



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

(21) International Application Number:
PCT/IL2019/051323

(22) International Filing Date:
02 December 2019 (02.12.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
16/236,918 31 December 2018 (31.12.2018) US

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(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: CUTTING HEAD HAVING TORQUE TRANSMISSION SURFACES ON A MOUNTING PROTUBERANCE AND ROTARY CUTTING TOOL HAVING SUCH CUTTING HEAD

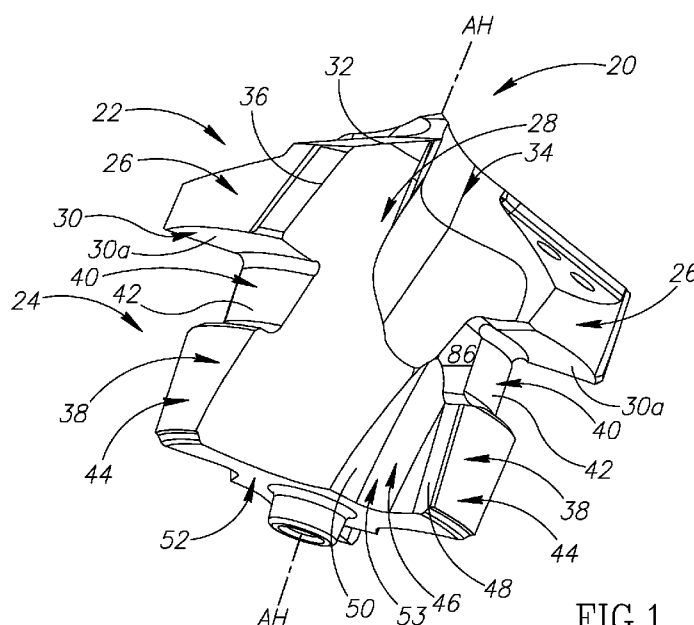


FIG.1

(57) Abstract: A cutting head (20) rotatable about a head axis (AH), has a cap portion (22) and a mounting protuberance (24) joined thereto and extending axially rearwardly therefrom. The mounting protuberance (24) has a plurality of circumferentially spaced apart torque portions (38) axially offset from a plurality of circumferentially spaced apart clamping portions (40). The clamping portions (40) have clamping surfaces (42) circumscribed by an imaginary clamping circle with a clamping diameter. The torque portions (38) have torque protrusions (44) and torque cut-outs (46), each torque protrusion (44) having a torque transmission surface (48) at least partially located outside an imaginary clamping cylinder defined by the imaginary clamping circle, and each torque cut-out (46) having a recessed surface (50) located inside the imaginary clamping cylinder. The cutting head (20) is releasably secured to a head receiving

(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))*

pocket of a tool shank, with each clamping surface (42) contacting a corresponding abutment surface of the pocket, and each torque transmission surface (48) contacting a corresponding drive surface of the pocket.

CUTTING HEAD HAVING TORQUE TRANSMISSION SURFACES ON A MOUNTING PROTUBERANCE AND ROTARY CUTTING TOOL HAVING SUCH CUTTING HEAD

FIELD OF THE INVENTION

The present invention relates to a cutting head having torque transmission surfaces on a mounting protuberance and a rotary cutting tool having such cutting head, 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 some examples of rotary cutting tools with cutting heads having torque transmission surfaces on a mounting protuberance.

US 6,582,164 discloses a removable tip having a front end and a rear end. The front end has two cutting portions circumferentially alternating with a two chip flutes, and the rear end is defined by a shaft, adapted to be inserted in the connection bore of a drill body, and having diametrically opposed external threads extending therefrom. Each external thread has a diminishing radius defining a drive face which cooperates with the drive face of a corresponding internal thread of the drill body, for transmitting rotational forces between the drill body and the removable tip.

US 10,071,430 discloses a cutting head formed for insertion into a support in a modular rotary tool. The cutting head has a coupling pin having torque surfaces and clamping surfaces on its outer periphery. The coupling pin is divided into a front pin part and a rear pin part. The front pin part is defined by a circumferential groove. Stop surfaces for an axial pullout safety are formed in the transition area between the two the front pin part and the rear pin part. The torque surfaces and the clamping surfaces are arranged in different pin parts. The clamping surfaces are preferably formed on the front pin part and the torque surfaces are preferably formed in the rear pin part.

It is an object of the present invention to provide an improved cutting head having torque transmission surfaces on a mounting protuberance.

It is also an object of the present invention to allow the cutting head's cutting portions to be arranged in an optimized manner.

It is a further object of the present invention to enable efficient and stable torque transmission between a tool shank and the cutting head.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a cutting head having a head axis establishing an axial forward direction and an axial rearward direction, the cutting head rotatable about the head axis in a direction of rotation, and comprising:

- a cap portion having a plurality of N cutting portions circumferentially alternating with a plurality of N head flutes, and a cap base surface facing in the axial rearward direction; and

- a mounting protuberance joined to the cap portion, extending axially rearwardly from the cap base surface, and comprising:

- an end surface distal from the cap portion and facing in the axial rearward direction, and

- a plurality of N circumferentially spaced apart torque portions axially offset from a plurality of N circumferentially spaced apart clamping portions,

- each clamping portion having a radially outward facing clamping surface, and

- each torque portion having a radially outward extending torque protrusion and a circumferentially adjacent and rotationally trailing torque cut-out, each torque protrusion having a torque transmission surface facing opposite the direction of rotation,

- wherein in a first cross-section taken in a first head plane perpendicular to the head axis and intersecting the plurality of clamping portions:

- an imaginary clamping circle having a clamping diameter circumscribes the plurality of clamping surfaces,

- and wherein in a second cross-section taken in a second head plane parallel to the first head plane and intersecting the plurality of torque portions:

- each torque transmission surface is at least partially located outside an imaginary clamping cylinder defined by the imaginary clamping circle, and

- each torque cut-out has a recessed surface located inside the imaginary clamping cylinder.

Also, in accordance with the present invention, there is provided a rotary cutting tool comprising a tool shank extending along a shank axis, and a cutting head of the sort described above releasably secured to a head receiving pocket of the tool shank at forward end thereof.

In the cutting tool, the shank's forward end has a shank support surface transverse to the shank axis and the head receiving pocket is formed in the shank support surface,

wherein in an assembled position:

the cap base surface faces the shank support surface;

the head axis is coincident with the shank axis;

each clamping surface is in contact with a corresponding radially inward facing abutment surface of the head receiving pocket; and

each torque transmission surface is in contact with a corresponding drive surface of the head receiving pocket, which faces in the direction of rotation.

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 first perspective view of a cutting head in accordance with some embodiments of the present invention;

Fig. 2 is a second perspective view of the cutting head in accordance with some embodiments of the present invention;

Fig. 3 is a side view of the cutting head shown in Figs. 1 and 2;

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

Fig. 5 is a cross-sectional view of the cutting head shown in Fig. 3, taken along the line V-V;

Fig. 6 is a detailed view of the cutting head shown in Fig. 5;

Fig. 7 is an exploded perspective view of a rotary cutting tool in accordance with some embodiments of the present invention;

Fig. 8 is a side view of the rotary cutting tool shown in Fig. 7;

Fig. 9 is an end view of a tool shank in accordance with some embodiments of the present invention;

Fig. 10 is a cross-sectional view of the tool shank shown in Fig. 9, taken along the line X-X;

Fig. 11 is a detailed view of the rotary cutting tool shown in Fig. 8;

Fig. 12 is a cross-sectional view of the rotary cutting tool shown in Fig. 8, taken along the line XII-XII;

Fig. 13 is a cross-sectional view of the rotary cutting tool shown in Fig. 8, taken along the line XIII-XIII; and

Fig. 14 is a cross-sectional view of the rotary cutting tool shown in Fig. 8, taken along the line XIV-XIV.

DETAILED DESCRIPTION OF THE INVENTION

A first aspect of the present invention relates to a cutting head **20** rotatable about a head axis **AH** in a direction of rotation **R1**. The head axis **AH** establishes an axial forward direction **DF** and an axial rearward direction **DR** of the cutting head **20**.

In some embodiments of the present invention, the cutting head **20** may preferably be manufactured by form pressing and sintering a cemented carbide, such as tungsten carbide, and may be coated or uncoated.

As shown in Figs. 1 to 5, the cutting head **20** comprises a cap portion **22** and a mounting protuberance **24** joined to the cap portion **22**.

The cap portion **22** has a plurality of **N** cutting portions **26** circumferentially alternating with a plurality of **N** head flutes **28**, and a cap base surface **30** facing in an axial rearward direction **DR**.

In some embodiments of the present invention, each cutting portion **26** may have a radially extending cutting edge **32**, and each head flute **28** may have a web thinning region **34** adjacent to a portion of its associated cutting edge **32**.

Also, in some embodiments of the present invention, each cutting portion **26** may have an axially extending leading edge **36**, and the cap portion **22** may have a cutting diameter **DCU** defined by the plurality of leading edges **36**.

Further, in some embodiments of the present invention, the cap base surface **30** may be perpendicular to the head axis **AH**.

Yet further, in some embodiments of the present invention, the cap base surface **30** may have **N** circumferentially spaced apart cap base sub-surfaces **30a**.

As shown in Figs. 1 and 3, the mounting protuberance **24** extends axially rearwardly from the cap base surface **30** and has a plurality of **N** circumferentially spaced apart torque portions **38** axially offset from a plurality of **N** circumferentially spaced apart clamping portions **40**.

In some embodiments of the present invention, the plurality of torque portions **38** may be located axially rearward of the plurality of clamping portions **40**.

Also, in some embodiments of the present invention, the mounting protuberance **24** may exhibit **N**-fold rotational symmetry about the head axis **AH**.

Further, in some embodiments of the present invention, that **N** is a whole number equal to three, i.e. **N** = 3.

As shown in Figs. 3 and 4, each clamping portion **40** has a radially outward facing clamping surface **42**.

In some embodiments of the present invention, each clamping surface **42** may be convex.

As shown in Fig. 4, in a first cross-section taken in a first head plane **PH1** perpendicular to the head axis **AH** and intersecting the plurality of clamping portions **40**, an imaginary clamping circle **CC** having a clamping diameter **DC** circumscribes the plurality of clamping surfaces **42**.

Also, as shown in Fig. 4, in the first cross-section taken in the first head plane **PH1**, each clamping surface **42** may be coincident with the imaginary clamping circle **CC**.

It should be appreciated that in the first cross-section taken in the first head plane **PH1**, none of the plurality of clamping portions **40** may extend outside of the imaginary clamping circle **CC**.

In some embodiments of the present invention, the plurality of clamping portions **40** may be circumferentially spaced apart by the plurality head flutes **28**.

Also, in some embodiments of the present invention, each clamping surface **42** may intersect a circumferentially adjacent and rotationally leading head flute **28**.

As shown in Figs. 3 and 5, each torque portion **38** has a radially outward extending torque protrusion **44** and a circumferentially adjacent and rotationally trailing torque cut-out **46**.

In some embodiments of the present invention, the plurality of torque portions **38** may be circumferentially spaced apart by the plurality head flutes **28**.

As shown in Figs. 2 and 5, each torque protrusion **44** has a torque transmission surface **48** facing opposite the direction of rotation **R1**.

In some embodiments of the present invention, each torque transmission surface **48** may be planar.

By configuring the plurality of torque transmission surfaces **48** to be disposed on the mounting protuberance **24**, as opposed to the cap portion **22**, advantageously allows the plurality of cutting portions **26** and web thinning regions **34** to be arranged in an optimized manner, for example, with respect to cutting chip development and cutting chip flow, without the requirement to provide additional space for torque transmission between a tool shank and the cutting head's cap portion **22**.

It should be appreciated that the significance of arranging the plurality of cutting portions **26** and the plurality of head flutes **28** in an optimized manner is greater for cap portions **22** having smaller cutting diameters, and for cutting heads **20** having a value of **N** which is greater than two, i.e. $N > 2$.

According to the present invention, as shown in Fig. 5, in a second cross-section taken in a second head plane **PH2** parallel to the first head plane **PH1** and intersecting the plurality of torque portions **38**, each torque transmission surface **48** is at least partially located outside an imaginary clamping cylinder **SC** defined by the imaginary clamping circle **CC**, and each torque cut-out **46** has a recessed surface **50** located inside the imaginary clamping cylinder **SC**.

In some embodiments of the present invention, the imaginary clamping cylinder **SC** may have an imaginary peripheral surface **IP** extending parallel to the head axis **AH**, and each clamping surface **42** may be coincident with the imaginary peripheral surface **IP**.

Also, in some embodiments of the present invention, each torque transmission surface **48** may be entirely located outside the imaginary clamping cylinder **SC**.

Further, in some embodiments of the present invention, each recessed surface **50** may extend radially inwardly in the axial rearward direction **DR**.

Yet further, in some embodiments of the present invention, each recessed surface **50** may intersect a circumferentially adjacent and rotationally trailing head flute **28**.

It should be appreciated that in some embodiments of the present invention, each recessed surface **50** may be circumferentially spaced apart from, and thus not intersect, a circumferentially adjacent and rotationally leading torque transmission surface **48**.

As shown in Figs. 5 and 6, in the second cross-section taken in the second head plane **PH2**, each torque cut-out **46** has a radially innermost cut-out point **N1** contained in a first radial plane **PR1** containing the head axis **AH**, and each torque transmission surface **48** has a radially outermost transmission point **N2** contained in a second radial plane **PR2** containing the head axis **AH**.

In some embodiments of the present invention, the first and second radial planes **PR1**, **PR2** associated with each torque portion **38** may form an acute first torque angle $\alpha 1$ of less than 45 degrees.

Also, in some embodiments of the present invention, as shown in Figs. 5 and 6, in the second cross-section taken in the second head plane **PH2**, each torque transmission surface **48** may form a zero or acute second torque angle $\alpha 2$ of less than 30 degrees with the second radial plane **PR2**.

Further, in some embodiments of the present invention, as shown in Figs. 5 and 6, in the second cross-section taken in the second head plane **PH2**, each torque transmission surface **48** may face its associated second radial plane **PR2**. In such embodiments, the entirety of each torque transmission surface **48** may be located rotationally forward of its associated second radial plane **PR2**, except at the radially outermost transmission point **N2**.

For embodiments of the present invention in which each torque transmission surface **48** forms a zero or acute second torque angle $\alpha 2$ of less than 30 degrees with the second radial plane **PR2**, efficient torque transmission is enabled between a tool shank and the cutting head **20**.

It should be appreciated that the efficiency of torque transmission is improved for cutting heads **20** having a value of **N** which is greater than two, i.e. $N > 2$.

As shown in Fig. 5, in the second cross-section taken in the second head plane **PH2**, the plurality of radially innermost cut-out points **N1** define an imaginary first torque circle **CT1** having a first torque diameter **DT1**.

In some embodiments of the present invention, the first torque diameter **DT1** may be less than seventy percent of the clamping diameter **DC**, i.e. $DT1 < DC * 0.70$.

Also, as shown in Fig. 5, in the second cross-section taken in the second head plane **PH2**, the plurality of radially outermost transmission points **N2** define an imaginary second torque circle **CT2** having a second torque diameter **DT2**.

In some embodiments of the present invention, the second torque diameter **DT2** may be greater than one hundred and ten percent of the clamping diameter **DC**, i.e. $DT2 > DC * 1.10$.

For embodiments of the present invention in which the second torque diameter **DT2** is greater than one hundred and ten percent of the clamping diameter **DC**, stable torque transmission is enabled between a tool shank and the cutting head **20**.

It should be appreciated that the stability of torque transmission is improved for cutting heads **20** having a value of **N** which is greater than two, i.e. $N > 2$.

In some embodiments of the present invention, the second torque diameter **DT2** may be greater than sixty percent of the cutting diameter **DCU**, i.e. $DT2 > DCU * 0.60$.

For embodiments of the present invention in which the second torque diameter **DT2** is greater than sixty percent of the cutting diameter **DCU**, efficient torque transmission is enabled between a tool shank and the cutting head **20**.

It should be appreciated that the efficiency of torque transmission is improved for cutting heads **20** having a value of **N** which is greater than two, i.e. $N > 2$.

As shown in Fig. 5, in the second cross-section taken in the second head plane **PH2**, each torque cut-out **46** has a rotationally trailing-most cut-out point **N3**.

Also, as shown in Fig. 5, in the second cross-section taken in the second head plane **PH2**, each rotationally trailing-most cut-out point **N3** is formed at the intersection of each torque cut-out **46** and its circumferentially adjacent and rotationally trailing head flute **28**.

In some embodiments of the present invention, the radially innermost cut-out point **N1** of each torque cut-out **46** may not be coincident with its associated rotationally trailing-most cut-out point **N3**.

As shown in Figs. 1 and 3, the mounting protuberance **24** may have an end surface **52** distal from the cap portion **22** and facing in the axial rearward direction **DR**.

In some embodiments of the present invention, each end surface **52** may be perpendicular to the head axis **AH**.

Also, in some embodiments of the present invention, each recessed surface **50** may intersect the end surface **52**.

As shown in Figs. 1, 5 and 6, a plurality of **N** recesses **53** are formed in the mounting protuberance **24** inside the imaginary clamping cylinder **SC**, each recess **53** located between a circumferentially adjacent and rotationally leading torque protrusion **44** and a circumferentially adjacent and rotationally trailing head flute **28**.

In some embodiments of the present invention, each recess **53** may open out to the end surface **52**.

It should be appreciated that in some embodiments of the present invention, each recess **53** may correspond with one of the torque cut-outs **46**.

As shown in Figs. 2 and 3, each torque protrusion **44** may have an axial stopper surface **54** facing in an axial forward direction **DF**.

It should be appreciated that the axial forward direction **DF** is opposite the axial rearward direction **DR**.

In some embodiments of the present invention, each axial stopper surface **54** may be perpendicular to the head axis **AH**.

Also, in some embodiments of the present invention, each axial stopper surface **54** may be disposed rotationally ahead of its associated torque transmission surface **48**.

As shown in Fig. 3, the end surface **52** may be located a first distance **DS1** axially rearward of the cap base surface **30**, and each axial stopper surface **54** may be located a second distance **DS2** axially forward of the end surface **52**.

In some embodiments of the present invention, the second distance **DS2** may be greater than half of the axial distance **DS1**, i.e. $DS2 > DS1 * 0.50$.

Also, in some embodiments of the present invention, each torque transmission surface **48** may have an axial extent **EA** of greater than eighty percent of the second distance **DS2**, i.e. $EA > DS2 * 0.80$.

For embodiments of the present invention in which the axial extent **EA** is greater than eighty percent of the second distance **DS2**, efficient torque transmission is enabled between a tool shank and the cutting head **20**.

As shown in Figs. 7 and 8, a second aspect of the present invention relates to a rotary cutting tool **56** having a tool shank **58** extending along a shank axis **AS**, and the cutting head **20** releasably secured to a head receiving pocket **60** of the tool shank **58** at forward end **62** thereof.

In some embodiments of the present invention, the tool shank **58** may preferably be manufactured from tool steel.

Also, in some embodiments the cutting head **20** may be releasably secured to the head receiving pocket **60** without the requirement of an additional fastening member, such as a clamping screw.

As shown in Figs. 9 and 10, the forward end **62** has a shank support surface **64** transverse to the shank axis **AS** and the head receiving pocket **60** is formed in the shank support surface **64**,

In some embodiments of the present invention, the shank support surface **64** may be perpendicular to the shank axis **AS**.

Also, in some embodiments of the present invention, the shank support surface **64** may contain an axially forwardmost shank point **N4** of the tool shank **58**.

As shown in Figs. 7 and 9, the tool shank **58** may have a plurality of **N** circumferentially spaced apart shank flutes **66** extending from the shank's forward end **62** along the shank axis **AS**.

In some embodiments of the present invention, the plurality of **N** shank flutes **66** may circumferentially alternate with a plurality of **N** shank lands **68**, and each shank flute **66** may extend helically along the shank axis **AS**.

Also, in some embodiments of the present invention, the plurality of **N** shank flutes **66** may communicate with the head receiving pocket **60**.

For embodiments of the present invention in which the plurality of **N** shank flutes **66** communicate with the head receiving pocket **60**, a plurality of **N** circumferentially spaced apart shank projections **70** may be formed.

Also, for embodiments of the present invention in which the plurality of **N** shank flutes **66** communicate with the head receiving pocket **60**, the shank support surface **64** may have a plurality of **N** circumferentially spaced apart shank support sub-surfaces **64a**, each shank support sub-surface **64a** being disposed on one of the shank projections **70**.

As shown in Figs. 8 and 11 to 14, in an assembled position of the rotary cutting tool **56**:

the cap base surface **30** faces the shank support surface **64**;

the head shank axis **AH** is coincident with the shank axis **AS**;

each clamping surface **42** is in contact with a corresponding radially inward facing abutment surface **72** of the head receiving pocket **60**; and

each torque transmission surface **48** is in contact with a corresponding drive surface **74** of the head receiving pocket **60**, which faces in the direction of rotation **R1**.

It should be appreciated that the head receiving pocket **60** and the shank flutes **66** may be configured so that the plurality of shank projections **70** are resiliently displaceable, and so that the plurality of clamping surfaces **42** are resiliently retained against the plurality of abutment surfaces **72**.

In some embodiments of the present invention, the cap base surface **30** may be in contact with the shank support surface **64**.

For embodiments of the present invention in which the shank support surface **64** contains the axially forwardmost shank point **N4** of the tool shank **58**, no portion of the tool shank **58** extends axially forward of the cutting head's cap base surface **30**.

By positioning the drive surfaces **74** axially rearward of the cutting head's cap portion **22** advantageously reduces the level of wear incurred by cutting chip flow on the shank projections **70**, which may be manufactured from tool steel, having a hardness less than cemented carbide.

As shown in Figs. 8 to 10, the head receiving pocket **60** may have a bottom surface **76** facing in the axial forward direction **DF**.

In some embodiments of the present invention, the bottom surface **76** may intersect the plurality of shank flutes **66**.

Also, in some embodiments of the present invention, the mounting protuberance's end surface **52** may be spaced apart from the bottom surface **76**.

As shown in Figs. 9 and 10, each drive surface **74** may be disposed on a radial extending rib portion **78** of the head receiving pocket **60**.

As shown in Figs. 13 and 14, in cross-sections taken in first and second shank planes **PS1**, **PS2** perpendicular to the shank axis **AS** and intersecting the plurality of rib portions **78**, the plurality of torque transmission surfaces **48** are in contact with the plurality of drive surfaces **74**.

In some embodiments of the present invention, the second shank plane **PS2** may be coincident with the second head plane **PH2**.

As shown in Figs. 13 and 14, each rib portion **78** may occupy one of the mounting protuberance's torque cut-outs **46**.

It should be appreciated that the plurality of rib portions **78** provide the head receiving pocket **60** with its necessary rigidity and strength, and the plurality of torque cut-outs **46** provide the necessary space to accommodate the plurality of rib portions **78**.

It should also be appreciated the use of the term "occupy" or "occupies" throughout the description and claims includes partial occupancy, for example, a configuration in which a part of each rib portion **78** occupies one of the mounting protuberance's torque cut-outs **46**.

As shown in Figs. 13 and 14, each rib portion **78** may have an elongated rib surface **80** located inside the imaginary clamping cylinder **SC**.

In some embodiments of the present invention, each elongated rib surface **80** may be spaced apart from the recessed surface **50** of its occupied torque cut-out **46**.

For embodiments of the present invention in which the plurality of elongated rib surfaces **80** are spaced apart from the plurality of recessed surfaces **50**, the plurality of elongated rib surfaces **80** do not make contact with the cutting head's mounting protuberance **24**, and the plurality of recessed surfaces **50** do not make contact with the tool shank's head receiving pocket **60**.

As shown in Figs. 9 and 10, each elongated rib surface **80** may extend radially inwardly in the axial rearward direction **DR**.

In some embodiments of the present invention, each elongated rib surface **80** may intersect one of the shank flutes **66**.

As shown in Figs. 13 and 14, in the cross-section taken in the first shank plane **PS1**, each rib surface **80** has a first circumferential extent **EC1**, and in the cross-section taken in the second shank plane **PS2**, each rib surface **80** has a second circumferential extent **EC2**.

In some embodiments of the present invention, the second shank plane **PS2** may be located axially rearward of the first shank plane **PS1**, and the second circumferential extent **EC2** may be greater than the first circumferential extent **EC1**.

For embodiments of the present invention in which the second circumferential extent **EC2** is greater than the first circumferential extent **EC1**, the plurality of rib portions **78** are advantageously robust.

As shown in Figs. 9 and 10, each abutment surface **72** may be disposed on a circumferentially extending ledge portion **82** of the head receiving pocket **60**, and the plurality of ledge portions **82** may be located axially forward of the plurality of rib portions **78**.

In some embodiments of the present invention, each shank support sub-surface **64a** may be disposed on one of the ledge portions **82** adjacent to one of the abutment surfaces **72**.

As shown in Fig. 12, in a cross-section taken in a third shank plane **PS3** perpendicular to the shank axis **AS** and intersecting the plurality of ledge portions **82**, the plurality of clamping surfaces **42** are in contact with the plurality of abutment surfaces **72**.

In some embodiments of the present invention, the third shank plane **PS3** may be coincident with the first head plane **PH1**.

As shown in Figs. 10 and 11, each ledge portion **82** may have an axial stopping surface **84** facing in the axial rearward direction **DR**.

In some embodiments of the present invention, each axial stopping surface **84** may be disposed adjacent to one of the abutment surfaces **72**.

Also, in some embodiments of the present invention, each axial stopping surface **84** may face one of the cutting head's axial stopper surfaces **54**.

As shown in Fig. 11, each axial stopper surface **54** may be spaced apart from its associated axial stopping surface **84** by an axial gap **G1**.

In some embodiments of the present invention, the axial gap **G1** may be less than 0.3mm, i.e. $G1 < 0.3\text{mm}$.

It should be appreciated that for instances of excessive axial 'pulling' forces acting on the cutting head **20**, the cap base surface **30** may not remain in contact with the shank support surface **64** and the plurality of axial stopper surfaces **54** may make contact with the plurality of axial stopping surfaces **84**, thus preventing the cutting head **20** from becoming detached from the tool shank **58**. Therefore, the axial stopping surfaces **84** collectively serve as a pullout preventer configured to prevent the cutting head **20** from becoming detached from the tool shank **58**.

In some embodiments of the present invention, it should also be appreciated that apart from the plurality of clamping surfaces **42** contacting the plurality of abutment surfaces **72**, the plurality of torque transmission surfaces **48** contacting the plurality of drive surfaces **74**, and the cap base surface **30** contacting the shank support surface **64** or the plurality of axial stopper surfaces **54** contacting the plurality of axial stopping surfaces **84**, there may be no contact between the cutting head **20** and the tool shank **58**.

The present invention further relates to a method of assembling the rotary cutting tool **56**, comprising the steps of:

- a) orienting the cap base surface **30** to face the shank support surface **64**;
- b) aligning the head axis **AH** with the shanks axis **AS**;
- c) rotationally aligning the plurality of torque protrusions **44** with the plurality of shank flutes **66**;
- d) inserting the mounting protuberance **24** into the head receiving pocket **60**; and
- e) rotating the cutting head **20** about its head axis **AH** opposite the direction of rotation **R1**, until the plurality of clamping surfaces **42** are retained against the plurality of abutment surfaces **72**, and the plurality of torque transmission surfaces **48** are in contact with the plurality of drive surfaces **74**.

In some embodiments of the present invention, in step d) of the tool assembly, the mounting protuberance **24** may be inserted into the head receiving pocket **60** until the cap base surface **30** makes contact with the shank support surface **64**.

As shown in Figs. 1, 3 and 4, each clamping portion **40** may have a clamping guide surface **86** circumferentially adjacent and rotationally trailing its associated clamping surface **42**.

In some embodiments of the present invention, each clamping guide surface **86** may taper radially inwardly in a direction opposite the direction of rotation **R1**.

Also, in some embodiments of the present invention, each clamping guide surface **86** may intersect its circumferentially adjacent and rotationally trailing head flute **28**.

It should be appreciated that the provision of a clamping guide surface **86** on each clamping portion **42** facilitates step e) of the tool assembly and prevents inadvertent snagging between the plurality of clamping portions **40** and the plurality of ledge portions **82**.

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 cutting head (20) having a head axis (AH) establishing an axial forward direction (DF) and an axial rearward direction (DR), the cutting head (20) rotatable about the head axis (AH) in a direction of rotation (R1), and comprising:

a cap portion (22) having a plurality of N cutting portions (26) circumferentially alternating with a plurality of N head flutes (28), and a cap base surface (30) facing in the axial rearward direction (DR); and

a mounting protuberance (24) joined to the cap portion (22), extending axially rearwardly from the cap base surface (30), and comprising:

a mounting protuberance end surface (52) distal from the cap portion (22) and facing in the axial rearward direction (DR), and

a plurality of N circumferentially spaced apart torque portions (38) axially offset from a plurality of N circumferentially spaced apart clamping portions (40),

each clamping portion (40) having a radially outward facing clamping surface (42), and

each torque portion (38) having a radially outward extending torque protrusion (44) and a circumferentially adjacent and rotationally trailing torque cut-out (46), each torque protrusion (44) having a torque transmission surface (48) facing opposite the direction of rotation (R1),

wherein in a first cross-section taken in a first head plane (PH1) perpendicular to the head axis (AH) and intersecting the plurality of clamping portions (40):

an imaginary clamping circle (CC) having a clamping diameter (DC) circumscribes the plurality of clamping surfaces (42), and

wherein in a second cross-section taken in a second head plane (PH2) parallel to the first head plane (PH1) and intersecting the plurality of torque portions (38):

each torque transmission surface (48) is at least partially located outside an imaginary clamping cylinder (SC) defined by the imaginary clamping circle (CC), and

each torque cut-out (46) has a recessed surface (50) located inside the imaginary clamping cylinder (SC).

2. The cutting head (20) according to claim 1, wherein each recessed surface (50) extends radially inwardly in the axial rearward direction (DR).

3. The cutting head (20) according to claim 1 or 2, wherein:

each torque cut-out (46) comprises a recess (53) formed in the mounting protuberance (24), inside the imaginary clamping cylinder (SC);

each recess (53) is located between a circumferentially adjacent and rotationally leading torque protrusion (44) and a circumferentially adjacent and rotationally trailing head flute (28); and

each recess (53) intersects the end surface (52).

4. The cutting head (20) according to any one of the preceding claims, wherein the plurality of torque portions (38) are located axially rearward of the plurality of clamping portions (40).

5. The cutting head (20) according to any one of the preceding claims, wherein:

the plurality of torque portions (38) are circumferentially spaced apart by the plurality head flutes (28), and

the plurality of clamping portions (40) are circumferentially spaced apart by the plurality head flutes (28).

6. The cutting head (20) according to claim 5, wherein each recessed surface (50) intersects a circumferentially adjacent and rotationally trailing head flute (28).

7. The cutting head (20) according to claim 5 or 6, wherein each clamping surface (42) intersects a circumferentially adjacent and rotationally leading head flute (28).

8. The cutting head (20) according to any one of the preceding claims, wherein in the first cross-section taken in the first head plane (PH1), each clamping surface (42) is coincident with the imaginary clamping circle (CC).

9. The cutting head (20) according to any one of the preceding claims, wherein in the second cross-section taken in the second head plane (PH2):

each torque cut-out (46) has a radially innermost cut-out point (N1) contained in a first radial plane (PR1) containing the head axis (AH),

each torque transmission surface (48) has a radially outermost transmission point (N2) contained in a second radial plane (PR2) containing the head axis (AH), and

the first and second radial planes (PR1, PR2) associated with each torque portion (38) form an acute first torque angle (α_1) of less than 45 degrees.

10. The cutting head (20) according to claim 9, wherein in the second cross-section taken in the second head plane (PH2):

each torque cut-out (46) has a rotationally trailing-most cut-out point (N3), and

the radially innermost cut-out point (N1) of each torque cut-out (46) is not coincident with its associated rotationally trailing-most cut-out point (N3).

11. The cutting head (20) according to claim 9 or 10, wherein in the second cross-section taken in the second head plane (PH2):

the plurality of radially outermost transmission points (N2) define an imaginary second torque circle (CT2) having a second torque diameter (DT2), and

the second torque diameter (DT2) is greater than one hundred and ten percent of the clamping diameter (DC).

12. The cutting head (20) according to any one of claims 9 to 11, wherein in the second cross-section taken in the second head plane (PH2):

the plurality of radially innermost cut-out points (N1) define an imaginary first torque circle (CT1) having a first torque diameter (DT1), and

the first torque diameter (DT1) is less than seventy percent of the clamping diameter (DC).

- 13.** The cutting head (20) according to any one of the preceding claims, wherein:
each torque protrusion (44) has an axial stopper surface (54) facing in the axial forward direction (DF) opposite the axial rearward direction (DR).
- 14.** A rotary cutting tool (56) comprising, in combination:
a tool shank (58) extending along a shank axis (AS) and having a head receiving pocket (60) at forward end (62) thereof, and
a cutting head (20) in accordance with any one of the preceding claims, releasably secured to the head receiving pocket (60), in an assembled position of the tool.
- 15.** The rotary cutting tool (56) according to claim 14, wherein:
the tool shank's forward end (60) has a shank support surface (64) transverse to the shank axis (A2) and the head receiving pocket (60) is formed in the shank support surface (64), and
in the assembled position of the tool:
the cap base surface (30) faces the shank support surface (64);
the head axis (AH) is coincident with the shank axis (AS);
each clamping surface (42) is in contact with a corresponding radially inward facing abutment surface (72) of the head receiving pocket (60); and
each torque transmission surface (48) is in contact with a corresponding drive surface (74) of the head receiving pocket (60), which faces in the direction of rotation (R1).
- 16.** The rotary cutting tool (56) according to claim 15, wherein:
each drive surface (74) is disposed on a radially extending rib portion (78) of the head receiving pocket (60), and
each rib portion (78) occupies one of the torque cut-outs (46).
- 17.** The rotary cutting tool (56) according to claim 16, wherein:
each rib portion (78) has an elongated rib surface (80) located inside the imaginary clamping cylinder (SC) of the cutting head (20).

- 18.** The rotary cutting tool (56) according to claim 17, wherein:
each elongated rib surface (80) is spaced apart from the recessed surface (50) of its occupied torque cut-out (46).
- 19.** The rotary cutting tool (56) according to claim 17 or 18, wherein:
each elongated rib surface (80) extends radially inwardly in the axial rearward direction (DR).
- 20.** The rotary cutting tool (56) according to any one of claims 17 to 19, wherein:
the tool shank (58) has a plurality of N shank flutes (66) helically extending along the shank axis (AS) and intersecting the shank support surface (64), and
each elongated rib surface (80) intersects one of the shank flutes (66).
- 21.** The rotary cutting tool (56) according to any one of claims 16 to 20, wherein:
each abutment surface (72) is disposed on a circumferentially extending ledge portion (82) of the head receiving pocket (60), and
the plurality of ledge portions (82) are located axially forward of the plurality of rib portions (78).
- 22.** The rotary cutting tool (56) according to claim 21, wherein:
each ledge portion (82) has an axial stopping surface (84) facing in the axial rearward direction (DR).
- 23.** The rotary cutting tool (56) according to claim 22, wherein:
each torque protrusion (44) has an axial stopper surface (54), and
each axial stopping surface (84) faces one of the axial stopper surfaces (54).
- 24.** A cutting head (20) having a head axis (AH) establishing an axial forward direction (DF) and an axial rearward direction (DR), the cutting head (20) rotatable about the head axis (AH) in a direction of rotation (R1), and comprising:

a cap portion (22) having a plurality of N cutting portions (26) circumferentially alternating with a plurality of N head flutes (28), and a cap base surface (30) facing in the axial rearward direction (DR); and

a mounting protuberance (24) joined to the cap portion (22), extending axially rearwardly from the cap base surface (30), and comprising:

a mounting protuberance end surface (52) distal from the cap portion (22) and facing in the axial rearward direction (DR);

a plurality of N circumferentially spaced apart clamping portions (40) each having a radially outward facing clamping surface (42), wherein in a first cross-section taken in a first head plane (PH1) perpendicular to the head axis (AH) and intersecting the plurality of clamping portions (40), an imaginary clamping circle (CC) having a clamping diameter (DC) circumscribes the plurality of clamping surfaces (42);

a plurality of N circumferentially spaced apart torque portions (38) axially offset from the plurality of N circumferentially spaced apart clamping portions (40), each having a radially outward extending torque protrusion (44) comprising a torque transmission surface (48) facing opposite the direction of rotation (R1), wherein in a second cross-section taken in a second head plane (PH2) parallel to the first head plane (PH1) and intersecting the plurality of torque portions (38), each torque transmission surface (48) is at least partially located outside an imaginary clamping cylinder (SC) defined by the imaginary clamping circle (CC); and

a plurality of N recesses (53) formed inside the imaginary clamping cylinder (SC) and opening out to the end surface (52), each recess (53) located between a circumferentially adjacent and rotationally leading torque protrusion (44) and a circumferentially adjacent and rotationally trailing head flute (28); wherein:

the torque portions (38) are located closer to the end surface (52) than the clamping portions (40).

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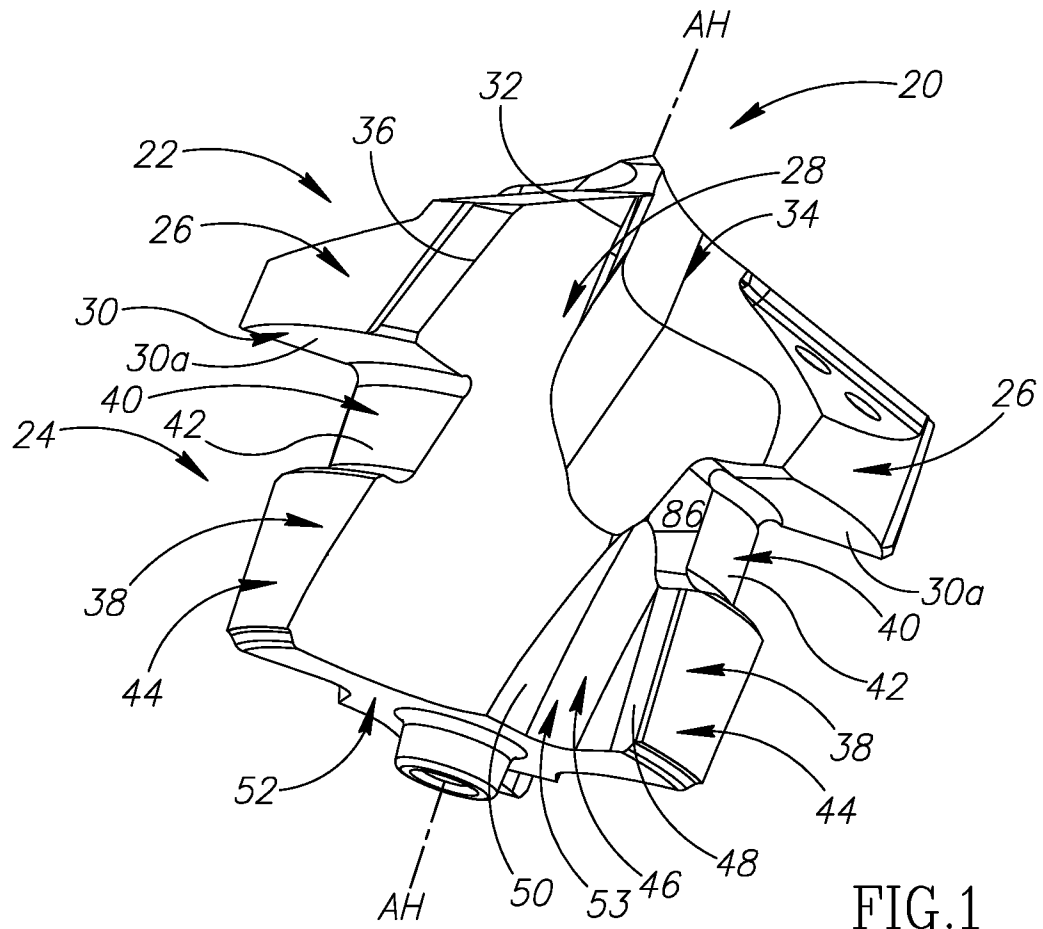


FIG.1

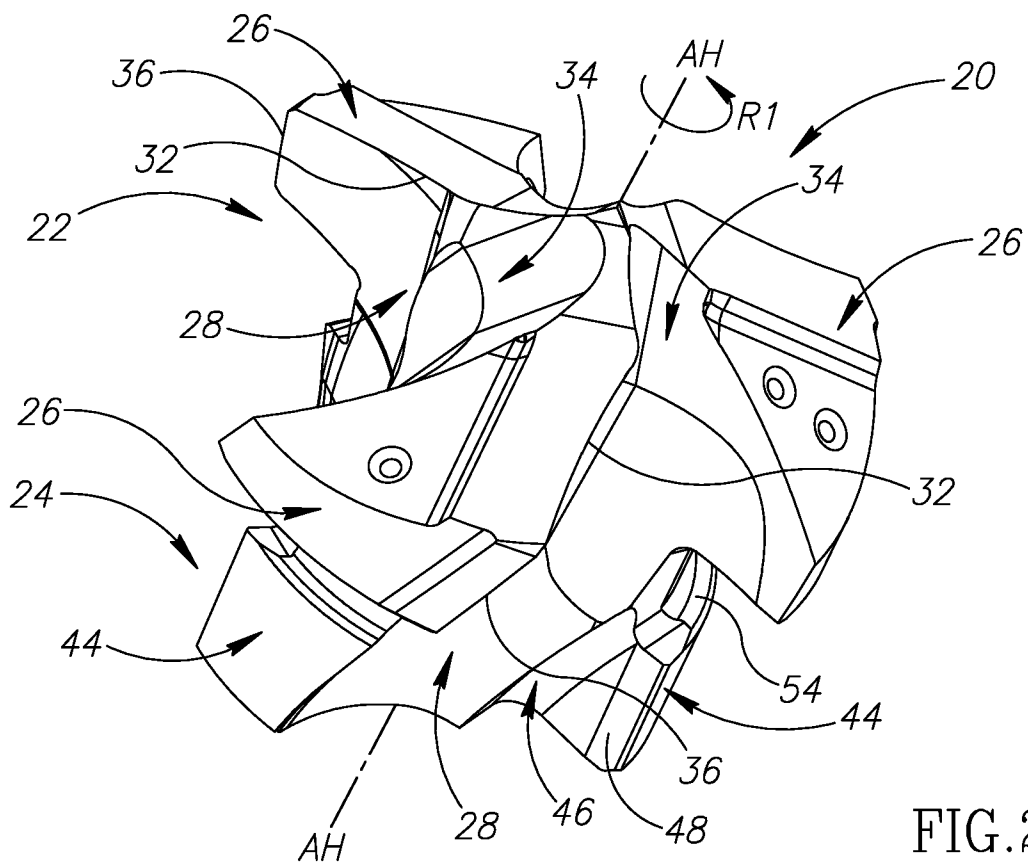
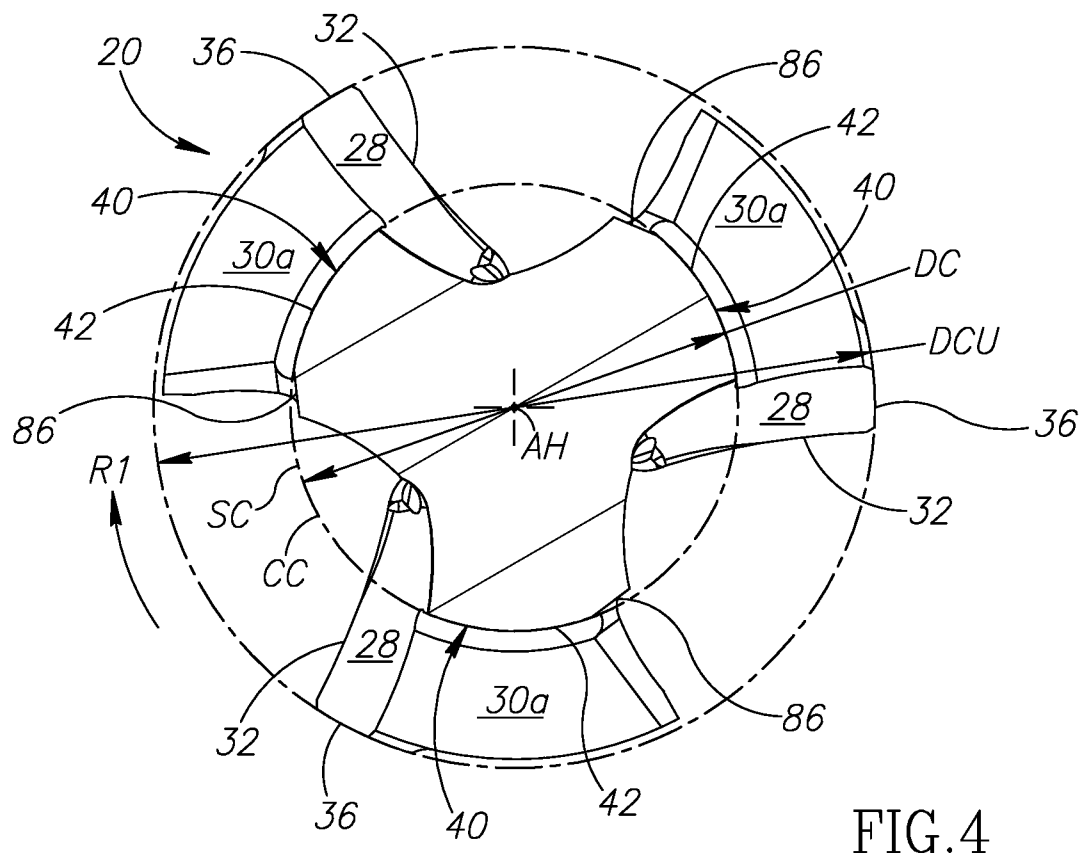
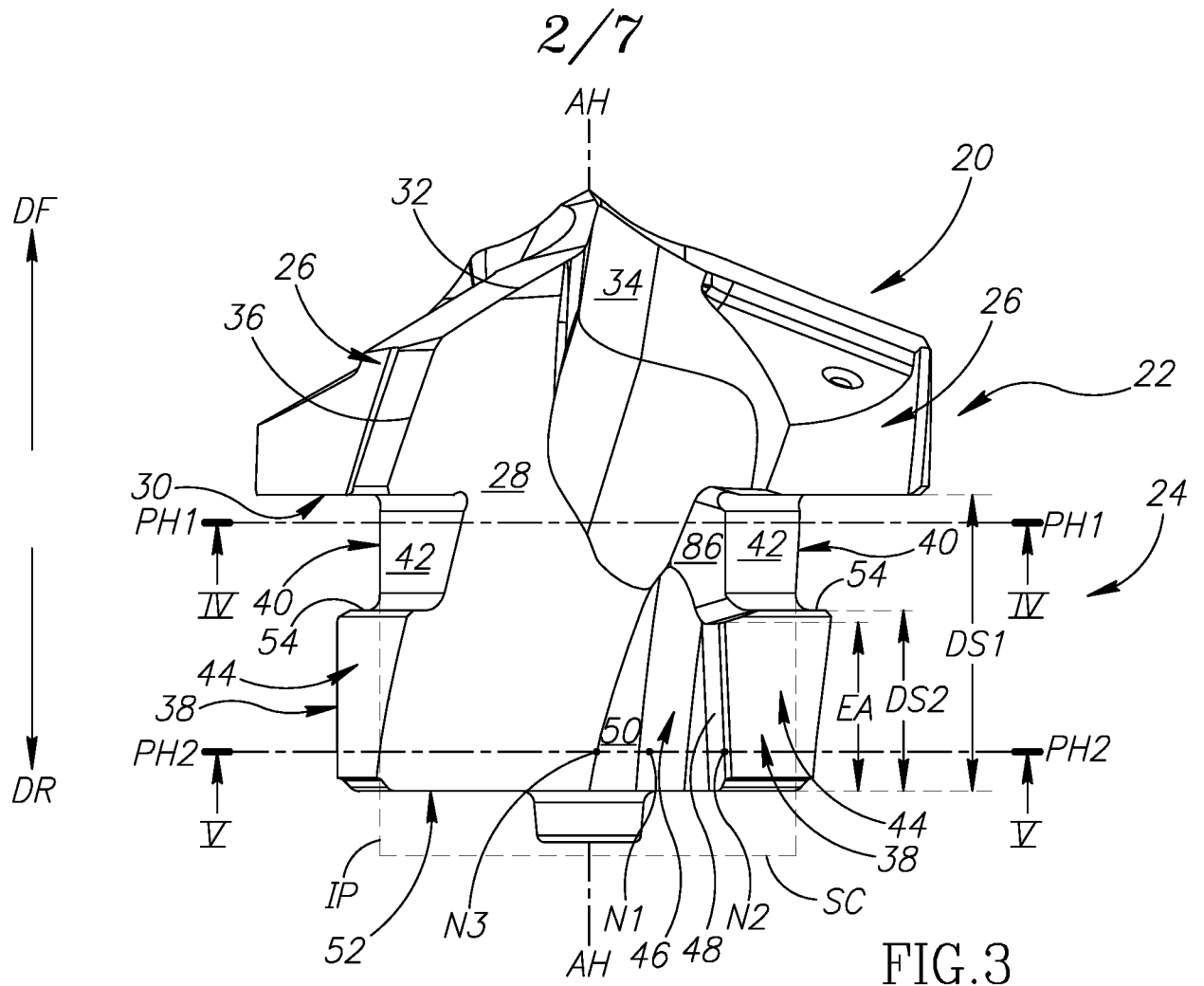


FIG.2



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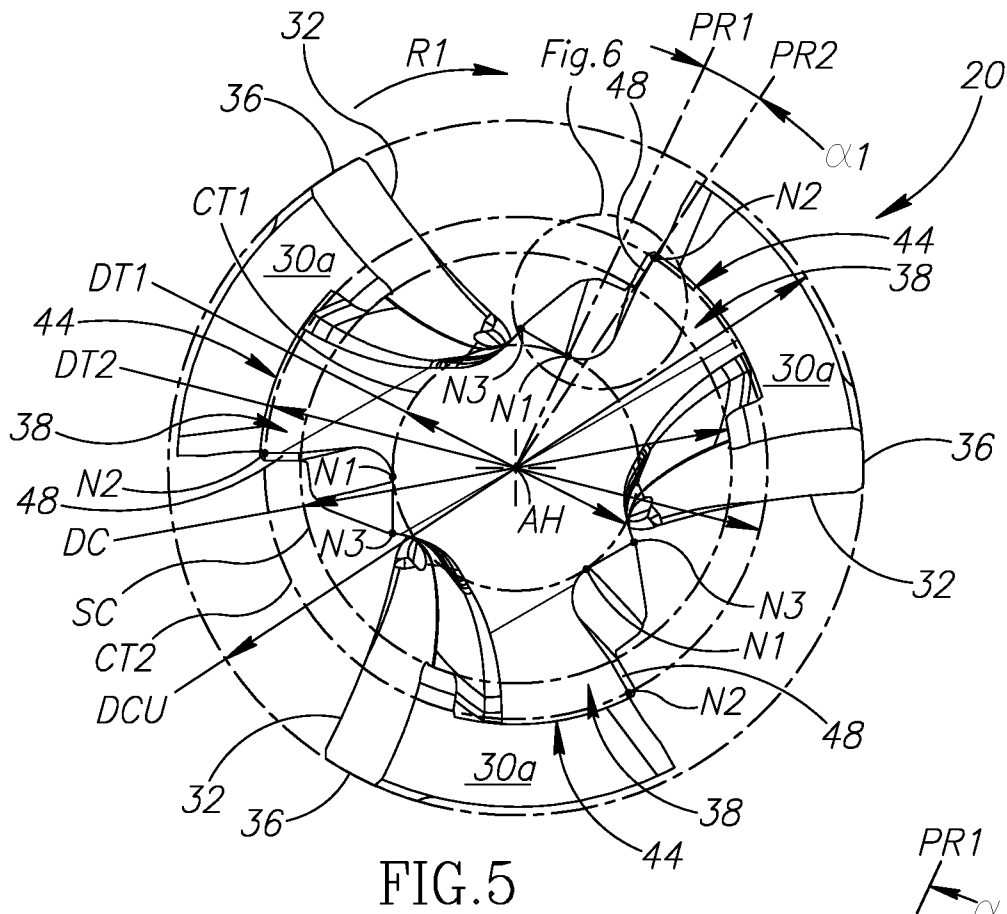


FIG. 5

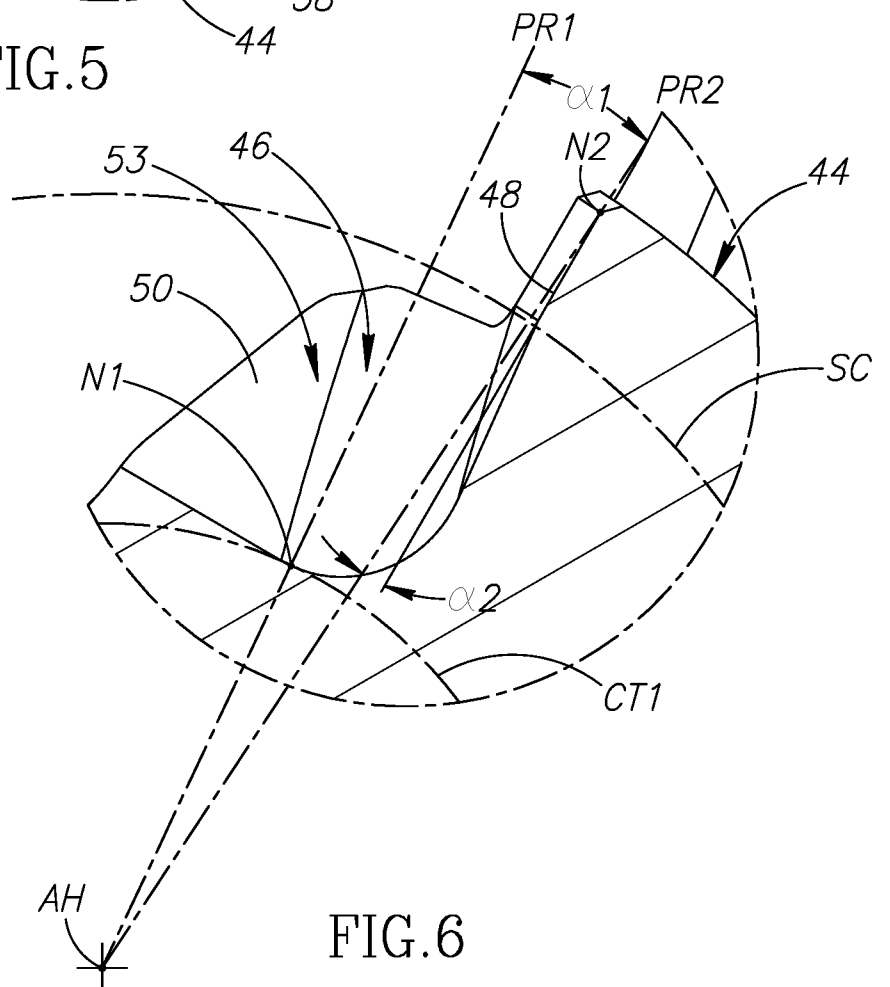
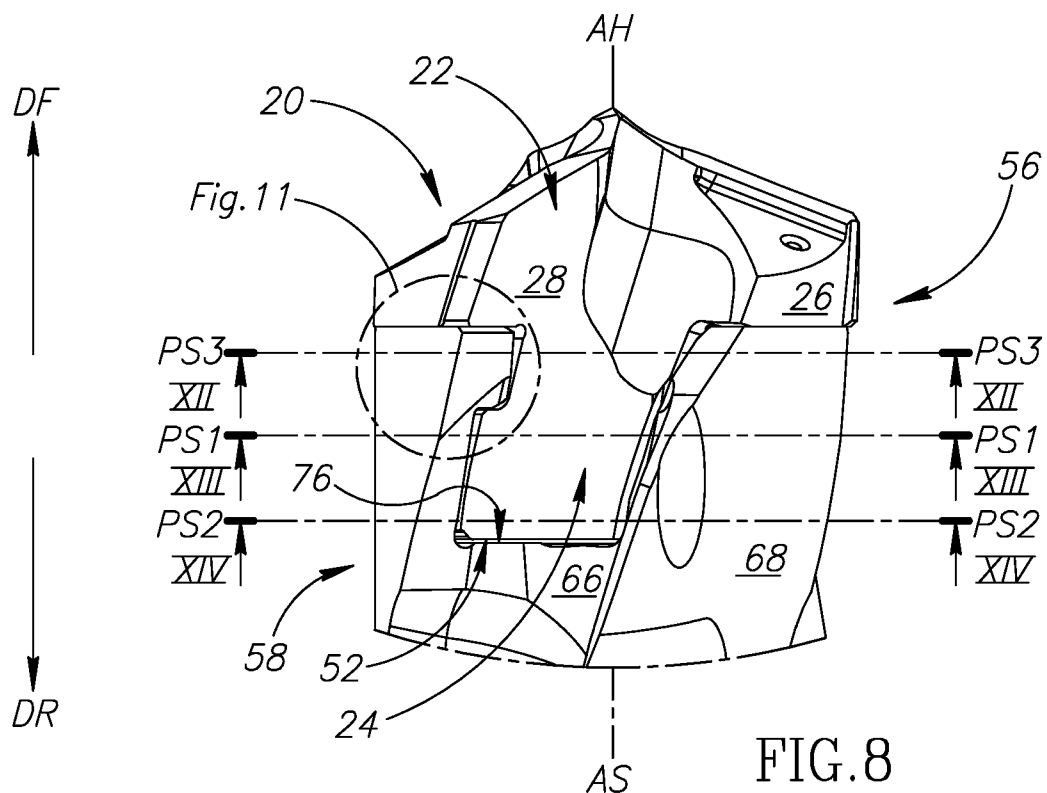
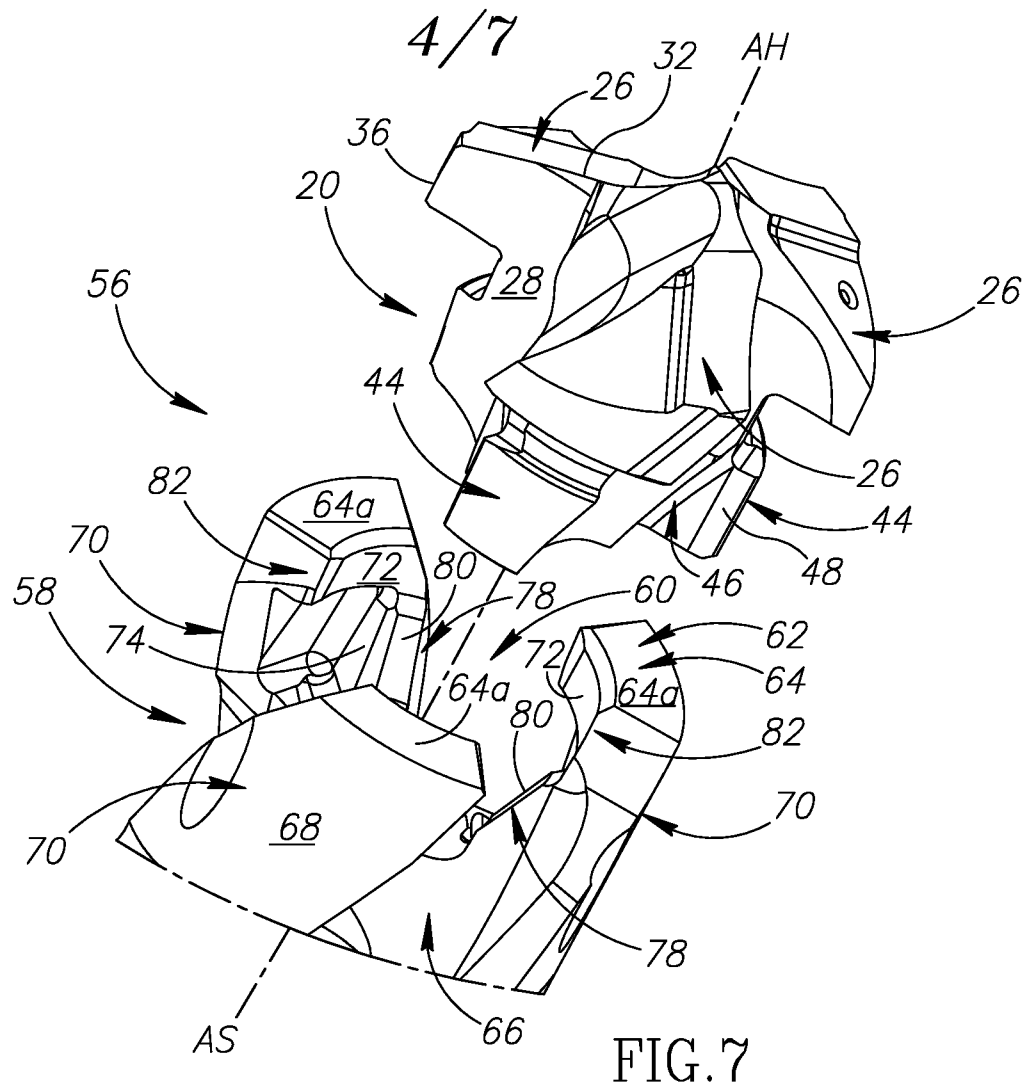


FIG. 6



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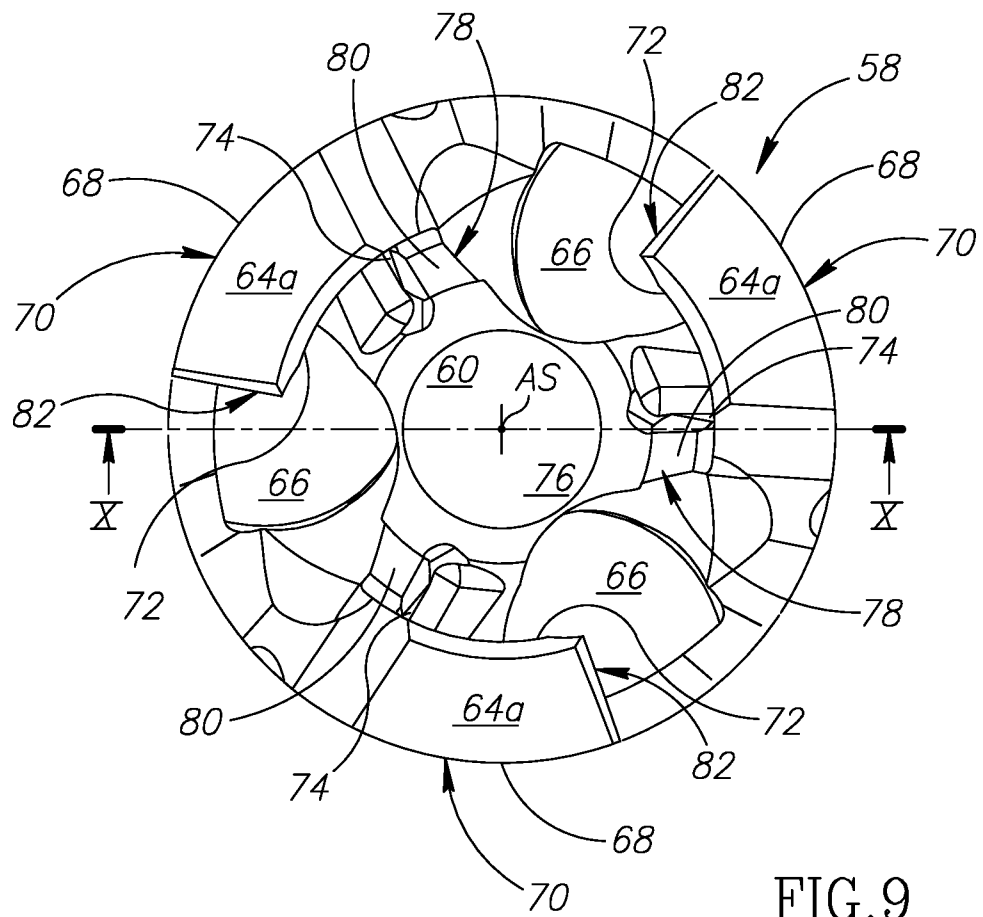


FIG. 9

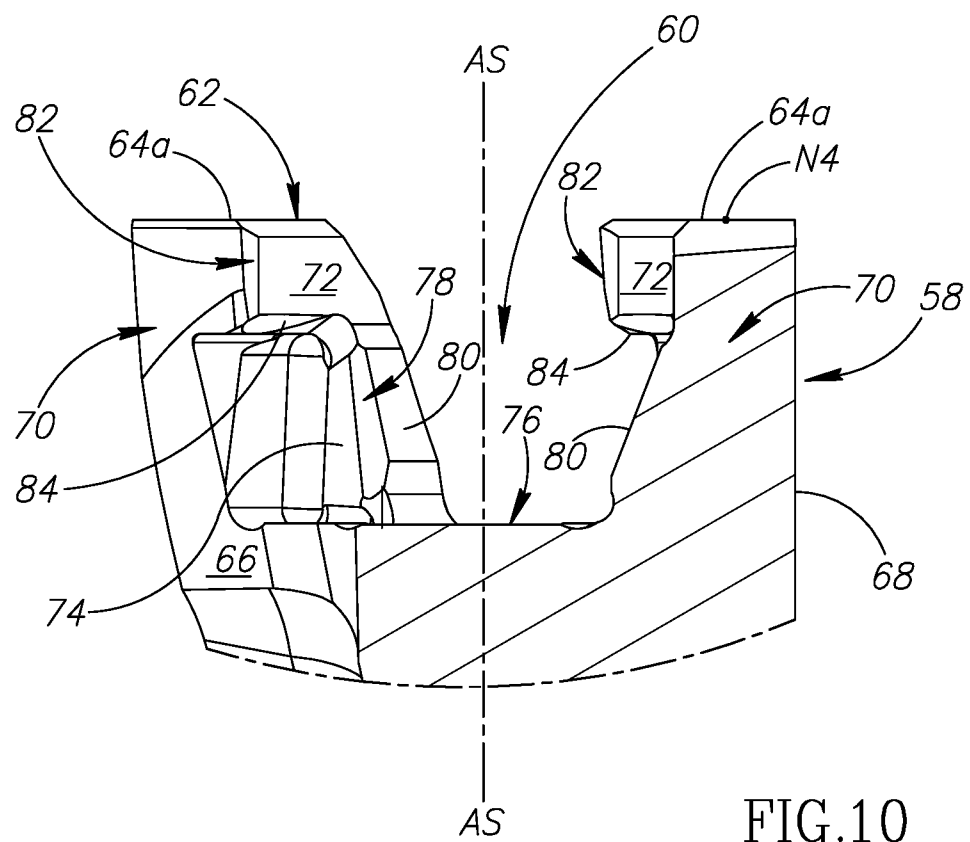


FIG. 10

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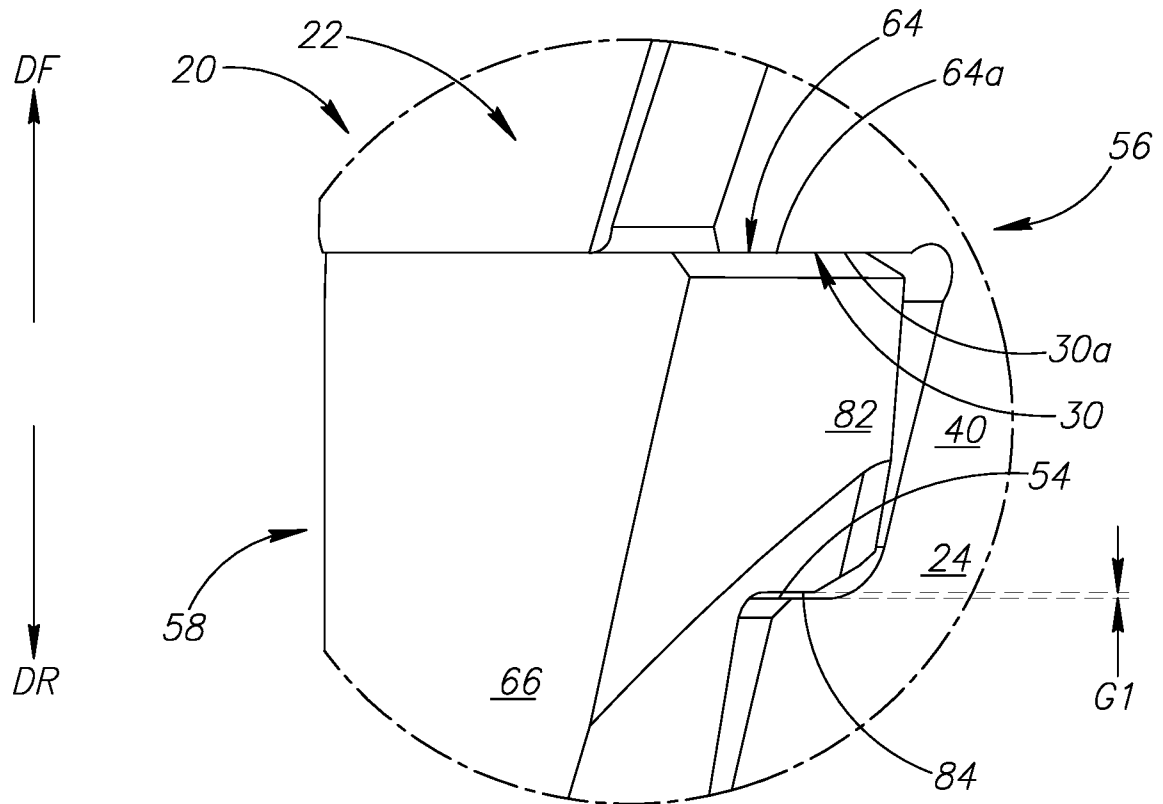
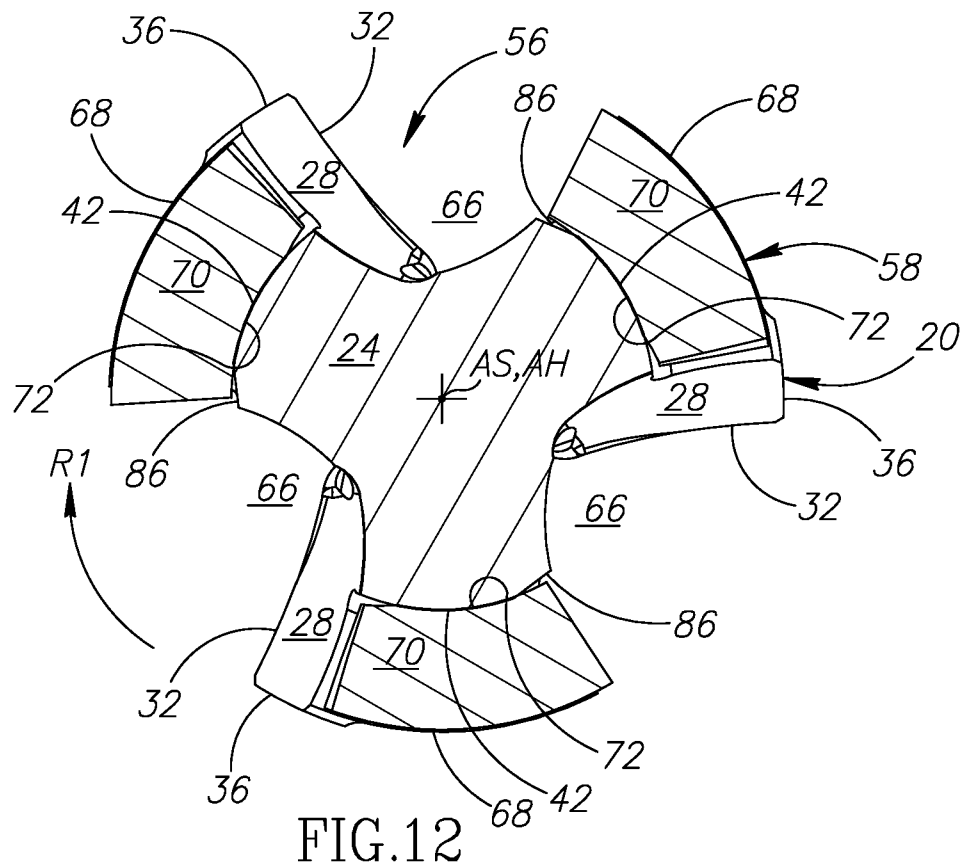


FIG.11



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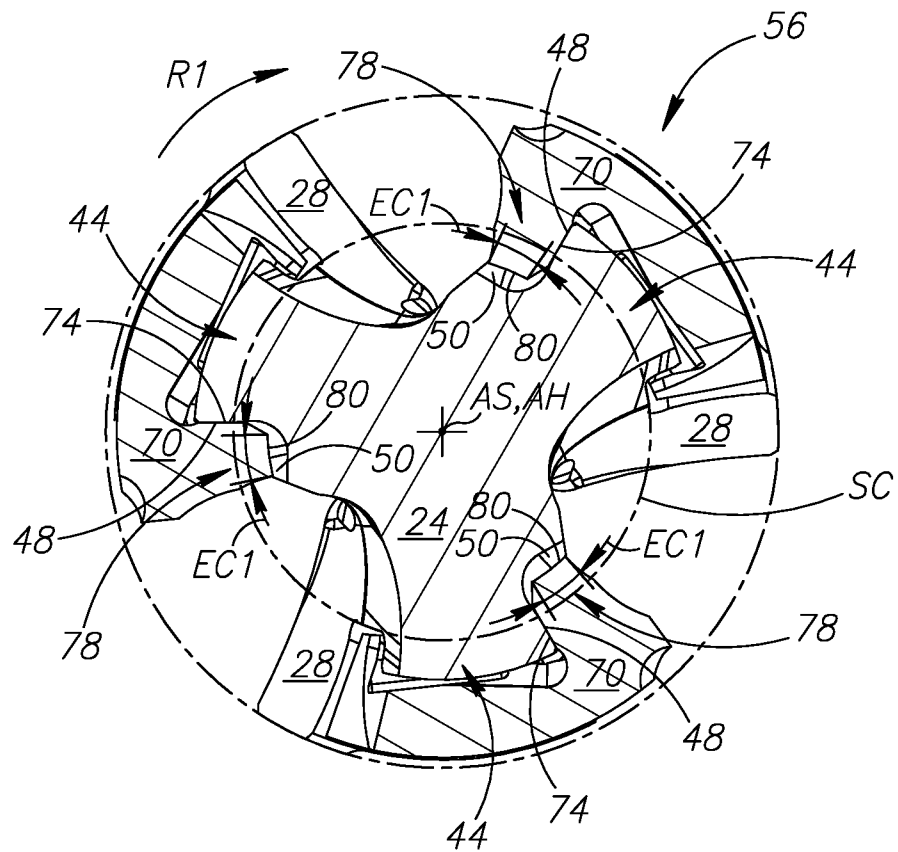


FIG.13

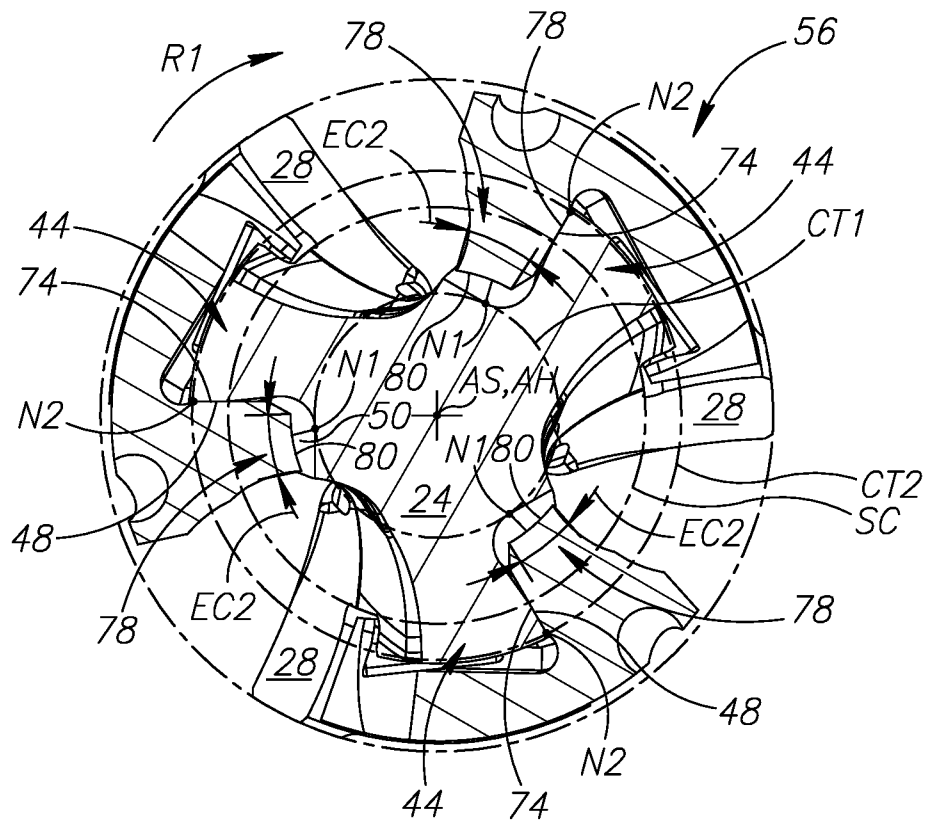


FIG.14

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2019/051323

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

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.
X	US 2017/100784 A1 (FROTA DE SOUZA FILHO RUY [US] ET AL) 13 April 2017 (2017-04-13) cited in the application pages 73-90; figures 1A-3E	1,2,4-14
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A	-----	1,24
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

31 January 2020

Date of mailing of the international search report

13/02/2020

Name and mailing address of the ISA/

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Lorence, Xavier

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IL2019/051323

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