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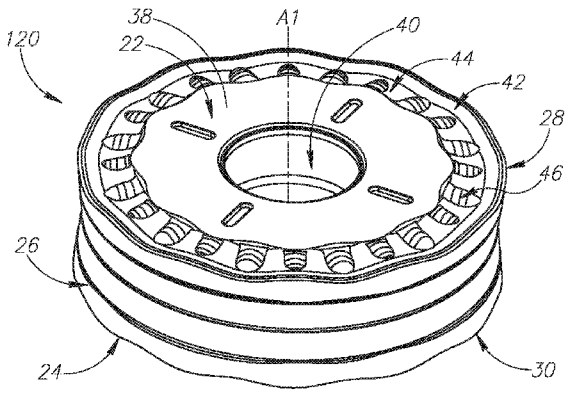

FIG.2A

(57) Abstract: A cutting tool has an insert holder with an indexable cutting insert (20, 120) removably secured therein. The cutting insert has upper and lower end surfaces (22, 24) with a peripheral side surface (26) and a through bore (40) extending therebetween, and a plurality of upper cutting edges (36) formed on an upper peripheral edge (28). The peripheral side surface (26) includes a non-circular upper relief surface (32) adjacent the upper peripheral edge (28) and a circular upper abutment surface (34a) spaced apart from the upper peripheral edge (28). Each upper cutting edge (36) exhibits mirror symmetry about a bisector plane, and is non-linear in a side view. The through bore (40) has an inner undercut formed by upper and lower bore surfaces located on opposite sides of a median plane, and a clamping member makes contact with one of the upper and lower bore surfaces at an inner contact zone located between the median plane and a seat surface of the insert holder.

CIRCULAR CUTTING INSERT HAVING NON-CIRCULAR PERIPHERAL EDGE

FIELD OF THE INVENTION

The present invention relates to a cutting tool and a cutting insert for use in metal cutting processes in general, and for turning and profiling operations in particular.

BACKGROUND OF THE INVENTION

Within the field of cutting tools used in turning and profiling operations, there are many examples of single-sided or double-sided cutting inserts that have a high degree of circularity in axial cross-sectional views and/or axial end views.

US 7,264,425 discloses a single-sided cutting insert in Figs. 3A-3C thereof, which is circular in an axial end view and non-circular in an axial cross-sectional view, due to its adjusted clearance surface, and which is suitable for turning operations.

US 7,677,145 discloses a double-sided cutting insert which is circular in both axial cross-sectional views and axial end views, and which is suitable for re-profiling railway vehicle wheels.

US 8,371,774 discloses a single-sided cutting insert in Figs. 1-4 thereof, which is circular in an axial end view and non-circular in an axial cross-sectional view, due to radial displacement of points along the cutting edge, and which is suitable for the longitudinal turning of flat faces.

It is an object of the present invention to provide an improved circular cutting insert having a non-circular peripheral edge, suitable for re-profiling railway vehicle wheels.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, there is provided an indexable cutting insert comprising:

opposing upper and lower end surfaces with a continuous peripheral side surface and a central axis extending therebetween,

upper and lower peripheral edges formed at the intersection of the peripheral side surface and the upper and lower end surfaces, respectively, and

a number N upper cutting edges formed on the upper peripheral edge, where $N \geq 2$,

the peripheral side surface including:

a continuous upper relief surface adjacent the upper peripheral edge which is non-circular in a cross-section taken in a first horizontal plane perpendicular to the central axis, and

a continuous upper abutment surface spaced apart from the upper peripheral edge which is circular in a cross-section taken in a second horizontal plane perpendicular to the central axis,

wherein:

each upper cutting edge exhibits mirror symmetry about a bisector plane containing the central axis;

in an end view of the cutting insert, the upper peripheral edge is non-circular and exhibits N-fold rotational symmetry about the central axis; and

in a side view of the cutting insert, each upper cutting edge is non-linear.

In accordance with another aspect of the disclosed subject matter, there is provided an indexable cutting insert comprising:

opposing upper and lower end surfaces with a continuous peripheral side surface and a central axis extending therebetween,

upper and lower peripheral edges formed at the intersection of the peripheral side surface and the upper and lower end surfaces, respectively,

a through bore coaxial with the central axis opening out to both the upper and lower end surfaces, the through bore having an upper bore surface and a lower bore surface, and

a median plane perpendicular to the central axis intersecting the through bore, midway between the upper and lower end surfaces;

wherein:

a cross-sectional area of the through bore perpendicular to the central axis is larger at the median plane than at points along the central axis closer to the upper and lower end surfaces;

the through bore and the peripheral side surface have inner and outer undercuts, respectively, with respect to an upward-downward direction parallel to the central axis; and

the inner and outer undercuts are visible in cross-sections taken in mutually perpendicular first and second vertical planes containing the central axis.

Also disclosed is a cutting tool comprising:

an insert holder having an insert receiving pocket formed in a front end thereof, the insert receiving pocket having a seat surface and a side wall transverse thereto, and

an indexable cutting insert in accordance with the aforementioned second aspect removably secured in the insert receiving pocket by a clamping member,

wherein:

one of the insert's upper and lower end surfaces faces towards the seat surface,

the clamping member makes contact with only one of the upper and lower bore surfaces at at least one inner contact zone; and

the at least one inner contact zone is entirely located between the median plane and the seat surface.

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. 1A is a perspective view of a cutting insert in accordance with a first embodiment of the present invention;

Fig. 1B is an end view of a cutting insert shown in Fig. 1A;

Fig. 1C is a side view of a cutting insert shown in Fig. 1A;

Fig. 1D is a cross-sectional cut view of the cutting insert shown in Fig. 1C, taken along the line D-D;

Fig. 1E is a cross-sectional cut view of the cutting insert shown in Fig. 1C, taken along the line E-E;

Fig. 1F is a cross-sectional view of the cutting insert shown in Fig. 1B, taken along the line F-F;

Fig. 1G is a cross-sectional view of the cutting insert shown in Fig. 1B, taken along the line G-G;

Fig. 1H is a cross-sectional view of the cutting insert shown in Fig. 1B, taken along the line H-H;

Fig. 2A is a perspective view of a cutting insert in accordance with a second embodiment of the present invention;

Fig. 2B is an end view of a cutting insert shown in Fig. 2A;

Fig. 2C is a side view of a cutting insert shown in Fig. 2A;

Fig. 2D is a cross-sectional cut view of the cutting insert shown in Fig. 2C, taken along the line D-D;

Fig. 2E is a cross-sectional cut view of the cutting insert shown in Fig. 2C, taken along the line E-E;

Fig. 2F is a cross-sectional view of the cutting insert shown in Fig. 2B, taken along the line F-F;

Fig. 2G is a cross-sectional view of the cutting insert shown in Fig. 2B, taken along the line G-G;

Fig. 2H is a cross-sectional view of the cutting insert shown in Fig. 2B, taken along the line H-H;

Fig. 3 is a perspective view of a cutting tool in accordance with some embodiments of the present invention;

Fig. 4 is a top view of the cutting tool shown in Fig. 3;

Fig. 5 is an exploded perspective view of the cutting tool shown in Fig. 3;

Fig. 6 is a cross-sectional view of the cutting tool shown in Fig. 5, taken along the line VI-VI;

Fig. 7 is a cross-sectional view of the cutting tool shown in Fig. 6, taken along the line VII-VII;

Fig. 8 is a side view of the cutting tool shown in Fig. 3;

Fig. 9 is a front view of the cutting tool shown in Fig. 3;

Fig. 10 is a cross-sectional view of the cutting tool shown in Fig. 5, taken along the line X-X; and

Fig. 11 is a cross-sectional view of the cutting tool shown in Fig. 6, taken along the line XI-XI.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to an indexable cutting insert **20, 120**, as shown in Figs. 1A-1C and 2A-2C, having opposing upper and lower end surfaces **22**, **24** with a continuous peripheral side surface **26** and a central axis **A1** extending therebetween.

Upper and lower peripheral edges **28**, **30** are formed at the intersection of the peripheral side surface **26** and the upper and lower end surfaces **22**, **24**, respectively.

In some embodiments of the present invention the cutting insert **20**, **120** may be indexable about the central axis **A1**.

In some embodiments of the present invention, the cutting insert **20, 120** may preferably be manufactured by form pressing and sintering a cemented carbide, such as tungsten carbide, and may be coated or uncoated.

In a first aspect of the present invention, the peripheral side surface **26** includes a continuous upper relief surface **32** adjacent the upper peripheral edge **28** and a continuous upper abutment surface **34a** spaced apart from the upper peripheral edge **28**.

In the first aspect of the present invention, as shown in Figs. 1D and 2D, the upper relief surface **32** is non-circular in a cross-section taken in a first horizontal plane P_{H1} perpendicular to the central axis **A1**, and as shown in Figs. 1E and 2E, the upper abutment surface **34a** is circular in a cross-section taken in a second horizontal plane P_{H2} perpendicular to the central axis **A1**.

It should be appreciated that the non-circularity of the upper relief surface **32** in Figs. 1D and 2D has been exaggerated to provide an improved understanding of the invention.

Also in the first aspect of the present invention, a number **N** ($N \geq 2$) upper cutting edges **36** are formed on the upper peripheral edge **28**, with each upper cutting edge **36** exhibiting mirror symmetry about a bisector plane P_B containing the central axis **A1**.

As shown in Figs. 1C and 2C, in a side view of the cutting insert **20**, **120**, each upper cutting edge **36** is non-linear.

As shown in Figs. 1B and 2B, in an end view of the cutting insert **20**, **120**, the upper peripheral edge **28** is non-circular and exhibits **N**-fold rotational symmetry about the central axis **A1**, thus providing the cutting insert **20**, **120** with **N** index positions.

It should be appreciated that the non-circularity of the upper peripheral edge **28** in Figs. 1B and 2B has been exaggerated to provide an improved understanding of the invention.

Although the upper peripheral edge **28** is non-circular in an end view of the cutting insert **20**, **120**, by tilting the cutting insert **20**, **120** in one of the bisector planes P_B, as shown in Fig. 4, the associated operative upper cutting edge **36** may present a substantially constant upper radius of curvature R_U to engage a rotating workpiece, making the cutting insert **20**, **120** particularly suitable for re-profiling railway vehicle wheels.

As shown in Figs. 1B and 2B, in an end view of the cutting insert **20**, **120**, a first imaginary circle **C1** may circumscribe the upper peripheral edge **28** at **N** discrete radially outermost points **No1**, **No2**, **No3**, **No4**.

In some embodiments of the present invention, the upper radius of curvature R_U may be greater than the radius of the first imaginary circle **C1**.

Also in some embodiments of the present invention, the upper radius of curvature R_U may be no more than 5% greater than the radius of the first imaginary circle **C1**.

Further in some embodiments of the present invention, each upper cutting edge **36** may extend between two of the **N** radially outermost points **No1**, **No2**, **No3**, **No4**.

Yet further in some embodiments of the present invention, any two circumferentially adjacent upper cutting edges **36** may merge at one of the **N** radially outermost points **No1**, **No2**, **No3**, **No4**, and the two end points of each upper cutting edge **36** may be coincident with two of the **N** radially outermost points **No1**, **No2**, **No3**, **No4**.

When considering the cutting insert **20** in a first embodiment of the present invention, as shown in Fig. 1C, the **N** radially outermost points **No1**, **No2**, **No3**, **No4** may be located closer to the second horizontal plane P_{H2} than any other point on the upper peripheral edge **28**.

By virtue of the **N** radially outermost points **No1**, **No2**, **No3**, **No4** being located closer to the second horizontal plane **P_{H2}** than any other point on the upper peripheral edge **28**, the height of each upper cutting edge **36** increases as it extends from each of its two end points towards its associated bisector plane **P_B**, such that the operative upper cutting edge **36** advantageously directs cutting chips away from the rotating workpiece.

When considering the cutting insert **120** in a second embodiment of the present invention, as shown in Fig. 2C, each upper cutting edge **36** may have a plurality of discrete axially uppermost points **Nu1**, **Nu2**, **Nu3**, **Nu4** located further from the second horizontal plane **P_{H2}** than any other point on the said upper cutting edge **36**.

Also in the second embodiment of the present invention, two of the axially uppermost points **Nu1**, **Nu4** of each upper cutting edge **36** may be coincident with two of the **N** radially outermost points **No1**, **No2**, **No3**, **No4**.

As shown in Fig. 2C, in a side view of the cutting insert **120**, each upper cutting edge **36** may be wave shaped.

By virtue of each upper cutting edge **36** having a plurality of discrete axially uppermost points **Nu1**, **Nu2**, **Nu3**, **Nu4** and being wave shaped, enables cutting operations to be performed with a relatively low cutting force and improves chip breakage and removal.

It should be appreciated that apart from instances of specific reference to either the first or second embodiments of the invention, the description and claims is applicable to some embodiments of the present invention, which includes both the first and second embodiments of the present invention.

In some embodiments of the present invention, each upper cutting edge **36** may circumferentially extend 360/**N**° along the upper peripheral edge **28**.

Also in some embodiments of the present invention, the upper peripheral edge **28** may have exactly four upper cutting edges **36**, and **N**=4.

As shown in Figs. 1B and 2B, in an end view of the cutting insert **20**, **120**, each upper cutting edge **36** may be non-linear.

Also as shown in Figs. 1B and 2B, in an end view of the cutting insert **20**, **120**, each upper cutting edge **36** may be outwardly convex in relation to the central axis **A1**.

In some embodiments of the present invention, any point on the upper peripheral edge **28** may be located further from the central axis **A1** than any point on the upper abutment surface **34a**.

Also in some embodiments of the present invention, the upper peripheral edge **28** may have **N** radially innermost points **NI1**, **NI2**, **NI3**, **NI4**, each contained in at least one of the bisector planes **PB**.

As shown in Figs. 1C, 1E and 2C, 2E, the upper abutment surface **34a** may be conical, having an upper abutment diameter **DU** which decreases in a direction away from the upper end surface **22**.

Also as shown in Figs. 1C and 2C, the upper end surface **22** may include a planar upper support surface **38**, and the upper peripheral edge **28** may be entirely located closer to the second horizontal plane **PH2** than the upper support surface **38**.

In some embodiments of the present invention, a through bore **40** coaxial with the central axis **A1** may open out to the upper support surface **38**.

As shown in Figs. 1A, 1B and 2A, 2B, the upper end surface **22** may include a continuous rake surface **42** adjacent to the upper peripheral edge **28** and a ramp surface **44** adjacent to the upper support surface **38**.

In some embodiments of the present invention, as shown in Figs. 1F and 2F, the rake surface **42** may extend radially inwardly towards the second horizontal plane **PH2**, and the ramp surface **44** may extend radially outwardly towards the second horizontal plane **PH2**.

Also in some embodiments of the present invention, as shown in Figs. 1A, 1B and 2A, 2B, the ramp surface **44** may be interrupted by a plurality of circumferentially spaced apart protrusions **46**.

Further in some embodiments of the present invention, each of the protrusions **46** may be partially located on the rake surface **42**.

As shown in Figs. 1B and 2B, in an end view of the cutting insert **20**, **120**, each of the protrusions **46** may include a convex shaped radially outer portion **48**.

In some embodiments of the present invention, the plurality of protrusions **46** may be greater in number than the plurality of **N** upper cutting edges **36**.

Also in some embodiments of the present invention, the plurality of protrusions **46** may be greater in number, by at least a factor of six, than the plurality of **N** upper cutting edges **36**.

As shown in Figs. 1C and 2C, the peripheral side surface **26** may include a continuous lower relief surface **50** adjacent the lower peripheral edge **30** and a continuous lower abutment surface **34b** spaced apart from the lower peripheral edge **30**.

In some embodiments of the present invention, the lower relief surface **50** may be identical to the upper relief surface **32**, and the lower abutment surface **34b** may be identical to upper abutment surface **34a**.

Also in some embodiments of the present invention, the lower peripheral edge **30** may be identical to the upper peripheral edge **28**, having a plurality of **N** lower cutting edges **52** formed thereon, and the cutting insert **20**, **120** may be described as 'double-sided' having a total of **N***2 upper and lower cutting edges **36**, **52**.

On reversing the 'double-sided' cutting insert **20**, **120** and tilting the cutting insert **20**, **120** in one of the bisector planes P_B, as shown in Fig. 4, the associated operative lower cutting edge **52** may present a substantially constant lower radius of curvature R_L to engage the rotating workpiece.

By tilting the 'double-sided' cutting insert **20**, **120** sufficient clearance is provided between the peripheral side surface **26** and the rotating workpiece.

In some embodiments of the present invention, the lower radius of curvature R_L may be equal to the upper radius of curvature R_U.

As shown in Figs. 1F-1H and 2F-2H, a median plane **M** perpendicular to the central axis **A1** may intersect the through bore **40**.

In some embodiments of the present invention, the median plane **M** may be located midway between the upper and lower end surfaces **22**, **24**.

Also in some embodiments of the present invention, the through bore **40** may exhibit mirror symmetry about the median plane **M**.

Further in some embodiments of the present invention, the peripheral side surface **26** may exhibit mirror symmetry about the median plane **M**.

Yet further in some embodiments of the present invention, the cutting insert **20**, **120** may exhibit mirror symmetry about the median plane **M**, and the upper relief and upper abutment surfaces **32**, **34a** may be located between the upper end surface **22** and the median plane **M**.

In a second aspect of the present invention, the through bore **40** opens out to both the upper and lower end surfaces **22**, **24**.

Also in the second aspect of the present invention, the through bore **40** and the peripheral side surface **26** have inner and outer undercuts **54**, **56**, respectively, with respect to an upward-downward direction D_{UD} parallel to the central axis **A1**.

Further in the second aspect of the present invention, as shown in Figs. 1G and 2G, the inner and outer undercuts **54**, **56** are visible in the cross-sections taken in mutually perpendicular first and second vertical planes **Pv1**, **Pv2** containing the central axis **A1**.

It should be appreciated that use of the term "undercut" throughout the description and claims refers to a recess or passage, where a straight line extending in the upward-downward direction **DUD** from a given sub-surface of the recess or passage intersects another sub-surface of the same recess or passage.

As shown in Figs. 1H and 2H, the inner and outer undercuts **54**, **56** may also be visible in a cross-section taken in a third vertical plane **Pv3** containing the central axis **A1** and bisecting the first and second vertical planes **Pv1**, **Pv2**.

In some embodiments of the present invention, the inner and outer undercuts **54**, **56** may be visible in a cross-section taken in any plane containing the central axis **A1**.

As shown in Figs. 1G and 2G, in the cross-sections taken in the first and second vertical planes **Pv1**, **Pv2**, the through bore **40** may exhibit mirror symmetry about the second and first vertical planes **Pv2**, **Pv1**, respectively.

In some embodiments of the present invention, the inner undercut **54** may be formed by upper and lower bore surfaces **58a**, **58b** of the through bore **40**, and the upper and lower bore surfaces **58a**, **58b** may be entirely located on opposite sides of the median plane **M**.

Also in some embodiments of the present invention, the upper and lower bore surfaces **58a**, **58b** may be spaced apart from one another by a median bore surface **58c**.

As shown in Figs. 1E and 2E, the upper and lower bore surfaces **58a**, **58b** may be circular in cross-sections taken in third and fourth horizontal planes **PH3**, **PH4**, respectively, perpendicular to the central axis **A1**.

In some embodiments of the present invention, the second and third horizontal planes **PH2**, **PH3** may be coplanar.

In other embodiments of the present invention (not shown), the first and third horizontal planes **PH1**, **PH3** may be coplanar.

As shown in Figs. 1G and 2G, in the cross-sections taken in the first and second vertical planes **Pv1**, **Pv2**, the upper and lower bore surfaces **58a**, **58b** may form a V-shape.

Also shown in Figs. 1G and 2G, in the cross-sections taken in the first and second vertical planes **Pv1**, **Pv2**, the upper and lower bore surfaces **58a**, **58b** may form an external obtuse bore angle **α1**.

It should be appreciated that use of the term "external angle" throughout the description and claims refers to an angle between two surface components as measured external to the member on which these components are formed.

In some embodiments of the present invention, the obtuse bore angle **α1** may have a value equal to or greater than 160°.

Also as shown in Figs. 1G and 2G, in the cross-sections taken in the first and second vertical planes **Pv1**, **Pv2**, the peripheral side surface **26** may exhibit mirror symmetry about the second and first vertical planes **Pv2**, **Pv1**, respectively.

In some embodiments of the present invention, the outer undercut **56** may be formed by the upper and lower abutment surfaces **34a**, **34b**, and the upper and lower abutment surfaces **34a**, **34b** may be entirely located on opposite sides of the median plane **M**.

Also in some embodiments of the present invention, the upper and lower abutment surfaces **34a**, **34b** may be spaced apart by a median peripheral surface **34c**.

As shown in Figs. 1G and 2G, in the cross-sections taken in the first and second vertical planes **Pv1**, **Pv2**, the upper and lower abutment surfaces **34a**, **34b** may form a V-shape.

In some embodiments of the present invention, in a cross-section taken in any plane containing the central axis **A1**, the upper and lower abutment surfaces **34a**, **34b** may form a V-shape.

As shown in Figs. 1G and 2G, in the cross-sections taken in the first and second vertical planes **Pv1**, **Pv2**, the upper and lower abutment surfaces **34a**, **34b** may form an external obtuse abutment angle **α2**.

In some embodiments of the present invention, the obtuse abutment angle **α2** may have a value equal to or greater than 160°.

Also in some embodiments of the present invention, both the upper and lower end surfaces **22**, **24** may include planar upper and lower support surfaces **38**, **60**, respectively, and the through bore **40** may open out to the upper and lower support surfaces **38**, **60**.

As shown in Figs. 1C and 2C, the upper and lower peripheral edges **28**, **30** may be entirely located closer to the median plane **M** than the upper and lower support surfaces **38**, **60**, respectively.

In some embodiments of the present invention, the upper and lower support surfaces **38**, **60** may be perpendicular to the central axis **A1**.

As shown in Figs. 3 to 5, the second aspect of the present invention also relates to a cutting tool **62** having an insert holder **64** with an insert receiving pocket **66** formed in a front end **68** thereof, and the cutting insert **20**, **120** removably secured in the insert receiving pocket **66** by a clamping member **70**.

In the second aspect of the present invention, the insert receiving pocket **66** has a seat surface **72** and a side wall **74** transverse thereto, and one of the upper and lower end surfaces **22**, **24** faces towards the seat surface **72**.

In some embodiments of the present invention, as shown in Fig. 6, the seat surface **72** may be planar, and the median plane **M** may be parallel to the seat surface **72**.

Also in some embodiments of the present invention, only one of the upper and lower cutting edges **36**, **52** may be operative, and the operative upper or lower cutting edge **36**, **52** may be associated with the one of the upper and lower end surfaces **22**, **24** facing away from the seat surface **72**.

In the second aspect of the present invention, as shown in Fig. 6, the clamping member **70** makes contact with only one of the upper and lower bore surfaces **58a**, **58b** at at least one inner contact zone Z_I, and the at least one inner contact zone Z_I is entirely located between the median plane **M** and the seat surface **72**.

As shown in Fig. 7, in a cross-section taken in an inner contact plane P_I intersecting the at least one inner contact zone Z_I and perpendicular to the central axis **A1**, the through bore **40** may be circular.

Also as shown in Fig. 7, the peripheral side surface **26** may not make contact with the side wall **74** in the cross-section taken in the inner contact plane P_I.

In some embodiments of the present invention, the clamping member **70** may make contact with one of the upper and lower bore surfaces **58a**, **58b** at a single inner contact zone Z_I, and the third vertical plane **Pv3**, bisecting the first and second vertical planes **Pv1**, **Pv2**, may intersect the single inner contact zone Z_I and the side wall **74**.

As shown in Fig. 6, in the cross-section taken in the third vertical plane **Pv3**, the upper and lower bore surfaces **58a**, **58b** may form a V-shape.

By virtue of the upper and lower bore surfaces **58a**, **58b** forming a V-shape in the cross-section taken in the third vertical plane **Pv3**, a clamping force **Fc** exerted at the inner contact zone **ZI** by the clamping member **70** may advantageously have a vertical component directed towards the seat surface **72**, thus ensuring firm and stable clamping.

In some embodiments of the present invention, the insert holder **64** may have opposing top and bottom holder surfaces **76**, **78**, and the insert receiving pocket **66** may be located adjacent to the top holder surface **76**.

Also in some embodiments of the present invention, the bottom holder surface **78** may be planar, and the central axis **A1** may intersect the bottom holder surface **78** and be non-perpendicular thereto.

As shown in Figs. 8 and 9, in side and front views of the cutting tool **62**, the central axis **A1** may form first and second inclination angles **β1**, **β2**, respectively, with first and second imaginary straight lines **L1**, **L2** perpendicular to the bottom holder surface **78**.

In some embodiments of the present invention, the first and second inclination angles **β1**, **β2** may have equal values of between 1 and 3 degrees.

Also in some embodiments of the present invention, the first and second inclination angles **β1**, **β2** may correspond to the extent of tilting of the cutting insert **20**, **120**, required for the operative upper or lower cutting edge **36**, **52** to present substantially constant radii of curvature **RU**, **RL** to engage the rotating workpiece.

In some embodiments of the present invention, only one of the upper and lower abutment surfaces **34a**, **34b** may make contact with the side wall **74** of the insert receiving pocket **66** at two spaced apart outer contact zones **Zo1**, **Zo2**, and the two outer contact zones **Zo1**, **Zo2** may be entirely located between the median plane **M** and the seat surface **72**.

As shown in Figs. 10 and 11, the two outer contact zones **Zo1**, **Zo2** may be comprised of first and second outer contact zones **Zo1**, **Zo2**, and the first and second vertical planes **Pv1**, **Pv2** may intersect the first and second outer contact zones **Zo1**, **Zo2**, respectively.

By virtue of the upper and lower abutment surfaces **34a**, **34b** forming a V-shape in the cross-sections taken in the first and second vertical planes **Pv1**, **Pv2**, reaction forces **FR** at the two outer contact zones **Zo1**, **Zo2**, directed away from the side wall **74** of the insert receiving

pocket **66**, may advantageously have vertical components directed towards the seat surface **72**, thus ensuring firm and stable clamping.

As shown in Fig. 11, in a cross-section taken in an outer contact plane **Po** intersecting the two outer contact zones **Zo1**, **Zo2** and perpendicular to the central axis **A1**, the two outer contact zones **Zo1**, **Zo2** may be located an equal radial contact distance **DR** from the central axis **A1**.

Also as shown in Fig. 11, the peripheral side surface **26** may be circular in the cross-section taken in the outer contact plane **Po**, enabling the cutting insert **20**, **120** to be indexed about the central axis **A1** without being removed from the insert receiving pocket **66**.

Further as shown in Fig. 11, the clamping member **70** may not make contact with the through bore **40** in the cross-section taken in the outer contact plane **Po**.

In some embodiments of the present invention, the inner contact plane **PI** may be located closer to the seat surface **72** than the outer contact plane **Po**, thus ensuring that any moment of force, resulting from the clamping force **FC** and the reaction forces **FR**, urges the cutting insert **20**, **120** towards the seat surface **72**.

Visual markings adjacent the upper and lower cutting edges **36**, **52**, and a visual reference marking on the insert holder **64**, may be provided to assist an operator when indexing the cutting insert **20**, **120**.

In some embodiments of the present invention, a shim **80** having opposing top and bottom shim surfaces **82**, **84** may be located between the cutting insert **20**, **120** and the seat surface **72**.

As shown in Figs. 5, the one of the upper and lower end surfaces **22**, **24** facing towards the seat surface **72** makes contact with the top shim surface **82**, and the bottom shim surface **84** makes contact with the seat surface **72**.

In some embodiments of the present invention, the clamping member **70** may be non-threadingly retained in the insert holder **64**.

Also in some embodiments of the present invention, the clamping member **70** may be in the form of a clamping lever **86** operatively connected to an actuating member **88**.

As shown in Fig. 6, the actuating member **88** may be threadingly retained in the insert holder **64** and not make contact with the cutting insert **20**, **120**.

While the present invention has been described with reference to one or more specific embodiments, the description is intended to be illustrative as a whole and is not to be construed

as limiting the invention to the embodiments shown. It is appreciated that various modifications may occur to those skilled in the art that, while not specifically shown herein, are nevertheless within the scope of the invention.

CLAIMS

What is claimed is:

1. An indexable cutting insert (20, 120) comprising:

opposing upper and lower end surfaces (22, 24) with a continuous peripheral side surface (26) and a central axis (A1) extending therebetween,

upper and lower peripheral edges (28, 30) formed at the intersection of the peripheral side surface (26) and the upper and lower end surfaces (22, 24), respectively, and

a number N upper cutting edges (36) formed on the upper peripheral edge (28) where $N \geq 2$,

the peripheral side surface (26) including:

a continuous upper relief surface (32) adjacent the upper peripheral edge (28) which is non-circular in a cross-section taken in a first horizontal plane (P_{H1}) perpendicular to the central axis (A1), and

a continuous upper abutment surface (34a) spaced apart from the upper peripheral edge (28) which is circular in a cross-section taken in a second horizontal plane (P_{H2}) perpendicular to the central axis (A1),

wherein:

each upper cutting edge (36) exhibits mirror symmetry about a bisector plane (P_B) containing the central axis (A1);

in an end view of the cutting insert (20, 120), the upper peripheral edge (28) is non-circular and exhibits N-fold rotational symmetry about the central axis (A1); and

in a side view of the cutting insert (20, 120), each upper cutting edge (36) is non-linear.

2. The cutting insert (20, 120) according to claim 1, wherein each upper cutting edge (36) circumferentially extends 360/N° along the upper peripheral edge (28).

3. The cutting insert (20, 120) according to claim 1 or 2, wherein the upper abutment surface (34a) is conical, having an upper abutment diameter (D_U) which decreases in a direction away from the upper end surface (22).

4. The cutting insert (20, 120) according to any of the preceding claims, wherein any point on the upper peripheral edge (28) may be located further from the central axis (A1) than any point on the upper abutment surface (34a).

5. The cutting insert (20, 120) according to any of the preceding claims, wherein:

the cutting insert (20, 120) exhibits mirror symmetry about a median plane (M) perpendicular to the central axis (A1), and

the upper relief and upper abutment surfaces (32, 34a) are located between the upper end surface (22) and the median plane (M).

6. The cutting insert (20, 120) according to any of the preceding claims, wherein in an end view of the cutting insert (20, 120), each upper cutting edge (36) is non-linear.

7. The cutting insert (20, 120) according to any of the preceding claims, wherein in an end view of the cutting insert (20, 120), each upper cutting edge (36) is outwardly convex in relation to the central axis (A1).

8. The cutting insert (20, 120) according to any of the preceding claims, wherein:

the peripheral side surface (26) includes a continuous lower relief surface (50) adjacent the lower peripheral edge (30) and a continuous lower abutment surface (34b) spaced apart from the lower peripheral edge (30); and

the lower relief surface (50) is identical to the upper relief surface (32); and

the lower abutment surface (34b) is identical to upper abutment surface (34a).

9. The cutting insert (20, 120) according to claim 8, wherein in cross-sections taken in mutually perpendicular first and second vertical planes (Pv1, Pv2) containing the central axis (A1), the upper and lower abutment surfaces (34a, 34b) form a V-shape.

10. The cutting insert (20, 120) according to claim 9, wherein in the cross-sections taken in the first and second vertical planes (Pv1, Pv2), the upper and lower abutment surfaces (34a, 34b) form an external obtuse abutment angle ($\alpha 2$).

11. The cutting insert (20, 120) according to any one of claims 8 to 10, wherein in a cross-section taken in any plane containing the central axis (A1), the upper and lower abutment surfaces (34a, 34b) form a V-shape.

12. The cutting insert (20, 120) according to any of the preceding claims, wherein in an end view of the cutting insert (20, 120), a first imaginary circle (C1) circumscribes the upper peripheral edge (28) at N discrete radially outermost points (No1, No2, No3, No4).

13. The cutting insert (20, 120) according to claim 12, wherein each upper cutting edge (36) extends between two of the N radially outermost points (No1, No2, No3, No4).

14. The cutting insert (20, 120) according to claim 12 or 13, wherein any two circumferentially adjacent upper cutting edges (36) merge at one of the N radially outermost points (No1, No2, No3, No4).

15. The cutting insert (20) according to any one of claims 12 to 14, wherein the N radially outermost points (No1, No2, No3, No4) are located closer to the second horizontal plane ($P_{H}2$) than any other point on the upper peripheral edge (28).

16. The cutting insert (120) according to any of the preceding claims, wherein each upper cutting edge (36) has a plurality of discrete axially uppermost points (Nu1, Nu2, Nu3, Nu4) located further from the second horizontal plane ($P_{H}2$) than any other point on the said upper cutting edge (36).

17. The cutting insert (20, 120) according to any of the preceding claims, wherein the upper peripheral edge (28) has exactly four upper cutting edges (36), and N=4.

18. The cutting insert (20, 120) according to any of the preceding claims, wherein:

the upper end surface (22) includes a planar upper support surface (38), and

the upper peripheral edge (28) is entirely located closer to the second horizontal plane (P_{H2}) than the upper support surface (38).

19. The cutting insert (20, 120) according to claim 18, comprising a through bore (40) coaxial with the central axis (A1) opening out to the upper support surface (38).

20. The cutting insert (20, 120) according to claim 18 or 19, wherein:

the upper end surface (22) includes a continuous rake surface (42) adjacent to the upper peripheral edge (28) and a ramp surface (44) adjacent to the upper support surface (38);

the rake surface (42) extends radially inwardly towards the second horizontal plane (P_{H2}); and

the ramp surface (44) extends radially outwardly towards the second horizontal plane (P_{H2}).

21. The cutting insert (20, 120) according to any one of claims 18 to 20, wherein the ramp surface (44) is interrupted by a plurality of circumferentially spaced apart protrusions (46).

22. The cutting insert (20, 120) according to any one of claims 18 to 21, wherein each of the protrusions (46) is partially located on the rake surface (42).

23. The cutting insert (20, 120) according to claim 21 or 22, wherein, in an end view of the cutting insert (20, 120), each of the protrusions (46) includes a convex shaped radially outer portion (48).

24. The cutting insert (20, 120) according to any one of claims 21 to 23, wherein the plurality of protrusions (46) are greater in number than the plurality of N upper cutting edges (36).

25. The cutting insert (20, 120) according to any one of claims 21 to 24, wherein the plurality of protrusions (46) are greater in number, by at least a factor of six, than the plurality of N upper cutting edges (36).

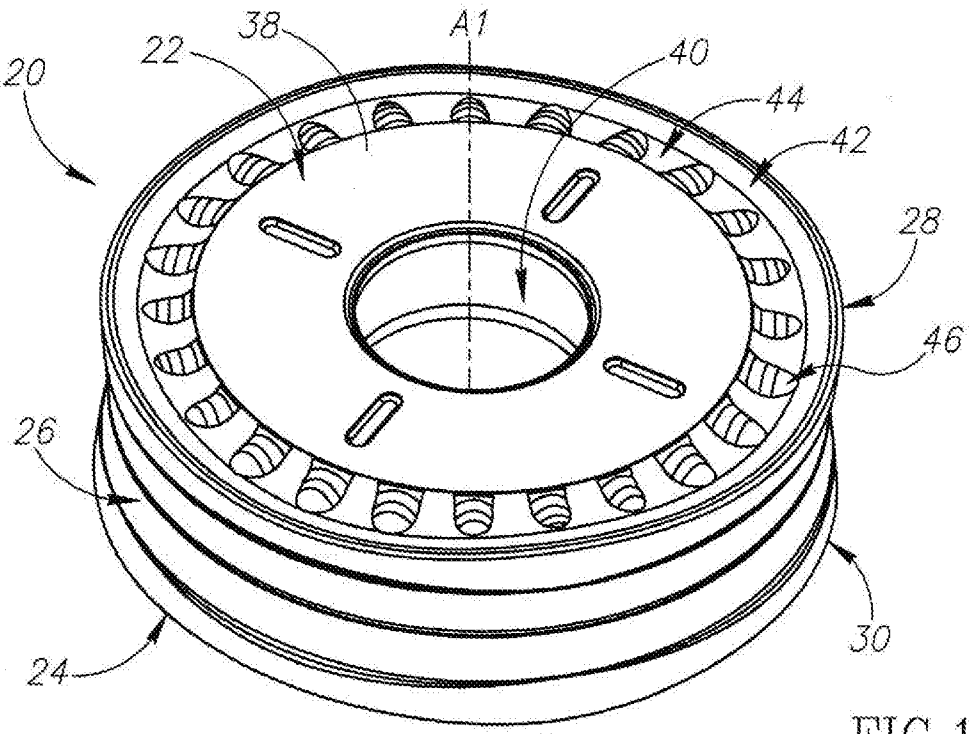
A1
38
22
40
20
44
42
28
46
26
30
24

FIG.1A

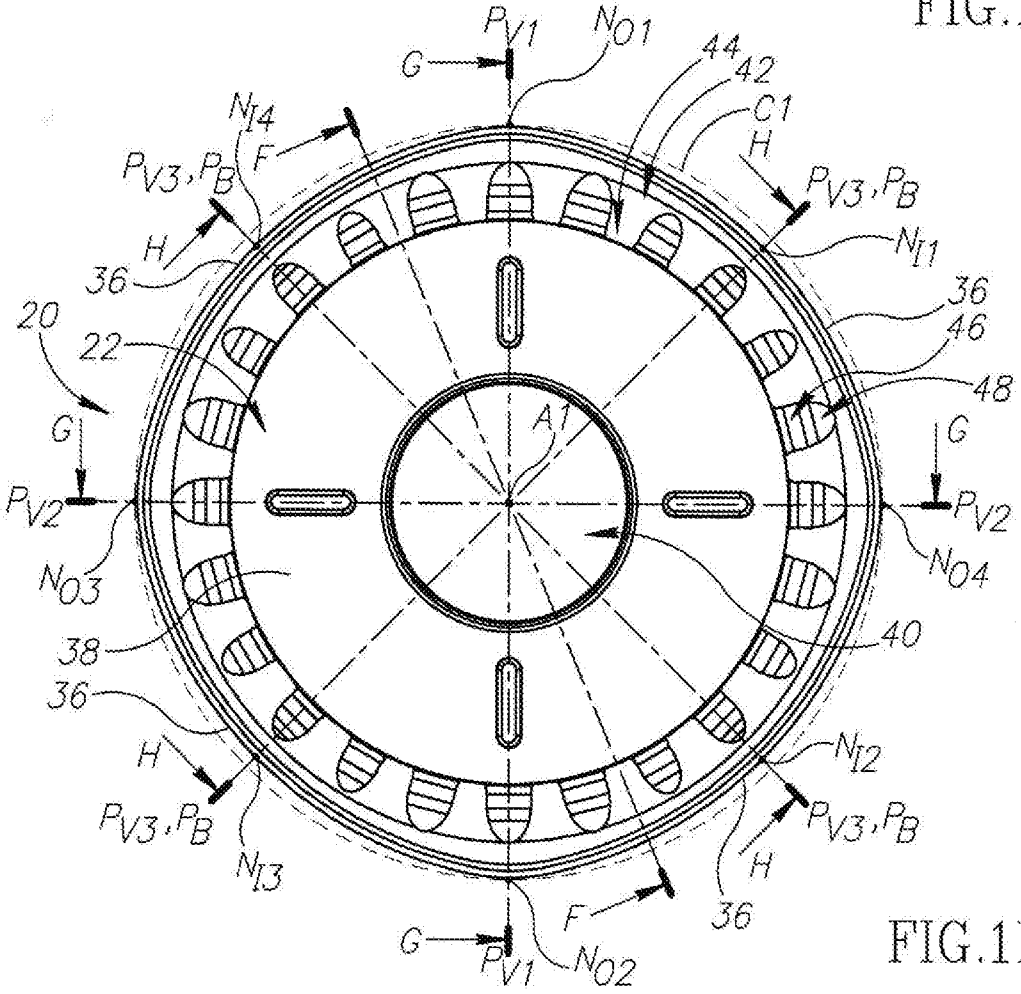
P_{V1}
N_{O1}
G
44
42
C1
H
N_{I4}
F
P_{V3}, P_B
N_{I1}
36
20
22
46
48
A1
G
P_{V2}
N_{O3}
N_{O4}
38
40
N_{I2}
N_{I3}
N_{O2}

FIG.1B

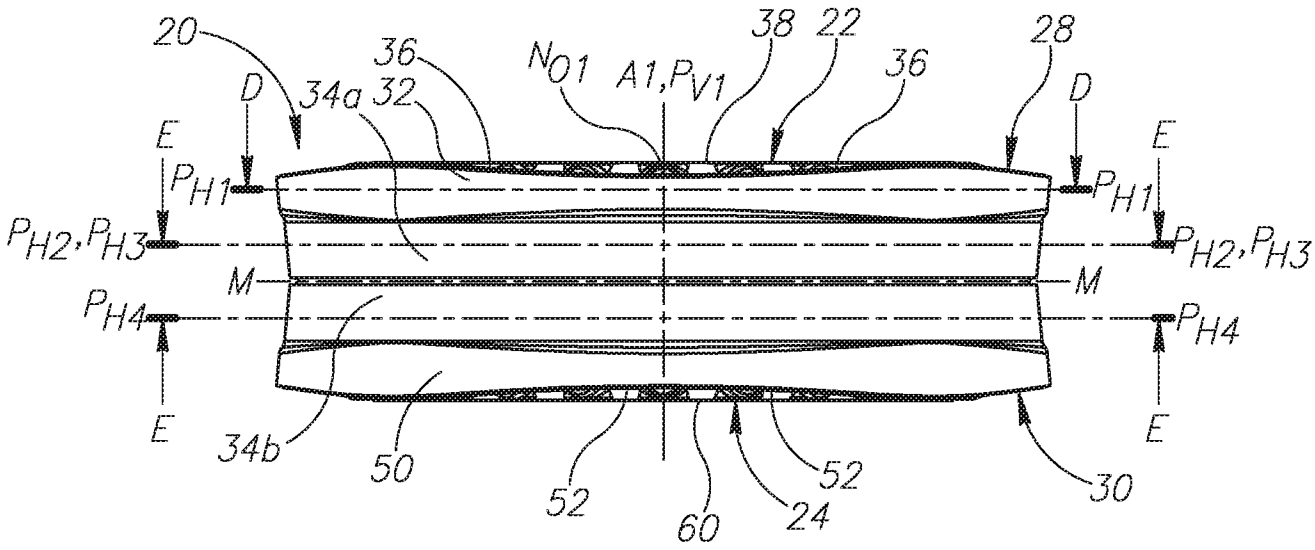
20
36
N01
A1,PV1
38
22
36
28
D
34a
32
D
E
E
PH1
PH1
PH2,PH3
PH2,PH3
M
M
PH4
PH4
E
E
34b
50
52
60
24
52
30

FIG.1C

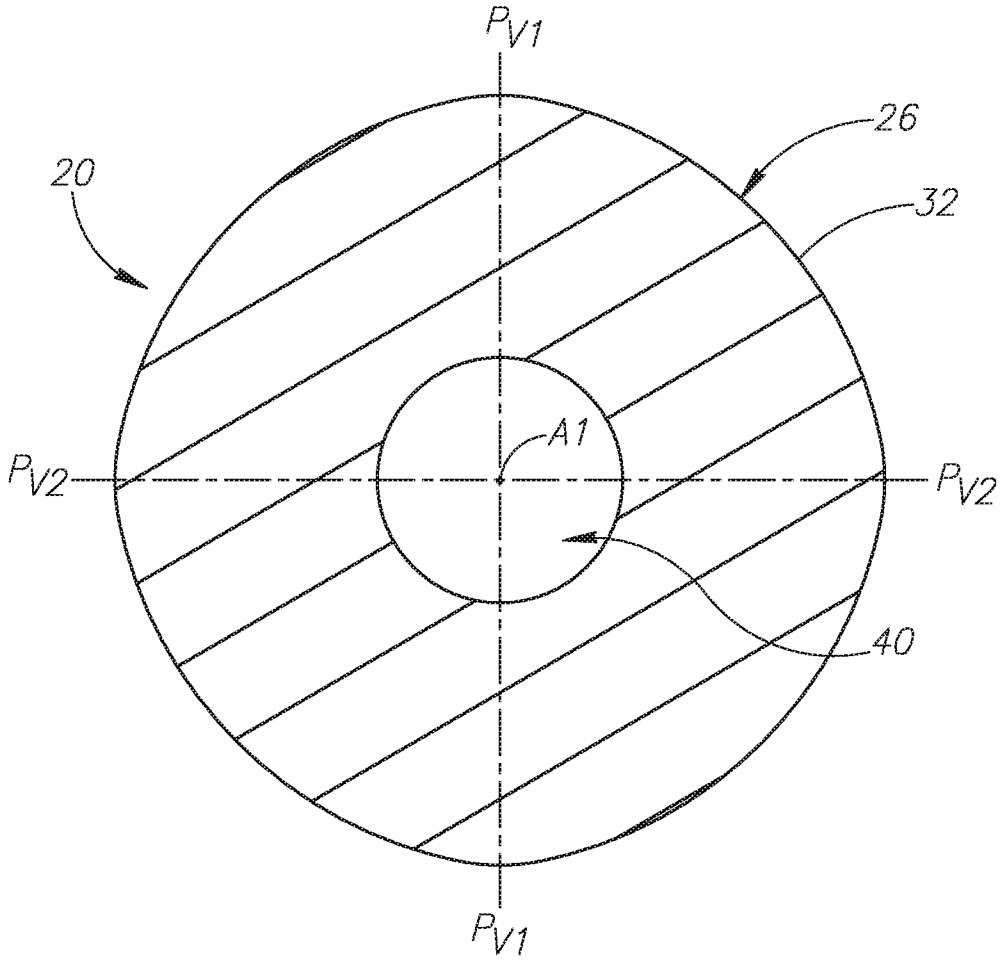
PV1
26
20
32
A1
PV2
PV2
40
PV1

FIG.1D

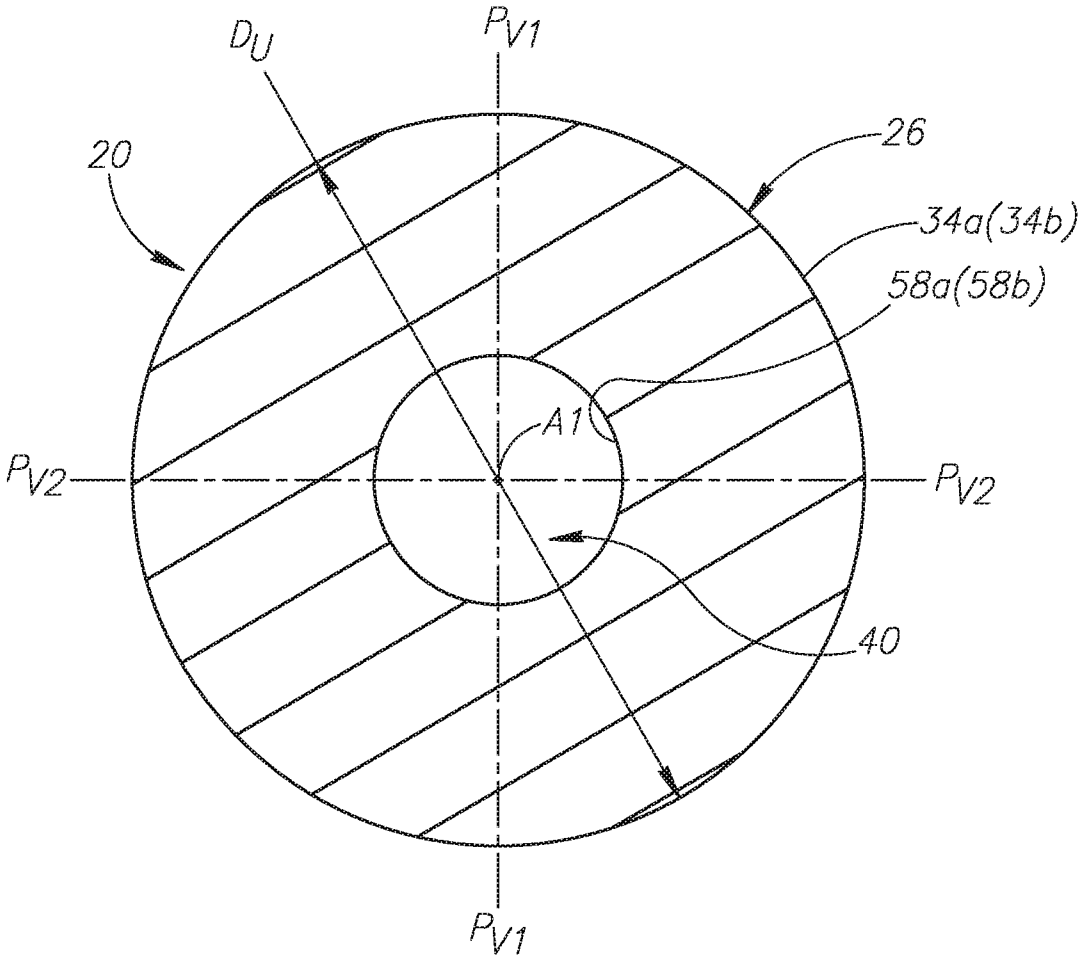
D_U
P_{V1}
20
26
34a(34b)
58a(58b)
A1
P_{V2}
P_{V2}
40
P_{V1}

FIG.1E

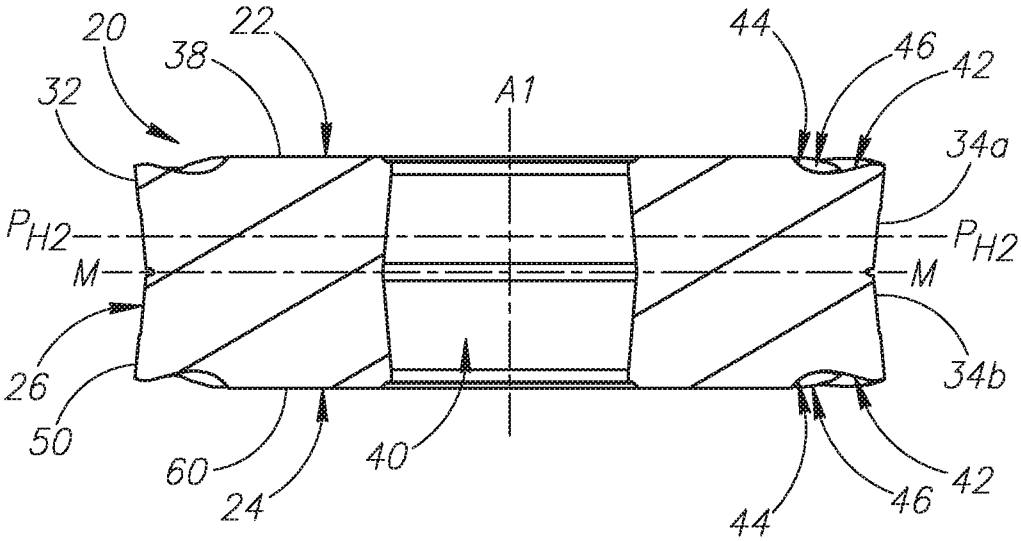
20
22
38
44
46
42
32
A1
34a
P_{H2}
P_{H2}
M
M
26
34b
50
60
40
24
44
46
42

FIG.1F

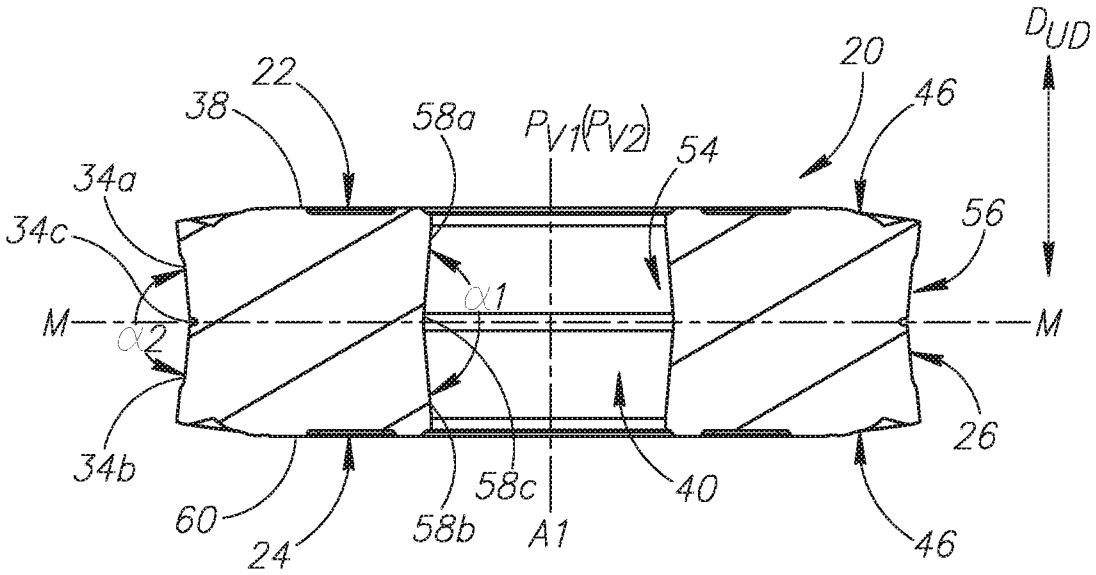
D_{UD}
20
22
38
58a
$P_{V1}(P_{V2})$
54
46
34a
34c
56
α1
M
α2
M
26
34b
60
24
58b
58c
A1
40
46

FIG.1G

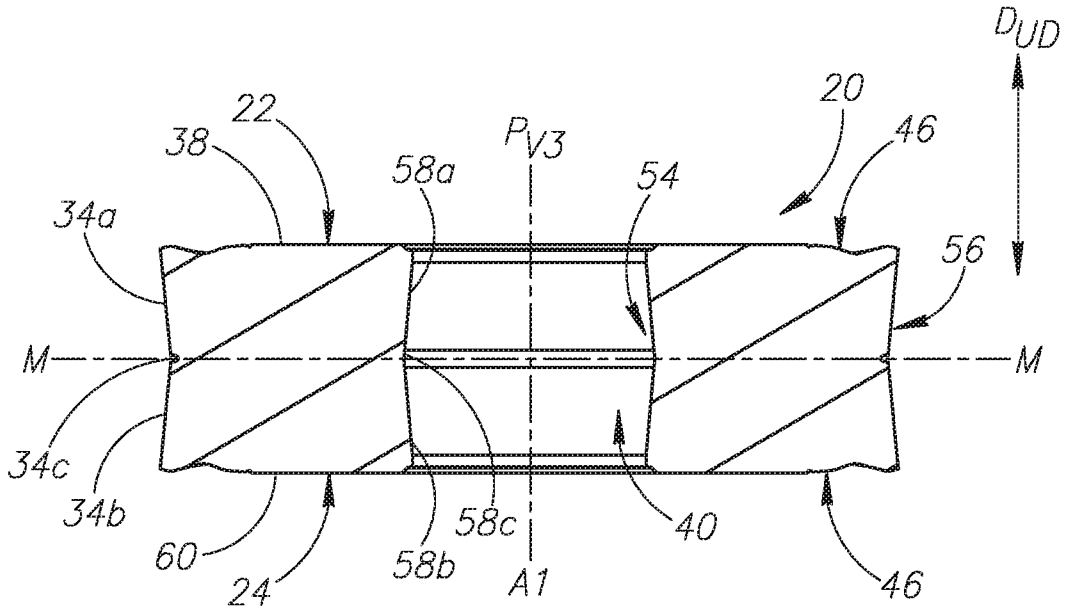
D_{UD}
20
22
38
P_{V3}
58a
54
46
34a
56
M
M
34c
34b
60
24
58b
58c
A1
40
46

FIG.1H

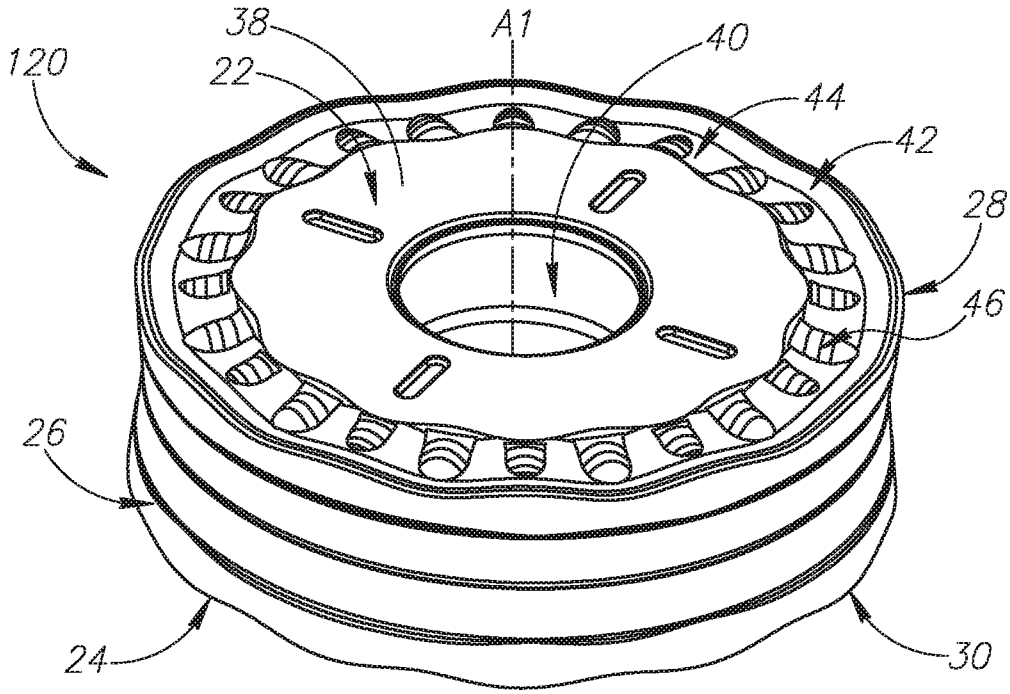
38
A1
40
120
22
44
42
28
46
26
24
30

FIG.2A

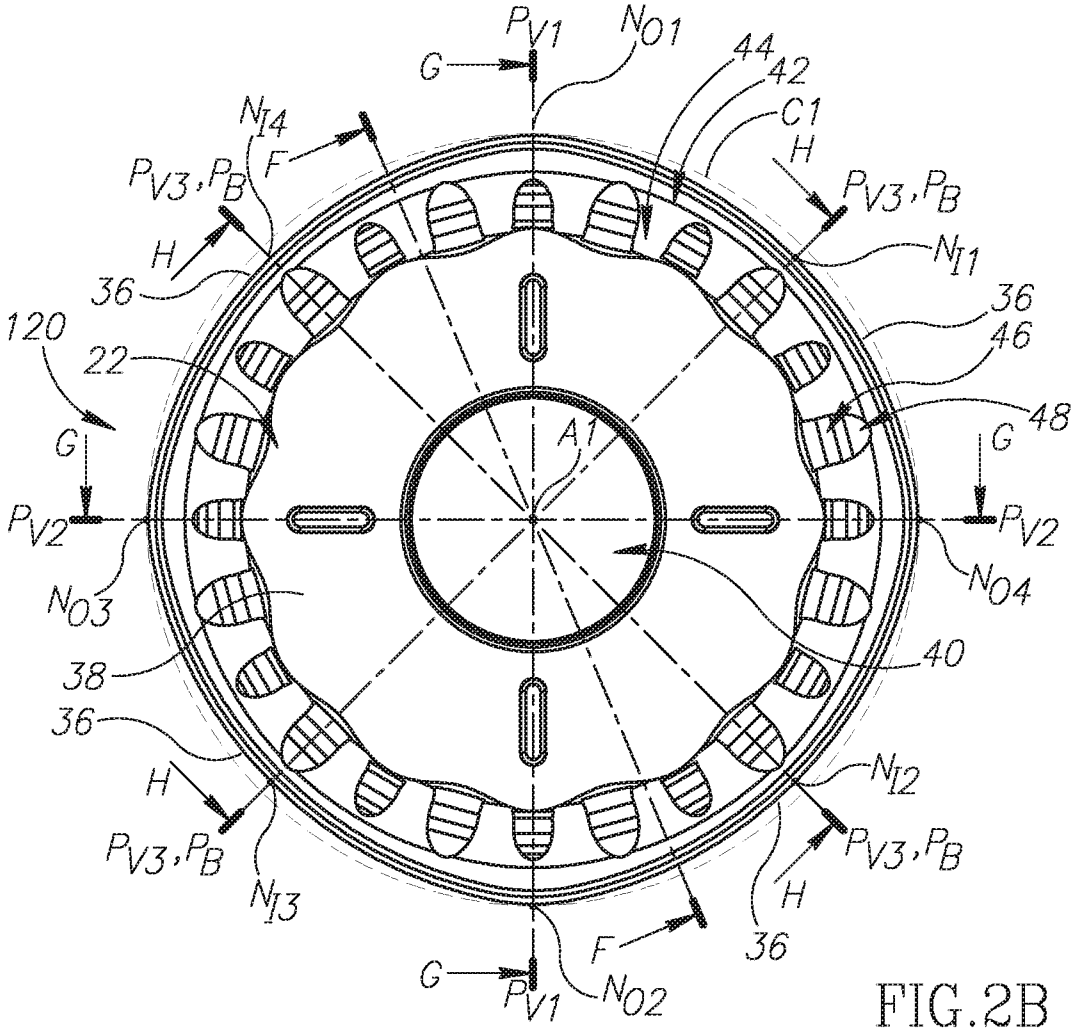
P_{V1}
N_{O1}
G
44
42
C1
N_{I4}
F
H
P_{V3}, P_B
P_{V3}, P_B
H
N_{I1}
36
36
120
22
46
48
G
A1
G
P_{V2}
P_{V2}
N_{O3}
N_{O4}
38
40
36
H
N_{I2}
P_{V3}, P_B
P_{V3}, P_B
N_{I3}
H
F
36
G
P_{V1}
N_{O2}

FIG.2B

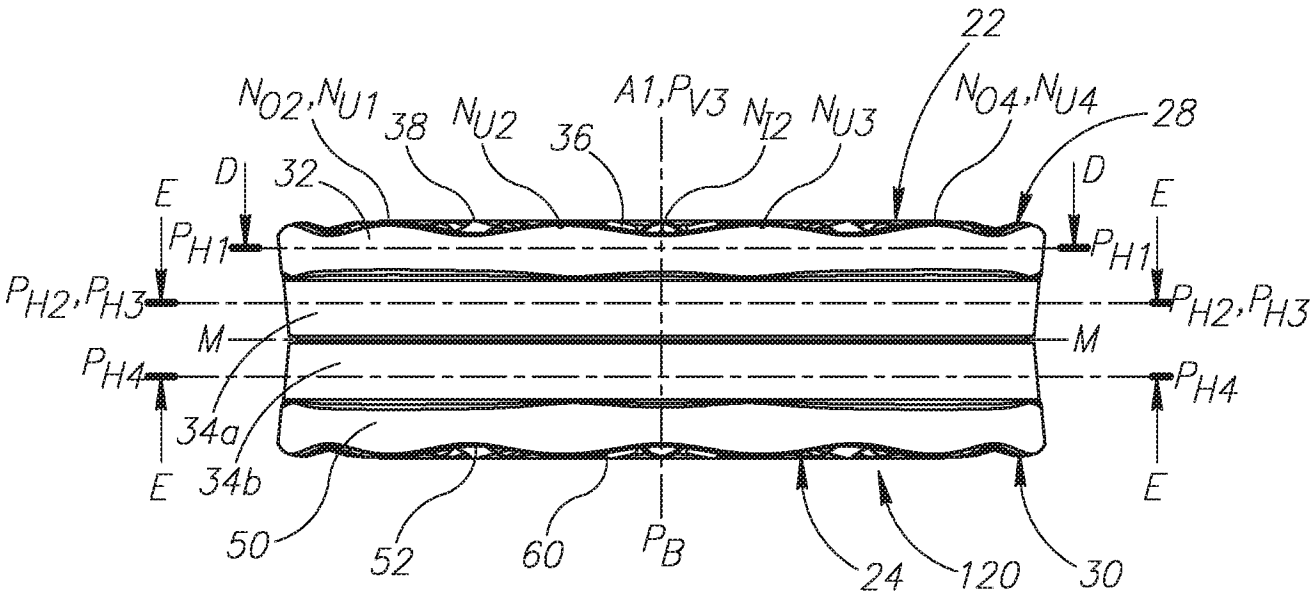
22
N_{O2},N_{U1}
38
N_{U2}
36
A1,P_{V3}
N_{I2}
N_{U3}
N_{O4},N_{U4}
28
D
32
D
E
E
P_{H1}
P_{H1}
P_{H2},P_{H3}
P_{H2},P_{H3}
M
M
P_{H4}
P_{H4}
34a
34b
E
E
50
52
60
P_B
24
120
30

FIG.2C

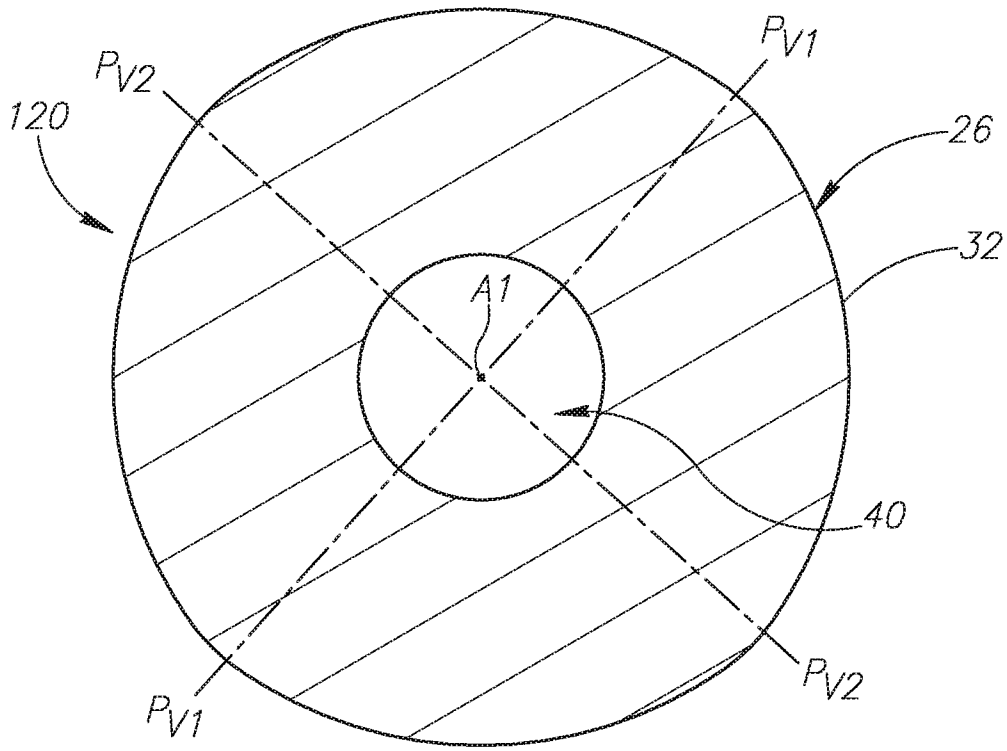
P_{V1}
P_{V2}
120
26
32
A1
40
P_{V2}
P_{V1}

FIG.2D

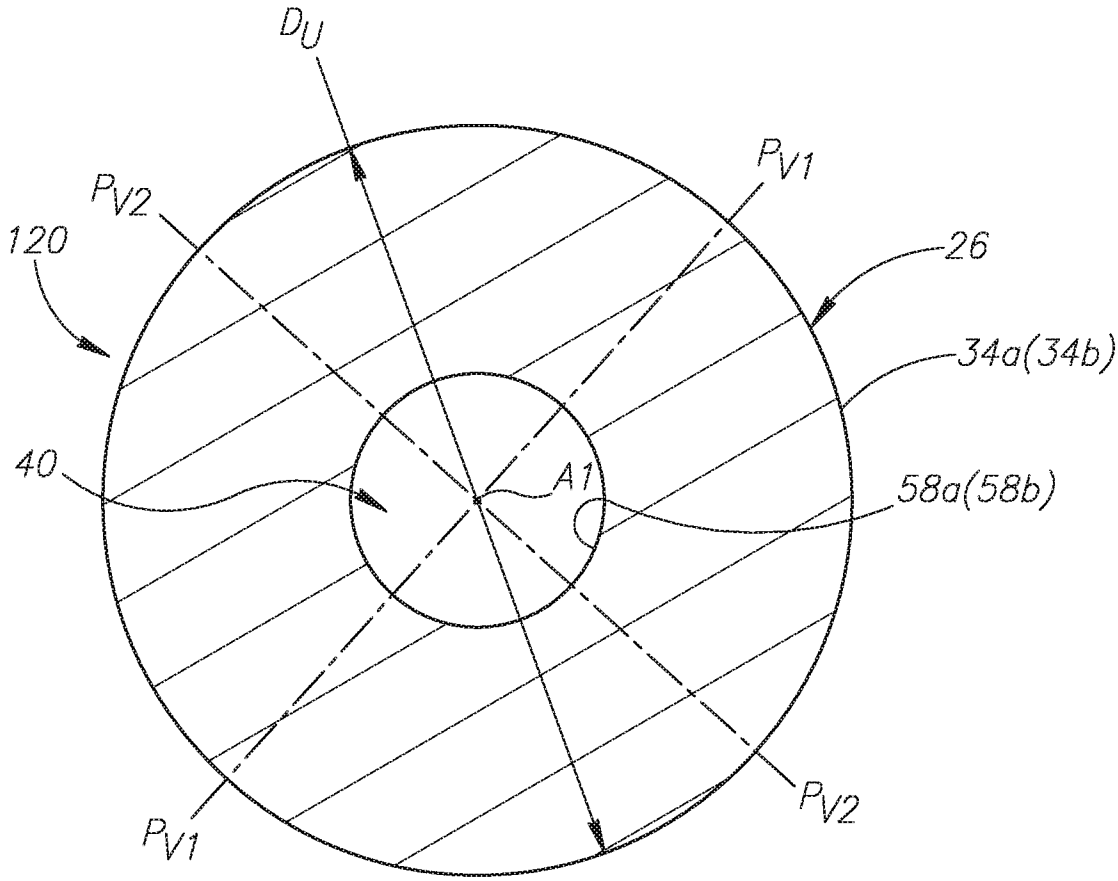
D_U
P_{V1}
P_{V2}
120
26
34a(34b)
40
A1
58a(58b)
P_{V2}
P_{V1}

FIG.2E

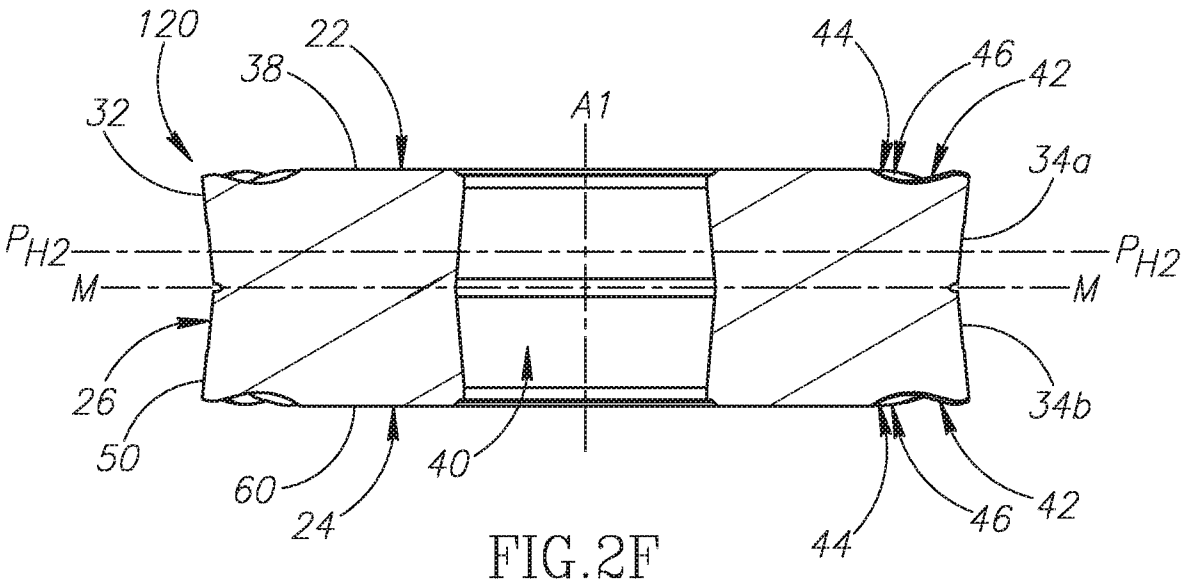
120
22
38
32
A1
44
46
42
34a
P_{H2}
M
P_{H2}
M
26
50
60
24
40
34b
44
46
42

FIG.2F

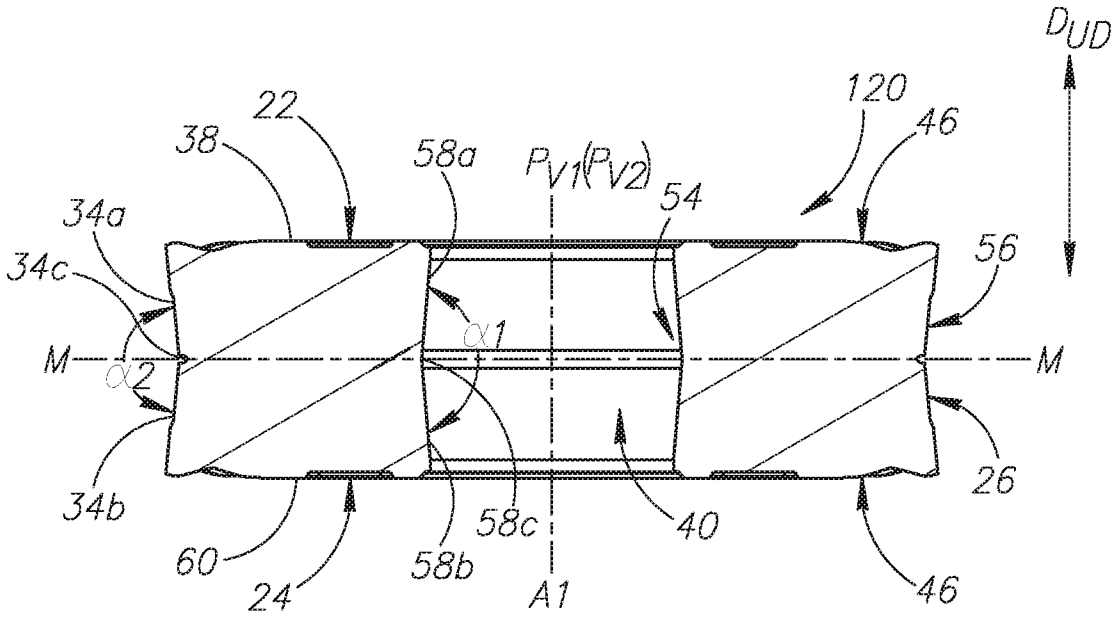
D_{UD}
22
38
58a
$P_{V1}(P_{V2})$
120
46
54
34a
34c
56
M
α1
α2
M
34b
58c
40
26
60
58b
24
A1
46

FIG.2G

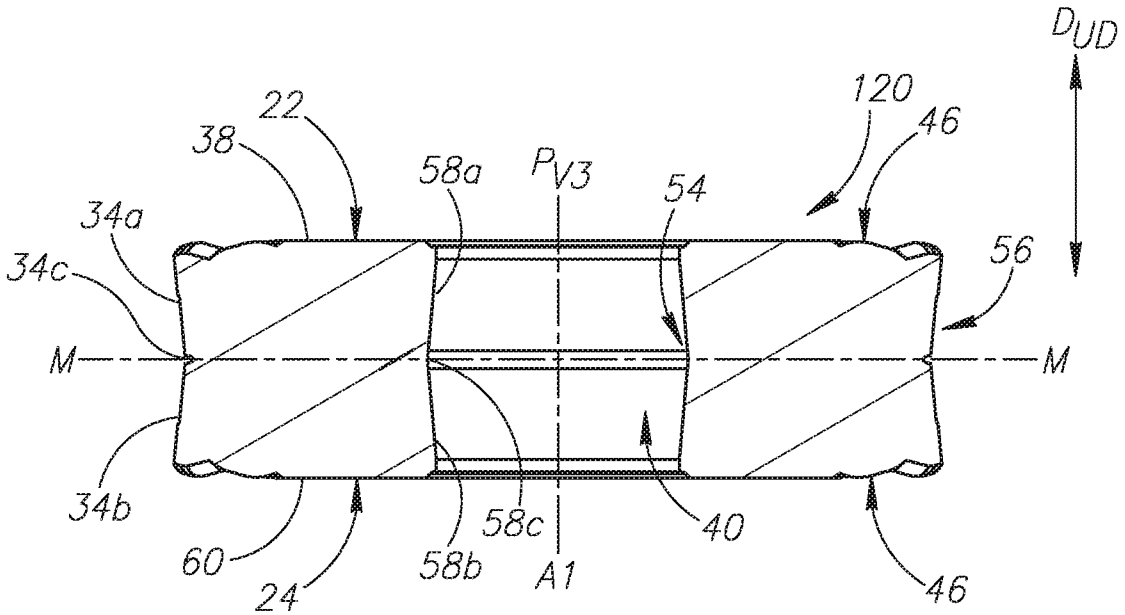
D_{UD}
22
38
58a
P_{V3}
120
46
54
34a
34c
56
M
M
34b
58c
40
60
58b
24
A1
46

FIG.2H

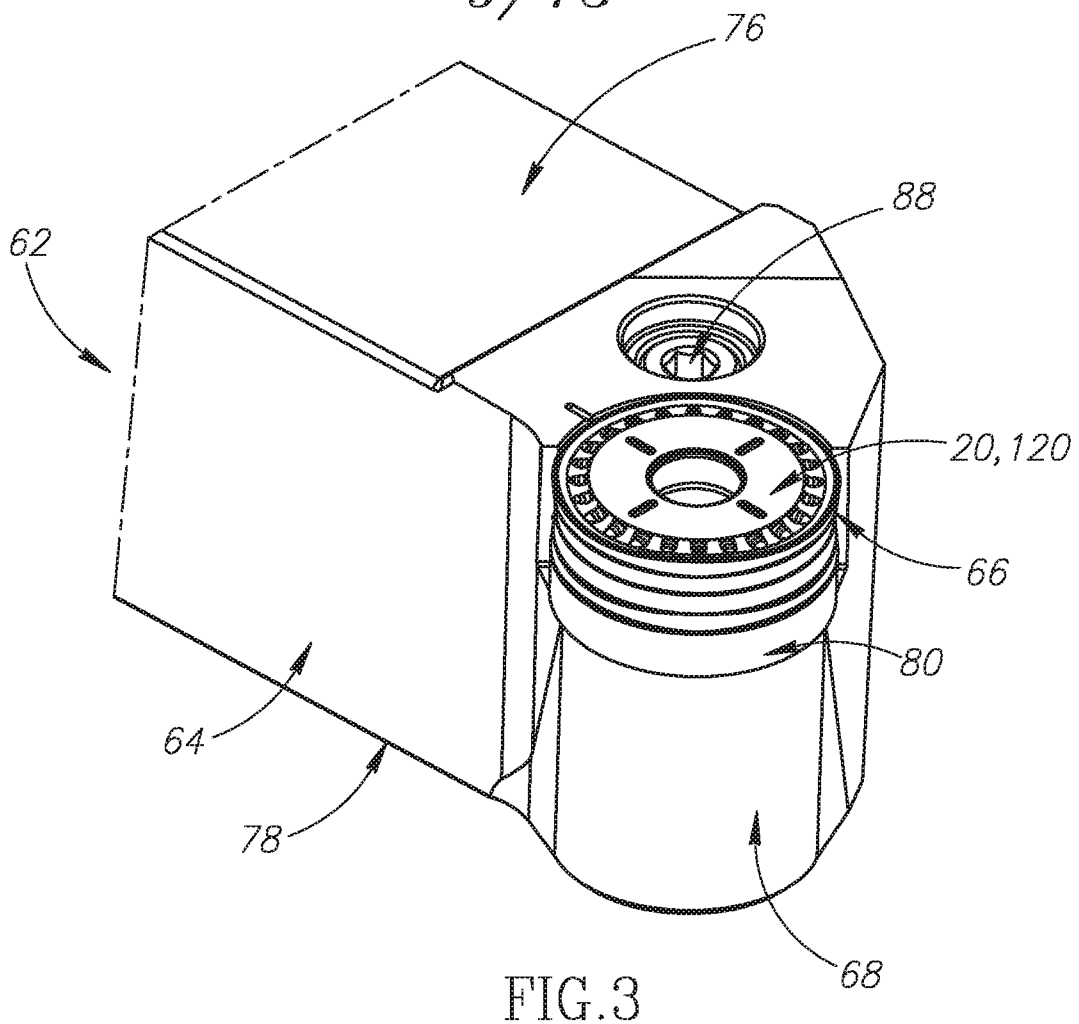
76
88
62
20,120
66
80
64
78
68

FIG.3

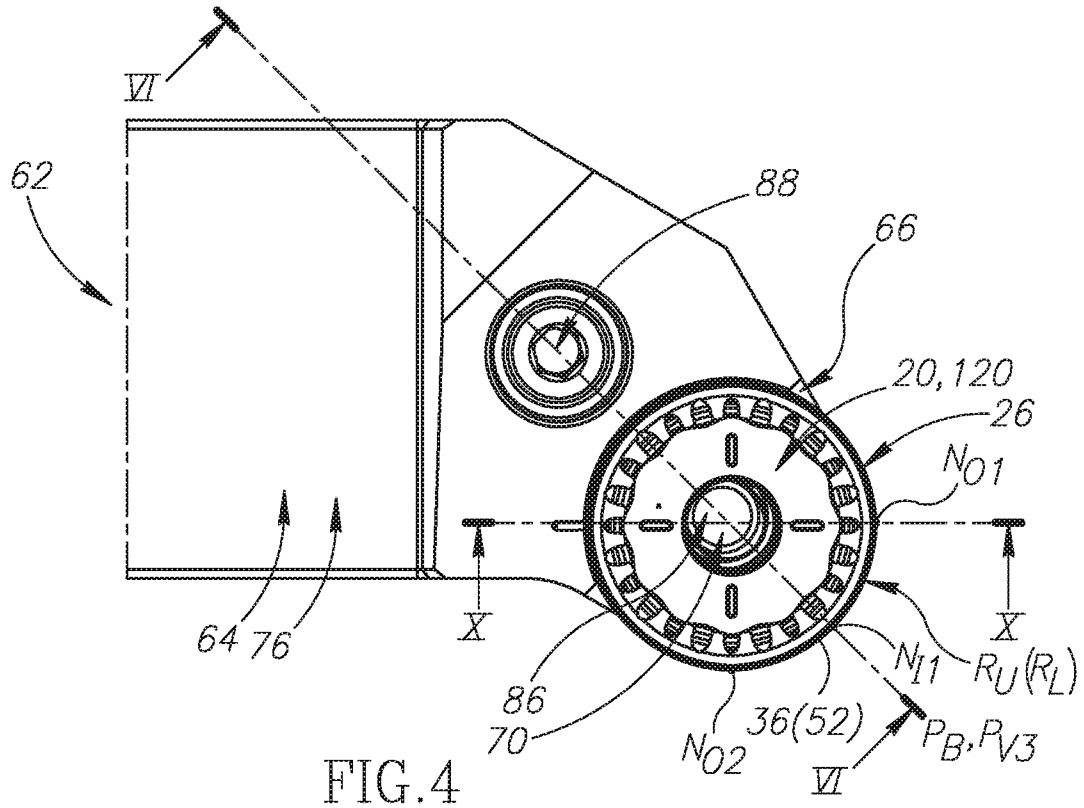
VI
62
88
66
20,120
26
N_{01}
X
X
64
76
N_{11}
$R_U(R_L)$
86
70
N_{02}
36(52)
P_B, P_{V3}
VI

FIG.4

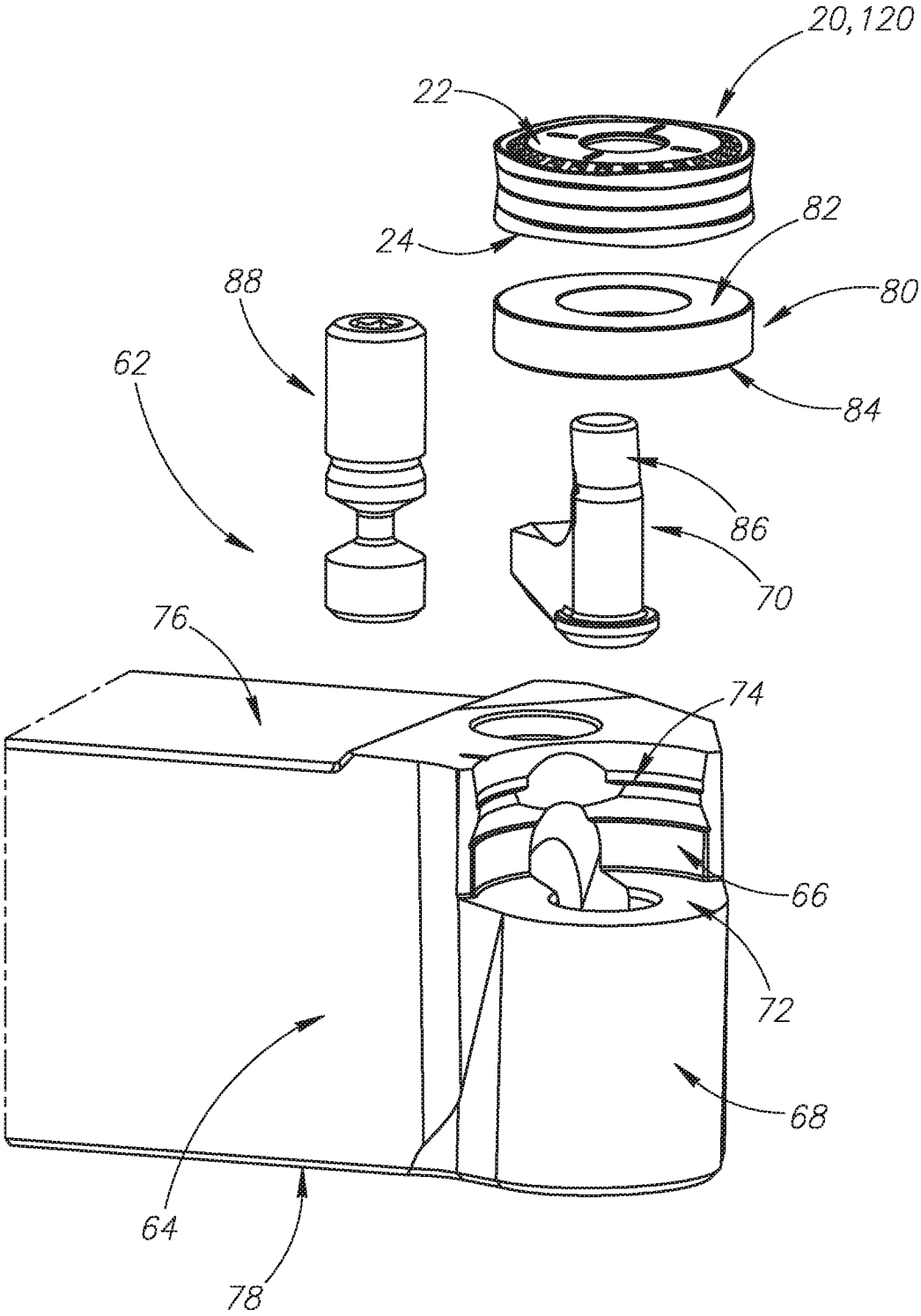

FIG.5

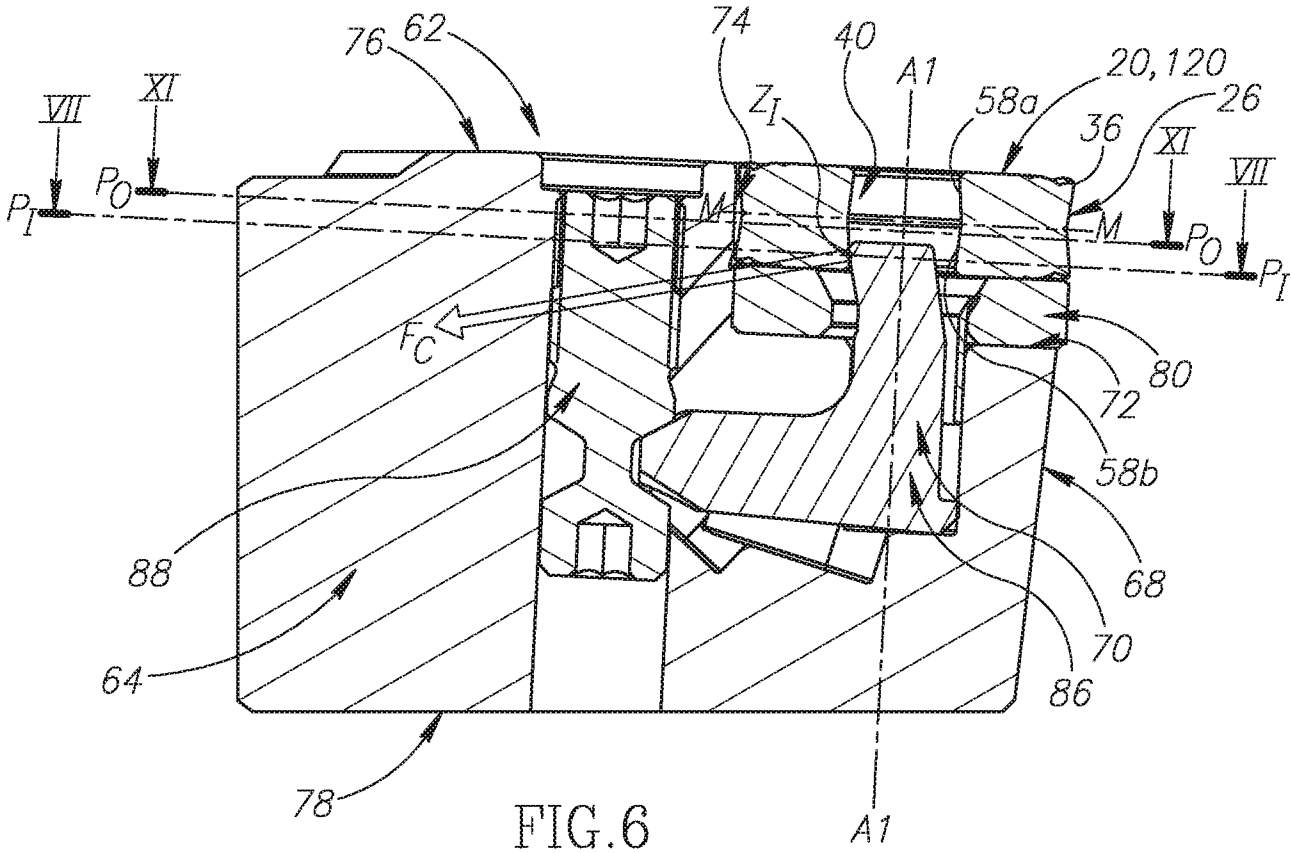
76
62
74
40
A1
20,120
26
58a
36
XI
VII
Z_I
P_O
P_I
M
F_C
80
72
58b
68
70
86
88
64
78
A1

FIG.6

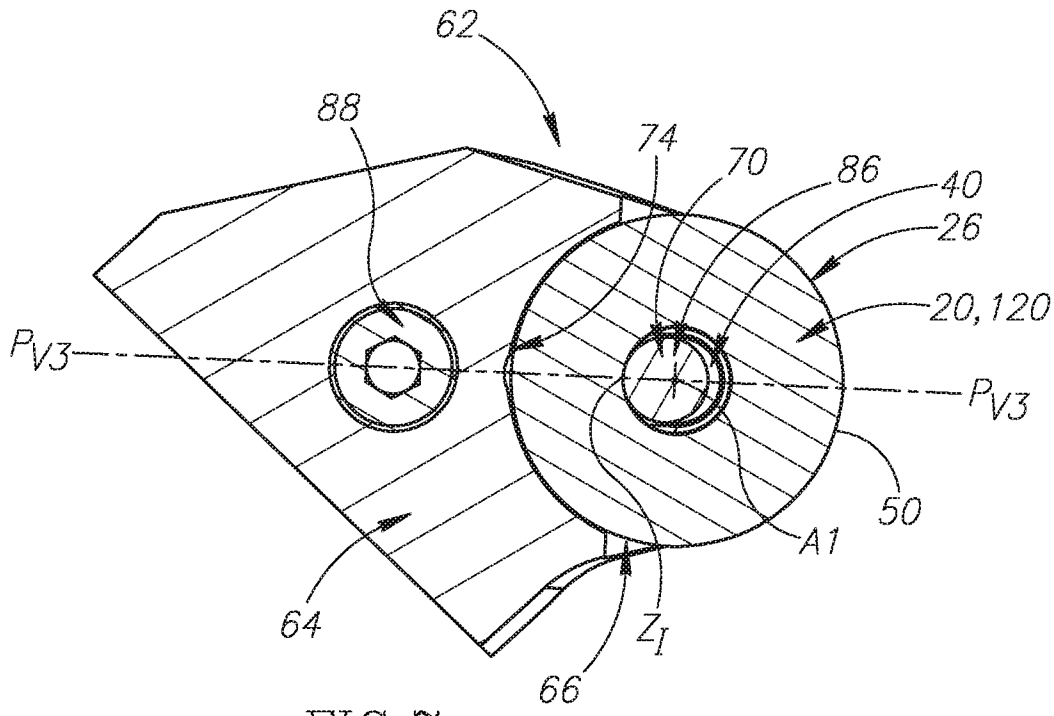
62
88
74
70
86
40
26
20,120
P_{V3}
50
A1
64
Z_I
66

FIG.7

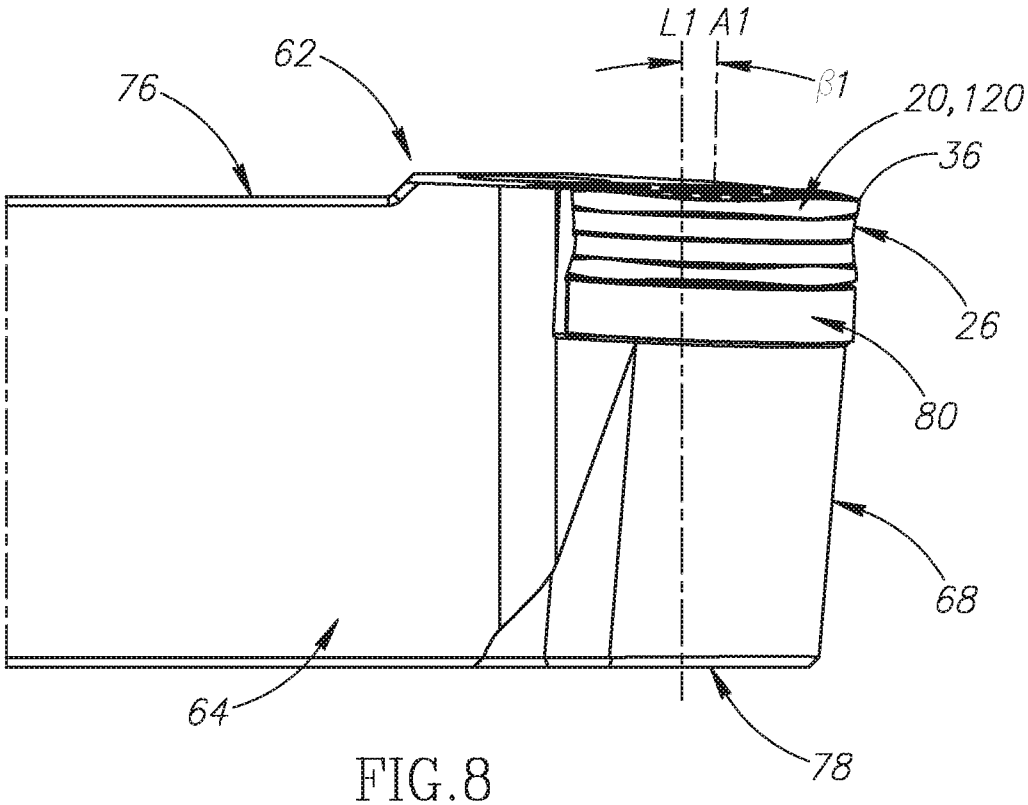
L1 A1
62
76
β1
20,120
36
26
80
68
64
78

FIG.8

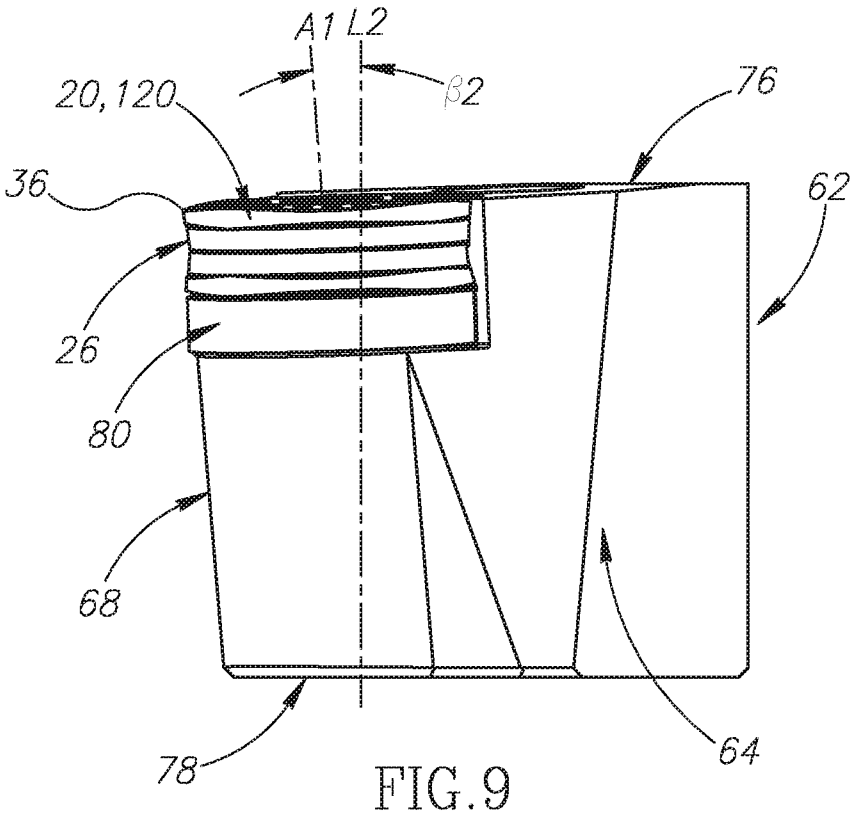
A1 L2
20,120
β2
76
36
62
26
80
68
78
64

FIG.9

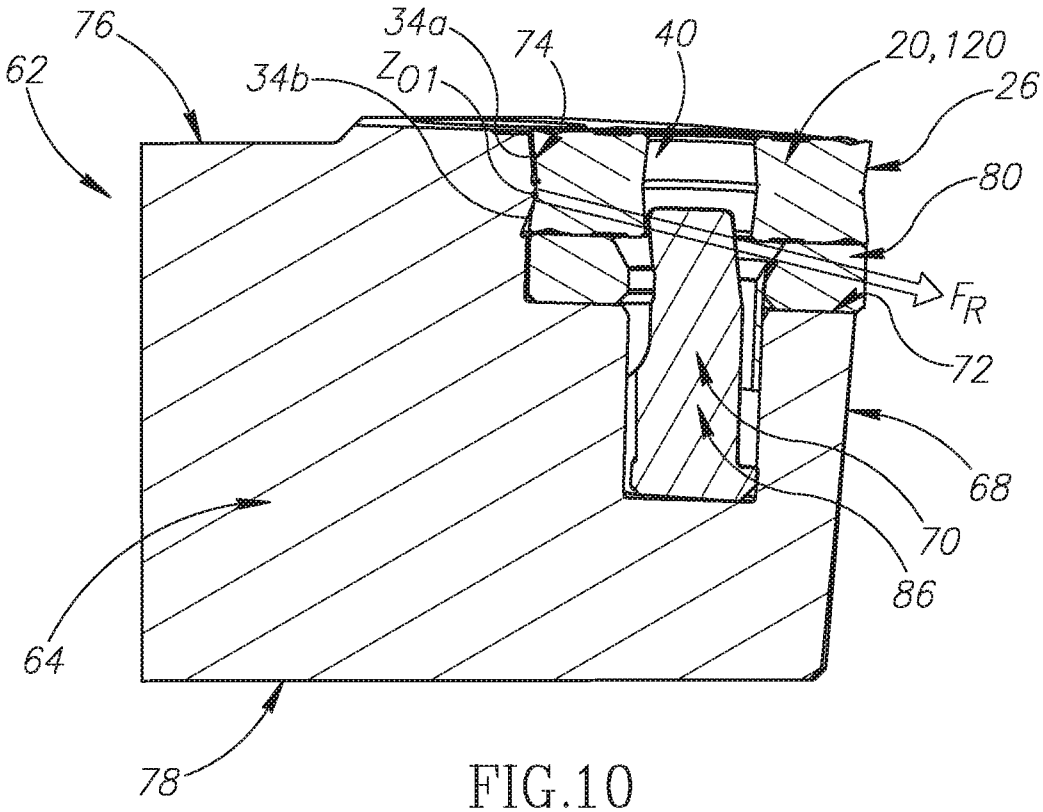
76
62
34a
34b
Z_{01}
74
40
20,120
26
80
F_R
72
68
70
86
64
78

FIG.10

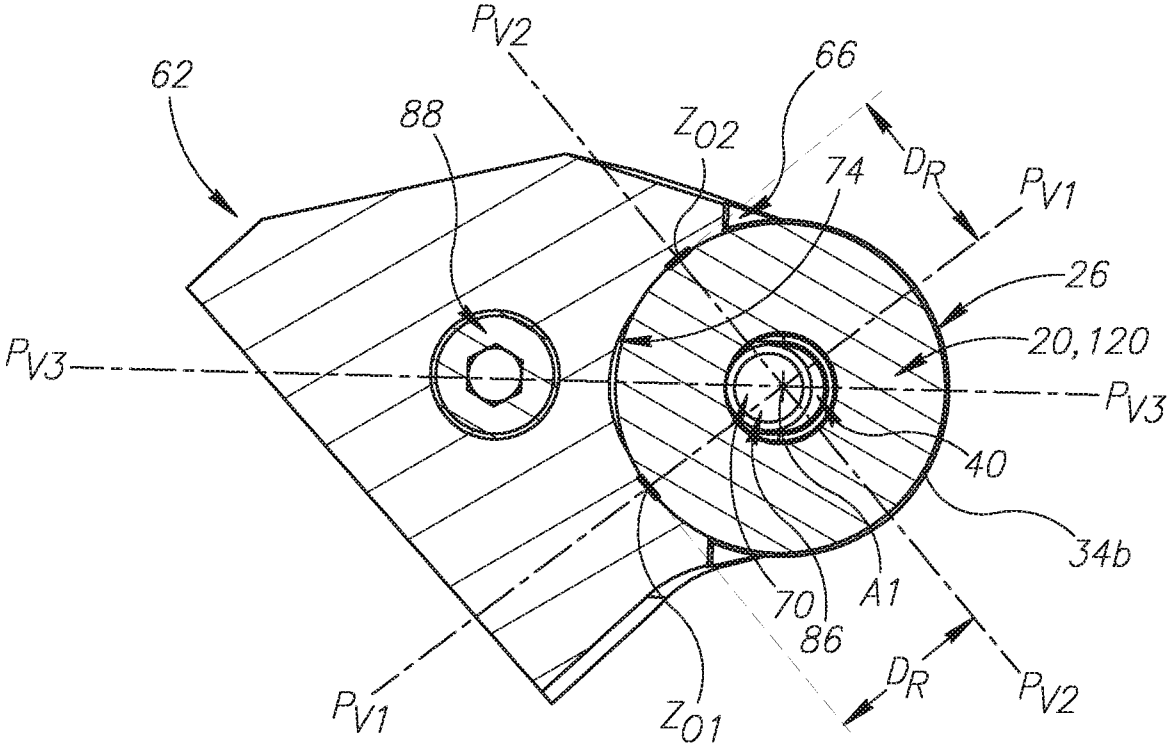
P_{V2}
62
66
88
Z_{02}
74
D_R
P_{V1}
26
20,120
P_{V3}
P_{V3}
40
34b
70
86
A1
P_{V1}
Z_{01}
D_R
P_{V2}

FIG.11

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2017/050068

A. CLASSIFICATION OF SUBJECT MATTER
INV. B23B27/14
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 7 264 425 B1 (VIOL KENT [SE]) 4 September 2007 (2007-09-04) cited in the application	1-4,6,7, 12-14,16
A	column 4, lines 43-54 figures 3A-3C	15,17,19

A	EP 2 620 243 A1 (SANDVIK INTELLECTUAL PROPERTY [SE]) 31 July 2013 (2013-07-31) paragraph [0031] figures 1-19	1-25

A	JP 2007 090496 A (TUNGALOY CORP) 12 April 2007 (2007-04-12) figures 1, 2	1-25

A	US 2011/164934 A1 (CHEN SHI [US] ET AL) 7 July 2011 (2011-07-07) figures 1-6	1-25

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 April 2017	25/04/2017

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2017/050068

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006 192567 A (MITSUBISHI MATERIALS CORP) 27 July 2006 (2006-07-27) figures 6, 7, 8, 9 -----	1-25

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IL2017/050068

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7264425 B1	04-09-2007	CN 101384389 A	11-03-2009
		EP 1986805 A1	05-11-2008
		KR 20080100421 A	18-11-2008
		SE 0600338 A	16-08-2007
		US 2007189863 A1	16-08-2007
		WO 2007094722 A1	23-08-2007
EP 2620243 A1	31-07-2013	CN 103223518 A	31-07-2013
		EP 2620243 A1	31-07-2013
		JP 2013154466 A	15-08-2013
		KR 20130088078 A	07-08-2013
		SE 1250060 A1	31-07-2013
		US 2013195567 A1	01-08-2013
JP 2007090496 A	12-04-2007	JP 4752427 B2	17-08-2011
		JP 2007090496 A	12-04-2007
US 2011164934 A1	07-07-2011	US 2011164934 A1	07-07-2011
		WO 2011084934 A2	14-07-2011
JP 2006192567 A	27-07-2006	JP 4650272 B2	16-03-2011
		JP 2006192567 A	27-07-2006