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(54) **Titre : OUTIL DE FRAISAGE PRESENTANT AU MOINS DEUX RAYONS**
(54) **Title: MILLING TOOL HAVING AT LEAST TWO RADII**

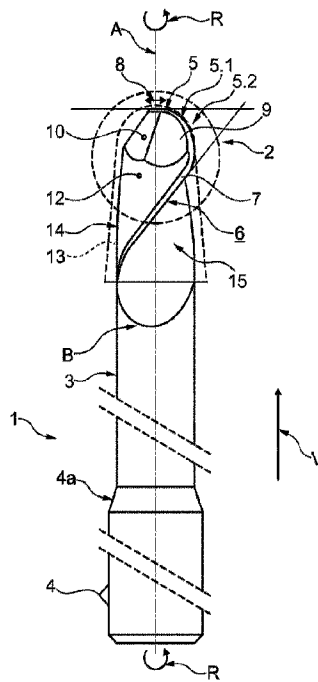


Fig. 1

(57) **Abrégé/Abstract:**

The invention relates to a milling tool (1) for milling and/or drilling workpieces as an alternative for a wide range of technical applications, comprising a milling head (2), which has a radius cutter (5), and comprising a main body (3), which has a main feature in the form of a helical depression that forms a conveyor helix, wherein the main feature is provided with a main cutter (6) in the form of a cutting edge, wherein the main feature has a smooth lateral surface (12) arranged on the side facing away from the main cutter (6) in the direction of rotation (R), and wherein the radius cutter (5) is composed of at least two circular arc-shaped portions (5.1, 5.2) having at least a first and a second radius, wherein the first radius is different from the second radius, so that the milling head (2) in rotation occupies a volume which is made up of at least two parts of spheres having the first or second radius.

Abstract

The invention relates to a milling tool (1) for milling and/or drilling workpieces as an alternative for a wide range of technical applications, comprising a milling head (2), which has a radius cutter (5), and comprising a main body (3), which has a main feature in the form of a helical depression that forms a conveyor helix, wherein the main feature is provided with a main cutter (6) in the form of a cutting edge, wherein the main feature has a smooth lateral surface (12) arranged on the side facing away from the main cutter (6) in the direction of rotation (R), and wherein the radius cutter (5) is composed of at least two circular arc-shaped portions (5.1, 5.2) having at least a first and a second radius, wherein the first radius is different from the second radius, so that the milling head (2) in rotation occupies a volume which is made up of at least two parts of spheres having the first or second radius.

Milling tool having at least two radii

The invention relates to a milling tool for milling workpieces according to the preamble of claim 1.

Various milling tools which also permit a processing of specific materials are known from the prior art, for example, the processing of plastics material or for use in conjunction with the production of dental work members or the like. In order to provide a sufficiently large material cross section, in some of these tools the covering face of the base member, in the region of the main groove or in the region which is located in the rotation direction behind the main cutter, is constructed in a ribbed manner. The base member is thereby additionally intended to obtain a high degree of stability. DE 20 2017 101 382 U1 also discloses inter alia a milling tool with a smooth rear in place of a rear which is provided with a ribbing.

An object of the invention is to provide a milling tool which forms an alternative to the prior art and which at the same time can be generally used for extremely varied technical applications.

This object, based on a milling tool of the type mentioned in the introduction, is achieved by the characterizing features of claim 1.

As a result of the measures mentioned in the dependent claims, advantageous embodiments and further developments of the invention are possible.

The milling tool according to the invention for milling workpieces first comprises a base member and on the upper side thereof a milling head which has a radius cutter which describes a circular-arc-like portion. The milling tool which can be rotated about a rotation axis has for the machining processing operation, thus in this instance for the milling operation, a prescribed rotation direction in which the cutters move toward the material of the workpiece during the rotation.

The base member has a main groove which is in the form of a helical recess with respect to the rotation volume occupied by the rotating milling tool. This main groove is in turn provided with a cutting edge as a main cutter. Via the helical recess, the material of the workpiece removed during the machining processing operation can where applicable (as with a conveying screw) also be transported away.

In the milling tool according to the invention, the main groove has a smooth covering face which is arranged at the side facing away from the main cutter in the rotation direction. It has surprisingly been found that such a tool according to the invention can not only be produced in a cost-effective manner since no additional projections and recesses have to be incorporated in the covering face, but this tool also has very good strength and stability. The smooth surface, even when the milling tool has penetrated comparatively deeply into the material of the workpiece, has a very low friction resistance in so far as the base member even becomes joined to the workpiece. As a result of these properties, the milling tool according to the invention can in principle also be used for a great variety of technical application areas, inter alia for the processing of:

- plastics materials, for example, PMMA,

- light metals, for instance aluminum, but also copper or brass,
- minerals such as zirconium (particularly hydrostatically pressed rather than sintered material) and ceramic materials (particularly non-fired),
- materials in dental and other medical technology.

If the milling tool is thus in rotation about the rotation axis thereof, the milling head is now according to the invention characterized in that the radius cutter has at least two regions with radii which are different from each other. That is to say, during this rotation, a volume which corresponds (partially) to at least two hemispherical rotation volumes which overlap is occupied. A particularly flexible use of the milling tool is thereby enabled. For example, smaller or larger contact faces between the tool end face and workpiece can be produced in a simpler manner depending on the application.

Furthermore, a particularly preferred further development of the invention is characterized in that the cutting action is improved by an additional main cutter at the center of the tool. The second main cutter may extend in a linear manner. The second main cutter may further extend perpendicularly to the rotation axis. However, instead in a preferred embodiment, it may also extend in a skewed manner with respect to the rotation axis in a plane which extends perpendicularly to the rotation axis. As a result of the skewed offset of the second main cutter with respect to the rotation axis, the rotation is carried out with an offset relative to the rotation center, and the torque is slightly increased. The advance can consequently be improved. In addition, the second main cutter may extend in such a wide manner that the second main cutter intersects or extends beyond an axis which extends from the rotation axis perpendicularly to the rotation axis and which in turn extends perpendicularly to the second main cutter. The

formation of a pin in the region of the center can consequently be prevented since a larger region is covered during the cutting. Furthermore, the second main cutter can advantageously form the tool tip in an advance direction.

Consequently, the tool according to the invention differs significantly from the conventional ball-head milling cutter or copy milling cutters. Instead it is much more a single-cutting tool having (at least) two radii.

In one embodiment of the invention, the intermediate region between the two angular segments of the radius cutter may also have a flowing transition between the two radii, whereby generally a smoother processed surface is produced in the workpiece and the tool resistance during processing is generally lower.

In an advantageous embodiment of the invention, the radius cutter merges into the main cutter. In this manner, the machining processing operation, even in the case of deep penetration of the tool into the material, always begins rotating at the same time at the same location so that a continuous processing is achieved without tilting the cutter and also the material removal via the helical recess can be facilitated. However, the transition between the radius cutter and the main cutter may but does not necessarily have to have a smooth path. Generally, as a result of the smooth path, the resistance during processing is reduced, the processed surfaces can extend in a smoother manner. Similarly, in an embodiment of the invention, the second main cutter may also merge into the radius cutter, in particular with a flowing transition, but also, for example, in a slightly angled manner.

Furthermore, in principle, two variants are conceivable, that is to say, a milling tool having a covering face which extends parallel with the rotation axis, or a milling tool in which the covering face is inclined relative to the rotation axis.

The covering face may advantageously extend in a cylindrical manner, whereby the processing resistance can be reduced.

If the covering face extends parallel with the rotation axis, as a result of this measure a tool which in terms of rotation or the rotation volume thereof has a cylindrical form as far as possible can be provided. When approaching the workpiece, the base member may thus laterally carry out a planar processing parallel with the rotation axis. If the milling tool has to penetrate deeply into a material, in this embodiment the cross section or the cross sectional surface-area thus does not change. With a covering face which is inclined relative to the rotation axis, it may be provided in particular conically with a cross sectional surface-area which decreases in the direction toward the milling head (or increases in the direction toward the shaft). The cross sectional surface-area in this embodiment thus becomes larger toward the side at which the tool is clamped into a tool holder of a machine tool. In this manner, the milling tool may obtain a higher degree of stability. Such a structural measure may be particularly advantageous when in the operating method provided for the milling tool primarily the milling head, that is to say, the "tip" of the tool is used, that is to say, the milling head alone is in contact with the workpiece, wherein, even with harder materials of the workpiece, a smooth running of the milling tool which is well stabilized and consequently a uniform, precise processing of the workpiece are enabled. Preferably, the covering face encloses with the rotation axis in this instance an angle between 0° and a maximum of 20° inclusive.

In one embodiment of the invention, the main cutter, with the exception of the additional second main cutter, may also be located partially or completely on the covering face of a cylinder.

Furthermore, in one embodiment of the invention, the surface of the rotation volume of the milling tool may be inclined relative to the rotation axis. This is in principle also the

case when the covering face of the base member is already inclined relative to the rotation axis. The main cutter is generally raised from the actual covering face, that is to say, when the main cutter is radially further away from the rotation axis than the covering face and the outer contour thereof consequently determines during the rotation of the milling tool the envelope, that is to say, the rotation volume. In this instance, angles between 0° and a maximum of 20° may also be provided. As a result of the offset of the main cutter, however, the friction resistance in the event of deep penetration into the material can also in principle be reduced.

In the rotation direction behind the radius cutter, a free face may be provided. This free face may facilitate the material disposal of the removed material from the workpiece and additionally reduce the resistance during penetration of the cutter into the material. In principle, however, precisely one free face is sufficient. In the rotation direction, in order to improve the material transport, additional free grinding portions may also be provided. If the free face is in particular still curved, as a result of the guiding along the curved surface, the material disposal may be facilitated. A curved free face may replace a series of free faces which are arranged one behind the other. In addition, it generally provides a lower mechanical resistance during processing or during transport of chips. With a planar face, there is where applicable more space available for disposal. Also in the case of free grinding portion, in principle more space is provided for material transport when the faces thereof extend closer to the rotation axis, that is to say, during the production of the free grinding portions, more material has been removed from the tool.

The free grinding portions may in different variants of the invention extend in a planar manner or with a curved surface; the curvature may in particular be carried out in a direction away from the surface. Whilst a curved surface enables the most uniform transition possible, as a result of a planar face

of the free grinding portion the maximum amount of space for material disposal can be provided.

A free face or the contour lines thereof may in principle extend parallel with the radius cutter and/or the main cutter.

In a further development of the invention, the radius cutter may merge into the main cutter with a smooth path. With a smooth transition, even when the tool penetrates deeply into the workpiece, a continuous transition between processing by means of the milling head and further processing by the base member can also be achieved.

Furthermore, however, the milling head may also be recessed by means of an undercut. In such an exemplary embodiment of the invention, even when the milling tool penetrates beyond the milling head with the base member into the material, the portion, which is adjacent to the milling head, of the base member initially will not contribute to the processing. Such an embodiment may be advantageous when, for example, the milling head is primarily used for processing. The processing resistance can thereby also be kept low. Furthermore, the base member may also be recessed from the shaft and/or the main cutter of the base member by means of an undercut.

Even when the covering face is inclined with respect to the rotation axis, in a further development of the invention the portion of the base member which is conically cut in this manner may be adjoined by a cylindrical portion. In particular, the main groove may terminate in front of the cylindrical portion or merge into the cylindrical portion. When the main groove terminates in front of this cylindrical portion, it may in principle merge into the portion for tool retention, the region of the shaft. The type of shaping is dependent in particular on the desired processing. If a portion of the main groove is further integrated in the cylindrical portion, this portion can thus also be used for machining processing. On the whole, the tool can be retained in the cylindrical portion in a slimmer manner.

With respect to the radius cutter, various further developments of the invention are conceivable. On the one hand, in a variant of the invention the radius cutter may form the highest point in the advance direction, that is to say, to some degree appear in the manner of a tip of the milling tool. As a result of the fact that the radius cutter on the whole also in the region of the milling head forms from one side of the rotation axis to the other the outer contour of the rotation volume, a spherical region can be cut out of the workpiece all the more precisely. According to the invention, at the center an additional main cutter is in any case arranged perpendicularly to the rotation axis and enables a planar material removal, good penetration into the workpiece material and consequently improved cutting action. This may form the highest point in the advance direction.

Another variant relates to the arrangement of the radius cutter in plan view on the milling head along the rotation axis. This is because, if the radius cutter is arranged offset with respect to a plane which contains the rotation axis, this may also in regions close to the rotation axis apply a greater force or a greater torque to the material to be processed. The central portion of the cutter around the rotation axis in the region of the tip of the tool ensures that no projection remains standing in the middle or at the center (pin) of the processed workpiece. Preferably, the radius cutter may be offset counter to the advance direction laterally with respect to an axis of symmetry of the rotation face taken up by the rotating milling tool. In particular, it may be arranged in its path, for example, in such a manner that it intersects at least once two mutually perpendicularly extending axes of symmetry of the rotation face which is taken up by the rotating milling tool. In this manner, a more effective processing can be carried out. The pin may, however, also already be overcome by the second main cutter.

It has already been set out that exemplary embodiments of the invention are suitable for different application areas.

Generally, the milling tool is, for example, produced from solid hard metal. Advantageously, the milling tool may have in one embodiment a coating, for example, a carbon coating, such as, for example, with diamond. The chip formation can thereby be improved and the stability of the tool can be increased.

Exemplary embodiment:

One exemplary embodiment of the invention is illustrated in the drawings and is explained in greater detail below with additional details and advantages being set out. In detail:

- Fig. 1: shows a side view of a milling tool according to the invention, and
- Fig. 2: shows a plan view along the rotation axis of the milling head of the milling tool from Figure 1 counter to the advance direction.

Figure 1 shows a milling tool 1 having a milling head 2, a base member 2 and a cylindrical portion as a shaft 4. On the milling head 2 there is a radius cutter 5 which merges in the region of the base member 3 into a main cutter 6 of the main groove. Both the radius cutter 5 and the main cutter 6 are accompanied in each case by precisely one free face 7 which extend parallel with the respective cutters 5, 6.

The radius cutter 5 can be subdivided into two regions 5.1, 5.2 which have different radii of curvature with respect to each other. The radius in the region 5.1 is smaller than that in the region 5.2. The transition between the two regions is carried out continuously and in a flowing manner, without any shoulder.

The tool 1 is additionally characterized in that there is provided an additional main cutter 8 which extends in a skewed manner with respect to the rotation axis A perpendicularly relative to the plane which extends relative to the rotation axis, and which ensures an additional planar material removal and better advance with slightly increased torque in the

advance direction V. In addition, the second main cutter 8 was selected to be so wide that it intersects or extends beyond the radius an axis M which extends perpendicularly from the rotation axis and which extends perpendicularly with respect to the second main cutter 8 (cf. in this regard also Figure 2). A pin formation in the region of the center can consequently be prevented since a larger region is covered during cutting. The additional second main cutter 8 forms in an advance direction the tool tip. The second main cutter 8 merges into the radius cutter 5.

In the rotation direction R behind the radius cutter 5 there are additionally arranged three free grinding portions 9, 10, 11, the surfaces of which are partially planar or curved away from the rotation axis A. The milling tool 1 consequently has during contact with a workpiece in the region of the milling head 2 a smaller friction in the region adjoining the radius cutter 5. In the rotation direction R behind the radius cutter 5 and the free face 7 there is the covering face 12 which is constructed in a smooth manner. The covering face 12 is recessed in terms of its spacing with respect to the rotation axis A behind the cutters 5, 6, and is thus closer to the rotation axis A than the cutters 5, 6. The rotation volume 13 is thus determined with respect to the outer limits or the surface thereof by the path of the cutters 5, 6. In the region of the milling head 2, therefore, a region of the workpiece which is intended to be processed can be removed, which region is composed of two different overlapping hemispheres; however, the transition between them is configured in a flowing manner. The outer edge 14 of the covering face 12 extends in an inclined manner with respect to the rotation axis A, wherein the cross sectional surface-area of the milling tool 1, as can also be seen in the body of the rotation volume 12, is enlarged in the direction toward the shaft 4. In the present exemplary embodiment, the shaft 4 is additionally still offset by means of a conically extending base 4a from the remaining base member 3.

However, the main groove or the main cutter 6 do not extend through the entire base member 3, but terminate at the point B. The remaining region of the base member 3 which is located below the point B in the direction toward the shaft 4 is constructed to be smooth. The main groove or the main cutter 6 terminate in Figure 1 above the point B in the direction toward the milling head 2 or in the portion of the base member 3 facing away from the shaft 4.

The main groove has a recess 15 below the cutter 6 which serves to dispose of chips which have been lifted off or material which has been removed from the workpiece which is intended to be processed.

Figure 2 shows the same milling tool 1 as a plan view with a viewing direction along the rotation axis A, counter to the advance direction V. If the milling tool 1 is rotating, the radius cutter 5 first strikes the workpiece. During continued rotation of the milling tool 1, the free face 7 and then the three free grinding portions 9, 10, 11 subsequently follow.

In a state perpendicular to the rotation axis A there extend two axes M, N which in each case intersect with the rotation axis A. The axes M and N extend in turn perpendicularly to each other. With regard to the rotation volume of the milling tool 1, the axes M, N in each case form axes of symmetry. The radius cutter 5 is arranged in the upper region thereof (facing away from the shaft 4) in a state laterally (in Figure 2 to the left) offset with respect to the center axis M so that a greater action of force or a greater torque can be applied to the workpiece since, as a result of the offset with respect to the center axis M or the rotation axis A, a larger lever can act. The highest point H in the advance direction V is reached by the circular-arc-like radius cutter at the intersection with the center axis N; subsequently, the radius cutter 5 extends counter to the advance direction V in the direction toward the free grinding portion 11. As a result of this arrangement, the center axis M is only intersected by the

radius cutter 5 in the continued path toward the transition into the main cutter 6.

The main cutter 6 is in its path slightly offset relative to the base member 3 by an undercut in the end region of the main groove. In this manner, the actual cutting region is even more significantly offset or spatially separated from the remaining region of the milling tool 1.

All exemplary embodiments and further developments of the invention have in common as an alternative to the prior art that the radius cutter is composed of at least two circular-arc-like portions having at least a first and a second radius, wherein the first radius is different from the second radius so that the milling head in rotation occupies a volume which is formed by at least two part-regions of spheres having the first or second radius in each case.

List of reference numerals:

1	Milling tool
2	Milling head
3	Base member
4	Shaft
4a	Base
5	Radius cutter
6	First main cutter
7	Individual free face
8	Second main cutter
9	Free grinding portion
10	Free grinding portion
11	Free grinding portion
12	Covering face
13	Rotation volume
14	Outer edge
15	Recess
A	Rotation axis
B	End point of the main groove
K	Intersection
M	Axis of symmetry
N	Axis of symmetry
R	Rotation direction
V	Advance direction

Claims:

1. A milling tool (1) for milling and/or drilling workpieces which can be rotated about a rotation axis (A) in a rotation direction (R) during the machining processing operation, comprising:
 - a milling head (2) which has a radius cutter (5),
 - a base member (3) which has a main groove in the form of a helical recess with respect to the rotation volume occupied by the rotating milling tool (1) in order to form a screw conveyor, wherein the main groove is provided with a cutting edge as a main cutter (6),
 - wherein the main groove has a smooth covering face (12) which is arranged at the side facing away from the main cutter (6) in the rotation direction (R),
 - characterized in that the radius cutter (5) is composed of at least two circular-arc-like portions (5.1, 5.2) having at least a first and a second radius, wherein the first radius is different from the second radius so that the milling head (2) occupies in rotation a volume which is formed by at least two part-regions of spheres each having the first or second radius.
2. The milling tool (1) as claimed in one of the preceding claims, characterized in that at least two, in particular all of the portions of the radius cutter (5) merge directly into each other by continuously changing the radii.
3. The milling tool (1) as claimed in one of the preceding claims, characterized in that the portion (5.1) of the radius cutter (5) with the first radius is located further forward in the advance direction than the portion (5.2) with the second radius, wherein the first radius is smaller than the second radius.
4. The milling tool (1) as claimed in one of the preceding claims, characterized in that the radius cutter (5) merges

into the main cutter (6).

5. The milling tool (1) as claimed in one of the preceding claims, characterized in that the covering face extends parallel with the rotation axis and/or in that the main cutter extends at least partially, in particular completely on the covering face of a cylinder.
6. The milling tool (1) as claimed in one of the preceding claims, characterized in that there is arranged at the center of the milling tool (1) a second main cutter (8) which:
 - extends at an angle of 90° with respect to the rotation axis or in a skewed manner in a plane which extends perpendicularly to the rotation axis (A) and/or
 - is located on the tool tip in the advance direction (V) and/or
 - is constructed to be so wide that it intersects and/or extends beyond an axis (M) which extends perpendicularly from the rotation axis and which extends perpendicularly to the second main cutter (8) and/or
 - merges into the radius cutter (5), in particular with a smooth path.
7. The milling tool (1) as claimed in one of the preceding claims, characterized in that the covering face (12) extends in an inclined manner with respect to the rotation axis (A), in particular in a conical manner with a cross section which decreases in the direction toward the milling head (2), wherein the covering face (12) preferably encloses with the rotation axis (A) an angle between 0° and a maximum of 20° inclusive.
8. The milling tool (1) as claimed in one of the preceding claims, characterized in that the surface of the rotation volume assumed by the rotating milling tool (1) is inclined with respect to the rotation axis (A), preferably extends parallel with the covering face (12), in particular preferably encloses with the rotation axis (A)

an angle between 0° and a maximum of 20° inclusive.

9. The milling tool (1) as claimed in one of the preceding claims, characterized in that precisely one free face (7) is arranged in the rotation direction (R) behind the main cutter (6) and/or the radius cutter (5).
10. The milling tool (1) as claimed in one of the preceding claims, characterized in that the free face (7) has a surface which is planar and/or curved away from the rotation axis (A).
11. The milling tool (1) as claimed in one of the preceding claims, characterized in that the radius cutter (5) merges into the main cutter (6) with a smooth path.
12. The milling tool (1) as claimed in one of the preceding claims, characterized in that the milling head is offset from the base member and/or the base member is offset from the shaft and/or the main cutter (6) is offset from the base member by means of an undercut (16).
13. The milling tool (1) as claimed in one of the preceding claims, characterized in that the portion of the base member (3) which has a conically extending covering face (12) is adjoined by a cylindrical portion (4) and the main groove terminates in front of the cylindrical portion or merges into the cylindrical portion.
14. The milling tool (1) as claimed in one of the preceding claims, characterized in that the shaft (4) is separated from the base member (3) by means of a conical base (4a).

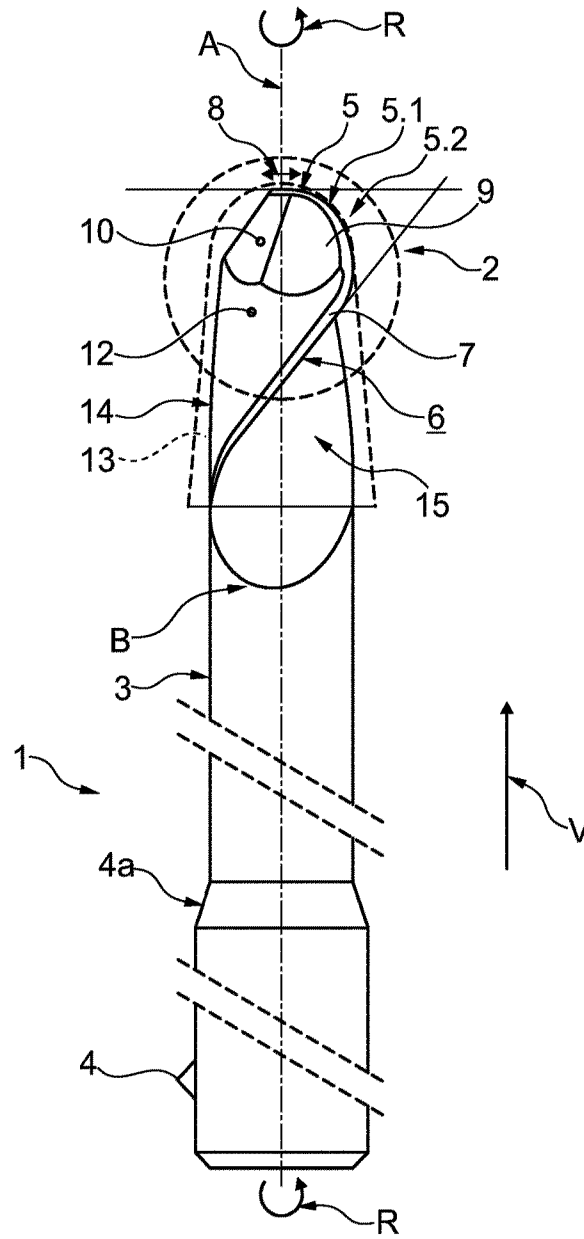


Fig. 1

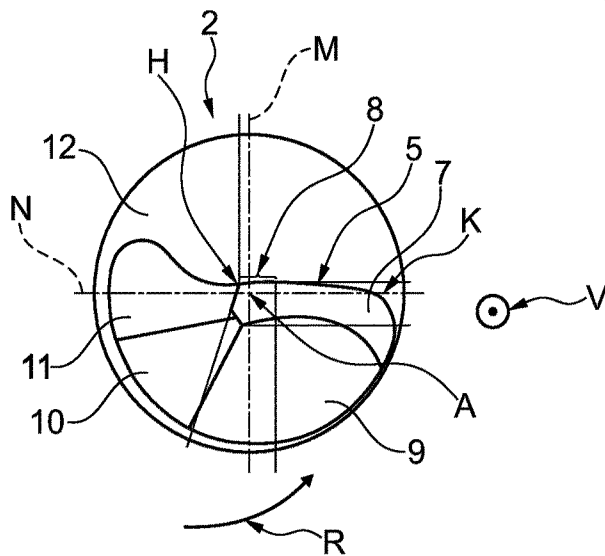


Fig. 2

ERSATZBLATT (REGEL 26)

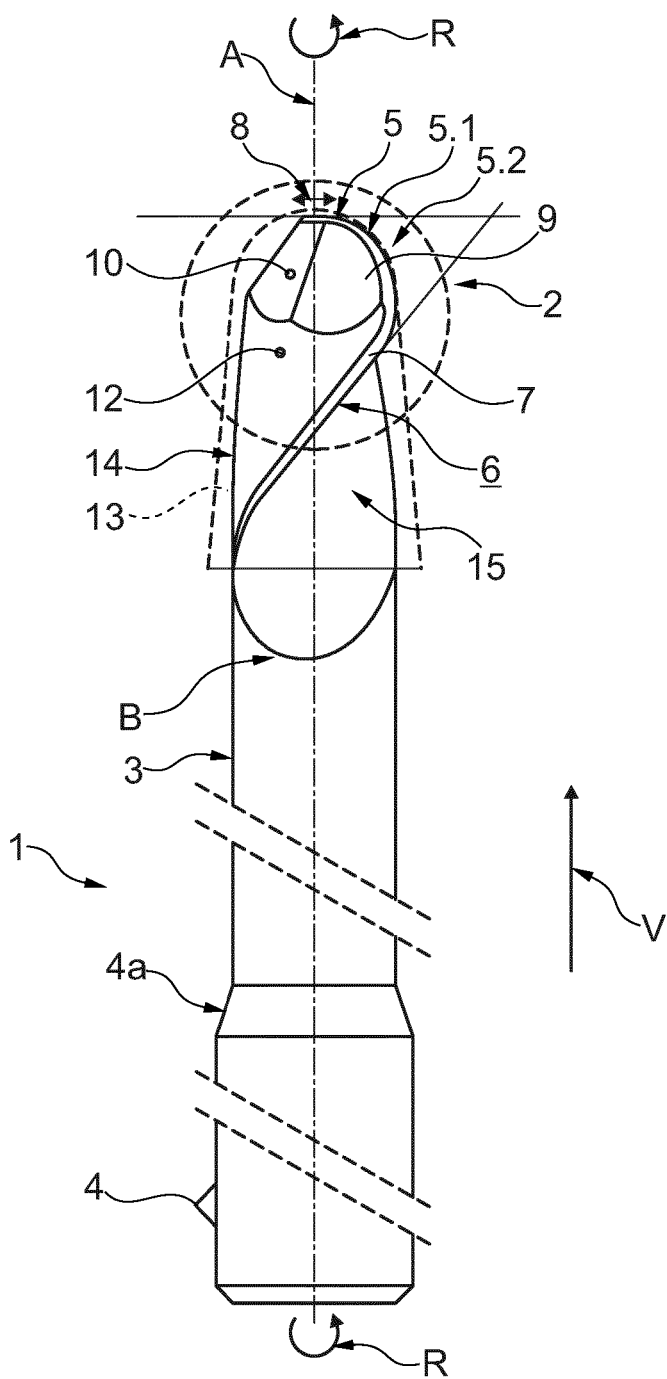


Fig. 1