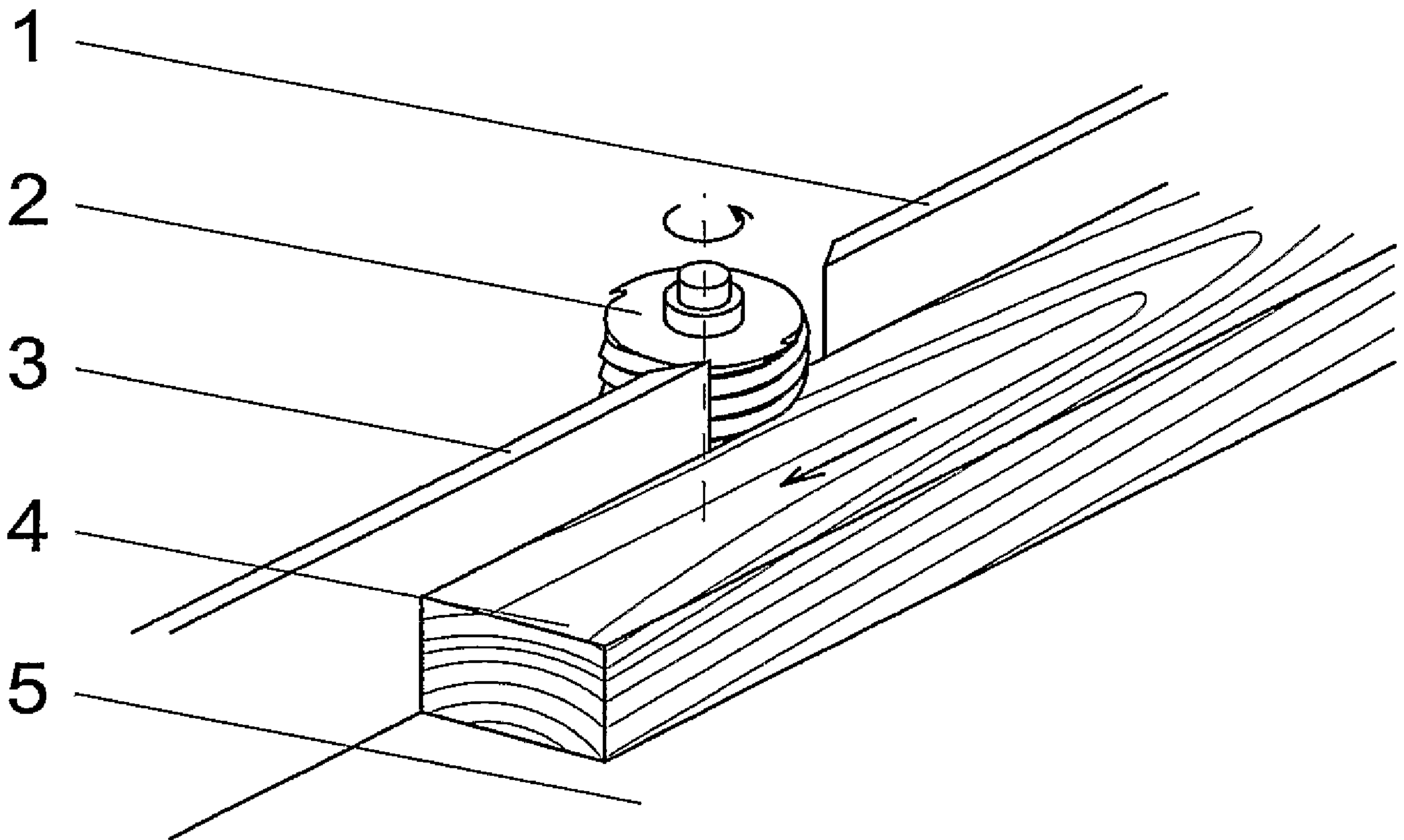




(86) Date de dépôt PCT/PCT Filing Date: 2006/03/23
(87) Date publication PCT/PCT Publication Date: 2007/09/27
(85) Entrée phase nationale/National Entry: 2008/09/23
(86) N° demande PCT/PCT Application No.: DE 2006/000553
(87) N° publication PCT/PCT Publication No.: 2007/107129

(51) Cl.Int./Int.Cl. *B27G 13/00* (2006.01),
B23P 15/34 (2006.01)
(71) Demandeur/Applicant:
TECHNISCHE UNIVERSITAET DRESDEN, DE
(72) Inventeurs/Inventors:
FISCHER, ROLAND, DE;
GOTTLOBER, CHRISTIAN, DE;
REHM, KLAUS, DE;
BUTTER, WOLFGANG, DE
(74) Agent: KIRBY EADES GALE BAKER

(54) Titre : FRAISEUSE CYLINDRIQUE A LAME DE COUPE DE FORME HELICOIDALE
(54) Title: CYLINDRICAL CUTTER WITH HELICAL CUTTING LINE



(57) Abrégé/Abstract:

The invention relates to a cylindrical cutter having one or more helically running cutting edges for machining wood, wooden materials and plastic and to a method of producing it. The tool according to the invention has a tool inclination angle λ of the cutting edges within the range of 70° up to nearly 90° , in particular around 80° to 88° , and a rake angle γ_r between the tool orthogonal plane P_o and the rake face A_r , measured in the tool reference plane P_r , of at least 5° . In the case of the tool, there is a

(57) Abrégé(suite)/Abstract(continued):

substantial difference between the effective angles and the ground orthogonal angles. The chips are mainly peeled off and discharged axially. The chips are long-fibred and can be processed (as a by-product) in the pulp industry. Approximately constant cutting force ratios are achieved. The surface quality of the machined wood is very good. In the case of the production according to the invention, either the cutting edge is produced separately from the subsequent tool parent body and is fitted into the latter in a positive-locking manner, or a cutting edge made of cutting material is helically applied to a cylindrical parent body made of a backing material and is subsequently ground to produce the desired cutting edge form.

ABSTRACT

The invention relates to a cylindrical cutter having one or more helically running cutting edges for machining wood, wooden materials and plastic and to a method of producing it. The tool according to the invention has a tool inclination angle λ_s of the cutting edges within the range of 70° up to nearly 90° , in particular around 80° to 88° , and a rake angle γ_r between the tool orthogonal plane P_o and the rake face A_y , measured in the tool reference plane P_r , of at least 5° . In the case of the tool, there is a substantial difference between the effective angles and the ground orthogonal angles. The chips are mainly peeled off and discharged axially. The chips are long-fibred and can be processed (as a by-product) in the pulp industry. Approximately constant cutting force ratios are achieved. The surface quality of the machined wood is very good. In the case of the production according to the invention, either the cutting edge is produced separately from the subsequent tool parent body and is fitted into the latter in a positive-locking manner, or a cutting edge made of cutting material is helically applied to a cylindrical parent body made of a backing material and is subsequently ground to produce the desired cutting edge form.

Cylindrical Cutter with Helical Cutting Line

The invention concerns a cylindrical cutter comprising one or several helically extending cutting edges for machining wood, wooden materials and plastics as well as a method for its manufacture.

For peripheral milling of wood, wooden materials, plastics and similar materials, rotating tools with several cutting edges are used, including cylindrical cutters with at least one cutting edge that extends helically. The cutting edges have an angular momentum about the axis of the cutter. These cutters have inter alia the advantage that, in comparison to cutters whose cutting edges extend parallel to the cutter axis, they run more smoothly because the cutting edge engagement and the cutting force change do not occur so suddenly.

Primarily, the helix angle λ_s of the tool is in the range of 0° to 25° . Frequently used are end milling cutters or cylindrical cutters having an angular moment of the cutting edges in accordance with this angle.

According to WO 98/04231, this slant angle (helix angle) is between 40° and 60° , preferably at 45° . EP 0 155 216 discloses 45° as well as 50° to 60° . According to JP 61197116 AA (Abstract) it is also between 40° and 60° .

In case of such helix angles each cutting edge impacts in most applications also once per revolution onto the surface to be processed. This impact causes as a result of the high rotary speed of modern wood processing machines significant noise levels at high frequency in accordance with the rotary speed and number of cutting edges. Moreover, because of this impact a compression of the surface results. This has the effect that the wood, in particular when treated with aqueous media, will swell and subsequently must be post-ground. As a result of

the kinematic chip removal principle, partially large-volume chips result that with the entire chip collective must be accelerated to cutting speed and thrown off tangentially. This causes high kinetic energies of the removed chips with diffuse directions of action. Accordingly, for suction removal and dust removal a high energetic and technical expenditure is required. The problem of complete
 5 removal of chips and dust has not been resolved to this day in a satisfactory way.

CH-PS 161 618 discloses a cylindrical cutter with a helically extending cutting
 10 edge for the cutter spindle of a planing machine. The figure shows that the cutting edge has a helix angle of $> 60^\circ$. A practical application of a cutter spindle designed in this way is not known to the applicant.

Obviously, it is not easy to provide a cylindrical cutter with a large helix angle or
 15 high overlap rate of the cutting edge with which high quality cuts can be performed. Also, the manufacture, grinding and regrinding of the cutting edges becomes more and more difficult as the helix angle increases.

It is an object of the invention to provide a cylindrical cutter with a high overlap
 20 rate of the helical cutting edges and means for its manufacture with which high quality machining of wood is possible.

According to the invention this object is solved in that the helix angle λ_s of the tool (according to DIN 6581) of at least one cutting edge is in the range of 70° to
 25 close to 90° , in particular 80° to 88° , and the rake angle γ_r between the tool orthogonal plane P_o and the rake face A_v - measured in the tool reference plane P_r - is at least 5° .

Tests have shown that with a cylindrical cutter according to the present invention

an excellent processing of wood is possible. An excellent surface is obtained and the tool runs smoothly. Surprisingly, long-fiber chips are peeled off that, as a spin-off product, can be used in pulp production. Obviously, this result is not only based on the large helix angle of the cutting edge but also to the
 5 assignment of unusual cutting edge angles.

A comparison to DIN 6581 shows that the tool angles of the cutting edge (rake angle, wedge angle, relief angle) are usually not measured in the tool reference plane P_r but in one of the other planes P_o , P_s etc. The rake angle γ of the tool is
 10 accordingly always the angle between the rake face A_γ and the tool reference plane P_r (see 4.1.2). The thus defined angle cannot be represented in the plane P_r .

The tool can be referred to as a peripheral milling cutter with an extremely large
 15 helix angle λ_s of the tool. Accordingly, a completely changed application behavior results. This tool construction can no longer be correlated with conventional peripheral cylindrical cutters. The cutting force direction is no longer primarily exerted in a tangential direction but is axial in important parts. Mostly each cutting edge runs several times about the circumference of the tool. Upon
 20 rotation of the tool about its usual axis of rotation that corresponds in this connection to the helix axis, two movements that overlay one another are carried out: the tangential movement causes a cut with extreme pulling action and the chip is therefore primarily peeled off laterally and transported away.

25 For a regular peripheral cutter it is obvious to measure and represent the cutting angle according to the aforementioned DIN. For the cylindrical cutter according to the invention with its extremely large helix angle of the tool and primarily axially acting cutting action the quality of the cutting edge can be recognized in the simplest way based on the illustration of the cutting edge angles in the tool

reference plane P_r , i.e., in deviation from the DIN standard.

When comparing in this respect the Fig. 2 of CH-PS 161 618 and the subsequent embodiment, the differences of both solutions become especially
 5 apparent. Both longitudinal sections correspond to a possible tool reference plane P_r . The longitudinal section of the cylindrical cutter according to CH-PS 161 618 shows that obviously relative to this plane a negative rake angle has been selected. With such a rake angle the chip will be forced to the side and (minimally) forced in the direction of the cut surface. The wood is sheared off in
 10 the lateral direction and not peeled off.

Fig. 2 of the subsequent embodiment shows moreover that the cutting edge according to the invention can be formed with a large wedge angle β_r - preferably 45° to 65° - and therefore is very wear-resistant relative to the primarily laterally
 15 occurring loads. For the conventional small relief angles there remains sufficient latitude for optimizing the rake angle γ_r above 5° .

In the shown embodiment, the correlation between the angles that are measured in the tool reference plane P_r and the angles that are measured in the tool
 20 orthogonal plane P_o in accordance with DIN standard is provided.

By means of several parallel extending cutting edges an especially smooth running and a high productivity are achieved. Moreover, in case of several cutting edges it is possible to make one of the outer diameters d of at least one
 25 of the cutting edges greater than that of the others. The cutting edge with the great diameter provides the surface quality. The cutting edges with smaller diameter ream - without relevance with regard to the surface quality of the finished surface - a part of the material of the layer to be cut off and reduce thus the wear of the cutting edge with the greatest diameter.

In a preferred embodiment a cutting edge is in the form of a helically bent blade that is detachable from the tool base member wherein the blade is positioned in grooves by means of helically bent spacers or lateral collars on the tool base member.

For attaching the detachable parts on the base member the cutting edge and the spacers are axially clamped relative to one another or secured by opposite rotation of the cutting edge ends. Also it is possible to produce first the initially detachable cutting edge in a finish-ground state and to secure it by gluing, by soldering or other material bonding on the tool base member.

The tool diameter, the helix angle of the tool, the number of helical cutting lines that in accordance with the present invention are interposed and the angles at the cutting edges can be varied. The material for cutting edge and base member can be optimized independent from one another.

A special advantage of this solution resides in facilitating grinding and regrinding of the cutting edge. As a result of the large helix angle there is normally little space available for grinding tools between the turns of the cutting edges. This intermediate space is instantly enlarged when several parallel extending cutting edges are provided and are ground sequentially wherein for grinding only one cutting blade is fastened on the tool base member.

Also, the detachable cutting blade can be ground and reground by means of a grinding spindle separate from the tool base member, even on a grinding spindle with a small helix angle, i.e., with a larger intermediate space between the turns.

As a result of the helix angle of the cutting edge a significant axial component of the cutting force is generated. For adjustment of the cutting forces to different

materials, in particular composite materials, it is advantageous to adjust the helix angle of the cutting edges to the individual layers of the material. In this way, cracking or chipping at the edges of the workpiece as a result of the cutting forces is prevented. The adaptation of the helix angle of the tool can be realized
 5 by application or grinding of different cutting edge shapes within a tool part or, advantageously, by assembling the tool from partial tools with different tool helix angles.

The latter is possible primarily in the known variant that two partial tools of the
 10 same outer diameter but with opposite pitch (right-handed and left-handed) are combined to a cylindrical cutter.

The use of chip breakers on the rake face has also been found to be beneficial in connection with the tools according to the invention.

15 The advantages of the cylindrical cutter according to the invention reside mainly in the constructively caused continuous cutting action as a result of the permanent cutting edge engagement and the significant change of the geometry of action relative to the orthogonal geometries. In this way an almost constant
 20 cutting force level and therefore a reduced noise emission are achieved. Additionally, a strong axial directional orientation of the resulting chips is provided, and the thus correlated possibility of an ordered removal and collection of chips is possible. With regard to surface quality great compression of the surface-near layers of the cut surface are prevented. The occurring forces are
 25 made much more uniform and their direction of action is almost perpendicular to the feed direction. In this way, it can be received by the workpiece support.

As a result of the contour of the tool a very good strength of the tool is provided so that a special suitability for HSC machining is present. The risk of
 30 detachment of individual parts of the tool and the thus resulting risk of imbalance

is not present in the design according to the invention.

The manufacture of the tools according to the invention requires application of a helical cutting edge of a great stretched length and constant curvature. This is
5 not possible with conventional manufacturing processes or possible only with significant expenditure.

In conventional manufacture the cutting edge is to be produced by material-removing methods from a blank made from cutting edge material; this causes
10 high expenditure in regard to labor and cutting edge material. A detachable cutting edge can be advantageously produced separate from the tool base member.

In a further method according to the invention, on a cylindrical base member of a
15 carrier material a cutting edge of cutting edge material is applied in a helical shape and subsequently ground to the desired cutting edge shape.

The application of the cutting edge material can be realized by gluing, by soldering or by build-up welding. For this purpose, the material is preferably
20 preshaped during the build-up welding process in the liquid phase so that after solidification only a minimal expenditure for the material-removing fine machining and grinding of the cutting edge are required. This preshaping can be realized by molds that shape the cutting material in the liquid phase and during the transition into the solid phase stabilize the predetermined shape.

Advantageously, the molds are made of ceramic material or other high-
25 temperature resistant materials wherein the cutting edge material to be built up is supplied in the form of wire, powder or rods and is melted in the cavity that provides shaping. The relative movement between mold and tool shapes the rough shape of the helical cutting edge wherein solidification of the cutting edge
30 material can be realized by heat dissipation into the tool body and also by an

additional cooling action of the shaping part of the mold.

In the subsequent embodiments, the drawings show in:

- 5 Fig. 1 a milling table with cylindrical cutter according to the invention;
- Fig. 2 a side view of a cylindrical cutter according to the invention with a
 detail of a longitudinal section in the P_r plane for the illustrated three
 cutting edge points;
- 10 Fig. 3 the section A-A according to Fig. 2;
- Fig. 4 a cylindrical cutter with removable cutting edge in accordance with
 the invention.

15 In Fig. 1 the cylindrical cutter 1 according to the invention is shown in use. It is
 mounted on a tool receptacle penetrating the machine table 5 and is driven by a
 motor with belt drive, not illustrated, in the rotational direction indicated by the
 arrow. The workpiece 4 to be machined is positioned on the machine table 5
20 and forced against the stop 3 and pushed in the direction of the arrow. By
 means of the cylindrical cutter a longitudinal side of the workpiece is machined.
 The chips are removed primarily in the downward direction.

 In Figs. 2 and 3 the cylindrical cutter according to the invention is illustrated in
25 two views. These figures serve primarily for explaining the cutting edge angles.

 Fig. 3 shows the section A-A. This section in accordance with the definitions of
 DIN 6581 is located in the tool orthogonal plane P_o of an observed cutting edge
 point, i.e., in Fig. 3 P_o is in the plane of the drawing sheet. In Fig. 3, the tool

reference plane P_r in section is illustrated as a line. It extends through the axis of the cylindrical cutter and through the cutting edge point shown in section and is perpendicular to P_o . In Fig. 2, this plane for the observed cutting edge points illustrated in the detail view is in the plane of the drawing sheet.

5

In Fig. 3, the tool orthogonal angle β_o and the tool orthogonal rake angle γ_o are measured and illustrated according to DIN 6581. As an example, the tool orthogonal rake angle γ_o is the angle between the tool reference plane P_r and the rake face A_γ relative to the tool orthogonal plane P_o . In Fig. 2 a rake angle γ_r and a wedge angle β_r - not defined in DIN 6581 - are shown wherein γ_r is the angle between the tool orthogonal plane P_o of the tool and the rake face A_γ . The tool orthogonal plane P_o is positioned in Fig. 2 parallel to the section plane A-A and perpendicular to the drawing plane and extends through the cutting edge point (here the tip of the angles γ_r and β_r).

15

Between these angles the following relationships are present.

$$\gamma_o = \arctan(\tan \lambda_s \cdot \tan \gamma_r)$$

20

$$\beta_o = \arctan(\tan \lambda_s \cdot \tan \gamma_r) - \arctan \left[\frac{\tan(90^\circ - \beta_o - \gamma_r)}{\tan \lambda_s} \right]$$

25

Figs. 2 and 3 show in addition to the already represented parameters the tool diameter d , the working engagement a_e , the feed speed v_f , the feed f , the tool rotary speed n , the pitch t , the cutting width for each engagement area b_t and the helix angle λ_s of the tool.

Fig. 4 shows a cylindrical cutter with detachable cutting edge. The cutting blade 7 winds in a helical shape about the tool base member 6. A helical spacer 8 is interposed for maintaining the pitch and for fastening. For attachment, the cutting edge 7 and the spacer 8 can be tightened against a collar connected to the base member 6 by means of a nut at the end face. Fig. 4 is purely schematic. The nut and the collar are not shown.

List of Reference Numerals

	1	tool
	2	workpiece
5	3	chip
	4	suction device
	5	machine stop
	6	tool base member
	7	cutting edge
10	8	spacer

Amended Claims**Received in the International Bureau on 29 May 2007 (29.05.2007)**

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1. Cylindrical cutter for machining wood, wooden materials and plastics, comprising one or several helical cutting edges (7), characterized in that the tool helix angle λ_s of the cutting edges is in the range of 70° to close to 90° , the rake angle γ_r between the tool orthogonal plane P_o and the rake face A_v - measured in the tool reference plane P_r - is at least 5° and the wedge angle β_r between the rake face A_v and the flank A_α - measured in the tool reference plane P_r - is 45° to 65° .
2. Cylindrical cutter according to claim 1, characterized in that the tool helix angle λ_s of the cutting edges is in a range of 80° to 88° .
3. Cylindrical cutter according to claim 1, characterized in that at least one of at least two parallel extending cutting edges (7) has a diameter that is different from that of the other cutting edges.
4. Cylindrical cutter according to one of the claims 1 - 3, characterized in that at least one cutting edge (7) is in the form of a helically bent blade detachable from the tool base member (6).
5. Cylindrical cutter according to claim 4, characterized in that between the turns of the at least one cutting edge (7) at least one helically bent spacer (8) is arranged.
6. Cylindrical cutter according to claim 5, characterized in that the spacer (8)

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is detachable from the tool base member (6).

7. Cylindrical cutter according to claim 4, characterized in that at least one detachable cutting edge (7) has lateral stop collars.
- 5 8. Cylindrical cutter according to claim 4, characterized in that at least one detachable cutting edge (7) is guided in a groove.
9. Cylindrical cutter according to claims 4 or 5, characterized in that the at least one cutting edge (7) and the spacer or spacers (8) are axially clamped relative to one another.
- 10 10. Cylindrical cutter according to claim 4, characterized in that the at least one detachable cutting edge (7) is tightened by relative rotation of their ends on the tool base member (6).
- 15 11. Cylindrical cutter according to claim 4, characterized in that the at least one initially detachable cutting edge (7) is fastened to the tool base member by gluing, soldering, or other material bonding.
- 20 12. Cylindrical cutter according to claim 1, characterized in that at least two interposed cutting edges (7) have different tool helix angles.
13. Cylindrical cutter according to claim 1, characterized in that the helical cutting line is interrupted.
- 25

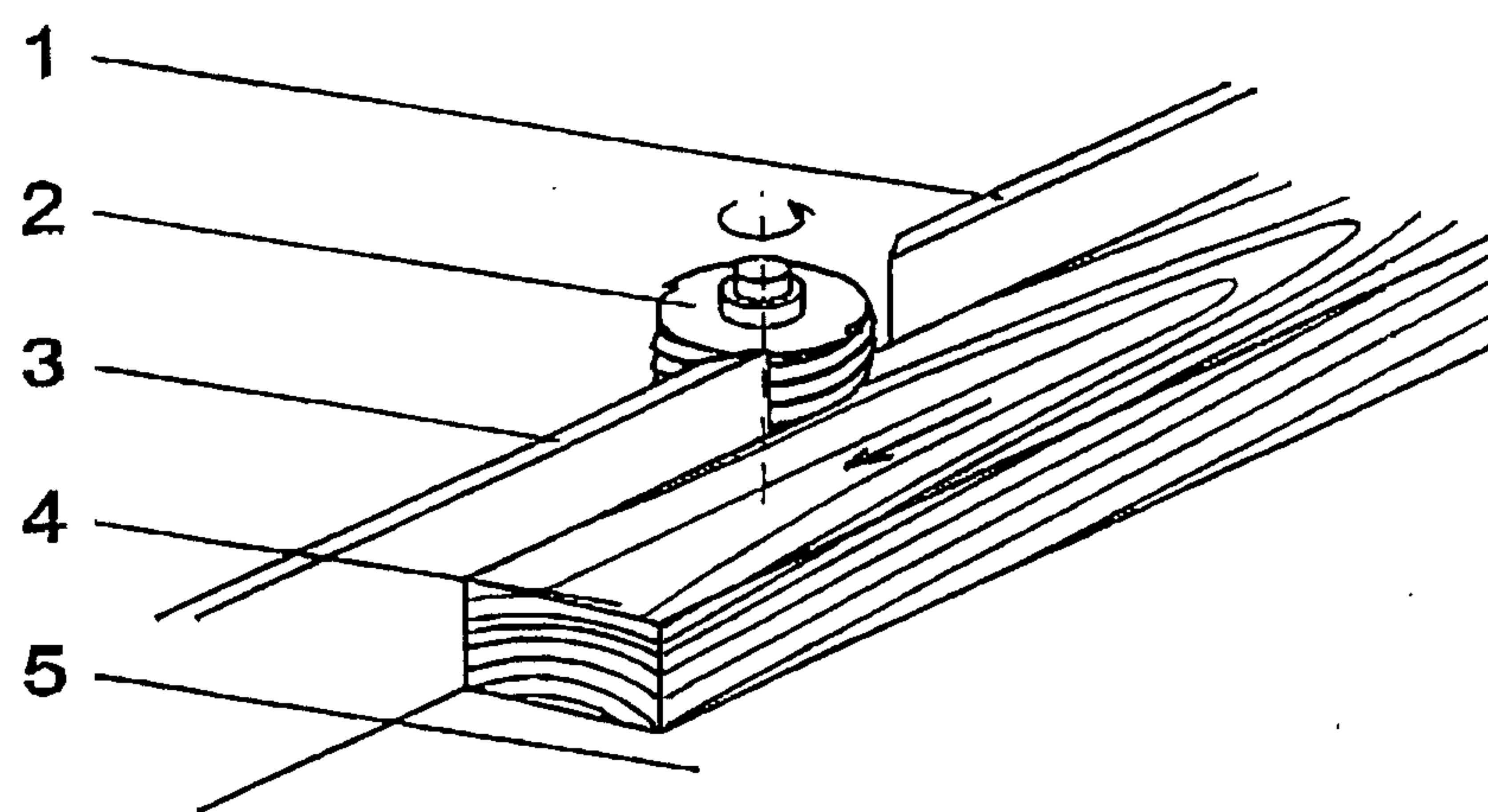


Fig. 1

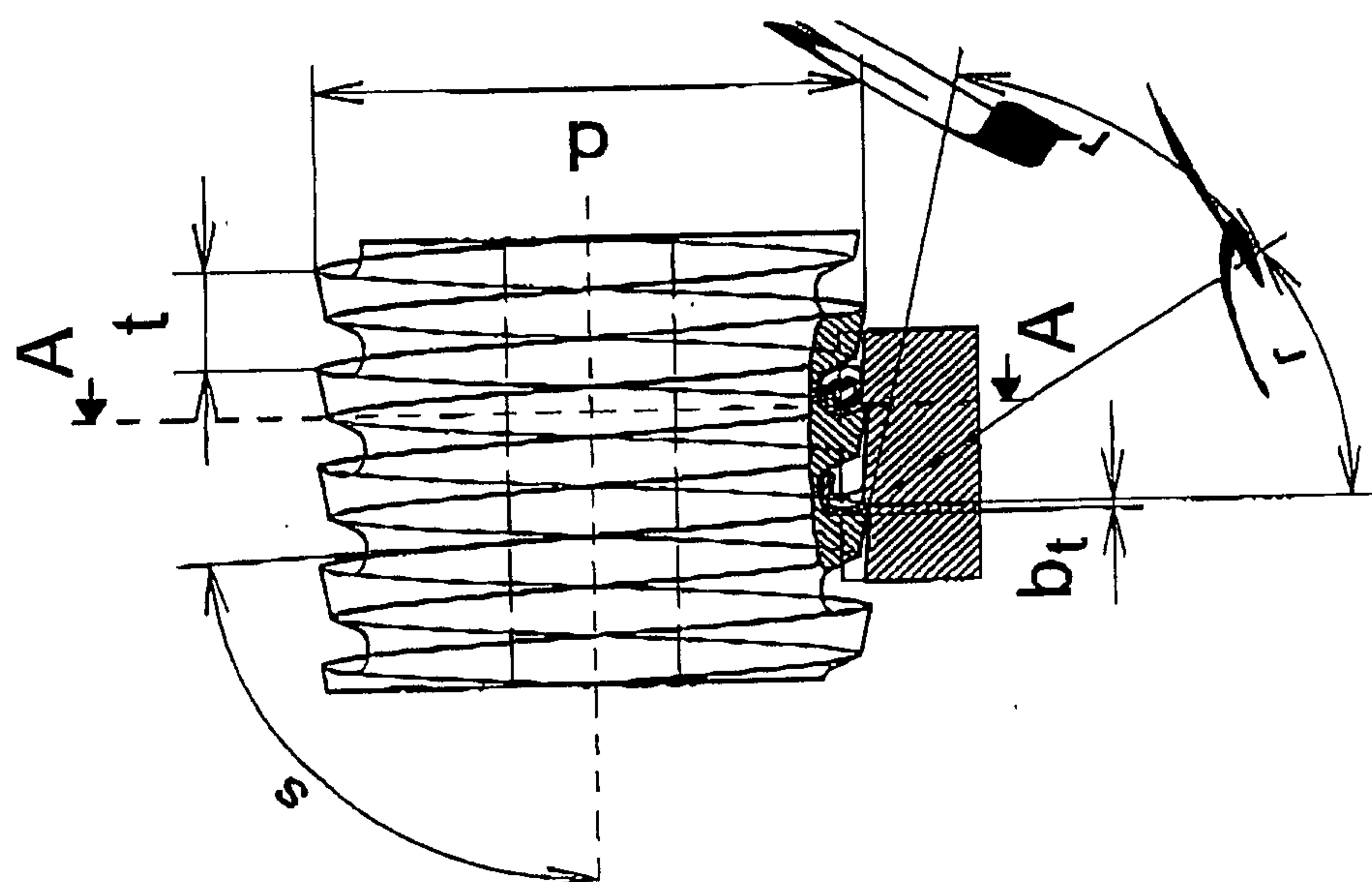


Fig. 2

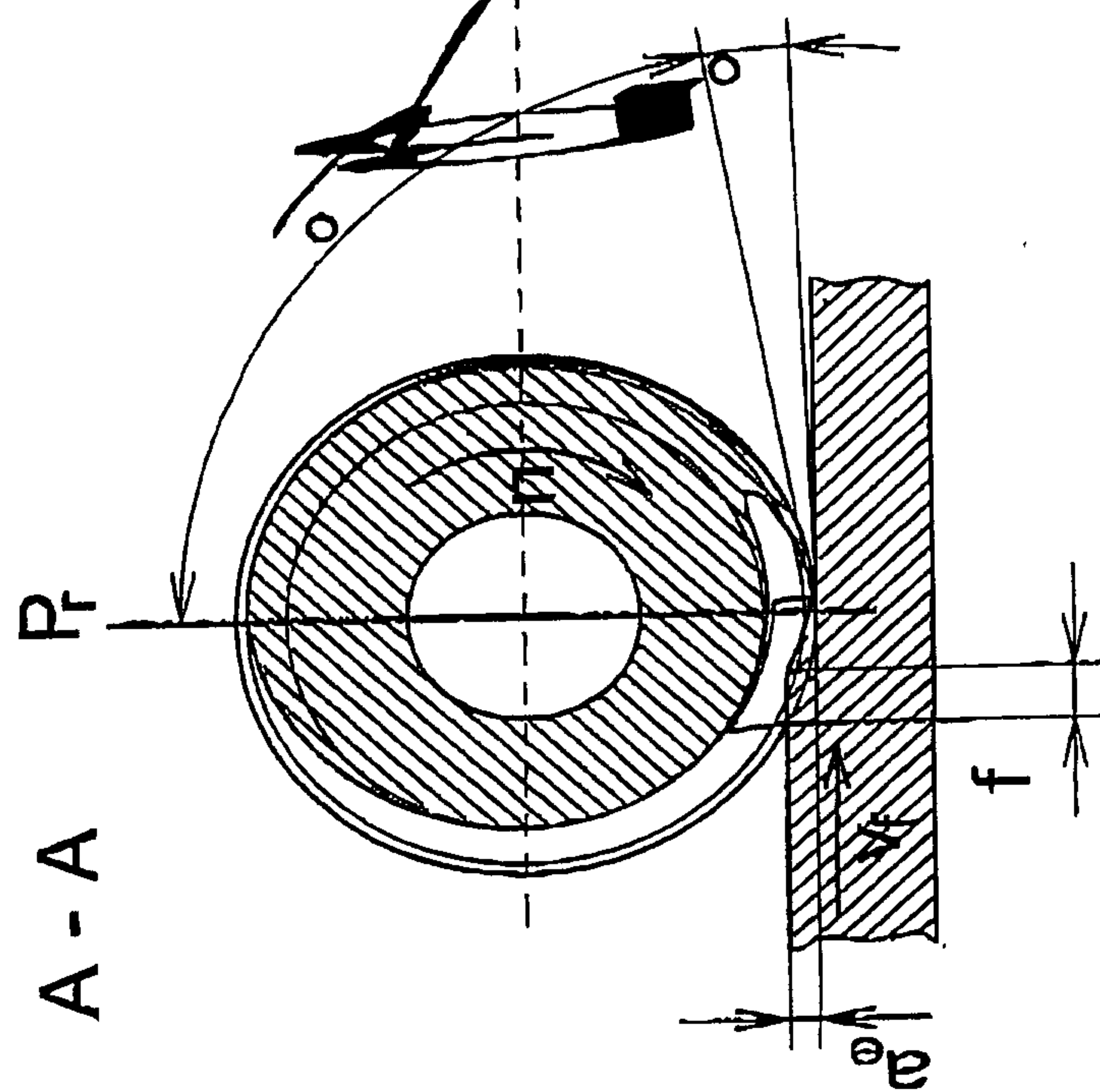


Fig. 3

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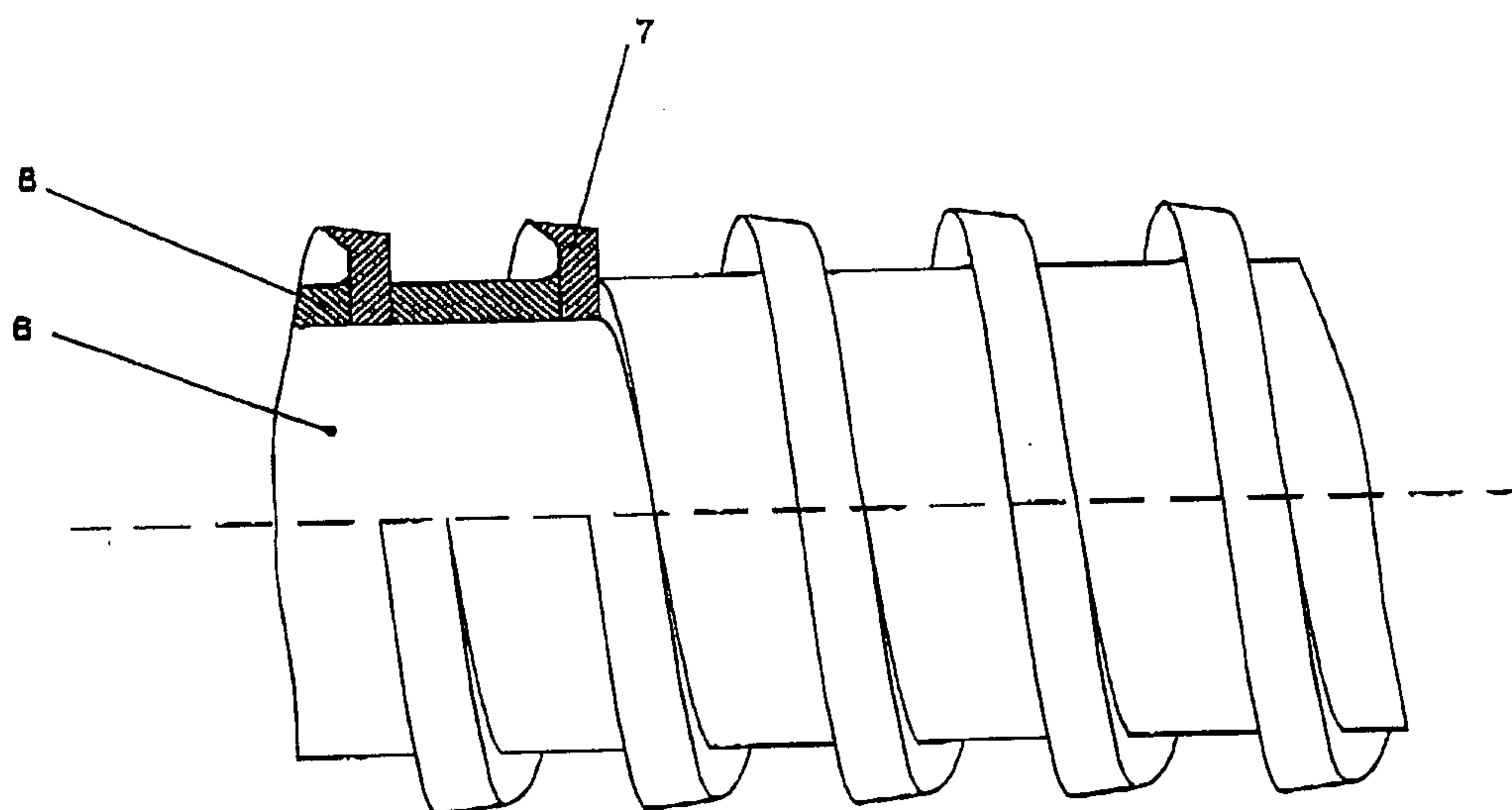


Fig. 4

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