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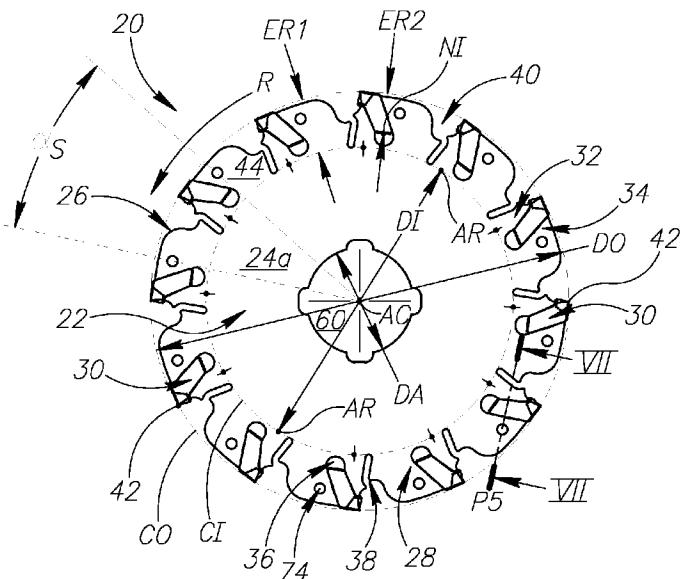


FIG. 4

(57) Abrégé/Abstract:

A slitting cutter (20) having a disk-shaped cutter body (22) with a plurality of circumferentially spaced insert receiving portions (28) and a plurality of cutting inserts (30) retained therein. Each insert receiving portion has first and second clamping jaws (32, 34) spaced apart by an insert receiving slot (36), the first clamping jaw resiliently displaceable and having a resilient axis of rotation (AR). The number of cutting inserts resiliently clamped in the slitting cutter is an inner cutting diameter (DI) defined by the plurality of resilient axes of rotation multiplied by a spacing factor of between 0.15 and 0.30. A tool key having first and second key prongs is used in combination with the slitting cutter. The second key prong has a thrust surface with a concave profile. In a partially assembled position of the slitting cutter the thrust surface contacts at least one of two spaced apart first and second corner surfaces of the respective cutting insert.

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**(54) Title:** SLITTING CUTTER AND TOOL KEY IN COMBINATION THEREWITH

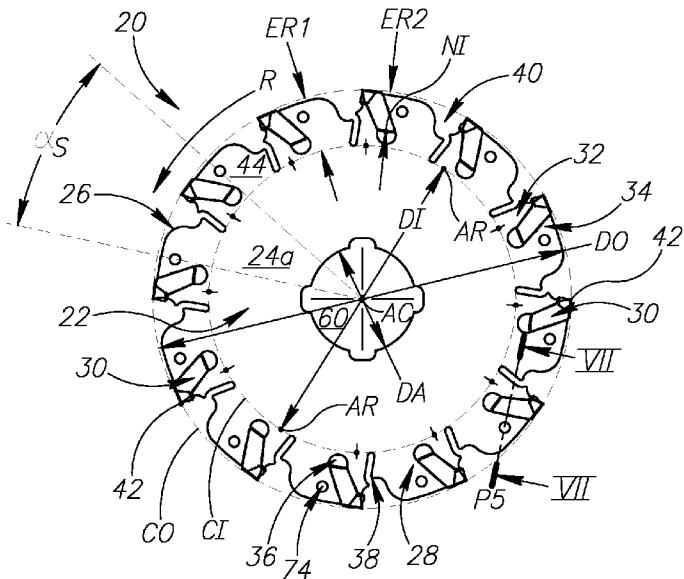


FIG. 4

**(57) Abstract:** A slitting cutter (20) having a disk-shaped cutter body (22) with a plurality of circumferentially spaced insert receiving portions (28) and a plurality of cutting inserts (30) retained therein. Each insert receiving portion has first and second clamping jaws (32, 34) spaced apart by an insert receiving slot (36), the first clamping jaw resiliently displaceable and having a resilient axis of rotation (AR). The number of cutting inserts resiliently clamped in the slitting cutter is an inner cutting diameter (D1) defined by the plurality of resilient axes of rotation multiplied by a spacing factor of between 0.15 and 0.30. A tool key having first and second key prongs is used in combination with the slitting cutter. The second key prong has a thrust surface with a concave profile. In a partially assembled position of the slitting cutter the thrust surface contacts at least one of two spaced apart first and second corner surfaces of the respective cutting insert.

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## SLITTING CUTTER AND TOOL KEY IN COMBINATION THEREWITH

### FIELD OF THE INVENTION

The present invention relates to a slitting cutter and a tool key in combination therewith, for use in metal cutting processes in general, and for slitting operations in particular.

### 5 BACKGROUND OF THE INVENTION

For the purpose of the specification and claims, the term "slitting cutter" is intended to be inclusive of tools configured for slitting or slotting applications.

Within the field of slitting cutters, there are many examples of integral one-piece slitting cutters having a plurality of cutting teeth. Figs. 1 and 2 show an integral one-piece slitting cutter 10 according to the prior art having an outer cutting diameter **DO** of 63mm, a cutting width **WC** of 1mm, and a plurality of 48 cutting teeth **142**. Such a slitting cutter, may be limited to a maximum rotational speed of approximately 1260 rpm for slitting operations in a workpiece material such as spring steel, and has a simple tooth design devoid of chip forming capabilities, which may limit the feed rate per tooth to approximately  $0.4\mu\text{m}$  due to the associated high cutting forces. Such limitations may result in a feed rate per revolution of approximately 0.02mm, and a feed rate per minute of 25-30mm. Further disadvantages of integral one-piece slitting cutters are the short life-cycle and the reduced repeatability after regrinding.

Within the field of slotting cutters, typically having wider cutting widths than slitting cutters, there are many examples of disk-shaped cutting bodies having a plurality of insert receiving portions circumferentially spaced about the cutter body and a plurality of cutting inserts removably retained therein, which use a tool key to aid insertion and extraction of the cutting inserts.

US 6,116,823 discloses a slot milling tool comprising a disc having a thickness in the range of 2-6mm and a plurality of insert receiving seats circumferentially arranged around the periphery thereof, each insert receiving seat having a cutting insert retained therein by means of an elastically resilient projection defined by two cutting slots, the inner ends of the two slots being located significantly radially inward of the insert receiving seat.

US 6,116,823 also discloses a tool used in combination with the slot milling tool, for insertion and extraction of the cutting inserts. The tool used for insertion and extraction of the cutting inserts has two cylindrical shaped pins, one of which is inserted into a hole adjacent the insert receiving seat and the other which is inserted into an opening formed at the outer end of one of the slots. Rotation of the tool around a fulcrum formed by the pin in the hole causes the other pin to lift the elastically resilient projection, thus providing sufficient space for insertion or extraction of the respective cutting insert.

5 There is a need in the field for an improved slitting cutter.

10 There is also a need in the field for an improved slitting cutter with a high feed rate per revolution.

There is a further a need in the field for an improved slitting cutter with a long life-cycle and a high level of repeatability.

15 There is yet a further need in the field for a tool key to be used in combination with the improved slitting cutter.

## SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a slitting cutter having features designed in an effort to satisfy one or more of the aforementioned needs in the field. The slitting cutter, under one aspect of the invention, comprising:

20 a disk-shaped cutter body having a cutter axis of rotation defining a direction of rotation about the cutter axis of rotation, opposing first and second body side surfaces, and a body peripheral surface extending therebetween,

a plurality of insert receiving portions circumferentially spaced about the body peripheral surface and a plurality of cutting inserts removably retained therein,

25 at least radially outer portions of the first and second body side surfaces contained in first and second reference planes, respectively, the first and second reference planes offset by a body width,

each insert receiving portion having first and second clamping jaws spaced apart by an insert receiving slot, the first clamping jaw resiliently displaceable relative to the second clamping jaw and having a resilient axis of rotation,

each cutting insert resiliently clamped in its respective insert receiving slot, and having a cutting edge intersecting the first and second reference planes,  
wherein:

the plurality of cutting edges define an outer imaginary circle having an outer cutting diameter, and the plurality of resilient axes of rotation define an inner imaginary circle having an inner cutting diameter,  
5

and wherein:

the number N of cutting inserts resiliently clamped in the slitting cutter, is the inner cutting diameter, in millimeters, multiplied by a spacing factor, and  
10

the spacing factor is between 0.15 and 0.30.

Also in accordance with the present invention, there is provided a slitting cutter in combination with a tool key:

the slitting cutter comprising a disk-shaped cutter body having a cutter axis of rotation defining a direction of rotation about the cutter axis of rotation, opposing first and second body side surfaces, and a body peripheral surface extending therebetween,  
15

a plurality of insert receiving portions circumferentially spaced about the body peripheral surface and a plurality of cutting inserts removably retained therein,  
20

at least radially outer portions of the first and second body side surfaces contained in first and second reference planes, respectively, the first and second reference planes spaced apart from one another by a body width,  
25

each insert receiving portion having first and second clamping jaws spaced apart by an insert receiving slot, the first clamping jaw resiliently displaceable relative to the second clamping jaw,  
30

each cutting insert resiliently clamped in its respective insert receiving slot, and having a cutting edge intersecting the first and second reference planes,  
the tool key comprising a first end portion with opposing first and second engagement side surfaces, and first and second key prongs protruding from the first engagement side surface along first and second key axes, respectively,  
35

the second key prong having a thrust surface, the thrust surface having a concave profile in a cross-section taken in a fourth reference plane containing the second key axis,

wherein in a partially assembled position of the slitting cutter with the tool key engaged thereto:

the first key prong engages a key recess adjacent one of the insert receiving slots, and

the thrust surface contacts at least one of two spaced apart first and second corner surfaces

5 of the respective cutting insert.

## 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 10 boundaries for partial views of a member and in which:

**Fig. 1** is a perspective view of a slitting cutter according to the prior art;

**Fig. 2** is a side view of the slitting cutter shown in Fig. 1;

**Fig. 3** is a perspective view of a slitting cutter in accordance with some embodiments of

15 the present invention;

**Fig. 4** is a side view of the slitting cutter shown in Fig. 3;

**Fig. 5** is a detailed exploded perspective view of the slitting cutter shown in Fig. 3;

**Fig. 6** is a detailed peripheral view of the slitting cutter shown in Fig. 3;

**Fig. 7** is a partial cross-sectional view of the slitting cutter shown in Fig. 4, taken along 20 the line VII-VII;

**Fig. 8** is a perspective view of the slitting cutter in a partially assembled position and a tool key engaged thereto;

**Fig. 9** is a detailed perspective view of the slitting cutter and the tool key shown in Fig. 8;

**Fig. 10** is a detailed side view of the slitting cutter and the tool key shown in Fig. 8;

**Fig. 11** is a partial cross-sectional view of the slitting cutter and the tool key shown in Fig. 25 10, taken along the line XI-XI; and

**Fig. 12** is a detailed view of the partial cross-sectional view shown in Fig. 11; and

**Fig. 13** is a detailed perspective view of the slitting cutter in a fully assembled position and the tool key engaged thereto.

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## DETAILED DESCRIPTION OF THE INVENTION

As shown in Figs. 3 to 6, the present invention relates to a slitting cutter **20** comprising a disk-shaped cutter body **22** having a cutter axis of rotation **AC** defining a direction of rotation **R** about the cutter axis of rotation **AC**, two opposing first and second body side surfaces **24a**, **24b**, and a body peripheral surface **26** extending therebetween.

5 A plurality of insert receiving portions **28** are circumferentially spaced about the body peripheral surface **26** and a plurality of cutting inserts **30** are removably retained therein.

In some embodiments of the present invention, the plurality of cutting inserts **30** may be equal in number to the plurality of insert receiving portions **28**.

10 In some embodiments of the present invention, the cutting inserts **30** may be manufactured by a suitably hard material, preferably by form pressing and sintering a cemented carbide, such as tungsten carbide, and the cutter body **22** may also be manufactured from a cemented carbide or a less hard material, such as steel.

15 As shown in Fig. 6, at least radially outer portions of the first and second body side surfaces **24a**, **24b** are contained in first and second reference planes **P1**, **P2**, respectively, and the first and second reference planes **P1**, **P2** are offset by a body width **WB**.

In some embodiments of the present invention, the body width **WB** may be at least 0.40mm and at most 1.20mm, i.e.  $0.40\text{mm} \leq \mathbf{WB} \leq 1.20\text{mm}$ .

20 As shown in Figs. 4 and 5, each insert receiving portion **28** has first and second clamping jaws **32**, **34** spaced apart by an insert receiving slot **36**, the first clamping jaw **32** being resiliently displaceable relative to the second clamping jaw **34** and having a resilient axis of rotation **AR**.

In some embodiments of the present invention, the second clamping jaw **34** may have greater rigidity than the first clamping jaw **32**.

Also in some embodiments of the present invention, each resilient axis of rotation **AR** may be parallel to the cutter axis of rotation **AC**.

25 Further in some embodiments of the present invention, each first clamping jaw **32** may be elongated, and extend radially outwardly from its resilient axis of rotation **AR**.

It should be appreciated that for such embodiments, each first clamping jaw **32** is elongated by virtue of the having a radial length **LR** greater than a terminal width **WT**, the terminal width **WT** being measured in a side view of the slitting cutter **20**, as shown in Fig. 10, in the vicinity of the resilient axis of rotation **AR**.

As shown in Figs. 3 to 6, each first clamping jaw **32** may be spaced apart from the second clamping jaw **34** of the circumferentially adjacent insert receiving portion **28** by an auxiliary slot **38**.

In some embodiments of the present invention, each auxiliary slot **38** may be located 5 rotationally forward of the insert receiving slot **36** associated with the same insert receiving portion **28**.

Also in some embodiments of the present invention, each auxiliary slot **38** may be unoccupied.

As shown in Figs. 3 to 6, each insert receiving slot **36** and each auxiliary slot **38** may 10 communicate with a chip evacuation recess **40** in the body peripheral surface **26**.

In some embodiments of the present invention, each chip evacuation recess **40** may be entirely located radially outward of the respective resilient axis of rotation **AR**.

For such embodiments of the present invention, each chip evacuation recess **40** may have a volume sufficient to efficiently evacuate chips during slitting operations at the optimum feed rate 15 per insert, without limiting the number of insert receiving portions **28** that can be circumferentially spaced about the body peripheral surface **26**.

As shown in Figs. 4 and 10, in side views of the slitting cutter **20**, each insert receiving slot **36** has a radially innermost receiving slot point **NR**, the auxiliary slot **38** has a radially innermost auxiliary slot point **NA**, and the resilient axis of rotation **AR** may be located between the radially innermost receiving slot point **NR** and the radially innermost auxiliary slot point **NA**. 20

In some embodiments of the present invention, the resilient axis of rotation **AR** may be located midway between the radially innermost receiving slot point **NR** and the radially innermost auxiliary slot point **NA**.

Also in some embodiments of the present invention, the radially innermost auxiliary slot 25 point **NA** may be located radially inward of the radially innermost receiving slot point **NR**.

As shown in Fig. 6, each cutting insert **30** is resiliently clamped in its respective insert receiving slot **36**, and has a cutting edge **42** intersecting the first and second reference planes **P1**, **P2**.

It should be appreciated that each cutting edge **42** may span a cutting width **WC** greater 30 than the body width **WB**, and each cutting edge **42** may be described as 'fully effective'.

It should also be appreciated that each cutting insert **30** is clamped in its respective insert receiving slot **36** in a self-retaining manner, relying on resilience of the first clamping jaw **32** and the rigidity of second clamping jaw **34**, and devoid of any additional non-integral insert retaining members, such as screws, cams or wedges.

5 It should be further appreciated that the maximum rotational speed of the slitting cutter **20** may be limited by the capacity of each insert receiving slot **36** to resiliently retain its respective cutting insert **30** against the centrifugal forces acting thereon, plus an acceptable factor of safety.

For such embodiments of the present invention, having an outer cutting diameter **DO** of 63mm, the maximum rotational speed may be approximately 1440 rpm for slitting operations in 10 a workpiece material such as spring steel.

As shown in Fig. 4, the plurality of cutting edges **42** define an outer imaginary circle **CO** having the outer cutting diameter **DO** and an outer cutting circumference of  $\pi^*DO$ .

Also, as shown in Fig. 4, the plurality of resilient axes of rotation **AR** define an inner imaginary circle **CI** having an inner cutting diameter **DI**, and thus an inner circumference of  $\pi^*DI$ .

15 An annular cutting portion **44** is formed between the inner imaginary circle **CI** and the outer imaginary circle **CO**.

In some embodiments of the present invention, the annular cutting portion **44** may exhibit rotational symmetry about the cutter axis of rotation **AC**.

As shown in Fig. 5, each cutting insert **30** may have opposing upper and lower surfaces **46**, 20 **48** and an insert peripheral surface **50** extending therebetween, and the insert peripheral surface **50** may have opposing front and rear surfaces **52**, **54** spaced apart by opposing first and second insert side surfaces **56a**, **56b**.

In some embodiments of the present invention, the cutting edge **42** may be formed at the intersection of the upper surface **46** and the front surface **52**.

25 Also in some embodiments of the present invention, each cutting insert **30** may be non-indexable and have only one cutting edge **42**.

As shown in Fig. 5, each insert's upper surface **46** may include a chip forming surface **58** adjacent the cutting edge **42**.

It should be appreciated that the chip forming surface **58** is configured to control the flow 30 of chips and reduce cutting forces acting on the cutting insert **30**, thus enabling slitting operations with a high feed rate per insert, for example 4.0 $\mu$ m in a workpiece material such as spring steel,

which is 10 times greater than the feed rate per tooth of the integral one-piece slitting cutter **120** according to the prior art, discussed above.

As shown in Fig. 4, the annular cutting portion **44** has a first radial extent **ER1** equal to half of the difference between the outer cutting diameter **DO** and the inner cutting diameter **DI**, i.e.  $\mathbf{ER1} = (\mathbf{DO}-\mathbf{DI})/2$ , and the magnitude of the first radial extent **ER1** may vary according to the configuration of the insert receiving portions **28**, and not the outer cutting diameter **DO**.

Also, as shown in Fig. 4, each cutting insert **30** has a radially innermost insert point **NI** located a second radial extent **ER2** radially inward of the outer imaginary circle **CO**, and the second radial extent **ER2** may be greater than half of the first radial extent **ER1**, i.e.  $\mathbf{ER2} > \mathbf{ER1}/2$ .

In some embodiments of the present invention, the second radial extent **ER2** may be greater than two-thirds of the first radial extent **ER1**, i.e.  $\mathbf{ER2} > \mathbf{ER1} \cdot 2/3$ .

Also in some embodiments of the present invention, the radially innermost insert point **NI** may be located on the insert's rear surface **54**.

According to a first aspect of the present invention, the number **N** of cutting inserts **30** resiliently clamped in the slitting cutter **20** is roughly proportional to the inner cutting diameter **DI**. More particularly, the number **N** is determined by the inner cutting diameter **DI** (in mm) multiplied by a spacing factor **FS** between 0.15 and 0.30, i.e.  $\mathbf{DI} \cdot 0.15 < \mathbf{N} < \mathbf{DI} \cdot 0.30$ . Thus, the angular spacing **as** (in degrees) between adjacent insert receiving slots **36** is roughly inversely proportional to the inner cutting diameter **DI** and falls within the range  $360^\circ / (\mathbf{DI} \cdot 0.30) < \mathbf{as} < 360^\circ / (\mathbf{DI} \cdot 0.15)$ .

It should be appreciated throughout the specification and claims, that the spacing factor **FS** has units of 1/mm, and the ratio of the number **N** of cutting inserts **30** to the inner cutting diameter **DI** applies when the inner cutting diameter **DI** is measured in millimeters.

It should also be appreciated that for embodiments of the present invention in which **FS** is between 0.15 and 0.30, and  $\mathbf{DI} \cdot 0.15 < \mathbf{N} < \mathbf{DI} \cdot 0.30$ , each first clamping jaw **32** maintains an adequate level of resilience and each second clamping jaw **34** maintains an adequate level of rigidity throughout slitting operations performed at the maximum rotational speed and high values of feed rate per insert.

It should be further appreciated that for embodiments of the present invention in which **FS** is between 0.15 and 0.30, and  $\mathbf{DI} \cdot 0.15 < \mathbf{N} < \mathbf{DI} \cdot 0.30$ , and the annular cutting portion **44** has a

relatively small first radial extent **ER1**, for example,  $\mathbf{ER1} < 10\text{mm}$ , the number **N** of cutting inserts **30** relative to the outer cutting diameter **DO**, and thus the feed rate per revolution, may be advantageously high.

For embodiments of the present invention having, for example, an outer cutting diameter **DO** equal to 63mm and an inner cutting diameter **DI** equal to 47mm, there may be a plurality of 12 cutting inserts **30** resiliently clamped in the slitting cutter **20**, advantageously resulting in a feed rate per revolution of approximately 0.048mm and a feed rate per minute of approximately 70mm for slitting operations in a workpiece material such as spring steel.

In some embodiments of the present invention, the spacing factor **FS** may be between 0.20 and 0.30, i.e.  $\mathbf{DI} \cdot 0.20 < \mathbf{N} < \mathbf{DI} \cdot 0.30$ .

Also in some embodiments of the present invention, the annular cutting portion **44** may exhibit **N**-fold rotational symmetry about the cutter axis of rotation **AC**.

As shown in Fig. 4, the cutter body **22** may include a central aperture **60** coaxial with the cutter axis of rotation **AC**, having an aperture diameter **DA**.

For embodiments of the present invention in which the body width **WB** is at least 0.40mm and at most 1.20mm, the outer cutting diameter **DO** may be no more than 120mm greater than the aperture diameter **DA**, i.e.  $\mathbf{DO} \leq \mathbf{DA} + 120\text{mm}$ .

In various embodiments, the outer cutting diameter **DO** may range from 30mm to 200mm while the inner cutting diameter **DI** may range from 12mm to 185mm. A diameter-width ratio **R<sub>DW</sub>** of the inner cutting diameter **DI** to the body width **WB** is typically in the range of  $10 < \mathbf{R}_{\mathbf{DW}} < 240$ .

According to an additional aspect of the present invention, as shown in Figs. 8 to 12, a tool key **62** is used in combination with the slitting cutter **20**.

As shown in Figs. 8 to 10, the tool key **62** has a first end portion **64** with opposing first and second engagement side surfaces **70a**, **70b**, and spaced apart first and second key prongs **66**, **68** protruding from the first engagement side surface **70a** along first and second key axes **K1**, **K2**, respectively.

In some embodiments of the present invention, the first and second key axes **K1**, **K2** may be perpendicular to the first engagement side surface **70a**.

Also in some embodiments of the present invention, the first key prong **66** may be cylindrical-shaped, and have a diameter of 1-2mm.

Further in some embodiments of the present invention, as shown in Fig. 11, the first end portion **64** may exhibit mirror symmetry about a third reference plane **P3** perpendicular to the first and second key axes **K1, K2**.

For such embodiments, the first end portion **64** may be described as both left-handed and 5 right-handed.

The second key prong **68** comprises a base portion **68a** connected to a head portion **68b** via a narrowed neck portion **68c**. The narrowed neck portion **68c** has a thrust surface **72**. As shown in Figs. 11 and 12, in a cross-section taken in a fourth reference plane **P4** containing the second key axis **K2**, the thrust surface **72** has a concave profile.

10 In a partially assembled position of the slitting cutter **20** with the tool key **62** engaged thereto, as shown in Figs. 8 to 12, the first key prong **66** engages a key recess **74** adjacent one of the insert receiving slots **36**. Additionally, the front surface **52** of the cutting insert **30** is received into the narrowed neck portion **68c** and the thrust surface **72** contacts at least one of two spaced apart first and second corner surfaces **76a, 76b** of the respective cutting insert **30**.

15 In such an arrangement, the first engagement side surface **70a** may be in contact with one of the first and second body side surfaces **24a, 24b**.

In some embodiments of the present invention, as shown in Figs. 11 and 12, in the cross-section taken in the fourth reference plane **P4**, the first and second corner surfaces **76a, 76b** may be curved.

20 As shown in Fig. 6, the first and second corner surfaces **76a, 76b** may be formed at intersection of the front surface **52** and the first and second insert side surfaces **56a, 56b**, respectively.

In some embodiments of the present invention, the key recess **74** may intersect the first and second body side surfaces **24a, 24b**.

25 Also in some embodiments of the present invention, the key recess **74** may be located rotationally rearward of the associated insert receiving slot **36**.

The thrust surface **72** may have two axially adjacent first and second flank surfaces **78a, 78b**, and as shown in Figs. 11 and 12, in the cross-section taken in the fourth reference plane **P4**, the first and second flank surfaces **78a, 78b** may diverge away from the second key axis **K2**.

In some embodiments of the present invention, at least one of the two first and second flank surfaces **78a**, **78b** may contact at least one of the two first and second corner surfaces **76a**, **76b**.

Also in some embodiments of the present invention, the first flank surface **78a** may be located axially further from the first engagement side surface **70a** than the second flank surface **78b**, and the first flank surface **78a** may contact one of the two first and second corner surfaces **76a**, **76b**.

For embodiments in which only the first flank surface **78b** is in contact with only one of the two first and second corner surfaces **76a**, **76b** (not shown), the first engagement side surface **70a** may provide lateral support for the cutting insert **30**, and thus a stable and repeatable means for urging each cutting insert **30** into its respective insert receiving slot **36**.

Further in some embodiments of the present invention, the first and second flank surfaces **78a**, **78b** both may contact the first and second corner surfaces **76a**, **76b**, respectively.

It should be appreciated that for embodiments of the present invention in which each insert's cutting edge **42** spans a relatively thin cutting width **WC**, for example 1mm, the abovementioned two-point contact between the second key prong's concave thrust surface **72** and the respective insert's first and second corner surfaces **76a**, **76b** advantageously provides a stable and repeatable means for urging each cutting insert **30** into its respective insert receiving slot **36**.

It should also be appreciated that in some embodiments of the present invention, the same tool key **62** may be suitable for providing one-point or two-point contact between the second key prong's concave thrust surface **72** and the respective insert's first and/or second corner surfaces **76a**, **76b** for slitting cutters **20** in which the body width **WB** is at least 0.40mm and at most 1.20mm.

As shown in Figs. 11 and 12, in the cross-section taken in the fourth reference plane **P4**, the first and second flank surfaces **78a**, **78b** may form an external wedge angle **α1**, and the wedge angle **α1** may be at least 70 degrees and at most 130 degrees, i.e.  $70^\circ \leq \alpha_1 \leq 130^\circ$ .

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 surface components are formed.

It should also be appreciated that for embodiments of the present invention in which the wedge angle **α1** is at least 70 degrees and at most 130 degrees, the first and second flank surfaces

**78a, 78b** may advantageously provide a stable and repeatable means for engaging each insert's first and second corner surfaces **76a, 76b**.

In some embodiments of the present invention, each of the first and second flank surfaces **78a, 78b** may have a frustoconical shape.

5 Also in some embodiments of the present invention, the first and second flank surfaces **78a, 78b** may be spaced apart by a transition groove **80**.

Further in some embodiments of the present invention, the second flank surface **78b** may be partially located in a clearance channel **81** in the first engagement side surface **70a**.

10 For such embodiments, the clearance channel **81** may have a depth sufficient to accommodate a laterally extending portion of the insert's cutting edge **42** without contact.

As shown in Figs. 11 and 12, in the cross-section taken in the fourth reference plane **P4**, an imaginary first straight line **L1** perpendicular to the second key axis **K2** and containing a radially innermost peripheral point **NP** of the thrust surface **72** may be located midway between the first and second corner surfaces **76a, 76b**.

15 In the partially assembled position of the slitting cutter **20**, as shown in Figs. 8 to 12, a first clamping surface **82** of the first clamping jaw **32** may be in partial contact with an upper fastening portion **84** of the respective insert's upper surface **46**, and a second clamping surface **86** of the second clamping jaw **34** may be in partial contact with a lower fastening portion **88** of the respective insert's lower surface **48**.

20 In some embodiments of the present invention, as shown in Figs. 4 and 5, the first and second clamping surfaces **82, 86** may extend radially along the insert receiving slot **36**.

Also in some embodiments of the present invention, rotation of the tool key **62** in a mounting direction **DM** about the first key axis **K1** may urge the associated cutting insert **30** into the insert receiving slot **36** until a finally assembled position of that cutting insert in the slitting cutter **20** is achieved. It is understood that this process may be repeated for each cutting insert **30** into a corresponding insert receiving slot **36**, until a finally assembled of the slitting cutter **20** is achieved.

30 In the finally assembled position of the slitting cutter **20**, as shown in Figs. 3 to 7 and 13, the first clamping surface **82** may be in full contact with the upper fastening portion **84** of the respective insert's upper surface **46**, and the second clamping surface **86** may be in full contact with the lower fastening portion **88** of the respective insert's lower surface **48**.

As shown in Fig. 7, in a cross-section taken in a fifth reference plane **P5** transverse to one of the insert receiving slots **36**, the first and second clamping surfaces **82, 86** may be V-shaped and the respective upper and lower fastening portions **84, 88** may be correspondingly V-shaped.

5 In the finally assembled position of the slitting cutter **20**, as shown in Figs. 3 to 5 and 13, a shoulder surface **90** of each insert's upper surface **46** may be in contact with a radially outward facing stopper surface **92** of the respective first clamping jaw **32**.

In some embodiments of the present invention, as shown in Fig. 5, the shoulder surface **90** may be located between the chip forming surface **58** and the upper fastening portion **84** of the insert's upper surface **46**.

10 Also in some embodiments of the present invention, each insert's rear surface **54** may face radially inwardly and not be in contact with the cutter body **22**.

As shown in Figs. 4 and 13, in the finally assembled position of the slitting cutter **20**, each insert's rear surface **54** may be spaced apart from the radially innermost receiving slot point **NR** of the respective insert receiving slot **36** to form an extraction recess **93**.

15 In some embodiments of the present invention, as shown in Figs. 8 to 10, the tool key **62** may have a second end portion **94** with opposing third and fourth engagement side surfaces **95a, 95b**, and third and fourth key prongs **96, 98** protruding from the third engagement side surface **95a**, along third and fourth key axes **K3, K4**, respectively.

20 Also in some embodiments of the present invention, the second end portion **94** may be spaced apart from the first end portion **64**.

In other embodiments of the present invention (not shown), the third and fourth key prongs **96, 98** may protrude from the second engagement side surface **70b** of the first end portion **64**.

25 As shown in Fig. 13, the extraction recess **93** may be configured to receive the third key prong **96**, and the fourth key prong **98** may contact the body peripheral surface **26**.

In such an arrangement, the third engagement side surface **95a** may be in contact with one of the first and second body side surfaces **24a, 24b**.

In some embodiments of the present invention, the first and third engagement side surfaces **70a, 95a** may be coplanar.

30 Also in some embodiments of the present invention, the third and fourth key prongs **96, 98** may each be cylindrical-shaped, and have a diameter of 1-2mm. In some embodiments, the third

and fourth key prongs **96, 98** may be cylindrical for their entire length, and thus both may be devoid of a narrowed neck portion **68c** and thrust portion **72** of the sort described above with respect to the second key prong **68**.

It should be appreciated that for embodiments of the present invention in which the radially innermost receiving slot point **NR** of each insert receiving slot **36** is located a short radial distance inward of the respective insert's rear surface **54** in the insert's finally assembled position, for example, a distance less than twice the diameter of the third key prong **96**, the annular cutting portion **44** may have a relatively small first radial extent **ER1**, for example,  $ER1 < 10\text{mm}$ .

Also in some embodiments of the present invention, as shown in Fig. 13, rotation of the tool key **62** in a dis-mounting direction **DD** about the fourth key axis **K4** may urge the cutting insert **30** out of the insert receiving slot **36** until a finally dis-assembled position of the slitting cutter **20** is achieved.

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 slitting cutter (20) comprising:

a disk-shaped cutter body (22) having a cutter axis of rotation (AC) defining a direction of rotation (R) about the cutter axis of rotation (AC), opposing first and second body side surfaces (24a, 24b), and a body peripheral surface (26) extending therebetween,

a plurality of insert receiving portions (28) circumferentially spaced about the body peripheral surface (26) and a plurality of cutting inserts (30) removably retained therein,

at least radially outer portions of the first and second body side surfaces (24a, 24b) contained in first and second reference planes (P1, P2), respectively, the first and second reference planes (P1, P2) offset by a body width (WB),

each insert receiving portion (28) having first and second clamping jaws (32, 34) spaced apart by an insert receiving slot (36), the first clamping jaw (32) resiliently displaceable relative to the second clamping jaw (34) and having a resilient axis of rotation (AR),

each cutting insert (30) resiliently clamped in its respective insert receiving slot (36), and having a cutting edge (42) intersecting the first and second reference planes (P1, P2), wherein:

the plurality of cutting edges (42) define an outer imaginary circle (CO) having an outer cutting diameter (DO), and the plurality of resilient axes of rotation (AR) define an inner imaginary circle (CI) having an inner cutting diameter (DI),

and wherein:

the number N of cutting inserts (30) resiliently clamped in the slitting cutter (20), is the inner cutting diameter (DI), in millimeters, multiplied by a spacing factor (FS), and

the spacing factor (FS) is between 0.15 and 0.30.

2. The slitting cutter (20) according to claim 1, wherein:

the spacing factor (FS) is between 0.20 and 0.30.

3. The slitting cutter (20) according to claim 1 or 2, wherein:

the body width (WB) is at least 0.40mm and at most 1.20mm.

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

each first clamping jaw (32) is spaced apart from the second clamping jaw (34) of the circumferentially adjacent insert receiving portion (28) by an auxiliary slot (38).

5. The slitting cutter (20) according to claim 4, wherein:

each auxiliary slot (38) is located rotationally forward of the insert receiving slot (36) associated with the same insert receiving portion (28).

6. The slitting cutter (20) according to claim 4 or 5, wherein in a side view of the slitting cutter (20):

each insert receiving slot (36) has a radially innermost receiving slot point (NR),

the auxiliary slot (38) has a radially innermost auxiliary slot point (NA), and

the resilient axis of rotation (AR) is located between the radially innermost receiving slot point (NR) and the radially innermost auxiliary slot point (NA).

7. The slitting cutter (20) according to claim 6, wherein:

the radially innermost auxiliary slot point (NA) is located radially inward of the radially innermost receiving slot point (NR).

8. The slitting cutter (20) according to any one of claims 4 to 7, wherein:

each insert receiving slot (36) and each auxiliary slot (38) communicate with a chip evacuation recess (40) in the body peripheral surface (26).

9. The slitting cutter (20) according to claim 8, wherein:

each chip evacuation recess (40) is entirely located radially outward of the respective resilient axis of rotation (AR).

10. The slitting cutter (20) according to any one of the preceding claims, wherein: the second clamping jaw (34) has greater rigidity than the first clamping jaw (32).

11. The slitting cutter (20) according to any one of the preceding claims, wherein: each first clamping jaw (32) is elongated and extends radially outwardly from its resilient axis of rotation (AR).

12. The slitting cutter (20) according to any one of the preceding claims, wherein: the inner cutting diameter (DI) ranges from 12mm to 185mm; the body width (WB) ranges from 0.40mm to 1.20mm; and a ratio of the inner cutting diameter (DI) to the body width (WB) is between 10 and 240.

13. A slitting cutter (20) in combination with a tool key (62):  
the slitting cutter (20) comprising a disk-shaped cutter body (22) having a cutter axis of rotation (AC) defining a direction of rotation (R) about the cutter axis of rotation (AC), opposing first and second body side surfaces (24a, 24b), and a body peripheral surface (26) extending therebetween,

a plurality of insert receiving portions (28) circumferentially spaced about the body peripheral surface (26) and a plurality of cutting inserts (30) removably retained therein,

at least radially outer portions of the first and second body side surfaces (24a, 24b) contained in first and second reference planes (P1, P2), respectively, the first and second reference planes (P1, P2) spaced apart from one another by a body width (WB),

each insert receiving portion (28) having first and second clamping jaws (32, 34) spaced apart by an insert receiving slot (36), the first clamping jaw (32) resiliently displaceable relative to the second clamping jaw (34),

each cutting insert (30) resiliently clamped in its respective insert receiving slot (36), and having a cutting edge (42) intersecting the first and second reference planes (P1, P2),

the tool key (62) comprising a first end portion (64) with opposing first and second engagement side surfaces (70a, 70b), and first and second key prongs (66, 68) protruding from the first engagement side surface (70a) along first and second key axes (K1, K2), respectively,

the second key prong (68) having a thrust surface (72), the thrust surface (72) having a concave profile in a cross-section taken in a fourth reference plane (P4) containing the second key axis (K2),

wherein in a partially assembled position of the slitting cutter (20) with the tool key (62) engaged thereto:

the first key prong (66) engages a key recess (74) adjacent one of the insert receiving slots (36), and

the thrust surface (72) contacts at least one of two spaced apart first and second corner surfaces (76a, 76b) of the respective cutting insert (30).

14. The slitting cutter (20) in combination with the tool key (62) according to claim 13, wherein:

each cutting insert (30) has opposing upper and lower surfaces (46, 48) and an insert peripheral surface (50) extending therebetween,

the insert peripheral surface (50) having opposing front and rear surfaces (52, 54) spaced apart by opposing first and second insert side surfaces (56a, 56b), the cutting edge (42) formed at the intersection of the upper surface (46) and the front surface (52).

15. The slitting cutter (20) in combination with the tool key (62) according to claim 14, wherein:

the first and second corner surfaces (76a, 76b) are formed at intersection of the front surface (52) and the first and second insert side surfaces (56a, 56b), respectively.

16. The slitting cutter (20) in combination with the tool key (62) according to any one of claims 13 to 15, wherein:

rotation of the tool key (62) in a mounting direction (DM) about the first key axis (K1) urges an associated one of the cutting inserts (30) into the insert receiving slot (36) until a finally assembled position of that cutting insert in the slitting cutter (20) is achieved.

17. The slitting cutter (20) in combination with the tool key (62) according to any one of claims 13 to 16, wherein:

the thrust surface (72) has two axially adjacent first and second flank surfaces (78a, 78b),  
 in the cross-section taken in the fourth reference plane (P4), the first and second flank surfaces (78a, 78b) diverge away from the second key axis (K2), and  
 at least one of the two first and second flank surfaces (78a, 78b) contacts the at least one of the two first and second corner surfaces (76a, 76b).

18. The slitting cutter (20) in combination with the tool key (62) according to claim 17, wherein:

the first flank surface (78a) is located axially further from the first engagement side surface (70a) than the second flank surface (78b), and

the first flank surface (78b) contacts one of the two first and second corner surfaces (76a, 76b).

19. The slitting cutter (20) in combination with the tool key (62) according to claim 17 or 18, wherein:

the first and second flank surfaces (78a, 78b) contact the first and second corner surfaces (76a, 76b), respectively.

20. The slitting cutter (20) in combination with the tool key (62) according to any one of claims 17 to 19, wherein, in the cross-section taken in the fourth reference plane (P4):

the first and second flank surfaces (78a, 78b) form an external wedge angle ( $\alpha 1$ ), and  
 the wedge angle ( $\alpha 1$ ) is at least 70 degrees and at most 130 degrees.

21. The slitting cutter (20) in combination with the tool key (62) according to any one of claims 17 to 20, wherein:

the second flank surface (78b) is partially located in a clearance channel (81) in the first engagement side surface (70a).

22. The slitting cutter (20) in combination with the tool key (62) according to any one of claims 17 to 21, wherein:

in the cross-section taken in the fourth reference plane (P4), the first and second corner surfaces (76a, 76b) are curved.

23. The slitting cutter (20) in combination with the tool key (62) according to any one of claims 13 to 22, wherein:

the first engagement side surface (70a) is in contact with one of the first and second body side surfaces (24a, 24b).

24. The slitting cutter (20) in combination with the tool key (62) according to any one of claims 13 to 23, wherein:

the body width (WB) is at least 0.40mm and at most 1.20mm.

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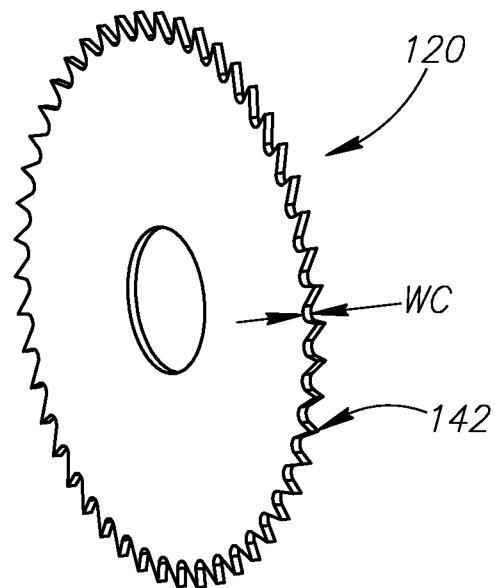


FIG.1  
(PRIOR ART)

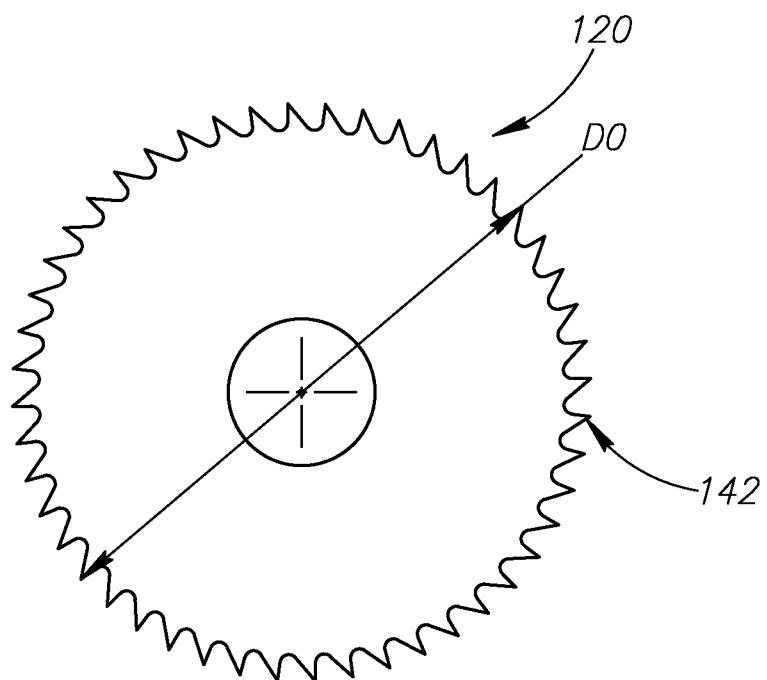


FIG.2  
(PRIOR ART)

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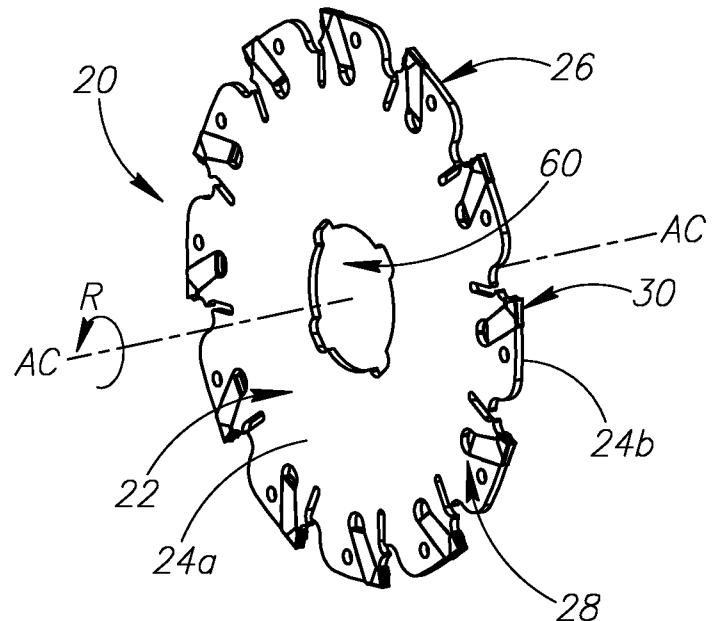


FIG.3

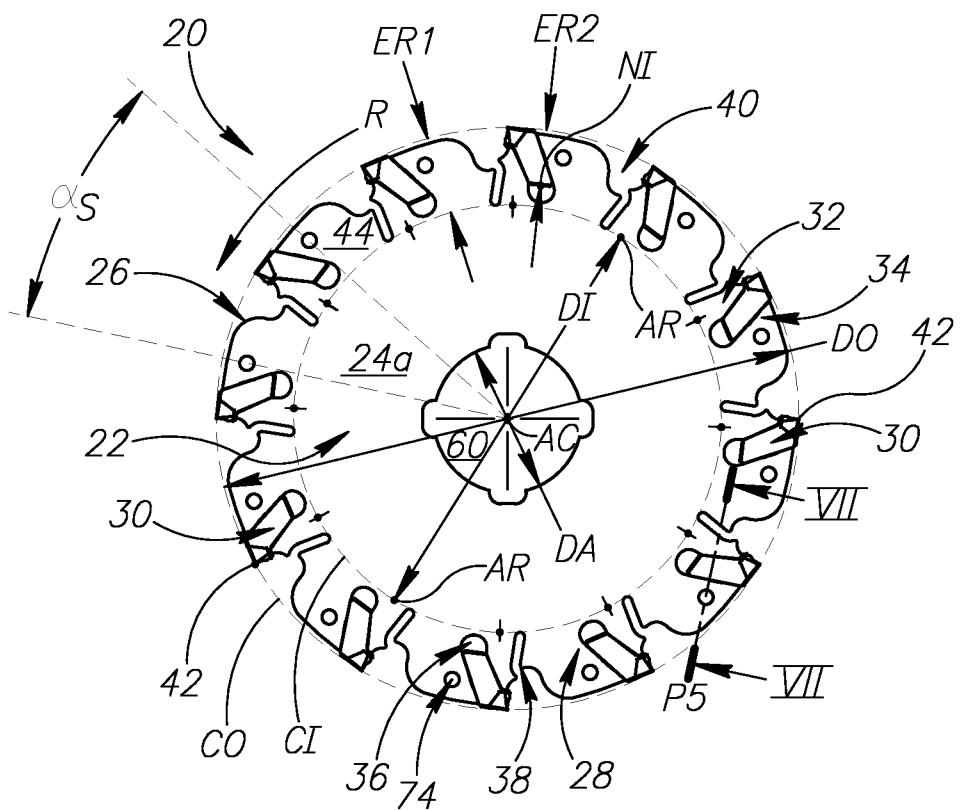


FIG. 4

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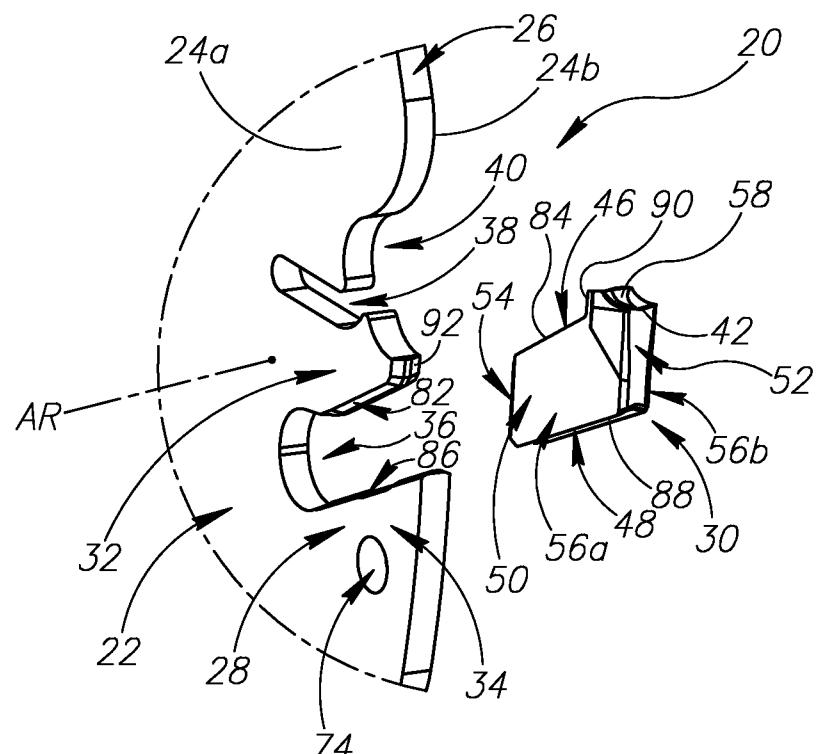


FIG.5

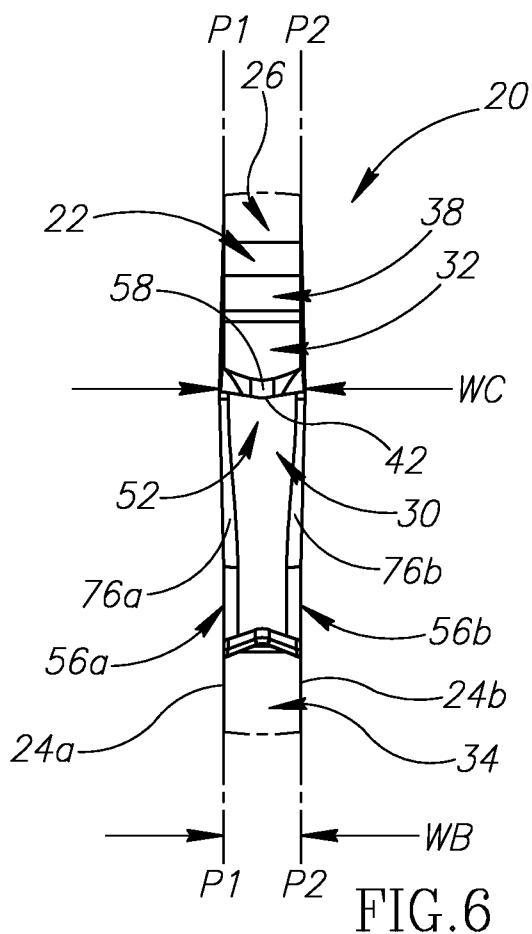


FIG.6

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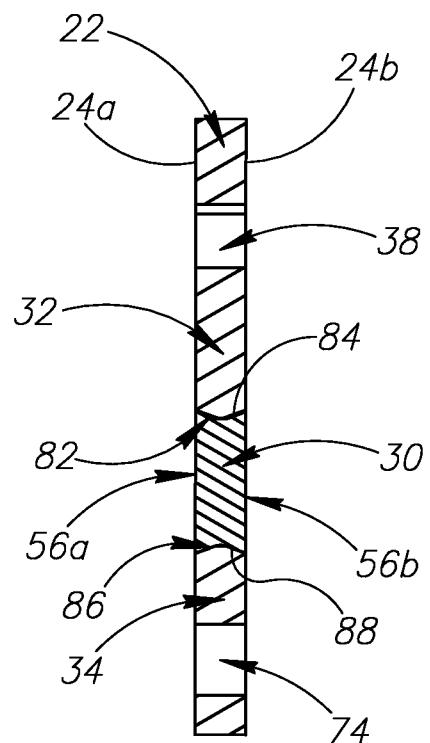


FIG. 7

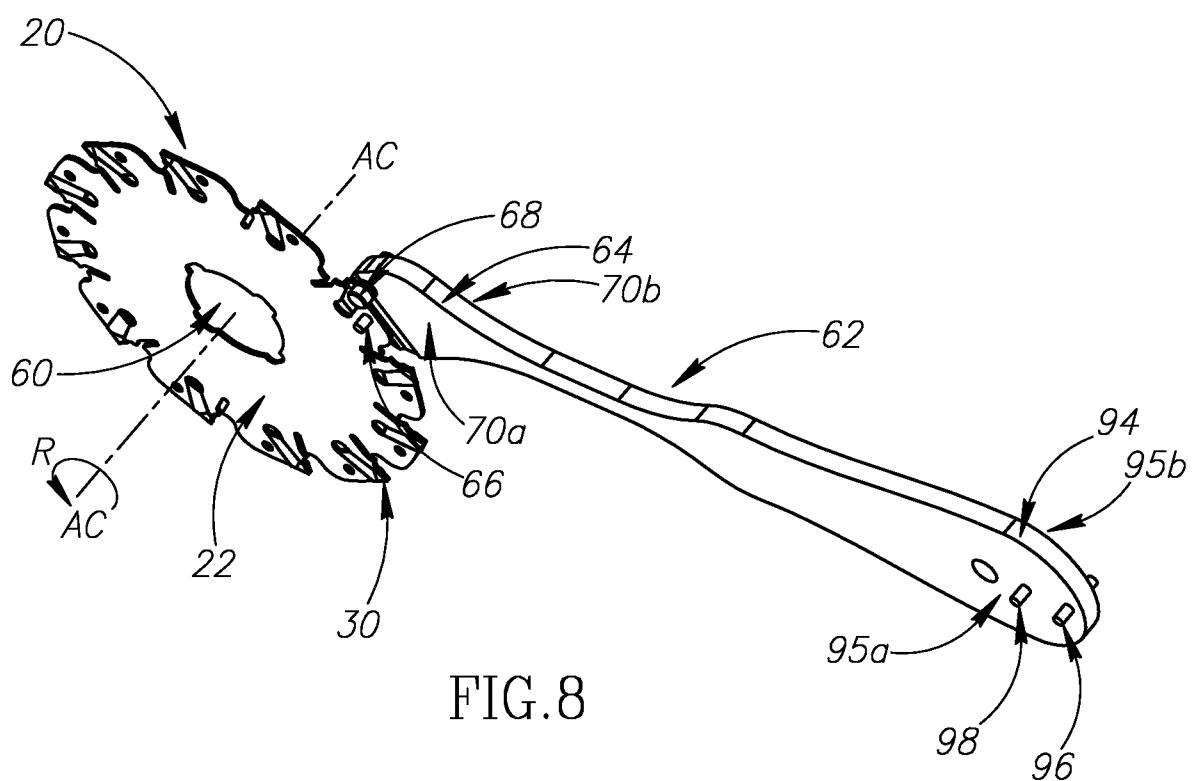


FIG. 8

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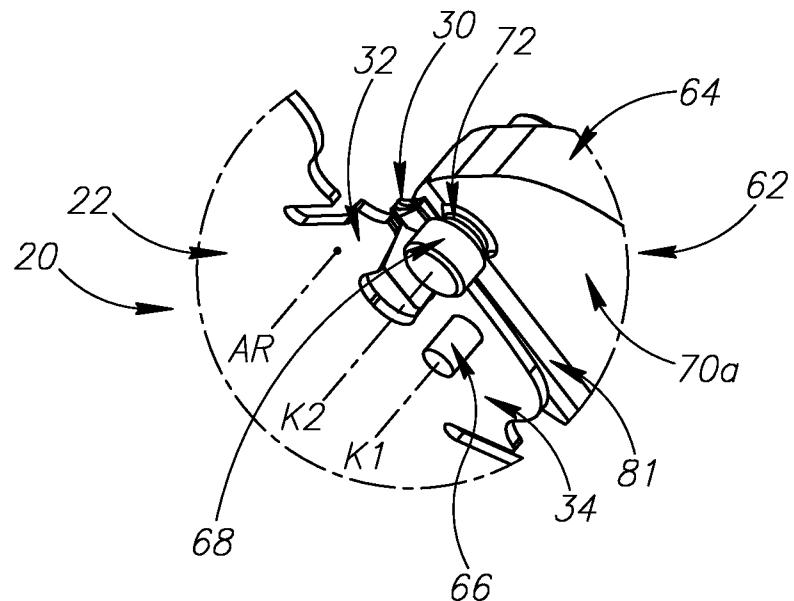


FIG. 9

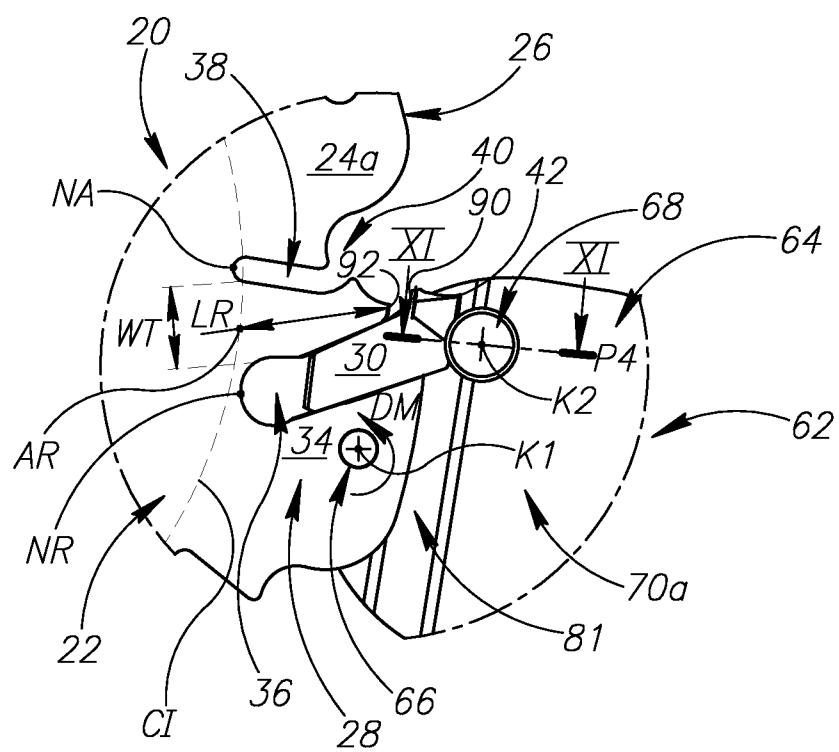
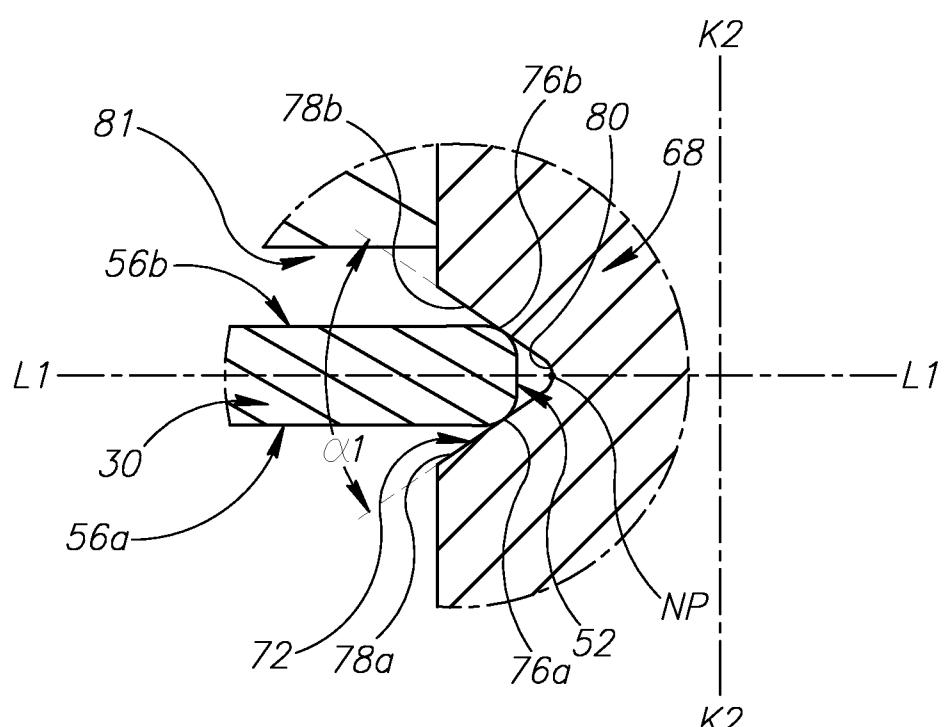
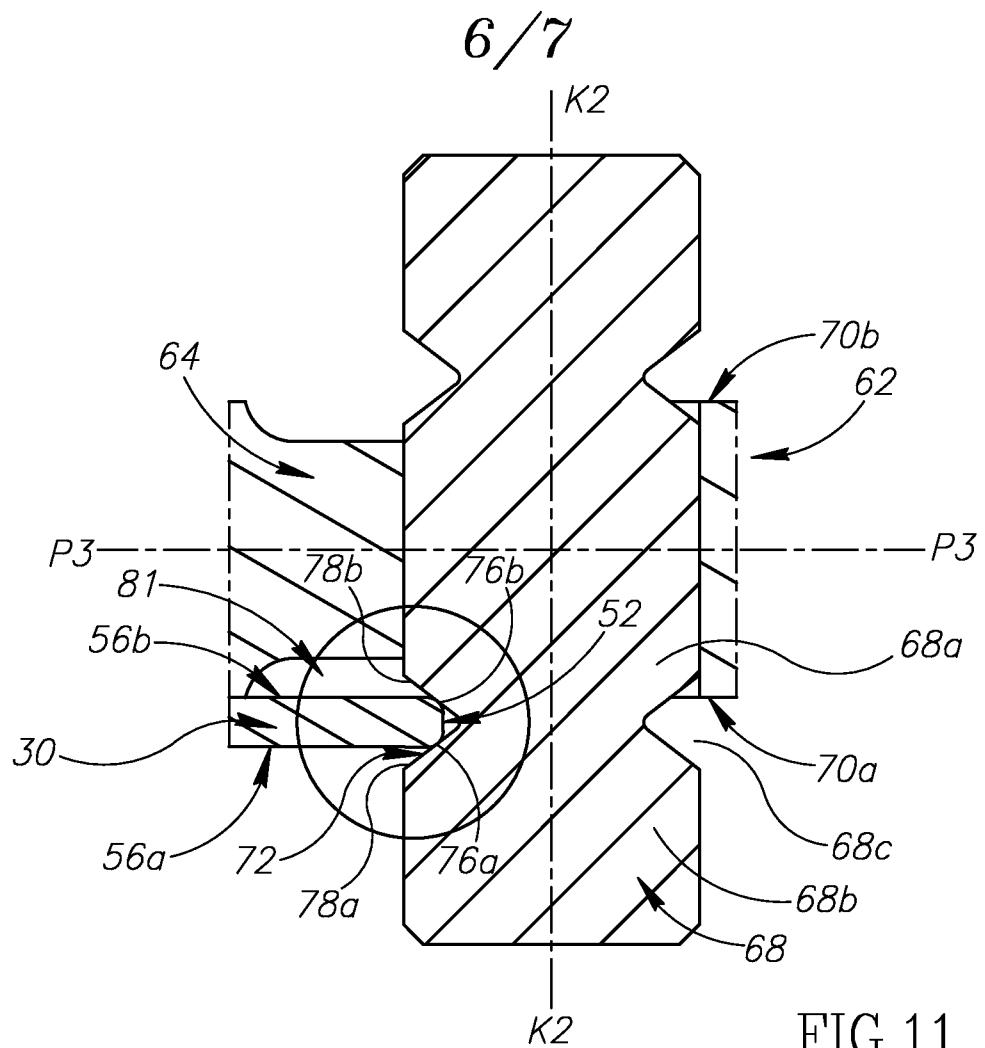


FIG. 10



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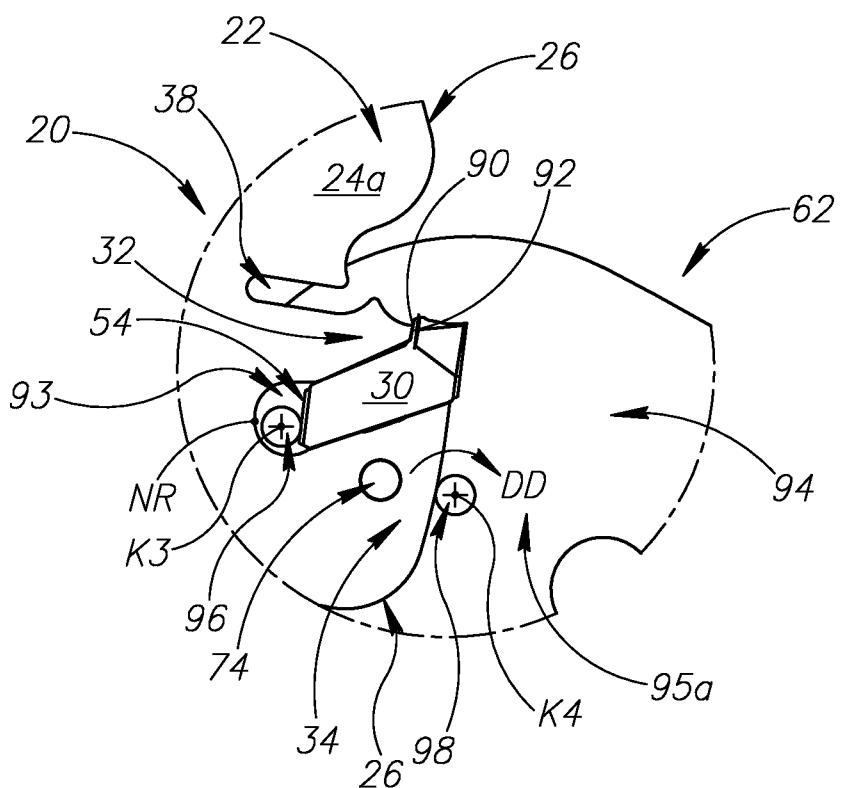


FIG.13

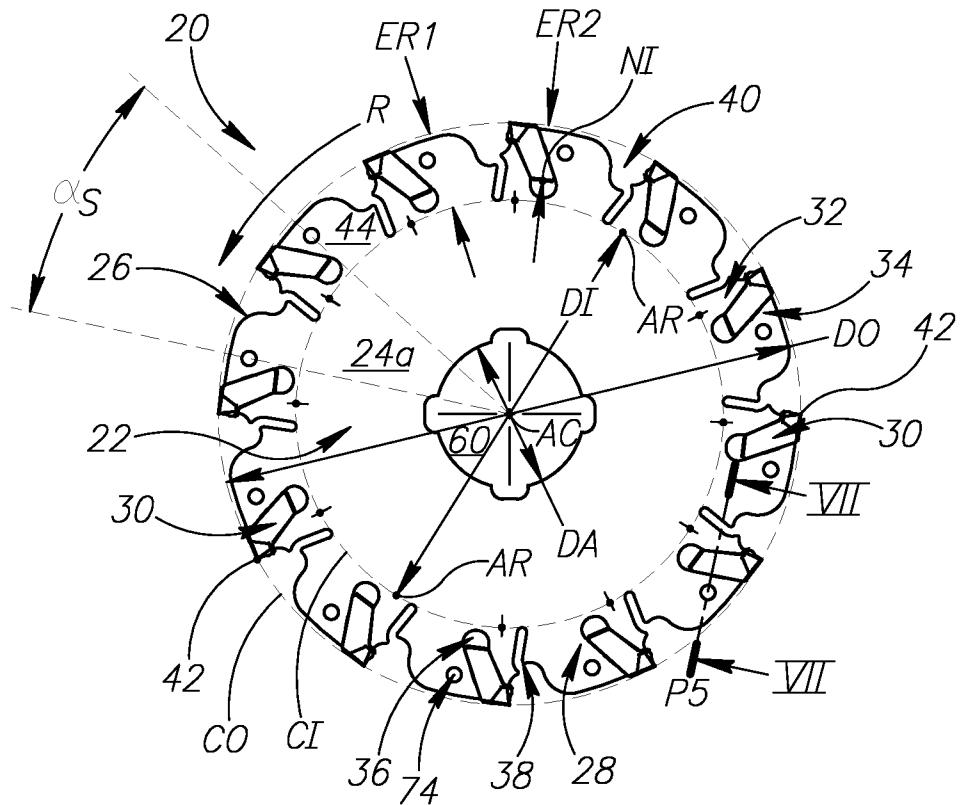


FIG.4