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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 March 2018 (15.03.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/047155 A1

(51) International Patent Classification:
B23B 51/02 (2006.01)

(21) International Application Number:
PCT/IL2017/050875

(22) International Filing Date:
08 August 2017 (08.08.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/384,401 07 September 2016 (07.09.2016) 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** et al.; 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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, 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.

(54) Title: TOOL SHANK WITH HEAD SUPPORT SURFACE HAVING CENTRAL RECESS PROVIDED WITH RESILIENTLY DISPLACEABLE ABUTMENT PORTIONS

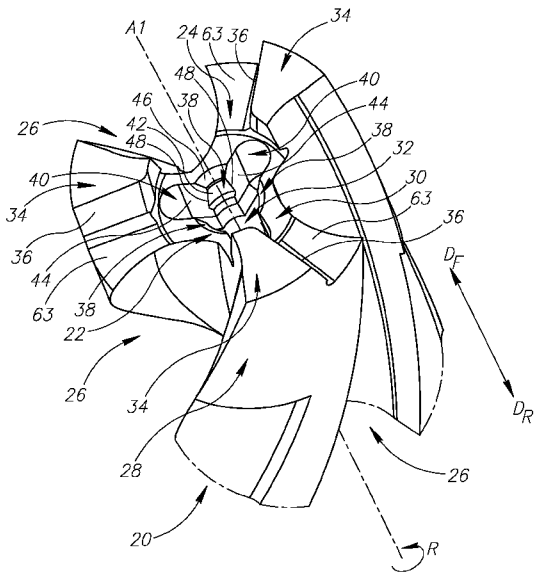

FIG.1

(57) Abstract: A tool shank (20) has a head receiving pocket (22) at a forward end (24), and a plurality of chip flutes (26) extending rearwardly therefrom along a longitudinal axis (Al). The head receiving pocket has a support surface (30) transverse to the longitudinal axis. A central recess (32) is formed in the support surface and extends rearwardly therefrom. The central recess has a plurality of resiliently displaceable abutment portions (38) circumferentially alternating with and spaced apart by a plurality of intermediate portions (40). Each abutment portion has a radially inward facing abutment surface (42), and each intermediate portion has an intermediate surface (44) intersecting two circumferentially adjacent abutment surfaces. A rotary cutting tool includes the shank and a cutting head releasably mounted thereto. The cutting head has a mounting portion provided with a base surface and an engagement member

WO 2018/047155 A1

[Continued on next page]

(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, ST, 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))*

protruding therefrom. In an assembled position, the engagement member is resiliently retained in the central recess against the plurality of abutment surfaces.

TOOL SHANK WITH HEAD SUPPORT SURFACE HAVING CENTRAL RECESS PROVIDED WITH RESILIENTLY DISPLACEABLE ABUTMENT PORTIONS

FIELD OF THE INVENTION

The present invention relates to a rotary cutting tool and a tool shank having a head receiving pocket with resiliently displaceable abutment portions, for use in metal cutting processes in general, and for drilling operations in particular.

BACKGROUND OF THE INVENTION

Within the field of cutting tools used in drilling operations, there are many examples of tool shanks having head receiving pockets with 'circumferentially open' central recesses and resiliently displaceable abutment portions.

US 7,360,974 discloses a rotary cutting tool having a tool shank and a replaceable cutting insert. The tool shank includes two longitudinally extending chip flutes and a location opening at the tip of the shank which is open to the chip flutes. The location opening has a circular cross-section. The cutting insert includes a fastening pin having a slightly elliptical cross-section which is inserted into the location opening and rotated into a braced position.

US 7,467,915 discloses a rotary cutting tool having a tool shank and a replaceable cutting head which is installed on and engages a head receiving pocket of the tool shank. The cutting head has a shank connection portion with a dovetail member. The head receiving pocket includes two generally symmetrical castellated wall sections projecting upwardly from a central floor portion. The castellated wall sections include internally facing frustoconical surfaces, and when the dovetail member is rotated into an interlocked position with respect to the head receiving pocket, the dovetail member engages the internally facing frustoconical surfaces.

It is an object of the present invention to provide an improved tool shank having a head receiving pocket with a 'circumferentially confined' central recess and resiliently displaceable abutment portions.

It is also an object of the present invention to provide an improved rotary cutting tool in which a cutting head is releasably mounted to the head receiving pocket of the tool shank with a high level of repeatability.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a tool shank having a longitudinal axis of rotation establishing a forward-to-rearward direction and comprising:

a head receiving pocket at a forward end, and a plurality of chip flutes extending in the rearward direction therefrom along the longitudinal axis of rotation,

the head receiving pocket having a support surface transverse to the longitudinal axis of rotation, and a central recess,

wherein:

the central recess is formed in the support surface and extends in the rearward direction therefrom, along the longitudinal axis of rotation,

the central recess has a plurality of resiliently displaceable abutment portions circumferentially alternating with and spaced apart by a plurality of intermediate portions,

each abutment portion has a radially inward facing abutment surface, and

each intermediate portion has an intermediate surface intersecting two circumferentially adjacent abutment surfaces.

Also in accordance with the present invention, there is provided a rotary cutting tool comprising a tool shank of the sort described above, and a cutting head releasably mounted in the head receiving pocket thereof,

the cutting head comprising:

a cutting portion and a mounting portion,

the mounting portion having a base surface and an engagement member protruding therefrom along a head axis,

wherein in an assembled position:

the base surface faces the support surface,

the head axis is coincident with the longitudinal axis of rotation, and

the engagement member is resiliently retained in the central recess against the plurality of abutment surfaces.

Further in accordance with the present invention, there is provided a method of the assembling a rotary cutting tool of the sort described above,

in which the engagement member has a plurality of radially outward facing engagement surfaces circumferentially alternating with a plurality of joining surfaces,

comprising the steps of:

a) orienting the base surface to face the support surface;

b) aligning the head axis with the longitudinal axis of rotation;

c) rotationally aligning the plurality of engagement surfaces with the plurality of intermediate surfaces;

d) inserting the engagement member into the central recess; and

e) rotating the cutting head about its head axis until the plurality of engagement surfaces are resiliently retained against the plurality of abutment surfaces.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding, the invention will now be described, by way of example only, with reference to the accompanying drawings in which chain-dash lines represent cut-off boundaries for partial views of a member and in which:

Fig. 1 is a perspective view of a tool shank in accordance with some embodiments of the present invention;

Fig. 2 is an end view of the tool shank shown in Fig. 1;

Fig. 3 is a side view of the tool shank shown in Fig. 1;

Fig. 4 is a cross-sectional view of the tool shank shown in Fig. 3, taken along the line IV-IV;

Fig. 5 is the cross-sectional view shown in Fig. 4, in the presence of radially outward forces;

Fig. 6 is an exploded perspective view of a rotary cutting tool in accordance with some embodiments of the present invention;

Fig. 7 is a side view of the rotary cutting tool shown in Fig. 6; and

Fig. 8 is a cross-sectional view of the rotary cutting tool shown in Fig. 7, taken along the line VIII-VIII.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a tool shank **20** having a longitudinal axis of rotation **A1** establishing a forward direction **DF** to rearward direction **DR**. As shown in Figs. 1 to 3, the tool shank **20** has a head receiving pocket **22** at a forward end **24**, and a plurality of chip flutes **26** extending in the rearward direction **DR** therefrom along the longitudinal axis of rotation **A1**.

In some embodiments of the present invention, the plurality of chip flutes **26** may be formed in a cylindrical shank peripheral surface **28** of the tool shank **20**.

Also in some embodiments of the present invention, the plurality of chip flutes **26** may helically extend along the longitudinal axis of rotation **A1**.

Further in some embodiments of the present invention, the tool shank **20** may have three chip flutes **26**.

Yet further in some embodiments of the present invention, the tool shank **20** may preferably be manufactured from tool steel.

According to the present invention, as shown in Figs. 1 to 3, the head receiving pocket **22** has a support surface **30** transverse to the longitudinal axis of rotation **A1**.

A central recess **32** is formed in the support surface **30** and extends in the rearward direction **DR** therefrom, along the longitudinal axis of rotation **A1**.

As shown in the end view of Fig. 2, the support surface **30** may be radially spaced apart from the shank peripheral surface **28** of the tool shank **20** and located in a central area of the pocket **22**, and thus may be considered to be a "central" support surface **30**.

In some embodiments of the present invention, the central recess **32** may not intersect any of the plurality of chip flutes **26**.

Also in some embodiments of the present invention, the head receiving pocket **22** may be devoid of a passage communicating the central recess **32** with any of the plurality of chip flutes **26**.

Further in some embodiments of the present invention, the support surface **30** may be planar and perpendicular to the longitudinal axis of rotation A1.

Yet further in some embodiments of the present invention, a plurality of drive members **34** may protrude forwardly from the support surface **30**, and each drive member **34** may include a drive surface **36** facing in a rotation direction **R** about the longitudinal axis of rotation **A1**.

As shown in Fig. 4, in a cross-section taken in a first plane **P1** perpendicular to the longitudinal axis of rotation **A1** and passing through the central recess **32**, the central recess **32** may be non-circular, and therefore may have a non-circular cross-section.

In some embodiments of the present invention, the central recess **32** may exhibit rotational symmetry about the longitudinal axis of rotation **A1**.

Also in some embodiments of the present invention, as shown in Fig. 2, the central recess **32** may exhibit mirror symmetry about a second plane **P2** containing the longitudinal axis of rotation **A1**.

According to the present invention, as shown in Figs. 1 and 2, the central recess **32** has a plurality of resiliently displaceable abutment portions **38** circumferentially alternating with and spaced apart by a plurality of intermediate portions **40**.

In some embodiments of the present invention, the plurality of abutment portions **38** may be resiliently displaceable in a radially outward direction **Do**.

Also in some embodiments of the present invention, the plurality of abutment portions **38** may be equal in number to the plurality of intermediate portions **40**.

Further in some embodiments of the present invention, the plurality of abutment portions **38** may be equal in number to the plurality of chip flutes **26**.

According to the present invention, as shown in Fig. 2, each abutment portion **38** has a radially inward facing abutment surface **42**, and each intermediate portion **40** has an intermediate surface **44** intersecting two circumferentially adjacent abutment surfaces **42**. Each intermediate surface **44** extends radially outward of the two adjacent abutment surfaces **42**.

By virtue of the plurality of abutment surfaces **42** circumferentially alternating with the plurality of intermediate surfaces **44**, the head receiving pocket **22** has a 'circumferentially confined' central recess **32**, which improves the resilience of the plurality of abutment portions **38** and extends the useful life of the tool shank **20**.

In some embodiments of the present invention, the plurality of intermediate surfaces **44** may extend along the entire longitudinal extent of the plurality of abutment surfaces **42**.

As shown in the hidden detail of Fig. 3, the plurality of intermediate surfaces **44** may extend to a first recess depth **H1** rearward of the support surface **30** to a central recess floor **45**, and the plurality of abutment surfaces **42** may extend to a second recess depth **H2** rearward of the support surface **30** and be longitudinally spaced apart from the central recess floor **45**.

In some embodiments of the present invention, a ratio of the first recess depth **H1** to the second recess depth **H2** may have a range of between 1.3 and 2.5 ($1.3 < \mathbf{H1/H2} < 2.5$). This provides the plurality of abutment portions **38** with an optimum level of resilience in the region of the abutment surfaces **42**.

Also in some embodiments of the present invention, the plurality of intermediate surfaces **44** may intersect the support surface **30**.

Further in some embodiments of the present invention, each abutment portion **38** may include an abutment chamfer **46** between its abutment surface **42** and the support surface **30**.

Yet further in some embodiments of the present invention, the plurality of abutment surfaces **42** may diverge in the rearward direction $\mathbf{D_R}$.

Yet still further in some embodiments of the present invention, two transition edges **48** may be formed at the intersection of each intermediate surface **44** and its two circumferentially adjacent abutment surfaces **42**.

As shown in Fig. 3, in some embodiments, in a tool shank side view tangential to the support surface **30**, the entire central recess **32** (whose outline is indicated by the broken lines) may be hidden from view, with no portion of the abutment surfaces **42** and the intermediate surfaces **44** being visible. Thus, the central recess **32** can be considered to be a "sunken" central recess **32** which is formed in the support surface **30**.

As shown in Fig. 4, in the cross-section taken in the first plane **P1**, each abutment surface **42** has a first circumferential angular extent **E1** and each intermediate surface **44** has a second circumferential angular extent **E2**.

In some embodiments of the present invention, the combined circumferential angular extent of the plurality of abutment surfaces **42** and the plurality of intermediate surfaces **44** may be equal to 360°.

Also in some embodiments of the present invention, the second circumferential angular extent **E2** may be greater than the first circumferential angular extent **E1**.

As shown in Fig. 4, in the cross-section taken in the first plane **P1**, an imaginary first circle **C1** coaxial with the longitudinal axis of rotation **A1** inscribes the central recess **32**.

In some embodiments of the present invention, the imaginary first circle **C1** may contact the plurality of abutment surfaces **42**.

Also in some embodiments of the present invention, the plurality of intermediate surfaces **44** may be located outside the imaginary first circle **C1**.

Further in some embodiments of the present invention, the plurality of abutment surfaces **42** may form a plurality of spaced apart abutment arcs **50** coincident with the imaginary first circle **C1**.

As shown in Fig. 4, in the cross-section taken in the first plane **P1**, an imaginary second circle **C2** coaxial with the longitudinal axis of rotation **A1** is tangent to the plurality of chip flutes **26** at a plurality of first flute points $N_{F}1$.

In some embodiments of the present invention, a third plane **P3** containing the longitudinal axis of rotation **A1** and at least one of the first flute points $N_{F}1$ may intersect at least one of the abutment surfaces **42**.

Also in some embodiments of the present invention, the imaginary first circle **C1** has a first diameter **D1**, the imaginary second circle **C2** has a second diameter **D2**, and first diameter **D1** may be greater than half the second diameter **D2**.

It should be appreciated that the first diameter **D1** of the imaginary first circle **C1** is measured in the absence of radially outward forces **Fo** being applied to the plurality of abutment surfaces **42**.

As shown in Fig. 5, in the presence of radially outward forces **Fo** being applied to the plurality of abutment surfaces **42**, the imaginary first circle **C1** has a first loaded diameter $D_{L}1$.

In some embodiments of the present invention, the first diameter **D1** may be less than the first loaded diameter $D_{L}1$.

As shown in Fig. 4, a radial axis **A2** is formed at the intersection of the first and third planes **P1**, **P3**.

In some embodiments of the present invention, each first flute point $N_{F}1$ may be located a minimum first distance **d1** from its adjacent abutment surface **42** along the radial axis **A2**.

As shown in Fig. 4, in the cross-section taken in the first plane **P1**, each chip flute **26** has a second flute point **NF2** spaced apart from the first flute point **NF1**, and the second flute point **NF2** is located a minimum second distance **d2** from its adjacent intermediate surface **44**.

In some embodiments of the present invention, the minimum second distance **d2** may be equal to or less than the minimum first distance **d1**.

As shown in Figs. 6 and 7, the present invention further relates to a rotary cutting tool **52** comprising the tool shank **20** and a cutting head **54** releasably mounted in the head receiving pocket **22** of the tool shank **20**.

In some embodiments of the present invention, the cutting head **54** may preferably be manufactured by form pressing and sintering a cemented carbide, such as tungsten carbide, and may be coated or uncoated.

Also in some embodiments, the cutting head **54** may be releasably mounted in the head receiving pocket **22** without the requirement of an additional fastening member, such as a clamping screw.

According to the present invention, the cutting head **54** has a cutting portion **56** and a mounting portion **58**, and the mounting portion **58** has a base surface **60** and an engagement member **62** protruding therefrom along a head axis **A3**.

In an assembled position:

the base surface **60** faces the support surface **30**,

the head axis **A3** is coincident with the longitudinal axis of rotation **A1**, and

the engagement member **62** is resiliently retained in the central recess **32** against the plurality of abutment surfaces **42**.

In some embodiments of the present invention, the engagement member **62** may be located distal from the cutting portion **56**.

As shown in Fig. 8, in the cross-section taken in the first plane **P1**, the engagement member **62** may be non-circular.

In some embodiments of the present invention, the base surface **60** may make contact with the support surface **30**, or a plurality of shoulder surfaces **63** offset therefrom.

It should be appreciated that the first diameter **D1** of the imaginary first circle **C1** is measured in a non-assembled position, in which the engagement member **62** is not resiliently retained in the central recess **32**.

In the assembled position, as shown in Fig. 8, the imaginary first circle **C1** has a first assembly diameter $D_{A}1$.

In some embodiments of the present invention, the first diameter **D1** may be less than the first assembly diameter $D_{A}1$.

As shown in Fig. 6, the engagement member **62** may have a plurality of radially outward facing engagement surfaces **64** circumferentially alternating with a plurality of joining surfaces **66**.

In some embodiments of the present invention, in the assembled position, the plurality of engagement surfaces **64** may make contact with the plurality of abutment surfaces **42** belonging to the central recess **32**.

Also in some embodiments of the present invention, the plurality of engagement surfaces **64** may diverge in the rearward direction D_{R}, and the engagement member **62** may have a dovetail shape.

As shown in Fig. 8, in the cross-section taken in the first plane **P1**, each engagement surface **64** has a third circumferential angular extent **E3**.

In some embodiments of the present invention, the second circumferential angular extent **E2** may be greater than the third circumferential angular extent **E3**.

During assembly of the rotary cutting tool **52**, by virtue of the second circumferential angular extent **E2** being greater than the third circumferential angular extent **E3**, the plurality of engagement surfaces **64** can be rotationally aligned with the plurality of intermediate surfaces **44** and the engagement member **62** can be easily inserted into the central recess **32**.

As shown in Fig. 8, in the cross-section taken in the first plane **P1**, an imaginary third circle **C3** coaxial with the longitudinal axis of rotation **A1** circumscribes the engagement member **62**.

In some embodiments of the present invention, the imaginary third circle **C3** may contact the plurality of engagement surfaces **64**.

Also in some embodiments of the present invention, the plurality of joining surfaces **66** may be located inside the imaginary third circle **C3**.

Further in some embodiments of the present invention, the plurality of engagement surfaces **64** may form a plurality of spaced apart engagement arcs **68** coincident with the imaginary third circle **C3**.

Yet further in some embodiments of the present invention, the imaginary third circle **C3** may have a third diameter **D3** equal to the first assembly diameter **DA1**.

As shown in Figs. 6 and 7, the mounting portion **58** may have a plurality of circumferentially spaced apart side surfaces **70** extending away from the base surface **60** towards the cutting portion **56**, with each side surface **70** including a torque transmission surface **72**.

In some embodiments of the present invention, each drive surface **36** may make contact with one of the torque transmission surfaces **72**.

Also in some embodiments of the present invention, each side surface **70** may include a flute extension surface **74**, and each flute extension surface **74** may intersect a leading surface **76** of the cutting portion **56** to form a cutting edge **78**.

Further in some embodiments of the present invention, a plurality of head peripheral surfaces **80** may circumferentially alternate with the plurality of side surfaces **70**, and each flute extension surface **74** may intersect one of the head peripheral surfaces **80** to form a leading edge **82**.

The present invention further relates to a method of assembling the rotary cutting tool **52**, comprising the steps of:

a) orienting the base surface **60** to face the support surface **30**;

b) aligning the head axis **A3** with the longitudinal axis of rotation **A1**;

c) rotationally aligning the plurality of engagement surfaces **64** with the plurality of intermediate surfaces **44**;

d) inserting the engagement member **62** into the central recess **32**; and

e) rotating the cutting head **54** about its head axis **A3** until

the plurality of engagement surfaces **64** are resiliently retained against the plurality of abutment surfaces **42**.

In some embodiments of the present invention, in step d), the engagement member **62** may be inserted into the central recess **32** until the base surface **60** makes contact with the support surface **30**, or the plurality of shoulder surfaces **63**.

Also in some embodiments of the present invention, in step e), the cutting head **54** may be rotated about its head axis **A3** in a direction opposite to the rotation direction **R** until each drive surface **36** makes contact with one of the torque transmission surfaces **72**.

Although the present invention 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

What is claimed is:

1. A tool shank (20) having a longitudinal axis of rotation (A1) establishing a forward-to-rearward direction (D_F, D_R) and comprising:

a head receiving pocket (22) at a forward end (24), and a plurality of chip flutes (26) extending in the rearward direction (D_R) therefrom along the longitudinal axis of rotation (A1),

the head receiving pocket (22) having a support surface (30) transverse to the longitudinal axis of rotation (A1), and a central recess (32),

wherein:

the central recess (32) is formed in the support surface (30) and extends in the rearward direction (D_R) therefrom, along the longitudinal axis of rotation (A1),

the central recess (32) has a plurality of resiliently displaceable abutment portions (38) circumferentially alternating with and spaced apart by a plurality of intermediate portions (40),

each abutment portion (38) has a radially inward facing abutment surface (42), and

each intermediate portion (40) has an intermediate surface (44) intersecting two circumferentially adjacent abutment surfaces (42).

2. The tool shank (20) according to claim 1, wherein

in a cross-section taken in a first plane (P1) perpendicular to the longitudinal axis of rotation (A1) and passing through the central recess (32):

each abutment surface (42) has a first circumferential angular extent (E1),

each intermediate surface (44) has a second circumferential angular extent (E2), and

the combined circumferential angular extent of the plurality of abutment surfaces (42) and the plurality of intermediate surfaces (44) is equal to 360°.

3. The tool shank (20) according to claim 2, wherein:

the second circumferential angular extent (E2) is greater than the first circumferential angular extent (E1).

4. The tool shank (20) according to any one of the preceding claims, wherein:

in a cross-section taken in a first plane (P1) perpendicular to the longitudinal axis of rotation (A1) and passing through the central recess (32):

an imaginary first circle (C1) coaxial with the longitudinal axis of rotation (A1) inscribes the central recess (32).

5. The tool shank (20) according to claim 4, wherein:

in the absence of radially outward forces (F_O) being applied to the plurality of abutment surfaces (42), the imaginary first circle (C1) has a first diameter (D1),

in the presence of radially outward forces (F_O) being applied to the plurality of abutment surfaces (42), the imaginary first circle (C1) has a first loaded diameter (D_{L1}), and

the first diameter (D1) is less than the first loaded diameter (D_{L1}).

6. The tool shank (20) according to claim 4 or 5, wherein

in the cross-section taken in the first plane (P1):

an imaginary second circle (C2) coaxial with the longitudinal axis of rotation (A1) is tangent to the plurality of chip flutes (26) at a plurality of first flute points (N_{F1}), and

a third plane (P3) containing the longitudinal axis of rotation (A1) and at least one of the first flute points (N_{F1}) intersects at least one of the abutment surfaces (42).

7. The tool shank (20) according to claim 6, wherein:

the imaginary first circle (C1) has a first diameter (D1),

the imaginary second circle (C2) has a second diameter (D2), and

first diameter (D1) is greater than half the second diameter (D2).

8. The tool shank (20) according to claim 6 or 7, wherein:

a radial axis (A2) is formed at the intersection of the first and third planes (P1, P3), and

each first flute point (N_{F1}) is located a minimum first distance (d1) from its adjacent abutment surface (42) along the radial axis (A2).

9. The tool shank (22) according to claim 8, wherein

in the cross-section taken in the first plane (P1):

each chip flute (26) has a second flute point (N_{F2}) spaced apart from the first flute point (N_{F1}),

the second flute point (N_{F2}) is located a minimum second distance (d2) from its adjacent intermediate surface (44), and

the minimum second distance (d2) is equal to or less than the minimum first distance (d1).

10. The tool shank (20) according to any one of claims 4 to 9, wherein:

the imaginary first circle (C1) contacts the plurality of abutment surfaces (42).

11. The tool shank (20) according to any one of the preceding claims, wherein:

the plurality of intermediate surfaces (44) extend to a first recess depth (H1) rearward of the support surface (30) to a central recess floor (45);

the plurality of abutment surfaces (42) extend to a second recess depth (H2) rearward of the support surface (30) and are longitudinally spaced apart from the central recess floor (45); and

a ratio of the first recess depth (H1) to the second recess depth (H2) is between 1.3 and 2.5 ($1.3 < H1/H2 < 2.5$).

12. The tool shank (20) according to any one of the preceding claims, wherein:

the central recess (32) does not intersect any of the plurality of chip flutes (26).

13. The tool shank (20) according to any one of the preceding claims, wherein:

the plurality of abutment surfaces (42) diverge in the rearward direction (D_R).

14. The tool shank (20) according to any one of the preceding claims, wherein:

the plurality of intermediate surfaces (44) intersect the support surface (30).

15. The tool shank (20) according to any one of the preceding claims, wherein:

the plurality of abutment portions (38) are resiliently displaceable in a radially outward direction (Do).

16. The tool shank (20) according to any one of the preceding claims, wherein:

in a tool shank side view tangential to the support surface (30), the entire central recess (32) is hidden from view, with no portion of the abutment surfaces (42) and the intermediate surfaces (44) being visible.

17. A rotary cutting tool (52) comprising the tool shank (20) in accordance with any one of the preceding claims, and a cutting head (54) releasably mounted in the head receiving pocket (22),

the cutting head (54) comprising:

a cutting portion (56) and a mounting portion (58),

the mounting portion (58) having a base surface (60) and an engagement member (62) protruding therefrom along a head axis (A3),

wherein in an assembled position:

the base surface (60) faces the support surface (30),

the head axis (A3) is coincident with the longitudinal axis of rotation (A1), and

the engagement member (62) is resiliently retained in the central recess (32) against the plurality of abutment surfaces (42).

18. The rotary cutting tool (52) according to claim 17, wherein

in a cross-section taken in a first plane (P1) perpendicular to the longitudinal axis of rotation (A1) and passing through the central recess (32):

an imaginary first circle (C1) coaxial with the longitudinal axis of rotation (A1) inscribes the central recess (32), and

wherein:

in a non-assembled position, in which the engagement member (62) is not resiliently retained in the central recess (32), the imaginary first circle (C1) has a first diameter (D1),

in the assembled position, the imaginary first circle (C1) has a first assembly diameter (D_{A1}), and

the first diameter (D1) is less than the first assembly diameter (D_{A1}).

19. The rotary cutting tool (52) according to claim 18, wherein:

the imaginary first circle (C1) contacts the plurality of abutment surfaces (42).

20. The rotary cutting tool (52) according to any one of claims 17 to 19, wherein:

the engagement member (62) has a plurality of radially outward facing engagement surfaces (64) circumferentially alternating with a plurality of joining surfaces (66), and

the plurality of engagement surfaces (64) make contact with the plurality of abutment surfaces (42).

21. The rotary cutting tool (52) according to claim 20, wherein:

in a cross-section taken in a first plane (P1) perpendicular to the longitudinal axis of rotation (A1) and passing through the central recess (32):

an imaginary third circle (C3) coaxial with the longitudinal axis of rotation (A1) circumscribes the engagement member (62).

22. The rotary cutting tool (52) according to claim 21, wherein:

the imaginary third circle (C3) contacts the plurality of engagement surfaces (64).

23. The rotary cutting tool (52) according to claim 21 or 22, wherein:

the plurality of engagement surfaces (64) form a plurality of spaced apart engagement arcs (68) coincident with the imaginary third circle (C3).

24. The rotary cutting tool (52) according to any one of claims 20 to 23, wherein:

the plurality of engagement surfaces (64) diverge in the rearward direction (D_R).

25. The rotary cutting tool (52) according to any one of claims 17 to 24, wherein:

the base surface (60) makes contact with the support surface (30), or a plurality of shoulder surfaces (63) offset therefrom.

26. A method of assembling the rotary cutting tool (52) according to any one of claims 17 to 25,

in which the engagement member (62) has a plurality of radially outward facing engagement surfaces (64) circumferentially alternating with a plurality of joining surfaces (66),

comprising the steps of:

f) orienting the base surface (60) to face the support surface (30);

g) aligning the head axis (A3) with the longitudinal axis of rotation (A1);

h) rotationally aligning the plurality of engagement surfaces (64) with the plurality of intermediate surfaces (44);

i) inserting the engagement member (62) into the central recess (32); and

j) rotating the cutting head (54) about its head axis (A3) until the plurality of engagement surfaces (64) are resiliently retained against the plurality of abutment surfaces (42).

27. The method according to claim 26, wherein:

in step d), the engagement member (62) is inserted into the central recess (32) until the base surface (60) makes contact with the support surface (30), or a plurality of shoulder surfaces (63) offset therefrom.

28. The method according to claim 27, wherein:

a plurality of drive members (34) protrude forwardly from the support surface (30), each drive member (34) including a drive surface (36) facing in a rotation direction (R) about the longitudinal axis of rotation (A1),

the mounting portion (58) has a plurality of circumferentially spaced apart side surfaces (70) extending away from the base surface (60) towards the cutting portion (56), each side surface (70) including a torque transmission surface (72), and

in step e), the cutting head (54) is rotated about its head axis (A3) in a direction opposite to the rotation direction (R) until each drive surface (36) makes contact with one of the torque transmission surfaces (72).

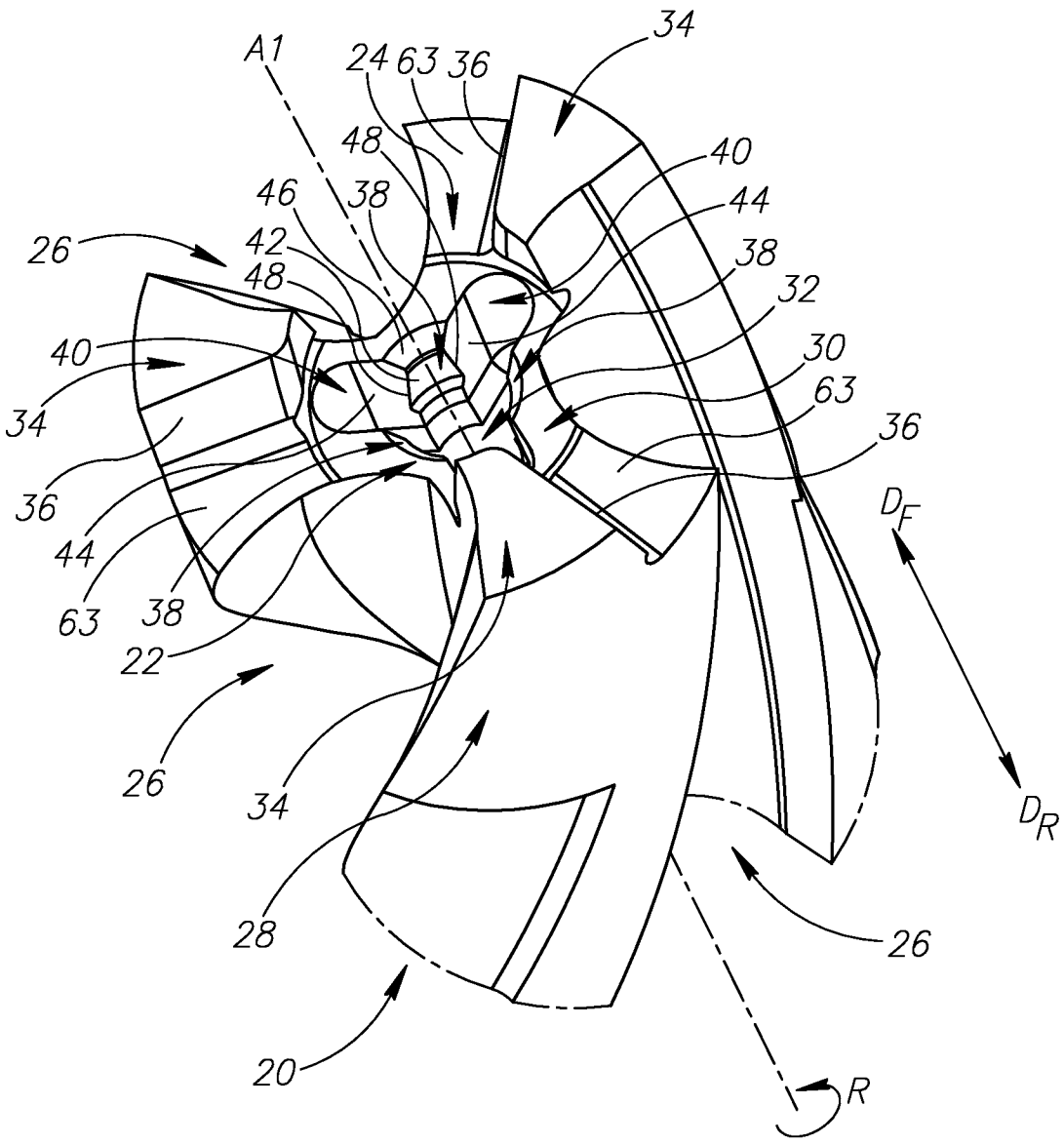
A1
24
63
36
34
48
40
46
38
44
42
26
48
38
32
40
30
34
63
36
36
D_F
44
63
38
22
26
34
D_R
28
26
20
R

FIG.1

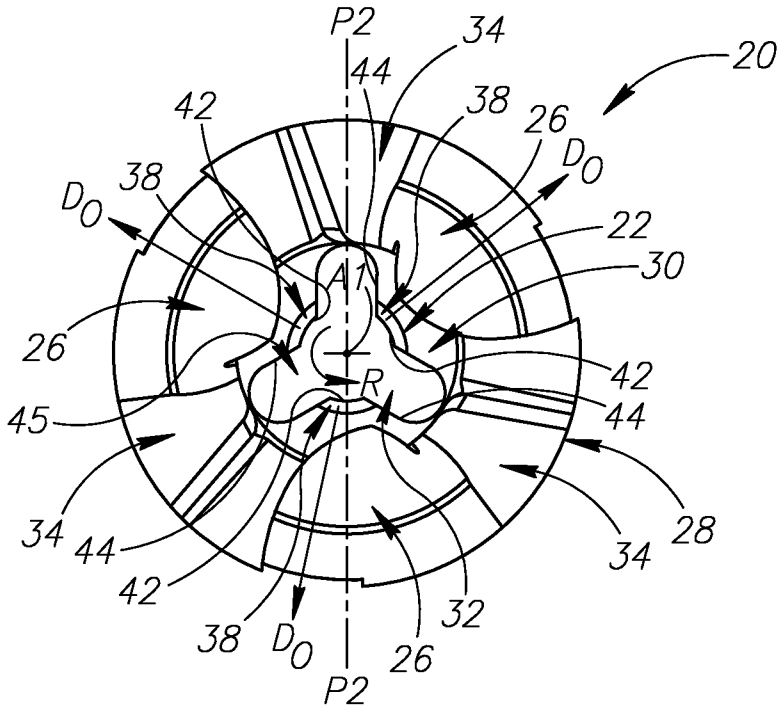
P2
34
44
20
42
38
26
D_O
38
D_O
22
30
A1
26
R
42
45
44
34
44
28
34
42
38
D_O
26
32
P2

FIG.2

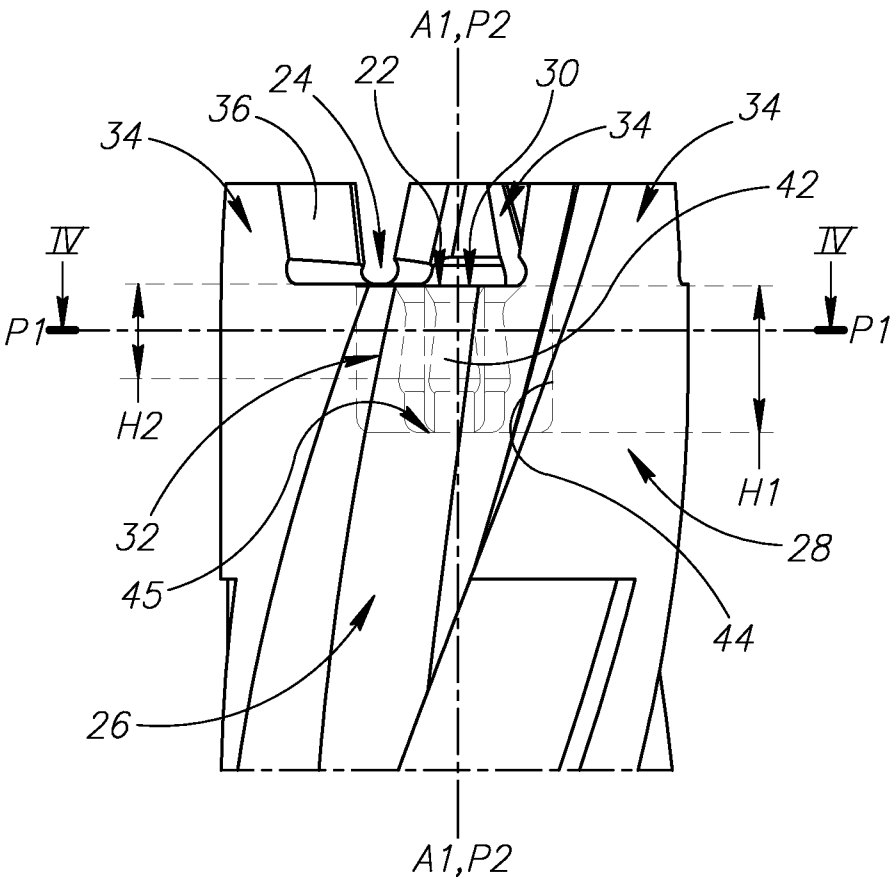
A1,P2
24
22
30
36
34
34
34
42
IV
IV
P1
P1
H2
H1
32
28
45
44
26
A1,P2

FIG.3

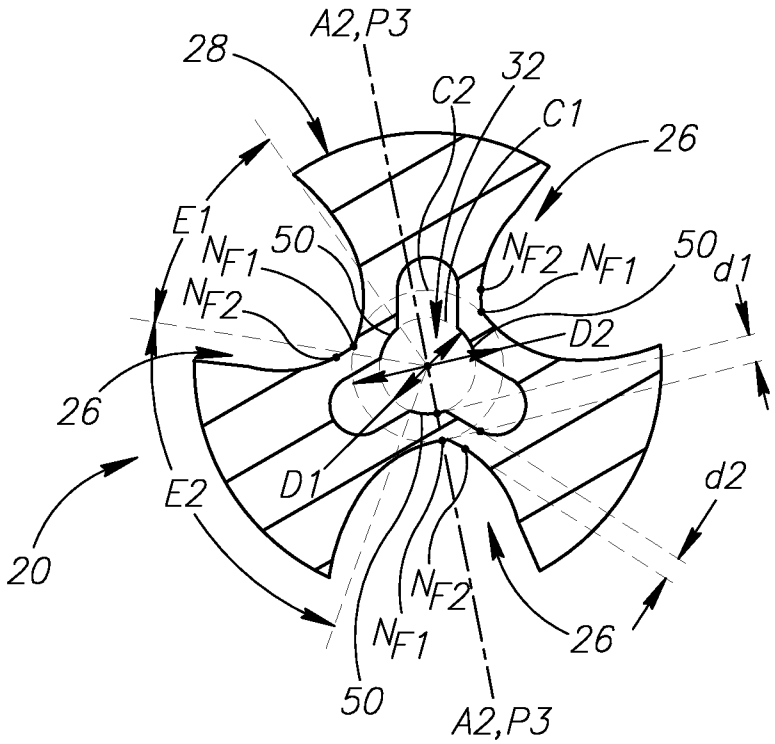
A2,P3
28
32
C2
C1
26
E1
N_{F1}
50
N_{F2}
N_{F2}
N_{F1}
50
d1
N_{F2}
D2
26
D1
E2
d2
20
N_{F2}
N_{F1}
26
50
A2,P3

FIG.4

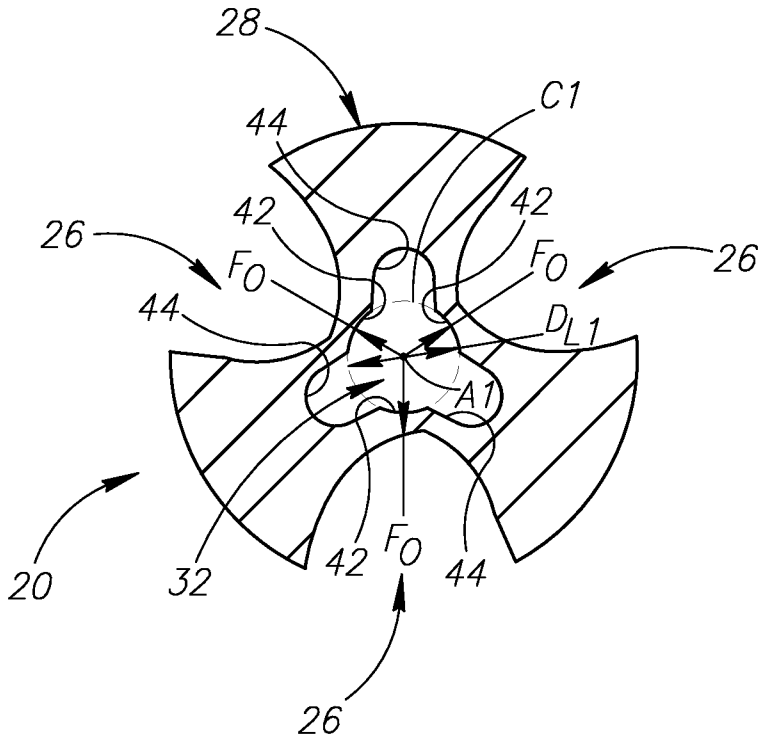
28
C1
44
42
42
26
F_O
F_O
26
44
D_{L1}
A1
20
32
42
F_O
44
26

FIG.5

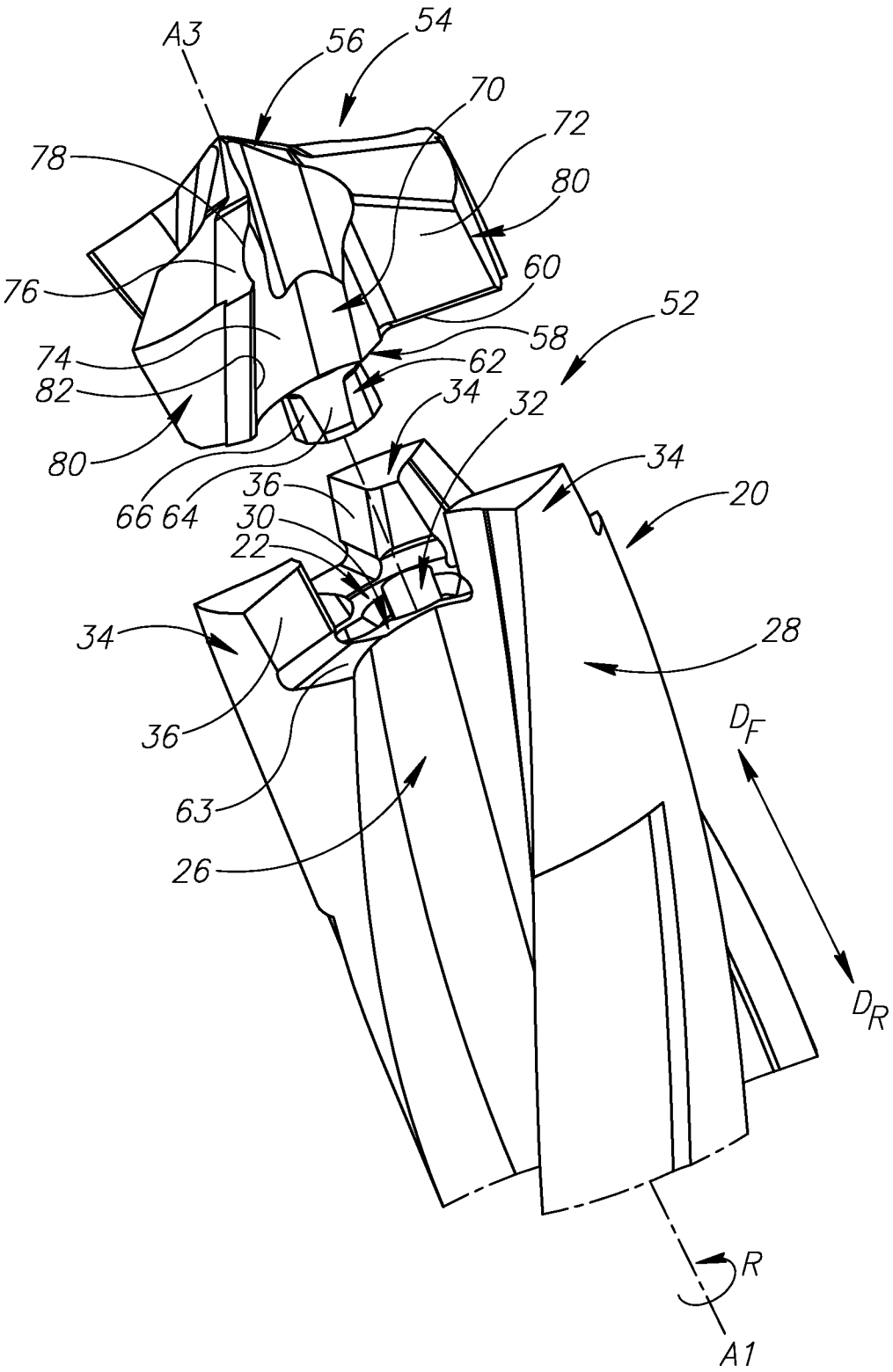
A3
56
54
70
72
78
80
76
60
52
58
74
62
82
34
32
80
66 64
36
34
20
30
22
34
28
36
D_F
63
26
D_R
R
A1

FIG.6

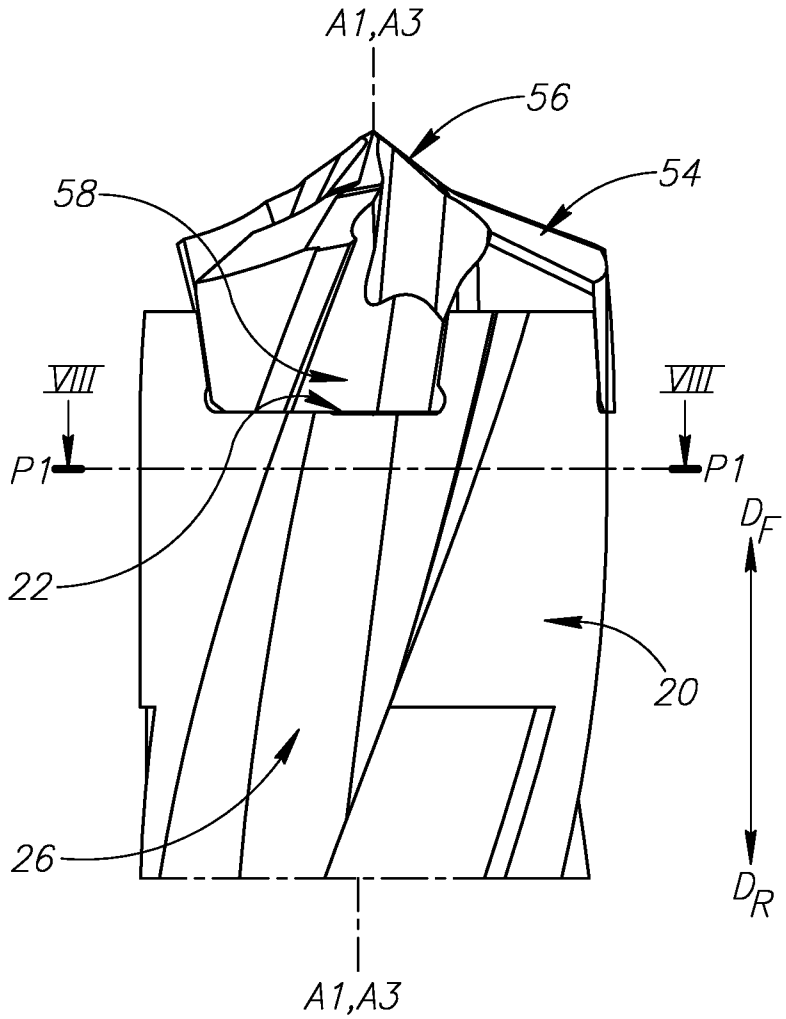
A1,A3
56
54
58
VIII
VIII
P1
P1
D_F
22
20
26
D_R
A1,A3

FIG.7

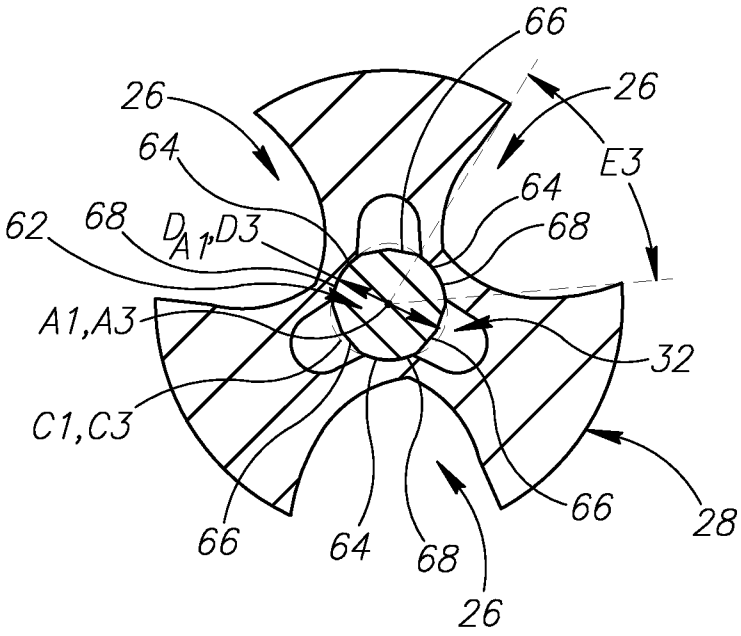
66
26
26
64
E3
64
62
68
D_{A1},D3
68
A1,A3
32
C1,C3
66
28
66
64
68
26

FIG.8

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2017/050875

A. CLASSIFICATION OF SUBJECT MATTER
INV. B23B51/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B23B B23C B23D B27G B28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2012/101622 A1 (ISCAR LTD [IL]; SHITRIT SHIM ON [IL]; GUY HANOCH [IL]) 2 August 2012 (2012-08-02) the whole document	1-28
A	WO 2008/099378 A1 (ISCAR LTD [IL]; HECHT GIL [IL]) 21 August 2008 (2008-08-21) the whole document	1-28

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 October 2017	08/11/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Lorence, Xavier

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IL2017/050875

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2012101622 A1	02-08-2012	CA 2822513 A1	02-08-2012
		CN 103328141 A	25-09-2013
		EP 2667993 A1	04-12-2013
		IL 210893 A	29-01-2015
		JP 5897041 B2	30-03-2016
		JP 2014507294 A	27-03-2014
		KR 20140002705 A	08-01-2014
		RU 2013139350 A	10-03-2015
		US 2012099938 A1	26-04-2012
		WO 2012101622 A1	02-08-2012
WO 2008099378 A1	21-08-2008	AR 065269 A1	27-05-2009
		AU 2008215750 A1	21-08-2008
		BR PI0806950 A2	06-05-2014
		CA 2676338 A1	21-08-2008
		CN 101605622 A	16-12-2009
		EP 2111319 A1	28-10-2009
		ES 2577352 T3	14-07-2016
		IL 181295 A	31-07-2011
		JP 5118153 B2	16-01-2013
		JP 2010517800 A	27-05-2010
		KR 20090118929 A	18-11-2009
		PL 2111319 T3	30-12-2016
		PT 2111319 T	29-07-2016
		RU 2009130034 A	27-03-2011
		TW 200835565 A	01-09-2008
		US 2008193238 A1	14-08-2008
		US 2011280677 A1	17-11-2011
		WO 2008099378 A1	21-08-2008