

a plurality of cutting members extending radially with respect to the head longitudinal axis; and

the mounting portion comprising a male coupling member protruding rearwardly from a base surface, the base surface extending transversely with respect to the head longitudinal axis, and defining a boundary between the cutting portion and the mounting portion, the male coupling member comprising:

three circumferentially spaced apart head fixation members, each head fixation member comprising a head peripheral surface spiraling inwardly in a direction against the direction of rotation and diverging rearwardly with respect to the head longitudinal axis.

[0010] In accordance with a further aspect of the subject matter of the present application, there is also provided a cutting tool comprising:

a replaceable cutting head; and

a tool holder, having a holder longitudinal axis extending in the forward to rearward direction, comprising a female coupling member extending rearwardly from a holder forward surface, the holder forward surface extending transversely with respect to the holder longitudinal axis, the female coupling member comprising:

three circumferentially spaced apart holder fixation members, each holder fixation member comprising a recessed holder peripheral surface diverging rearwardly with respect to the holder longitudinal axis; and

a holder rear surface extending transversely with respect to the holder longitudinal axis and intersecting each holder fixation member; wherein

the male coupling member further comprises a rear surface, the rear surface intersecting the rearmost portion of each head fixation member; and

the replaceable cutting head is rotatable between a released position and a locked position, wherein in the locked position:

the male coupling member is removably retained in the female coupling member;

each of the head peripheral surfaces abuts a corresponding holder peripheral surface;

the base surface abuts the holder forward surface; and

the rear surface is spaced apart from the holder rear surface.

[0011] In accordance with a yet further aspect of the subject matter of the present application, there is also provided a tool holder having a longitudinal axis extending in a forward to a rearward direction and a direction of rotation about the longitudinal axis, the tool holder comprising:

a female coupling member extending rearwardly from a holder forward surface, the holder forward surface extending transversely with respect to the holder longitudinal axis, the female coupling member comprising:

three circumferentially spaced apart holder fixation members, each holder fixation member comprising a recessed holder peripheral surface diverging rearwardly with respect to the holder longitudinal axis, wherein:

each holder peripheral surface spirals inwardly in a direction against the direction of rotation; and

each holder peripheral surface is formed as an undercut of a corresponding holder fixation member and hidden from view in a front view of the tool holder along the longitudinal axis; and

a holder rear surface extending transversely with respect to the holder longitudinal axis and intersecting each holder fixation member.

[0012] It is understood that the above-said is a summary, and that features described hereinafter may be applicable in any combination to the subject matter of the present application, for example, any of the following features may be applicable to the replaceable cutting head or the cutting tool:

[0013] A first angle α can be formed between the head longitudinal axis and a line tangential to any point on each head peripheral surface, wherein the first angle is in the range of $35° \leq \alpha \leq 55°$.

[0014] The first angle can be a 45° angle.

[0015] In each cross section of the male coupling member taken in a plane through the head peripheral surface and perpendicular to the head longitudinal axis, each head peripheral surface can lie on a spiral, having a spiral center, each head peripheral surface can form a spiral portion.

[0016] The two end points of each spiral portion can subtend a peripheral surface angle β relative to the spiral center, wherein the peripheral surface angle β can be in the range of $30° \leq \beta \leq 60°$.

[0017] Each spiral center can be coincident with the head longitudinal axis.

[0018] Each spiral can be an Archimedean spiral.

[0019] The pitch angle of each spiral portion can be less than 30°.

[0020] The head peripheral surfaces can serve as spiral driven surfaces applying torque transmission to the replaceable cutting head. The cutting portion can be devoid of a surface facing against the direction of rotation that can serve as a driven surface for applying torque transmission to the replaceable cutting head.

[0021] The head peripheral surfaces can serve as spiral driven surfaces applying torque transmission to the replaceable cutting head. The mounting portion can be devoid of a surface facing against the direction of rotation that can serve as a driven surface applying torque transmission to the replaceable cutting head.

[0022] The male coupling member can be devoid of a resilience slit.

[0023] The base surface can be perpendicular to the head longitudinal axis.

[0024] In an end view perpendicular to the head longitudinal axis, an imaginary cutting portion circle circumscribes the cutting portion has a maximum cutting portion diameter. The maximum cutting portion diameter can be greater than or equal to 25mm.

[0025] An imaginary base surface circle circumscribing a largest dimension of the base surface, taken perpendicular to the head longitudinal axis, has a maximum base surface diameter. An imaginary male coupling member circle circumscribing a largest dimension of the male coupling member, taken perpendicular to the head longitudinal axis, has a maximum male coupling member diameter and the maximum base surface diameter can be at least one and a half times as large as the maximum male coupling member diameter.

[0026] Measured in the forward direction along the head longitudinal axis from the base surface, the cutting portion has a maximum cutting portion length. Measured in the rearward

direction along the head longitudinal axis from the base surface, the mounting portion has a maximum mounting portion length. The maximum cutting portion length can be at least two and a half times greater than the maximum mounting portion length.

[0027] Measured in the rearward direction along the head longitudinal axis from the base surface, the mounting portion has a maximum mounting portion length. An imaginary base surface circle circumscribing a largest dimension of the base surface, taken perpendicular to the head longitudinal axis, has a maximum base surface diameter. The maximum base surface diameter can be at least three times greater than the maximum mounting portion length.

[0028] The male coupling member can exhibit 3-fold rotational symmetry about the head longitudinal axis.

[0029] The replaceable cutting head comprise a unitary integral one-piece construction.

[0030] Each head peripheral surface can lie on a portion of the curved surface of an associated imaginary irregular cone. The cone can have a spiral-shaped base surface.

[0031] The male coupling member can further comprise a rear surface. The rear surface can intersect the rearmost portion of each head fixation member.

[0032] The rear surface can be perpendicular with respect to the head longitudinal axis.

[0033] Each head fixation member can further include a chamfered surface, each chamfered surface can extend between its respective head peripheral surface and the rear surface and can converge rearwardly with respect to the head longitudinal axis.

[0034] Each head fixation member can further include a concave surface, extending between the base surface and each head peripheral surface.

[0035] The tool holder can further comprise a holder shank surface that can extend rearwardly from the holder forward surface. The female coupling member can open out to the holder shank surface at three circumferentially spaced apart holder flute surfaces. The holder forward surface comprises three spaced apart portions.

[0036] Each holder peripheral surface can spiral inwardly in a direction against the direction of rotation.

[0037] The head longitudinal axis can be coaxial with the holder longitudinal axis.

[0038] The peripheral portion of the holder forward surface can include a raised surface.

BRIEF DESCRIPTION OF THE FIGURES

[0039] For a better understanding of the present application and to show how the same may be carried out in practice, reference will now be made to the accompanying drawings, in which:

Fig. 1 is a front perspective view of a cutting tool;

Fig. 2 is an exploded rear perspective view of the cutting tool shown in Fig. 1;

Fig. 3 is a rear perspective view of a replaceable cutting head shown in Figs. 1 and 2;

Fig. 4 is a front perspective view of the replaceable cutting head shown in Fig. 3;

Fig. 5 is a front view of the replaceable cutting head shown in Figs. 3;

Fig. 6 is a side view of the replaceable cutting head shown in Figs. 3;

Fig. 7 is a rear view of the replaceable cutting head in Figs. 3;

Fig. 8 is a side view of a male coupling member shown in Fig. 6;

Fig. 9 is a cross section view taken along line IX- IX shown in Fig. 8;

Fig. 10 is a front perspective of a tool holder shown in Figs. 1 and 2;

Fig. 11 is a front view of the tool holder shown in Fig. 10;

Fig. 12 is a side view of the tool holder shown in Figs. 10 and 11;

Fig. 13 is a cross section view taken along line XIIV- XIIV shown in Fig. 12;

Fig. 14 is a side view of the cutting tool shown in Figs. 1 and 2;

Fig. 15 is a cross section view taken along line XV-XV shown in Fig. 14 when the cutting tool is in a released position; and

Fig. 16 is a cross section view taken along line XV-XV shown in Fig. 14 when the cutting tool is in a locked position.

[0040] It will be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity, or several physical components may be included in one functional block or element. Where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements.

DETAILED DESCRIPTION OF THE INVENTION

[0041] In the following description, various aspects of the subject matter of the present application will be described. For purposes of explanation, specific configurations and details are set forth in sufficient detail to provide a thorough understanding of the subject matter of the present application. However, it will also be apparent to one skilled in the art that the subject matter of the present application can be practiced without the specific configurations and details presented herein.

[0042] Attention is first drawn to Figs. 1 and 2 showing a cutting tool **20** of the type used for milling operations, in particular end milling, in accordance with embodiments of the subject matter of the present application. The cutting tool **20** has a replaceable cutting head **22** that has a head longitudinal axis **A,** around which the replaceable cutting head **22** rotates in a direction of rotation **R**. The replaceable cutting head **22** can be typically made from cemented carbide. The head longitudinal axis **A** extends in a forward $\mathbf{D_F}$ to rearward direction $\mathbf{D_R}$. The cutting tool **20** also has a tool holder **24**. The tool holder **24** can be typically made from steel. The replaceable cutting head **22** can be removably retained in the tool holder **24** by means of a coupling mechanism. Such a coupling mechanism could possibly be advantageous for other types of rotary cutting operations than those stated hereinabove, such as, for example, slotting or grooving.

[0043] It should be appreciated that use of the terms "forward" and "rearward" throughout the description and claims refer to a relative position in a direction of the head longitudinal axis **A** towards the left and right, respectively, in Figs. 6, 8, 12 and 14.

[0044] Reference is now made to Figs. 3 to 7. The replaceable cutting head **22** has a forward portion that forms a cutting portion **26** and a rearward portion that forms a mounting portion **28**. In accordance with some embodiments of the subject matter of the present application the replaceable cutting head **22** can be formed from a unitary integral one-piece construction. This provides an advantage in that the replaceable cutting head **22** has no detachable cutting inserts (not shown). Such detachable cutting inserts can be replaced periodically and this can be a time consuming procedure. There is also a possibility that threaded screws (not shown), for example, which can be used to releasably retain the detachable cutting inserts to the replaceable cutting head **22** can be mislaid and/or lost during the replacement operation.

[0045] As shown in Figs. 4 and 5, the cutting portion **26** includes a plurality of cutting members **30** that extend radially with respect to the head longitudinal axis **A**. In accordance with some embodiments of the subject matter of the present application, each cutting member **30** can include a relief surface **32**, a rake surface **34** and a cutting edge **36**, at the intersection thereof. The cutting edge **36** can extend in a direction generally parallel to the head longitudinal axis **A**. The relief surface **32** can be located circumferentially rearward of the cutting edge **36** and the rake surface **34** can be located circumferentially forward of the cutting edge **36**, both in respect to the direction of rotation **R**. The orientation of the cutting edge **36** with respect to the direction of rotation **R** allows metal cutting operations to be performed. Each cutting member **30** can include a head flute surface **38** for evacuating chips (not shown) that are produced during the cutting operation.

[0046] In accordance with some embodiments of the subject matter of the present application, the cutting portion **26** can be devoid of a surface that faces against the direction of rotation **R** that serves as a driven surface for applying torque transmission to the replaceable cutting head **22.**

[0047] Referring now to Fig. 5, in an end view perpendicular to the head longitudinal axis **A**, an imaginary cutting portion circle C_{CP} that circumscribes the cutting portion **26** has a maximum cutting portion diameter D_{CP}. In this non-limiting example, the maximum cutting portion diameter D_{CP} can be greater than or equal to 25mm. This is particularly applicable for a replaceable cutting head **22** used for a milling operation. In another non-limiting example, the maximum cutting portion diameter D_{CP} can be less than 25mm.

[0048] Making reference now to Figs. 3 and 6, the mounting portion **28** includes a male coupling member **40** that protrudes rearwardly from a base surface **42**. The base surface **42** extends transversely with respect to the head longitudinal axis **A** and defines a boundary between the cutting portion **26** and the mounting portion **28**. That is to say, the cutting portion **26** is formed forward of the base surface **42** and the mounting portion **28** is formed rearward of the base surface **42**. In accordance with some embodiments of the subject matter of the present application the male coupling member can be rigid. The base surface **42** can be perpendicular to the head longitudinal axis **A**. The base surface **42** is intended to abut a corresponding surface on the tool holder **24** when the cutting tool **20** is in a locked position, as will be described hereinafter.

[0049] Reference is now made to Figs. 3, 4, 7 and 9. The male coupling member **40** includes three circumferentially spaced apart head fixation members **44**. Each head fixation member **44** includes a head peripheral surface **46** that spirals inwardly in a direction against the direction of rotation **R**. Stated differently, in each cross section of the male coupling member **40** taken in a plane through the head peripheral surface **46** and perpendicular to the head longitudinal axis **A**, a first point **P1** on any head peripheral surface **46** is closer to the head longitudinal axis **A** than a second point **P2** on the same head peripheral surface **46**, the second point **P2** being circumferentially disposed further in the direction of rotation **R** relative to the first point **P1**. Each head peripheral surface **46** diverges rearwardly with respect to the head longitudinal axis **A**. Stated differently, each head peripheral surface **46** generally faces in the forward direction so that the male coupling member **40** has a general dove-tail shape in which the head fixation members **44** extend radially from a central portion of the male coupling member **40**.

[0050] It should be appreciated that use of the terms "inward" and "outward" throughout the description and claims refer to a relative position in a radial direction in relation to the head longitudinal axis **A** and/or holder longitudinal axis **C** inwardly and outwardly, respectively, in Fig. 5, 7, 9, 11, 13, 15 and 16.

[0051] By virtue of the configuration of the male coupling member **40** an improved coupling mechanism is provided where each head peripheral surface **46** is designed to abut a corresponding surface on the tool holder **24** when the cutting tool **20** is in a locked position, as will be described hereinafter, in order to provide a well-constrained coupling of the replaceable cutting head **22** and the tool holder **24**. It is pointed out that a male coupling member **40** having exactly two male fixation members **44** provides a coupling where the replaceable cutting head **22** is under-constrained.

[0052] As shown in Fig. 8, in accordance with some embodiments of the subject matter of the present application a first angle α is formed between the head longitudinal axis **A** and a line **T** tangential to any point on each head peripheral surface **46.** The first angle α can be greater than or equal to 35° and less than or equal to 55°. In particular, the first angle α can be constant and have a value of 45°.

[0053] In accordance with some embodiments of the subject matter of the present application each head peripheral surface **46** can lie on a portion of the curved surface of an associated imaginary irregular cone, where the cone has a spiral-shaped base surface (not shown).

[0054] Referring now to Fig. 9, in accordance with some embodiments of the subject matter of the present application, in each cross section of the male coupling member **40** taken in a plane through the head peripheral surface **46** and perpendicular to the head longitudinal axis **A**, each head peripheral surface **46** can lie on a spiral **S**, that has a spiral center $\mathbf{S_C}$. Each head peripheral surface **46** can form a spiral portion **SP**. The two end points of each spiral portion **SP** can form a first and second end point **PE1 PE2**, the first end point **PE1** being circumferentially rearward than the second end point **PE2** in respect to the direction of rotation **R**. The two end points **PE1, PE2** are the points furthest from each other on the same spiral portion **SP**. It can be equivalently stated, since each spiral portion **SP** lies on the head peripheral surface **46,** that the first and second end point **PE1 PE2** are formed at the extremities of each head peripheral surface **46,** in each said cross section. The two end points **PE1, PE2** can subtend a peripheral surface angle **β** relative to the spiral center $\mathbf{S_C}$. The peripheral surface angle **β** can be greater than or equal to 30° and less than or equal to 60°. Each spiral **S** can be an Archimedean spiral. The pitch angle **δ** of each spiral portion **SP** can be less than 30°. Each spiral center $\mathbf{S_C}$ can be coincident with the head longitudinal axis **A**. The pitch angle **δ** determines the magnitude of the force that must be applied in order to self-lock the replaceable cutting head 22 into the tool holder 24. It should be appreciated that use of the terms "pitch angle" throughout the description and claims refer the angle the spiral makes with circles centered at the spiral center $\mathbf{S_C}$.

[0055] In accordance with some embodiments of the subject matter of the present application the male coupling member **40** can further include a rear surface **48**. The rear surface **48** can intersect the rearmost portion of each head fixation member **44**. The rear surface **48** can be perpendicular with respect to the head longitudinal axis **A.** As is best shown in Figs. 8, each head fixation member **44** can further include a chamfered surface **50.** Each chamfered surface **50** can extend between its respective head peripheral surface **46** and the rear surface **48**, and can converge rearwardly with respect to the head longitudinal axis **A**. The chamfered surface **50** can have a frusto-conical shape. The chamfered surface **50** is intended to guide the male coupling member **40** into the correct position within a corresponding female coupling member. As seen in Fig. 6, each head fixation member **44** can further include a concave surface **66**, extending between the base surface **42** and each head peripheral surface **46**.

[0056] Making reference now to Fig. 7, in accordance with some embodiments of the subject matter of the present application an imaginary base surface circle $\mathbf{C_{BS}}$ that circumscribes a

largest dimension of the base surface **42**, taken perpendicular to the head longitudinal axis **A**, can have a maximum base surface diameter $\mathbf{D_{BS}}$. An imaginary male coupling member circle $\mathbf{C_{MCM}}$ that circumscribes a largest dimension of the male coupling member **40**, taken perpendicular to the head longitudinal axis **A**, can have a maximum male coupling member diameter $\mathbf{D_{MCM}}$. The maximum base surface diameter $\mathbf{D_{BS}}$ can be at least one and a half times as large as the maximum male coupling member diameter $\mathbf{D_{MCM}}$.

[0057] Making reference now to Fig. 6, in accordance with some embodiments of the subject matter of the present application, measured in the direction of the head longitudinal axis **A**, the cutting portion **26** has a maximum cutting portion length $\mathbf{L_{CP}}$ and the mounting portion **28** has a maximum mounting portion length $\mathbf{L_{MP}}$. The maximum cutting portion length $\mathbf{L_{CP}}$ is measured in the forward direction $\mathbf{D_F}$ from the base surface **42** to the forwardmost point of the cutting head. The maximum mounting portion length $\mathbf{L_{MP}}$ is measured in the rearward direction $\mathbf{D_R}$ from the base surface **42** to the rear surface **48**. The maximum cutting portion length $\mathbf{L_{CP}}$ can be at least two and a half times greater than the maximum mounting portion length $\mathbf{L_{MP}}$. This is particularly applicable when the replaceable cutting head **22** is intended for a milling operation. In another non-limiting example, the maximum cutting portion length $\mathbf{L_{CP}}$ can be less than two and a half times greater than the maximum mounting portion length $\mathbf{L_{MP}}$. This is particularly applicable when the replaceable cutting head is intended for a slotting or grooving operation. The maximum base surface diameter $\mathbf{D_{BS}}$ can be at least three times greater than the maximum mounting portion length $\mathbf{L_{MP}}$.

[0058] In accordance with some embodiments of the subject matter of the present application, the head peripheral surfaces **46** can serve as spiral driven surfaces applying torque transmission to the replaceable cutting head **22.** The mounting portion **28** can be devoid of a surface that faces against the direction of rotation **R** that serves as a driven surface for providing torque transmission to the replaceable cutting head **22**.

[0059] In accordance with some embodiments of the subject matter of the present application the male coupling member **40** can be devoid of a resilience slit. Referring now to Figs. 7, the male coupling member **40** can exhibit 3-fold rotational symmetry about the head longitudinal axis **A**. In this non-limiting example, the number of cutting members **30** can also be three. Also in this non-limiting example, the replaceable cutting head **22** can exhibit 3-fold rotational symmetry about the head longitudinal axis **A**.

[0060] Another aspect of the subject matter of the present application includes the cutting tool **20** that has the replaceable cutting head **22** and the tool holder **24**. The male coupling member **40** of the replaceable cutting head **22** includes a rear surface **48.** The rear surface **48** intersects the rearmost portion of each head fixation member **44**. Referring now to Figs. 10 to 12, the tool holder **24** has a holder longitudinal axis **C** that extends in the forward $\mathbf{D_F}$ to rearward direction $\mathbf{D_R}$. The tool holder **24** includes a female coupling member **52** that extends rearwardly from a holder forward surface **54**. The holder forward surface **54** extends transversely with respect to the holder longitudinal axis **C**. The female coupling member **52** includes three circumferentially spaced apart holder fixation members **56**. Each holder fixation member **56** includes a recessed holder peripheral surface **58** that diverges rearwardly with respect to the holder longitudinal axis **C**. Stated differently, each recessed holder peripheral surface **58** generally faces in the rearward direction $\mathbf{D_R}$. As seen from Figs. 11 and 12, each holder peripheral surface **58** is formed as an undercut of a corresponding holder fixation members **56** and thus is hidden from view in a front view of the tool holder **24** along the longitudinal axis **C**. The female coupling member **52** includes a holder rear surface **60** that extends transversely with respect to the holder longitudinal axis **C** and that intersects each holder fixation member **56**.

[0061] Referring now to Fig. 13, in accordance with some embodiments of the subject matter of the present application, in each cross section of the female coupling member **52** taken in a plane through the holder peripheral surface **58** and perpendicular to the holder longitudinal axis **C**, the two female end points on the same holder peripheral surface **58** form a first and second female end point **FPE1 FPE2**, the first female end point **FPE1** being circumferentially rearward than the second female end point **FPE2** in respect to the direction of rotation **R**. The two female end points **FPE1, FPE2** are the points furthest from each other on the same holder peripheral surface **58** in each cross section of the female coupling member **52** taken in a plane through the holder peripheral surface **58** and perpendicular to the holder longitudinal axis **C.**

[0062] Referring now to Figs. 15 and 16, the replaceable cutting head **20** is rotatable between a released position and a locked position. In the locked position, the male coupling member **40** is removably retained in the female coupling member **52**. As best shown in Figs. 14 and 16, each of the head peripheral surfaces **46** abuts a corresponding holder peripheral surface **58**. The base surface **42** abuts the holder forward surface **54**. The rear surface **48** is spaced apart from the holder rear surface **60**.

[0063] Further in a locked position, in accordance with some embodiments of the subject matter of the present application, in each cross section of the cutting tool **40** perpendicular to the head longitudinal axis **A** taken in a plane through the head peripheral surface **46** and holder peripheral surface **58**, each first end point **PE1** on the head peripheral surface **46** can be spaced apart from the female first end point **FPE1** on its associated holder peripheral surface **58**. Each second end point **PE2** on the head peripheral surface **46** can be adjacent to the second female end point **FPE2** on its associated holder peripheral surface **58.** It should be appreciated that use of the terms "associated" throughout the description in respect to the head peripheral surfaces **46** and holder peripheral surfaces **58** refer to the head peripheral surface **46** and the holder peripheral surface **58** that abut each other when the cutting tool **20** is in the locked position.

[0064] In accordance with some embodiments of the subject matter of the present application, the tool holder **24** can further include a holder shank surface **62** that extends rearwardly from the holder forward surface **54**. In this non-limiting example, the female coupling member **52** can open out to the holder shank surface **62** at three circumferentially spaced apart holder flute surfaces **64**. In this case the holder forward surface **54** can be formed from three spaced apart portions. In another non-limiting example the female coupling member **52** cannot open out to the holder shank surface **62.** Stated differently the female coupling member **52** is closed. In this case the holder forward surface **54** can be formed from a single continuous portion.

[0065] As best seen in Fig. 13, in accordance with some embodiments of the subject matter of the present application, each holder peripheral surface **58** can spiral inwardly in a direction against the direction of rotation **R**. The head longitudinal axis **A** can be coaxial with the holder longitudinal axis **C.** The peripheral portion of the holder forward surface **54** can include a raised surface **68**. Stated differently, the raised surface **68** protrudes in a forward direction $\mathbf{D_F}$ from the holder forward surface **54.** The raised surface **68** is intended to ensure that the abutment of the base surface **42** with the holder forward surface **54** occurs at a peripheral portion of the holder forward surface **54** in order to provide a solid support surface, and not, for example at an area close to the holder longitudinal axis **C.**

[0066] Another aspect of the subject matter of the present application includes a tool holder **24** as defined herein above. Each holder peripheral surface **58** spirals inwardly in a direction against the direction of rotation **R.**

[0067] Assembly of the cutting tool **20** is accomplished by performing the following steps. The male coupling member **40** is inserted into the female coupling member **52** such that each head fixation member **44** is located axially forward and circumferentially between, each adjacent pair of holder fixation members **56** (as best seen in Fig. 15). The replaceable cutting head **22** is then displaced rearwardly until the base surface **42** initially comes into contact with the holder forward surface **54**. It should be noted that the head fixation members **44** and the holder fixation members **56** are so designed so that there is adequate space between each adjacent pair of holder fixation members **56** to allow the placement of a head fixation member **44**. In this position the cutting tool **20** is in a released position.

[0068] It is pointed out that, as seen in Fig. 15, in the released position, in each cross section of the cutting tool **40** perpendicular to the head longitudinal axis **A** taken in a plane through the head peripheral surface **46** and holder peripheral surface **58**, the distance of the first end point **PE1** on each head peripheral surface **46** to the head longitudinal axis **A** is less than the distance of the corresponding second female end point **FPE2** on the associated holder peripheral surface **58** to the head longitudinal axis **A**. By virtue of the spiral shape of the head peripheral surface **46**, the distance of the second end point **PE2** on each head peripheral surface **46** to the head longitudinal axis **A** is more than the distance of the corresponding first female end point **FPE1** on an associated holder peripheral surface **58** to the head longitudinal axis **A**.

[0069] The replaceable cutting head **22** is rotated in a direction against the direction of rotation **R,** until each head peripheral surface **46** initially comes into contact with a corresponding respective holder peripheral surface **58**. Rotating the replaceable cutting head **22** further in a direction against the direction of rotation **R** pushes on the holder peripheral surfaces **58**, thereby forcing the corresponding holder fixation members **56** to be elastically displaced in a radially outwardly direction with respect to the holder longitudinal axis **C.** This is due to the increasing radius of the head peripheral surface **46.** Consequently the holder forward surface **54** is displaced axially forwardly until it firmly abuts the base surface **42**. The rear surface **48** is spaced apart from the holder rear surface **60.** In this locked position, a tight fit between the replaceable cutting head **22** and the tool holder **24** is accomplished. The coupling mechanism described herein above provides a self-lock between the replaceable cutting head **22** and the tool holder **24**.

[0070] It should be noted that the value of the pitch angle **δ** as described above determines the amount of rotational force required to accomplish the locked position of the cutting tool **20**. Stated differently, as the pitch angle approaches 0° less force is required to rotate the replaceable cutting head **22** in the tool holder **24.** However, more rotational displacement (e.g. rotations and/or partial rotations) of the replaceable cutting head **24** is required to accomplish a self-lock. Alternatively, as the pitch angle increases away from 0° more force is required to rotate the replaceable cutting head **22** in the tool holder **24.** Moreover, by virtue of the head peripheral surfaces **46** being spiraling surfaces, the magnitude of the rotational force required to accomplish the locked position increases gradually and smoothly.

[0071] It should also be noted that a feature of subject matter of the present application is that the male and female coupling members **40, 52** provide an improved coupling mechanism in particular for large replaceable cutting heads **22**, where the maximum cutting portion diameter $\mathbf{D_{CP}}$ can be greater than or equal to 25mm.

[0072] The design of the replaceable cutting head **22** and the tool holder **24** according to the subject matter of the present application and, particularly, the shape and orientation of the head peripheral surfaces **46** and the holder peripheral surfaces **58**, ensure that the friction between these surfaces is sufficient to keep them in their mutual abutment when the replaceable cutting **22** head and the tool holder **24** are coupled together. This allows for a tight fit of the replaceable cutting head **22** and the tool holder **24** in an accurately established mutual axial and radial position. Consequently, the replaceable cutting head **22** is accurately positioned and securely retained in the tool holder **24** in a self-locking manner. It will be understood from the foregoing that the head peripheral surfaces **46** are spiral driven surfaces applying torque transmission to the replaceable cutting head **22**.

[0073] Another feature of the subject matter of the present application is that the design of the male coupling member **40** allows for the head peripheral surface **46** to be ground.

[0074] Yet another feature of the subject matter of the present application is that there is no requirement for a surface on the cutting portion **26** or the mounting portion **28** that faces against the direction of rotation **R** and that serves as a driven surface for applying torque transmission to the replaceable cutting head **22.**

[0075] Yet another feature of the subject matter of the present application is that there is no requirement for a surface on the tool holder **24** that faces the direction of rotation **R** that serves as a driving surface for providing torque transmission to the replaceable cutting head **22.**

[0076] Yet another feature of the subject matter of the present application is that the size of the mounting portion **28** is small in relation to the size of mounting portions of other cutting tools having a cutting portion of comparable size. Therefore, manufacture of replaceable cutting heads **22**, in accordance with the subject matter of the present application, requires less material.

[0077] Although the subject matter of the present application has been described to a certain degree of particularity, it should be understood that various alterations and modifications could be made without departing from the spirit or scope of the invention as hereinafter claimed.

CLAIMS

1. A replaceable cutting head, for rotary cutting operations, having a head longitudinal axis (A) around which the replaceable cutting head rotates in a direction of rotation (R), the head longitudinal axis (A) extending in a forward (D_F) to rearward direction (D_R), comprising:

a forward portion forming a cutting portion and a rearward portion forming a mounting portion;

the cutting portion comprising:

a plurality of cutting members extending radially with respect to the head longitudinal axis (A); and

the mounting portion comprising a male coupling member protruding rearwardly from a base surface, the base surface extending transversely with respect to the head longitudinal axis (A), and defining a boundary between the cutting portion and the mounting portion, the male coupling member comprising:

three circumferentially spaced apart head fixation members, each head fixation member comprising a head peripheral surface spiraling inwardly in a direction against the direction of rotation (R) and diverging rearwardly with respect to the head longitudinal axis (A).

2. The replaceable cutting head according to claim 1, wherein

a first angle α is formed between the head longitudinal axis (A) and a line (T) tangential to any point on each head peripheral surface, wherein the first angle α is in the range of $35° \leq \alpha \leq 55°$.

3. The replaceable cutting head according to claim 2, wherein the first angle (α) is a 45° angle.

4. The replaceable cutting head according to any one of claims 1-3, wherein

in each cross section of the male coupling member taken in a plane through the head peripheral surface and perpendicular to the head longitudinal axis (A), each head peripheral surface lies on a spiral (S), having a spiral center (S_C), each head peripheral surface forming a spiral portion (SP).

5. The replaceable cutting head according to claim 4, wherein

the two end points (PE1, PE2) of each spiral portion (SP) subtend a peripheral surface angle β relative to the spiral center (S_C); wherein the peripheral surface angle β is in the range of $30° \leq \beta \leq 60°$.

6. The replaceable cutting head according to any one of claims 4-5, wherein each spiral center (S_C) is coincident with the head longitudinal axis (A).

7. The replaceable cutting head according to any one of claims 4-6, wherein each spiral (S) is an Archimedean spiral.

8. The replaceable cutting head according to claim 7, wherein the pitch angle (δ) of each spiral portion (SP) is less than 30°.

9. The replaceable cutting head according to any one of claims 1-8, wherein

the head peripheral surfaces serve as spiral driven surfaces applying torque transmission to the replaceable cutting head; and

both the cutting portion and the mounting portion are devoid of a surface facing against the direction of rotation (R) that serves as a driven surface for applying torque transmission to the replaceable cutting head.

10. The replaceable cutting head according to any one of claims 1-9, wherein

an imaginary base surface circle (C_{BS}) circumscribing a largest dimension of the base surface, taken perpendicular to the head longitudinal axis (A), has a maximum base surface diameter (D_{BS});

an imaginary male coupling member circle (C_{MCM}) circumscribing a largest dimension of the male coupling member, taken perpendicular to the head longitudinal axis (A), has a maximum male coupling member diameter (D_{MCM}); and

the maximum base surface diameter (D_{BS}) is at least one and a half times as large as the maximum male coupling member diameter (D_{MCM}).

11. The replaceable cutting head according to any one of claims 1-10, wherein,

measured in the forward direction (D_F) along the head longitudinal axis (A) from the base surface, the cutting portion has a maximum cutting portion length (L_{CP}),

measured in the rearward direction (D_R) along the head longitudinal axis (A) from the base surface, the mounting portion has a maximum mounting portion length (L_{MP}); and

the maximum cutting portion length (L_{CP}) is at least two and a half times greater than the maximum mounting portion length (L_{MP}).

12. The replaceable cutting head according to any one of claims 1-11, wherein,

measured in the rearward direction (D_F) along the head longitudinal axis (A) from the base surface, the mounting portion has a maximum mounting portion length (L_{MP});

an imaginary base surface circle (C_{BS}) circumscribing a largest dimension of the base surface, taken perpendicular to the head longitudinal axis (A), has a maximum base surface diameter (D_{BS}); and

the maximum base surface diameter (D_{BS}) is at least three times greater than the maximum mounting portion length (L_{MP}).

13. The replaceable cutting head according to any one of claims 1-12, wherein the male coupling member exhibits 3-fold rotational symmetry about the head longitudinal axis (A).

14. The replaceable cutting head according to any one of claims 1-13, wherein each head peripheral surface lies on a portion of the curved surface of an associated imaginary irregular cone, the cone having a spiral-shaped base surface.

15. The replaceable cutting head according to any one of claims 1-14, wherein

the male coupling member further comprises a rear surface, the rear surface intersecting the rearmost portion of each head fixation member; and

each head fixation member further comprises a chamfered surface, extending between the rear surface and each head peripheral surface, and converging rearwardly with respect to the head longitudinal axis (A).

16. The replaceable cutting head according to claim 15, wherein

each head fixation member further comprises a concave surface, extending between the base surface and each head peripheral surface.

17. A cutting tool comprising:

a replaceable cutting head in accordance with any one of claims 1-16; and

a tool holder, having a holder longitudinal axis (C) extending in the forward (D_F) to rearward direction (D_R), comprising a female coupling member extending rearwardly from a holder forward surface, the holder forward surface extending transversely with respect to the holder longitudinal axis (C), the female coupling member comprising:

three circumferentially spaced apart holder fixation members, each holder fixation member comprising a recessed holder peripheral surface diverging rearwardly with respect to the holder longitudinal axis (C); and

a holder rear surface extending transversely with respect to the holder longitudinal axis (C) and intersecting each holder fixation member; wherein

the male coupling member further comprises a rear surface, the rear surface intersecting the rearmost portion of each head fixation member; and

the replaceable cutting head is rotatable between a released position and a locked position, wherein in the locked position:

the male coupling member is removably retained in the female coupling member;

each of the head peripheral surfaces abuts a corresponding holder peripheral surface;

the base surface abuts the holder forward surface; and

the rear surface is spaced apart from the holder rear surface.

18. The cutting tool according to claim 17, wherein

the tool holder further comprises a holder shank surface extending rearwardly from the holder forward surface;

the female coupling member opens out to the holder shank surface at three circumferentially spaced apart holder flute surfaces; and

the holder forward surface comprises three spaced apart portions.

19. The cutting tool according to any one of claims 17-18, wherein each holder peripheral surface spirals inwardly in a direction against the direction of rotation (R).

20. The cutting tool according to any one of claims 17-19, wherein the head longitudinal axis (A) is coaxial with the holder longitudinal axis (C).

21. The cutting tool according to any one of claims 17-20, wherein the peripheral portion of the holder forward surface comprises a raised surface.

22. A tool holder having a longitudinal axis (C) extending in a forward (D_F) to a rearward direction (D_R) and a direction of rotation (R) about the longitudinal axis (C), the tool holder comprising:

a female coupling member extending rearwardly from a holder forward surface, the holder forward surface extending transversely with respect to the holder longitudinal axis (C), the female coupling member comprising:

three circumferentially spaced apart holder fixation members, each holder fixation member comprising a recessed holder peripheral surface diverging rearwardly with respect to the holder longitudinal axis (C), wherein:

each holder peripheral surface spirals inwardly in a direction against the direction of rotation (R); and

each holder peripheral surface is formed as an undercut of a corresponding holder fixation member and hidden from view in a front view of the tool holder along the longitudinal axis (C); and

a holder rear surface extending transversely with respect to the holder longitudinal axis (C) and intersecting each holder fixation member.

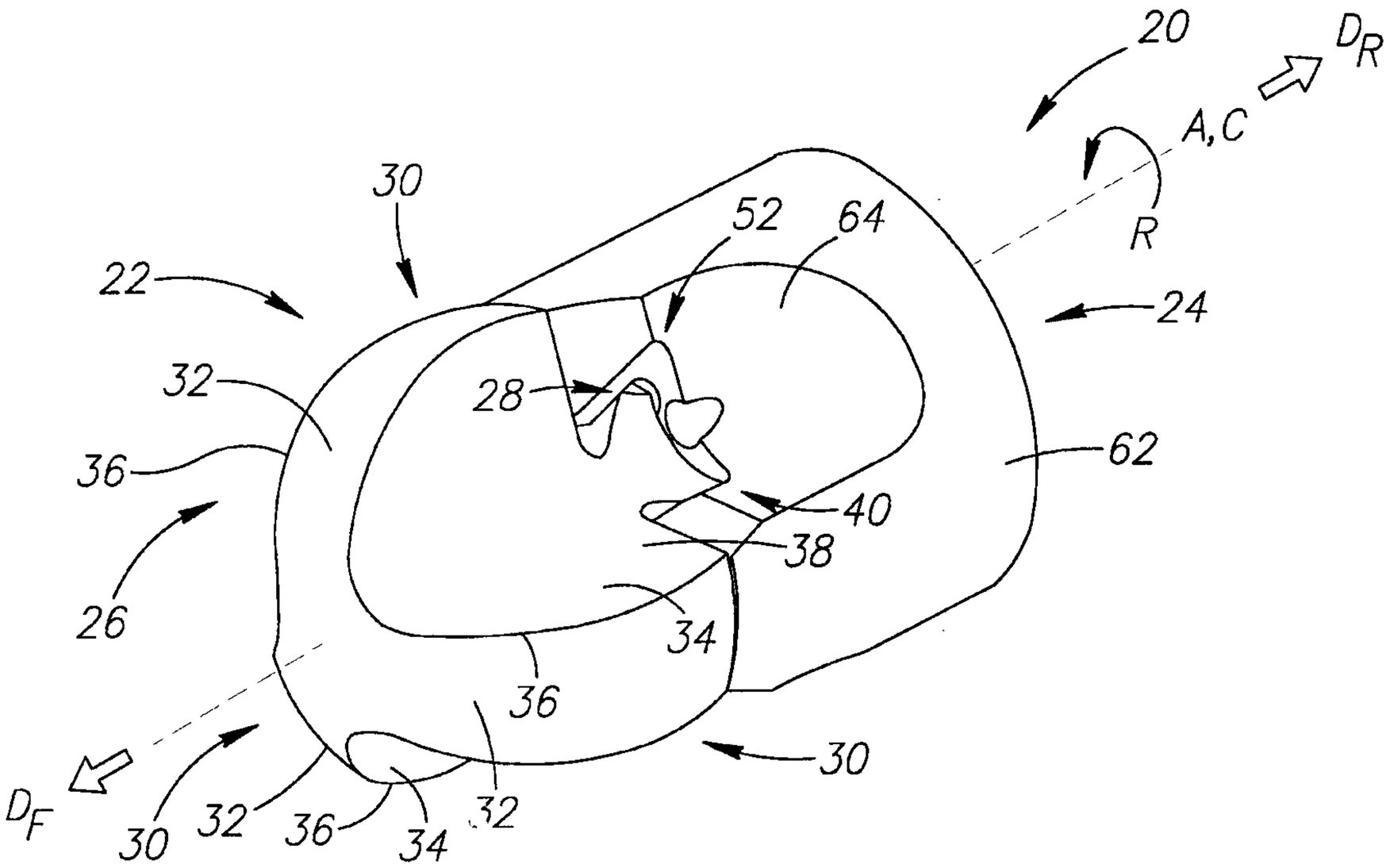

20
D_R
A,C
R
30
52
64
22
24
32
28
62
36
40
38
26
34
36
30
D_F
30
32
36
34
32

FIG.1

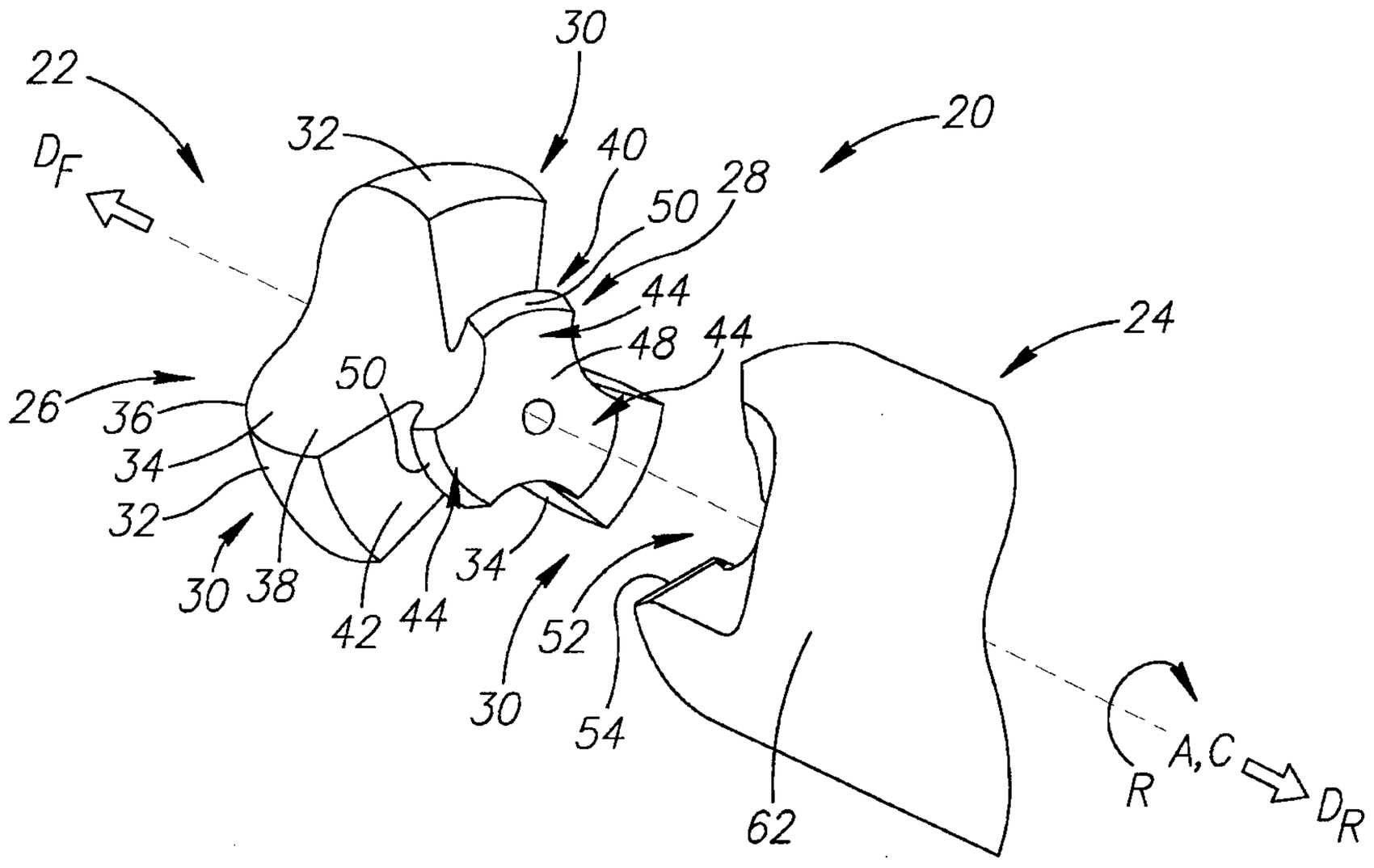

30
22
20
D_F
32
40
28
50
44
24
48
44
50
26
36
O
34
32
30
38
42
44
34
52
30
54
62
R
A,C
D_R

FIG.2

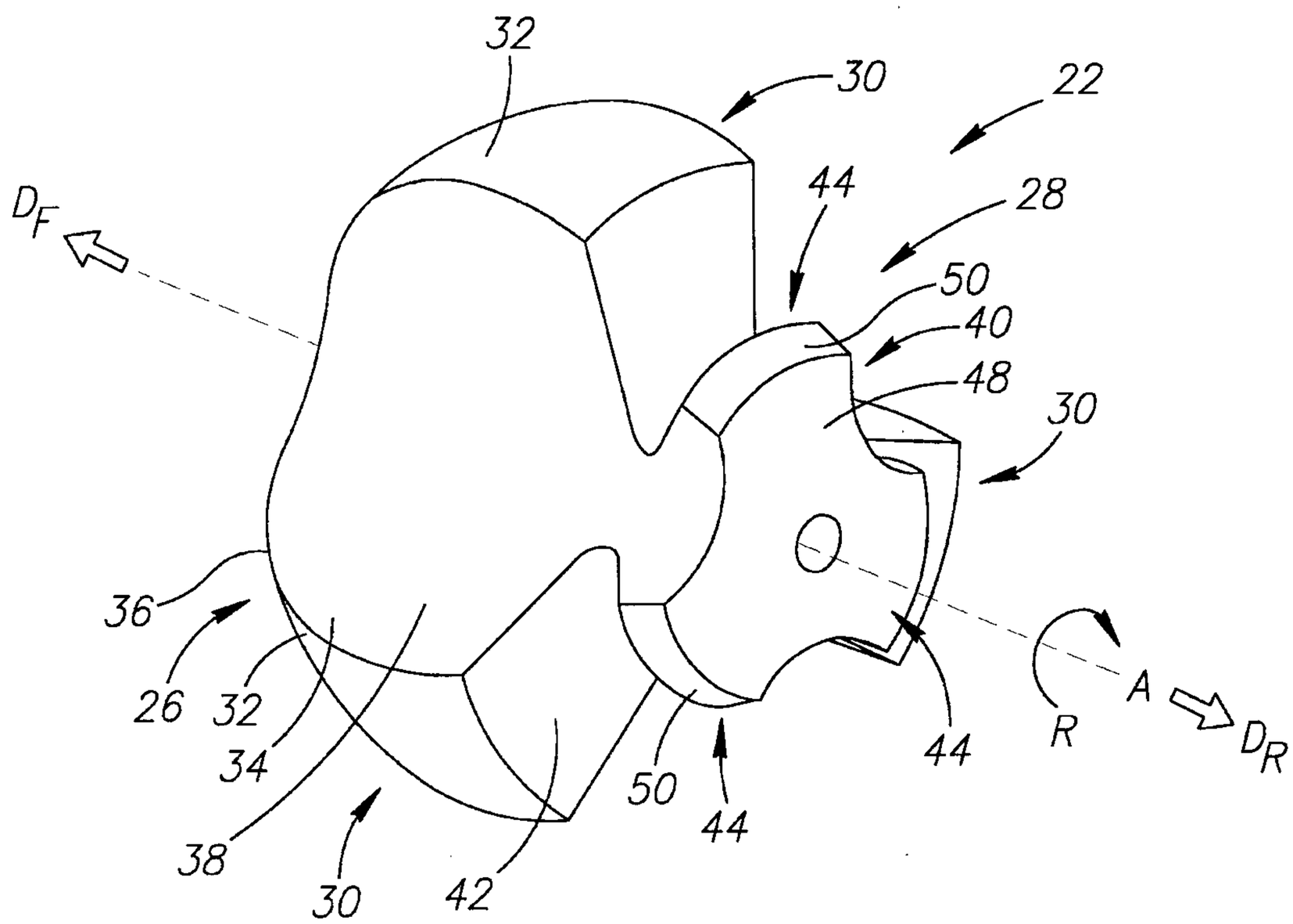

32
30
22
D_F
44
28
50
40
48
30
36
26
32
34
38
30
42
50
44
44
R
A
D_R

FIG.3

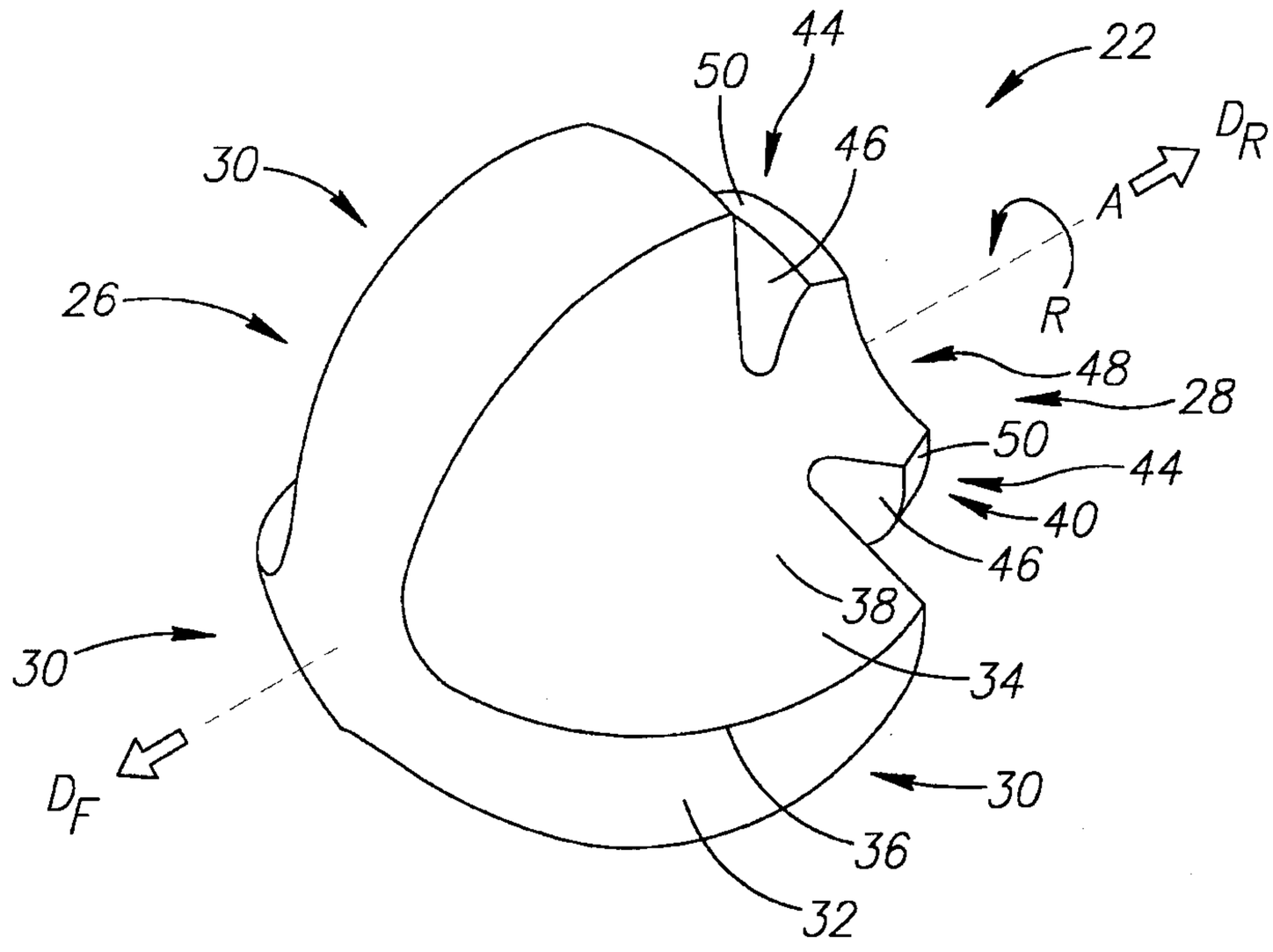

44
50
22
46
D_R
A
30
R
26
48
28
50
44
40
46
38
30
34
D_F
30
36
32

FIG.4

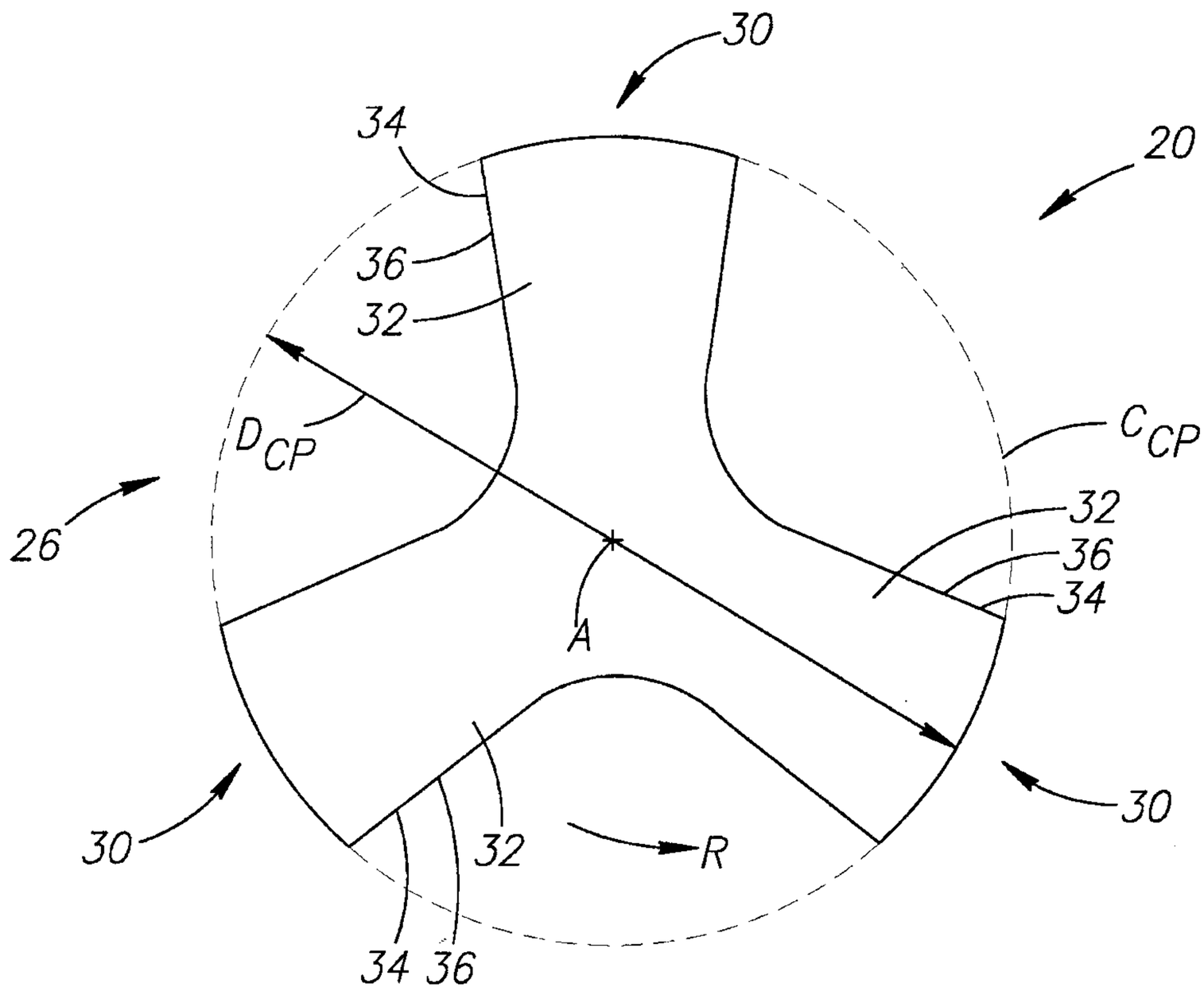

30
34
20
36
32
D_{CP}
C_{CP}
26
32
36
34
A
30
32
R
30
34 36

FIG.5

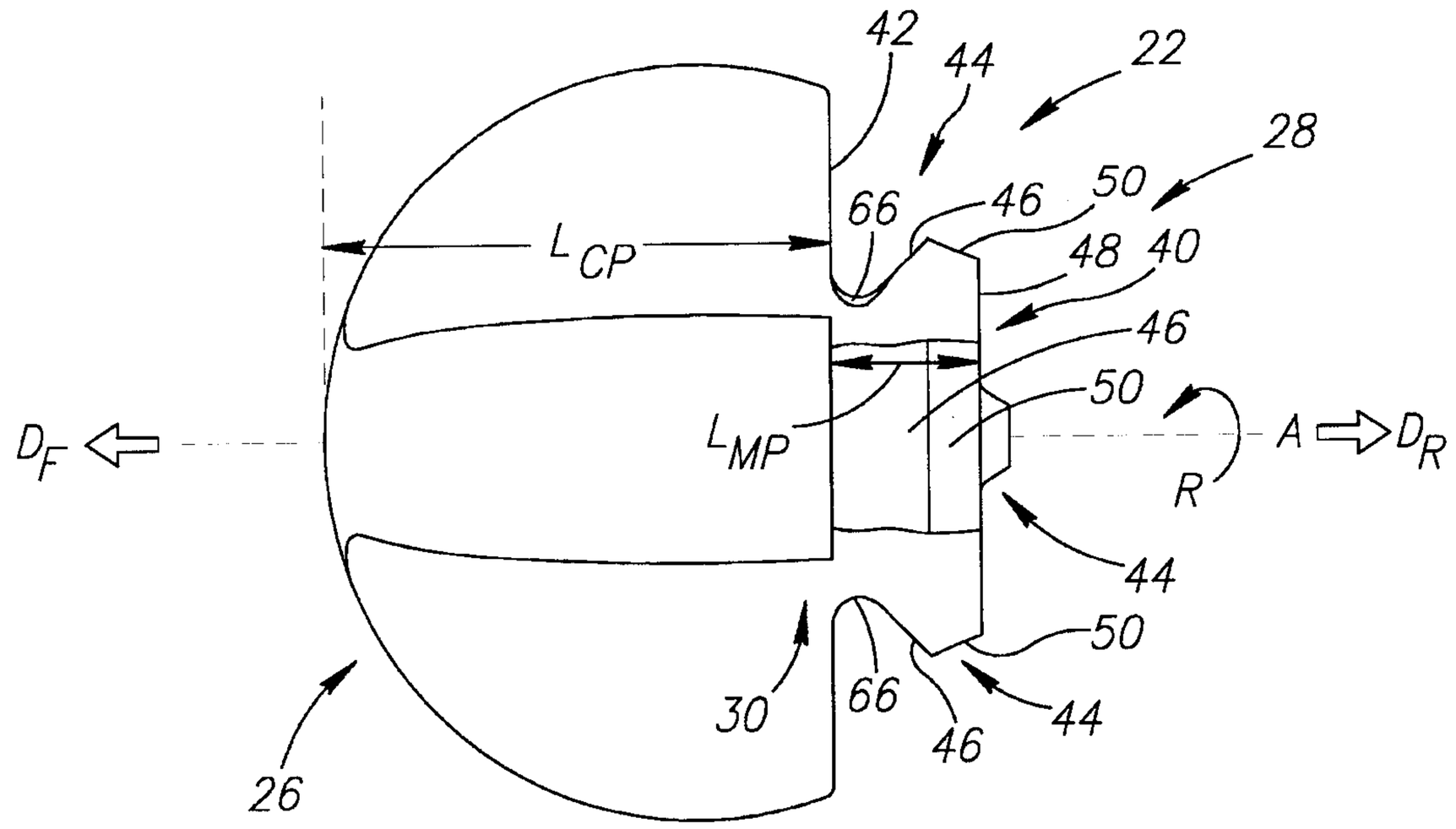

42
44
22
28
66
46
50
48
40
L_{CP}
46
50
D_F
L_{MP}
A
D_R
R
44
50
30
66
46
44
26

FIG.6

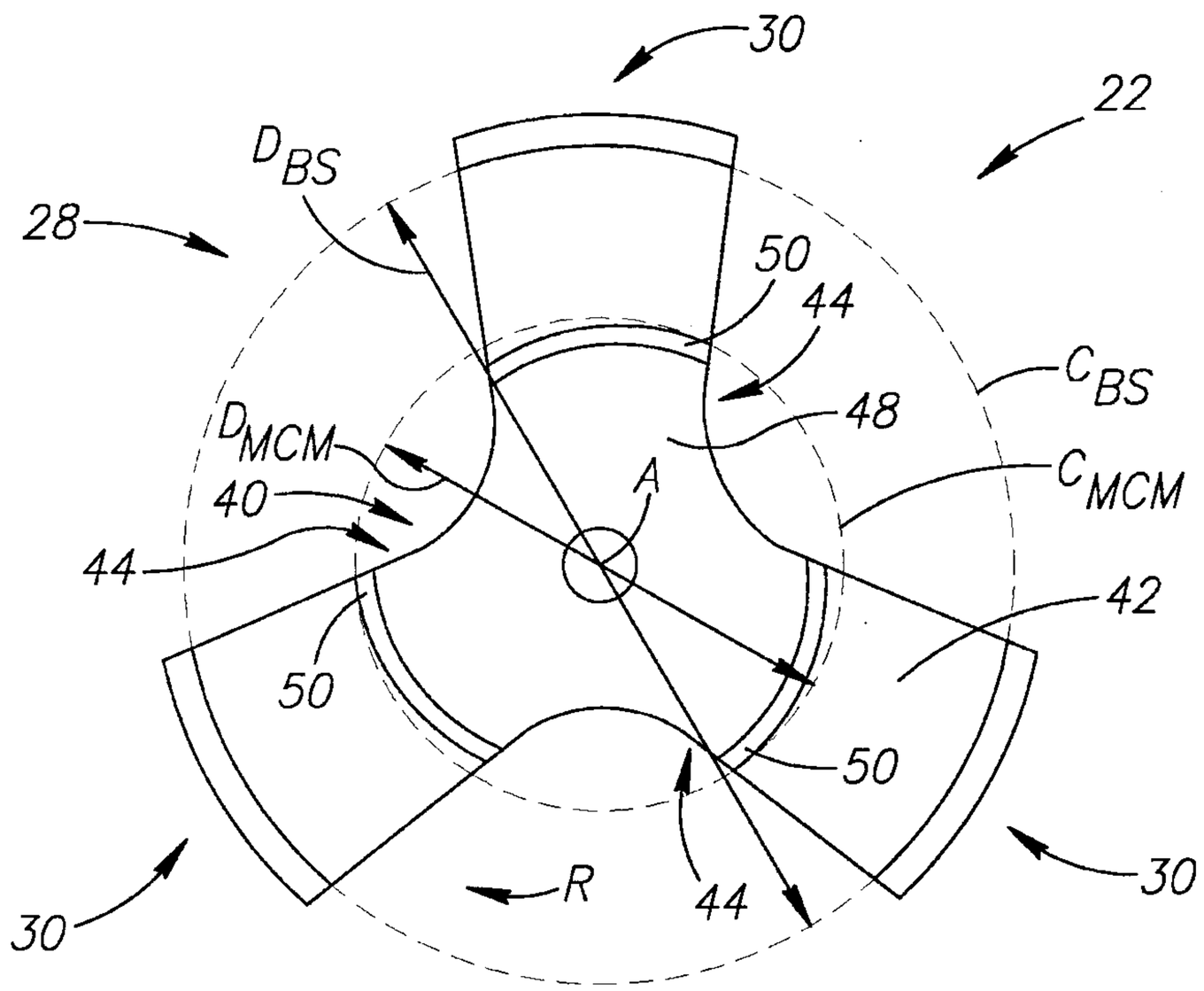

30
22
D_{BS}
28
50
44
C_{BS}
48
D_{MCM}
C_{MCM}
40
A
44
42
50
50
30
R
44
30

FIG.7

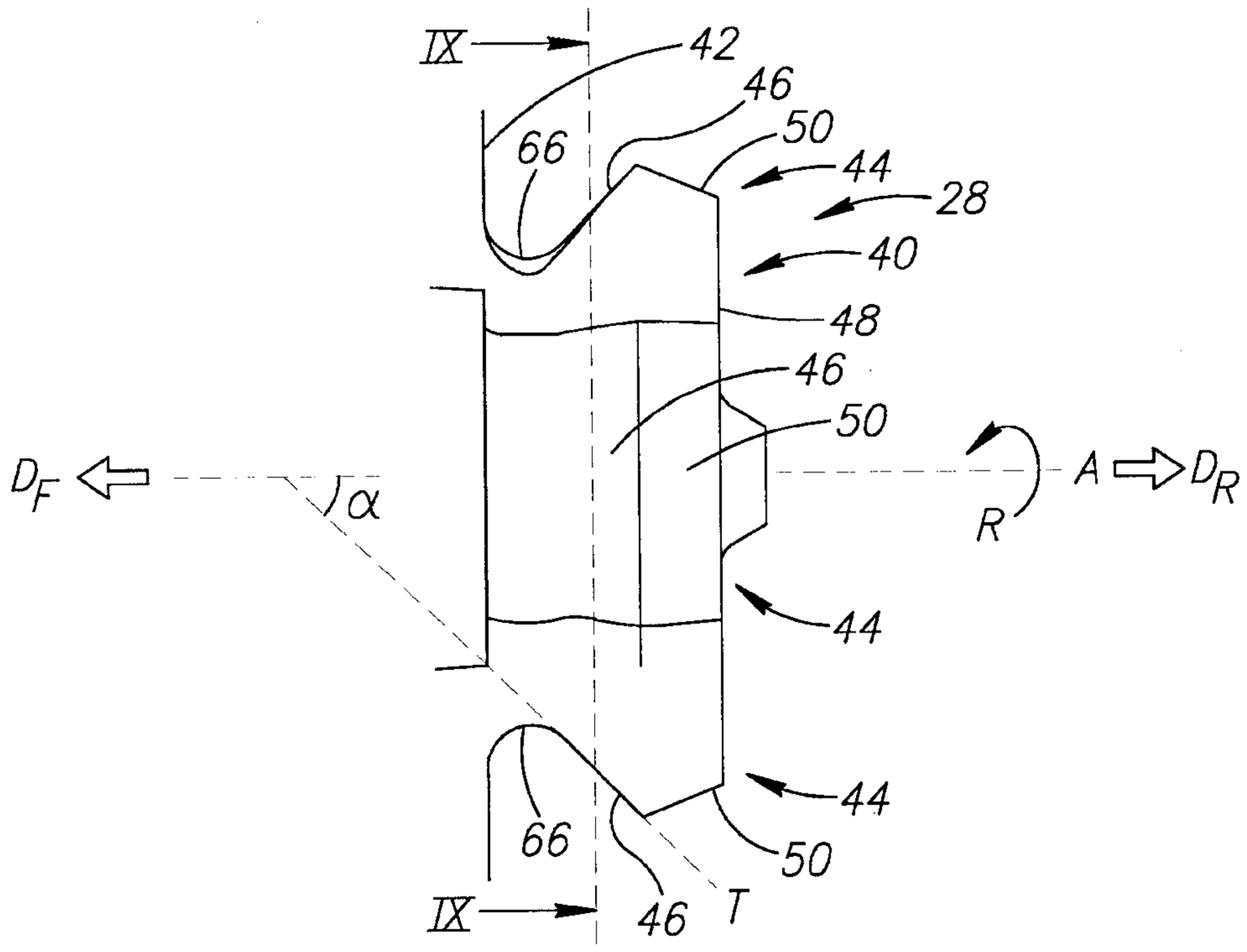

IX
42
46
66
50
44
28
40
48
46
50
D_F
α
A
D_R
R
44
44
66
50
IX
46
T

FIG.8

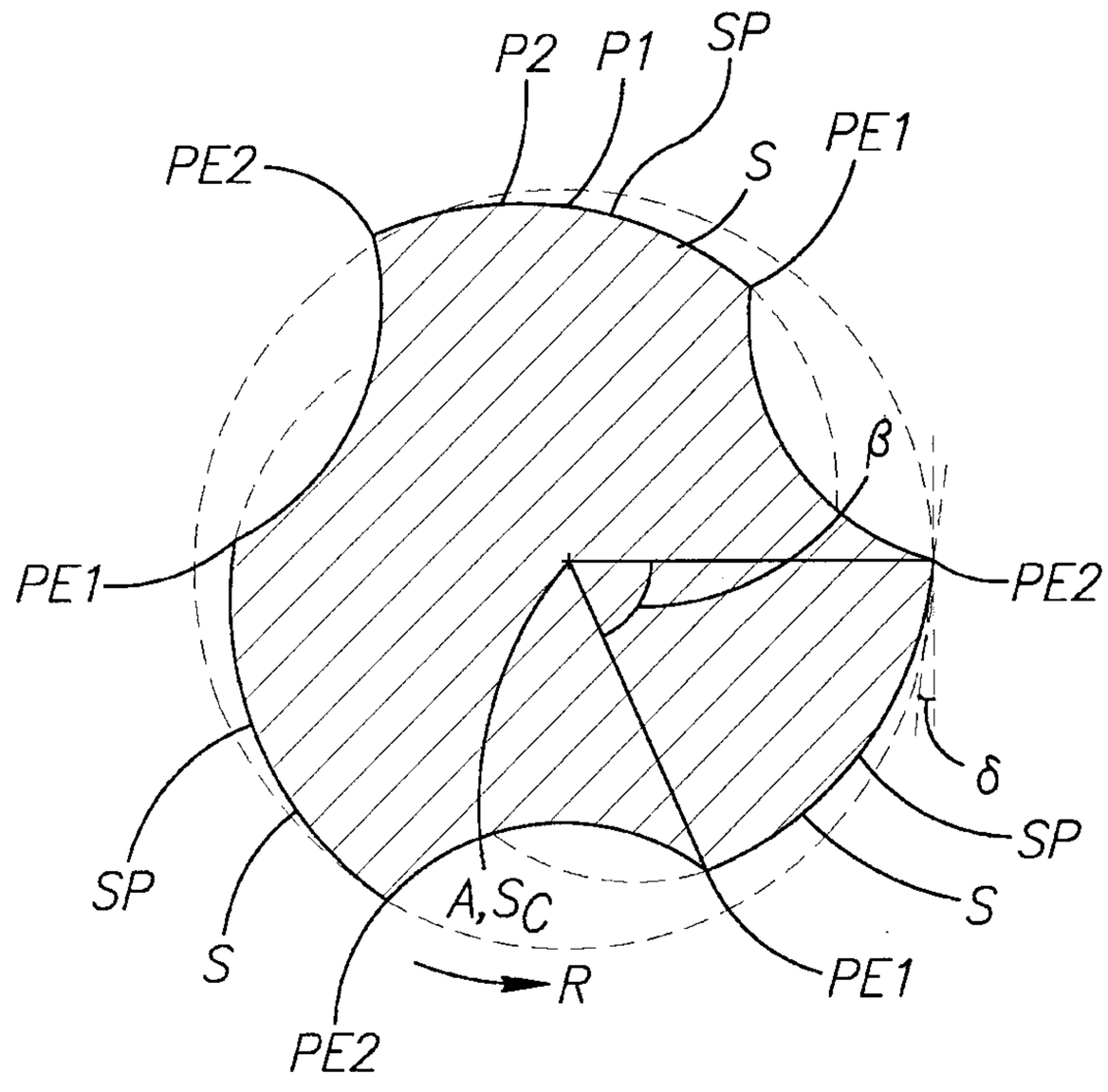

P2
P1
SP
PE2
S
PE1
β
PE1
PE2
δ
SP
SP
S
A, SC
S
R
PE1
PE2

FIG.9

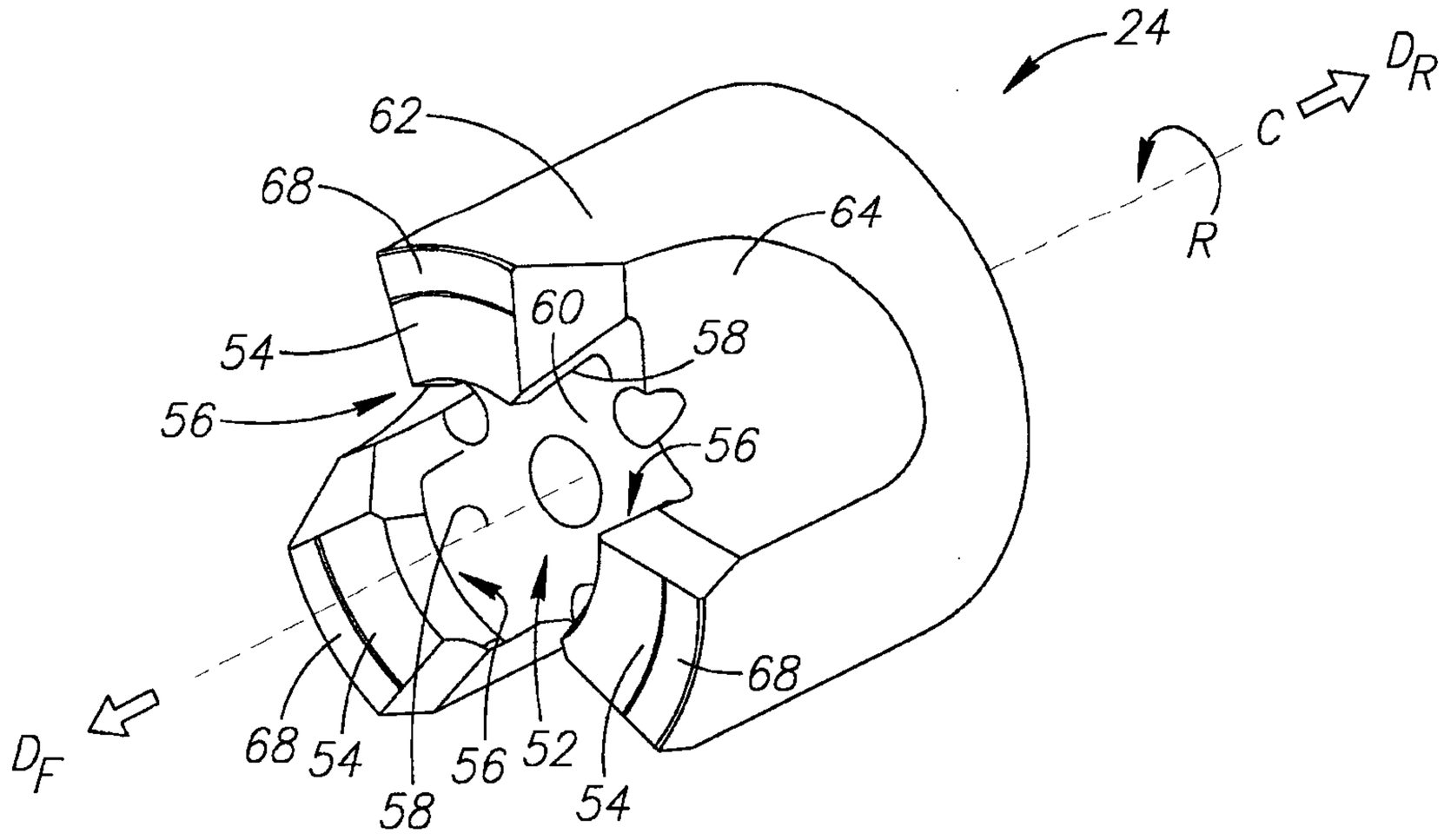

24
62
68
64
60
54
58
56
56
R
C
D_R
68
D_F
68
54
58
56
52
54

FIG.10

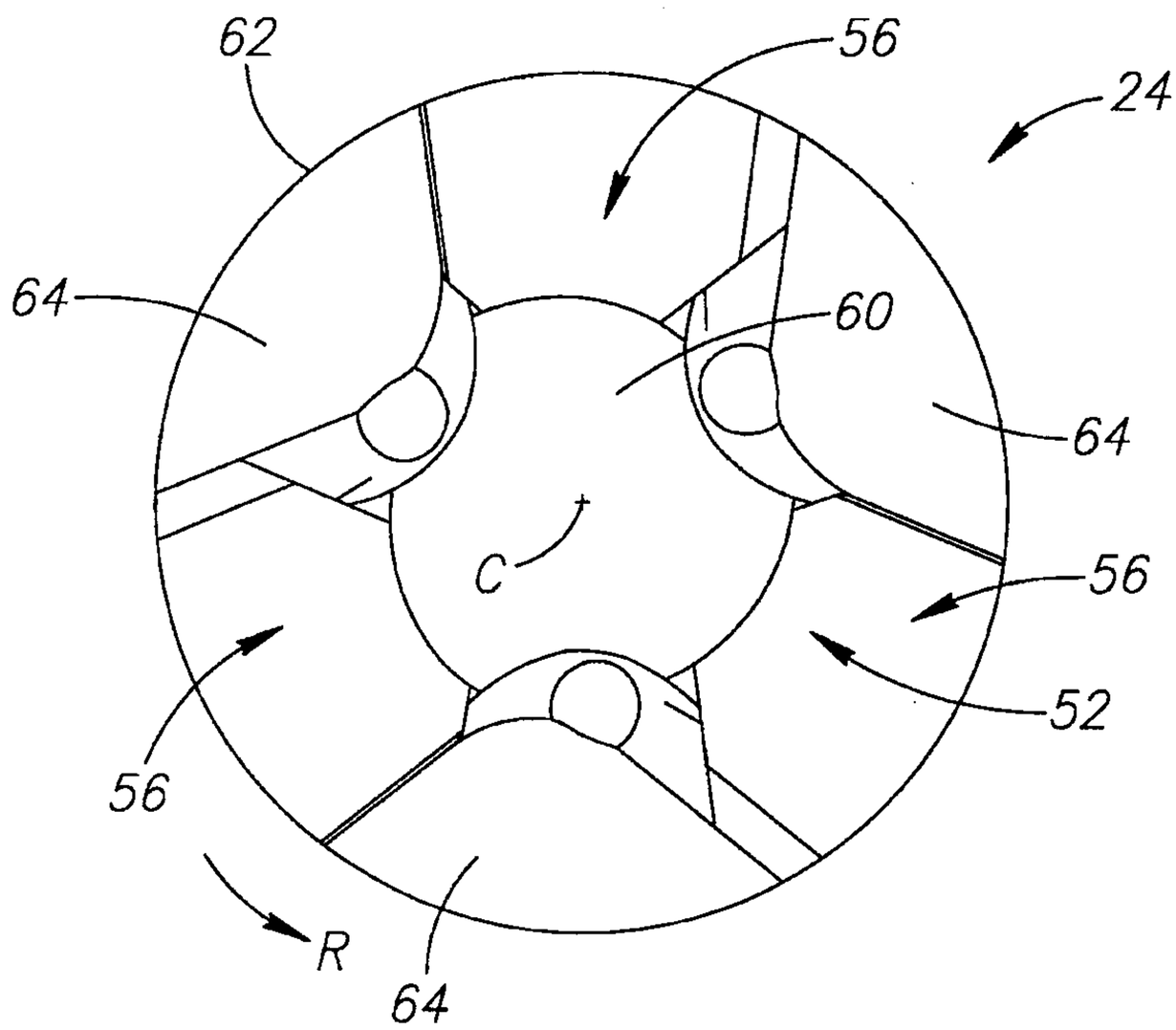

62
56
24
64
60
64
C
56
56
52
R
64

FIG.11

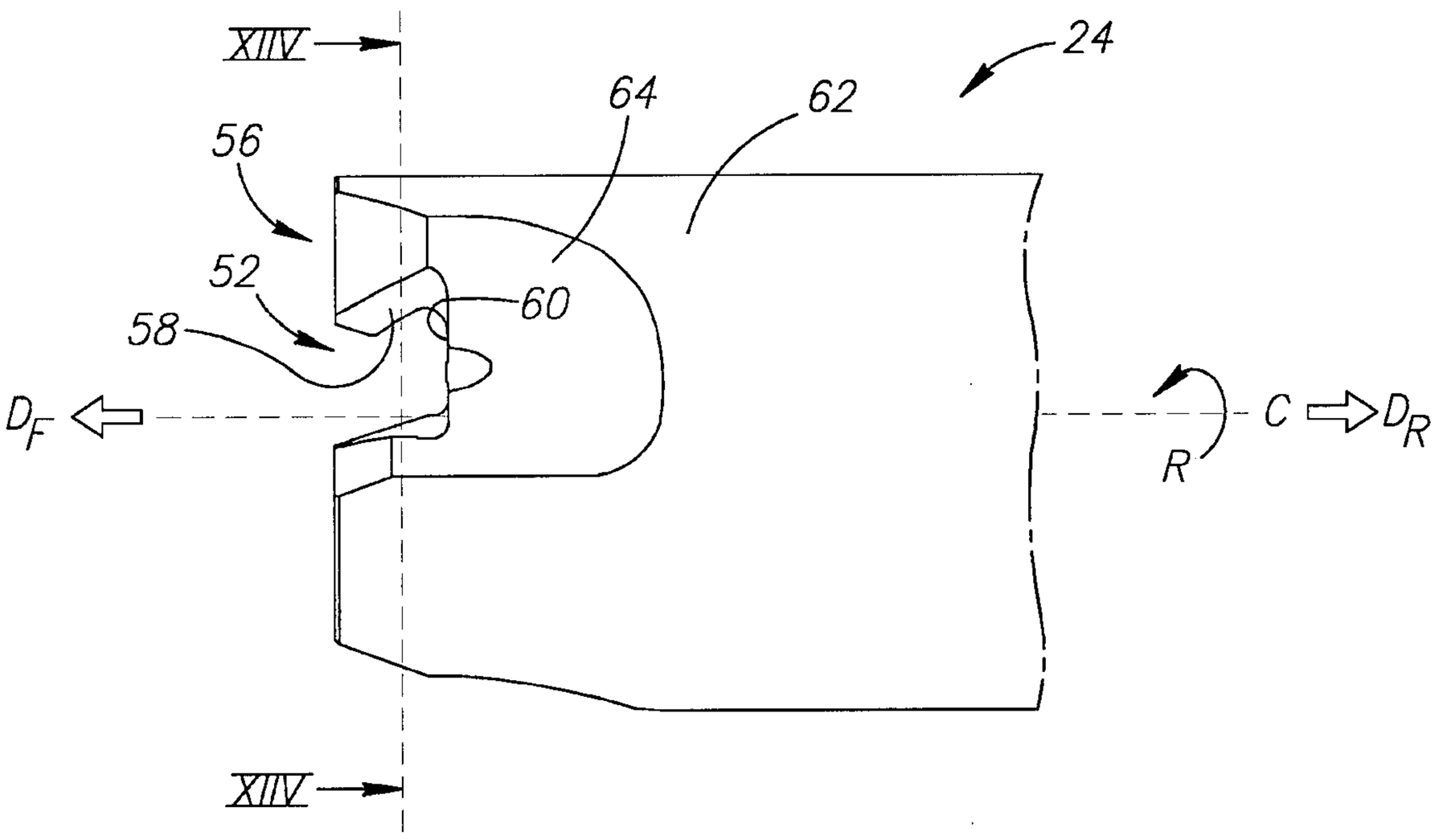

XIIV
24
64
62
56
52
60
58
D_F
C
D_R
R
XIIV

FIG.12

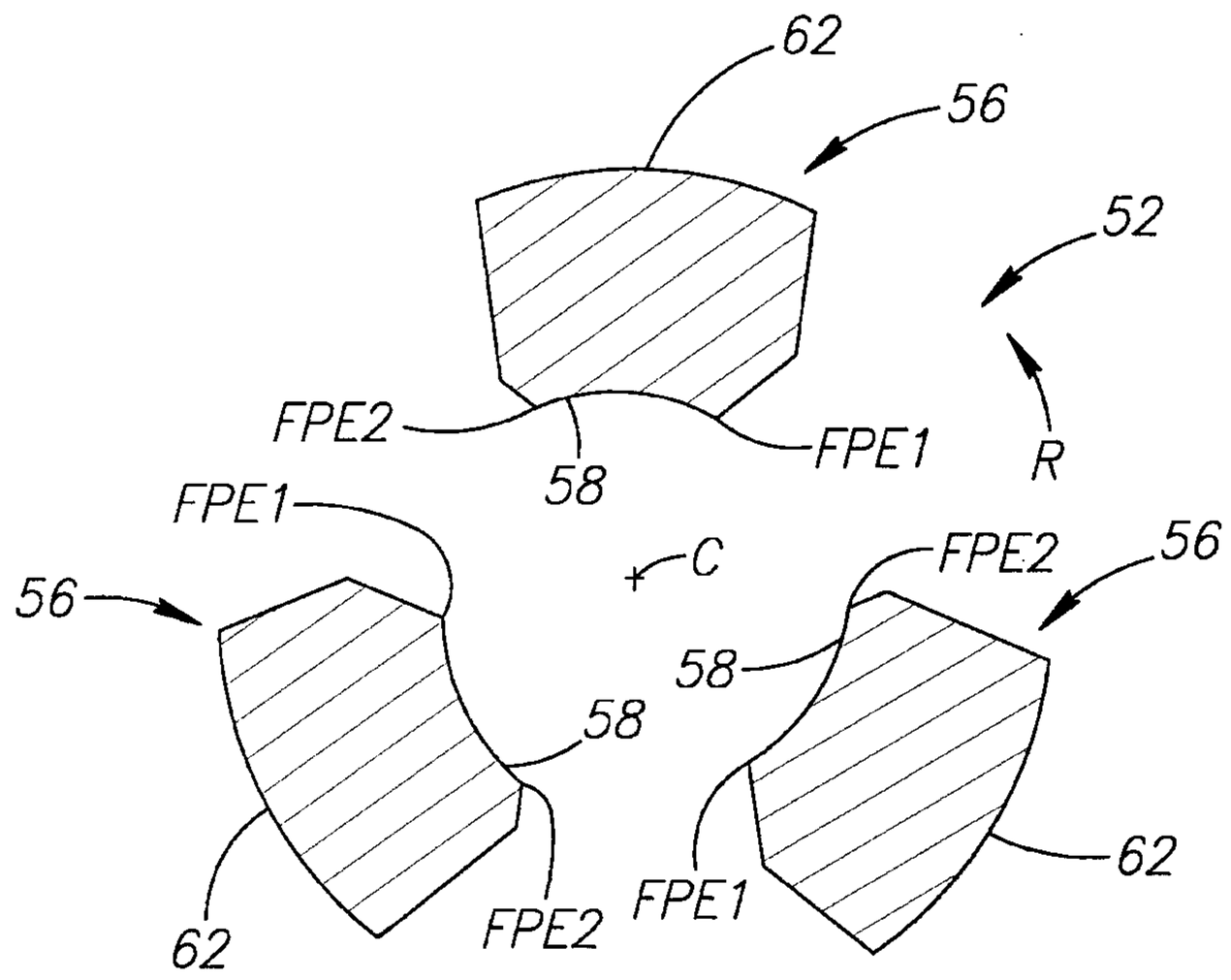

62
56
52
FPE2
58
FPE1
R
FPE1
56
C
FPE2
56
58
58
62
FPE2
FPE1
62

FIG.13

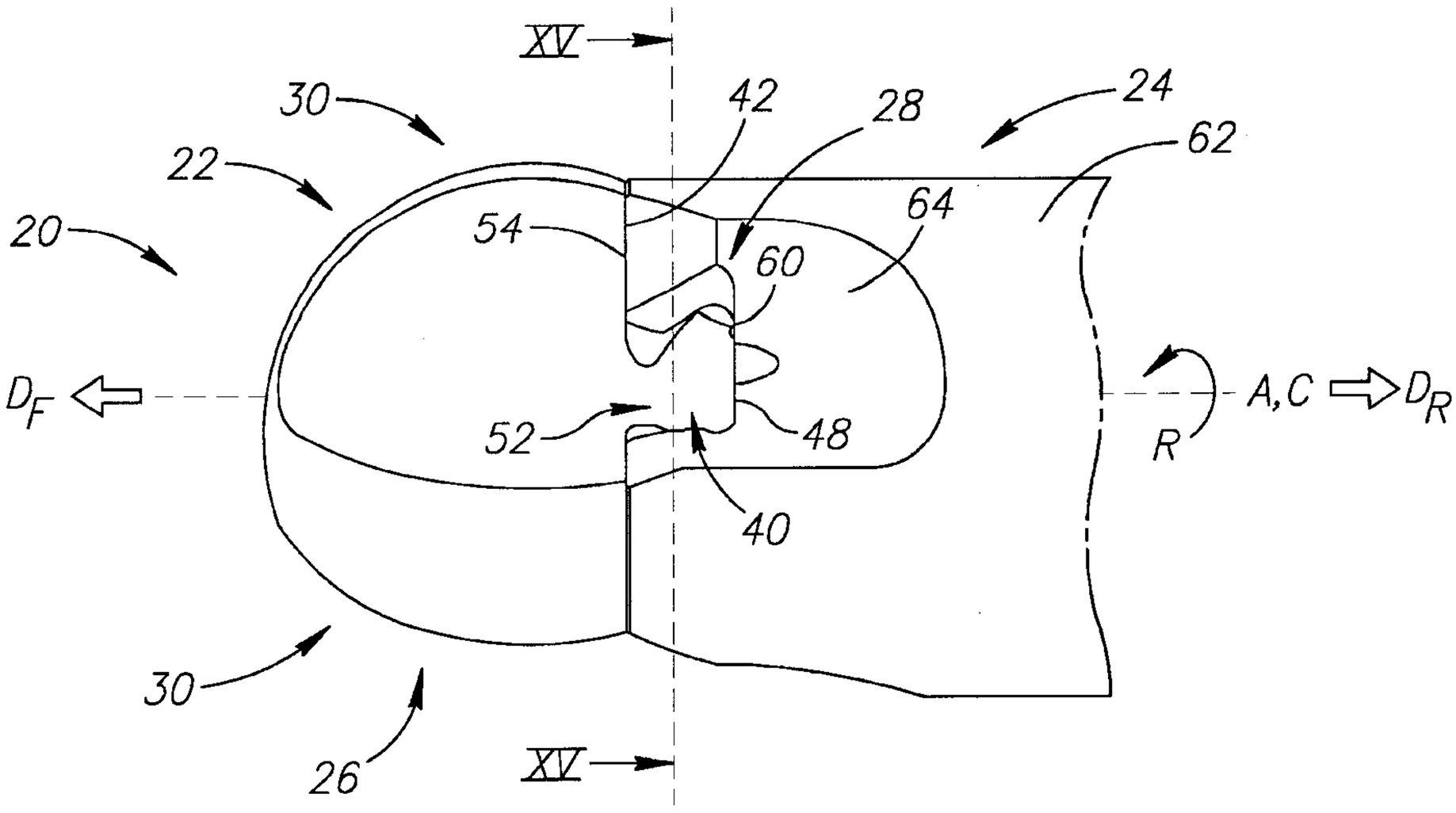

XV
30
42
28
24
22
62
20
54
64
60
D_F
52
48
A,C
D_R
R
40
30
26
XV

FIG.14

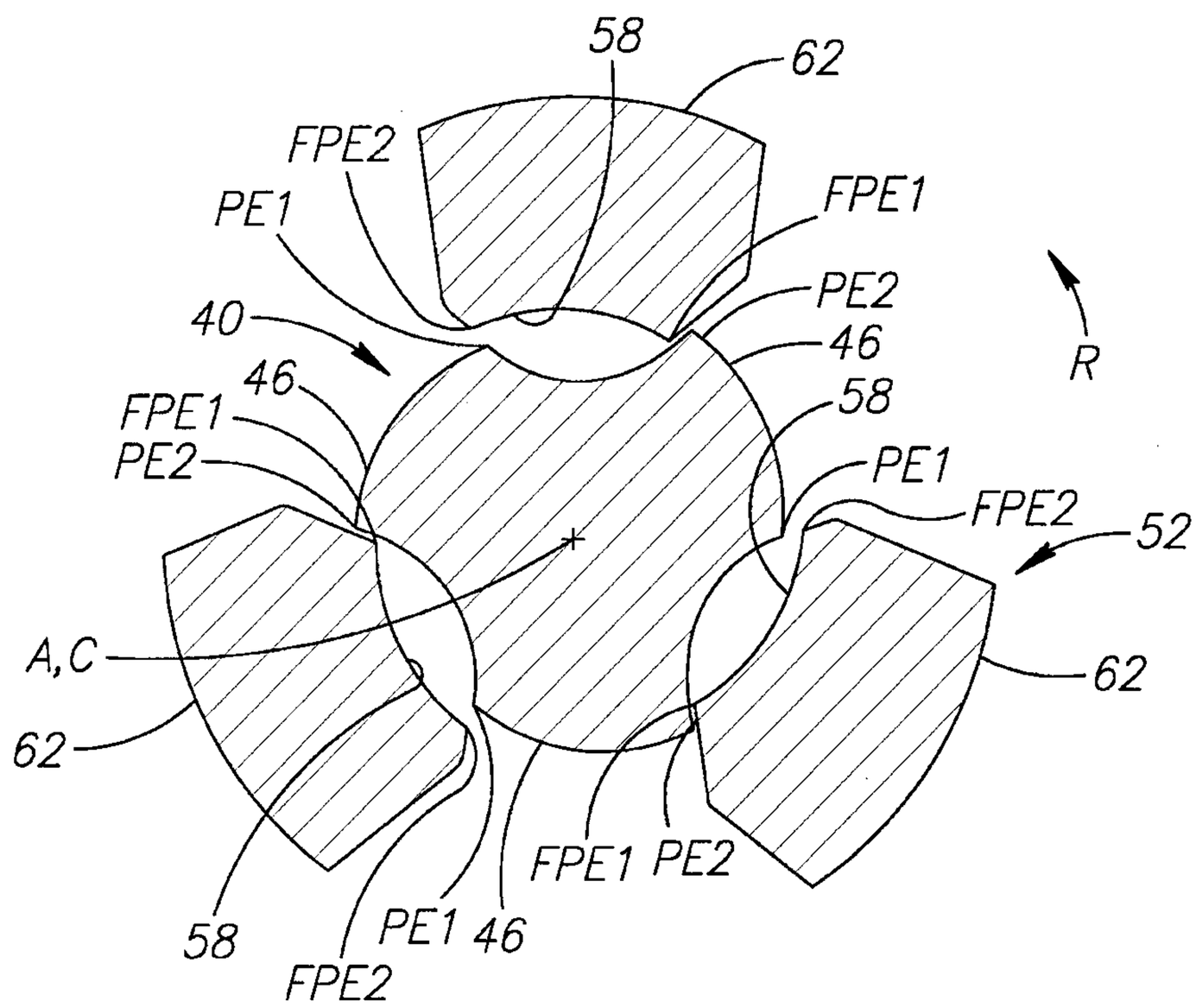

58
62
FPE2
FPE1
PE1
PE2
40
46
46
58
FPE1
PE1
PE2
FPE2
52
A,C
62
62
58
PE1
46
FPE1
PE2
58
FPE2
R

FIG.15

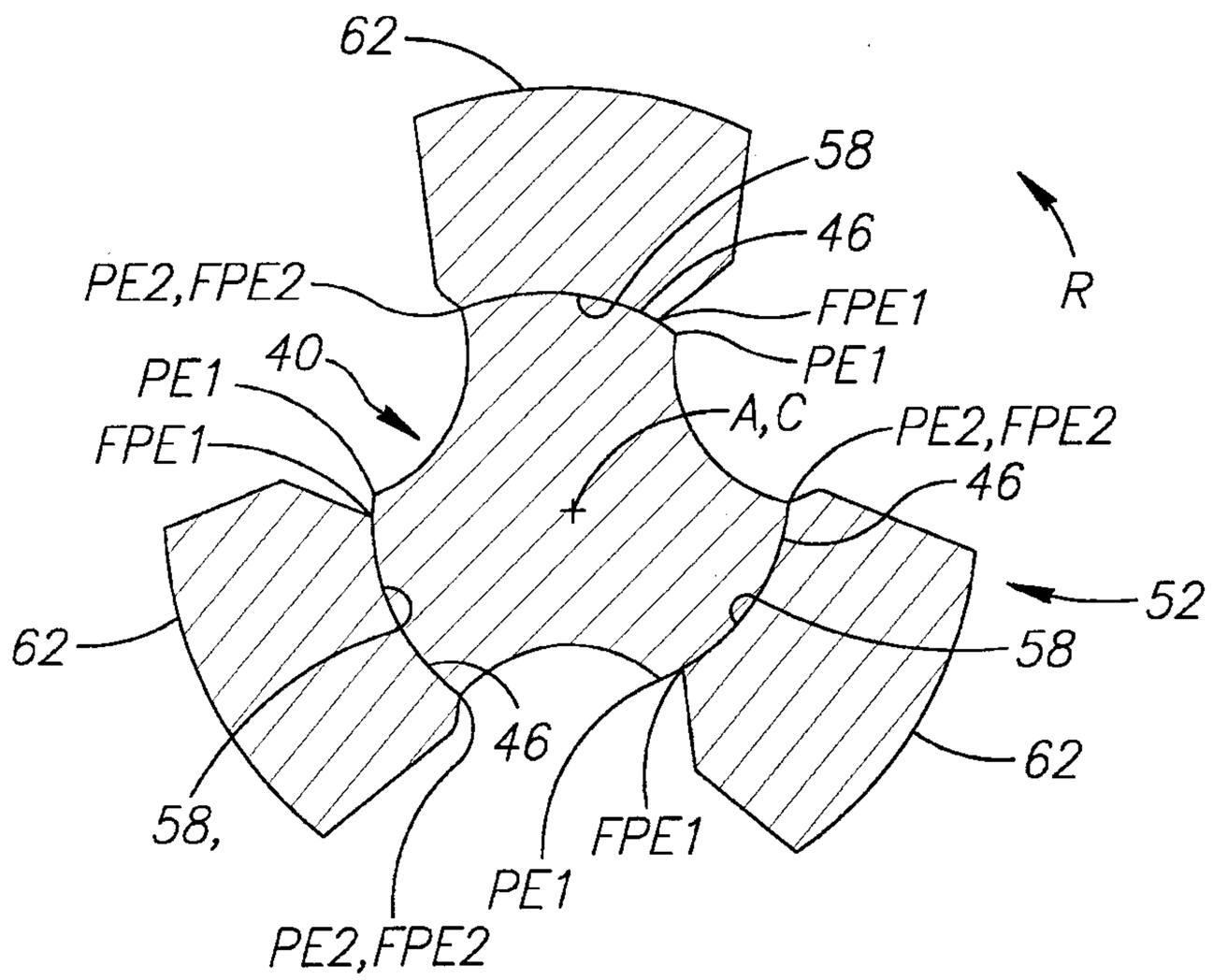
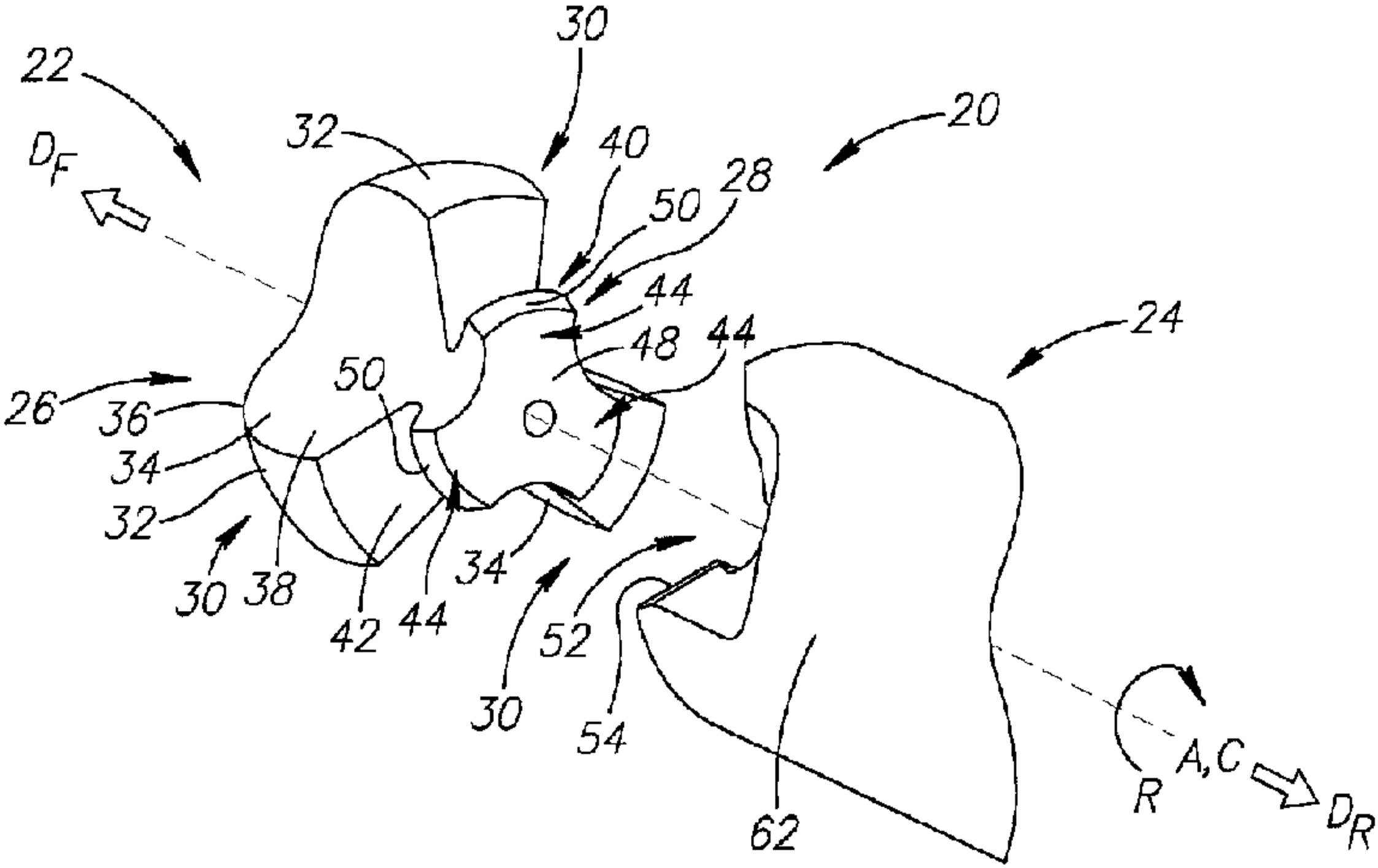

62
58
46
PE2,FPE2
FPE1
PE1
40
PE1
A,C
FPE1
PE2,FPE2
46
52
62
58
62
46
58,
PE1
FPE1
PE2,FPE2
R

FIG.16


22
30
20
32
40
D_F
50
28
44
24
48
44
26
50
36
34
32
30
38
42
44
34
52
30
54
62
A,C
R
D_R