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(54) GRINDING MACHINE AND METHOD OF OPERATING SUCH GRINDING MACHINE

(57) The present invention relates to a grinding machine (1) comprising a first and a second grinding wheel (2a, 2b) separated by a gap (3) and configured to contact a workpiece (100); a support blade (4) positioned in the gap (3) and having a contact surface (4a) having a work profile (40a) shaped to contact at one and only one point at a time the workpiece (100), and being further shaped to contact the workpiece (100) with different working angles (γ), in different respective working steps.

Also, the present invention relates to a method for operating such grinding machine comprising a support blade configured to arrange the workpiece (100) at a first working height (h_{w1}) with a first working angle (γ_1) in the first working step, and at a second working height (h_{w2}) with a second working angle (γ_2), in the second step.

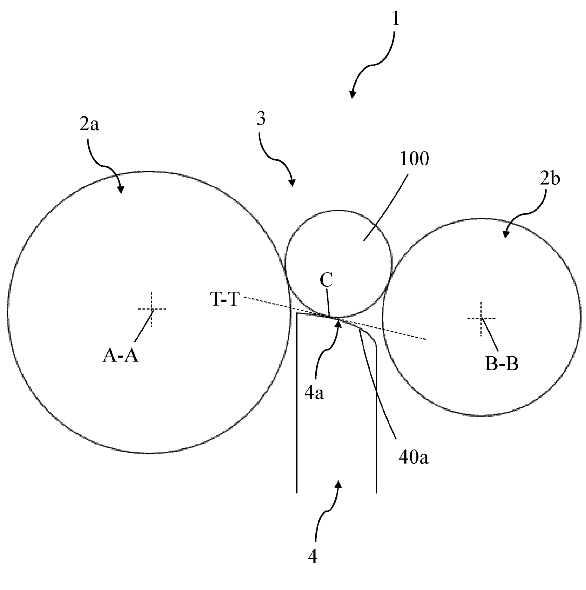

Fig. 1

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Description

Technical Field

[0001] The present invention relates to a grinding machine, in particular of the centreless plunge type and a method for operating such grinding machine to minimize the formation of corrugations on a workpiece, according to the preamble of claim 1 and 6, respectively.

[0002] The grinding machine which is the object of the present invention is used in the field of mechanical processing for removing shavings.

State of the Art

[0003] The centreless plunge grinding process and the machine tools that allow it to be implemented are well known in the state of the art.

[0004] In such grinding process, a workpiece is arranged between a driving wheel and a working wheel rotating about a respective axis of rotation, and is supported by a support blade. This particular configuration, in which the workpiece is supported on three points, makes the process susceptible to roundness errors, as the workpiece is free to swing while being worked, thus generating a plurality of lobes on its surface.

[0005] As a first approximation, given a plunge centreless grinding machine, this roundness error depends on geometric working factors such as the working angle and height.

[0006] In the context of the present invention, working angle means the inclination of the surface of the support blade at the point contacting the workpiece, and working height means the distance of the centre of the workpiece from the plane containing the axis of rotation of the operating wheel and the medium point of the axis of rotation of the driving wheel.

[0007] They are known in the state of the art centreless grinding machines that are adapted to minimise the formation of lobes on the workpiece profile by acting on the working height during the process itself.

[0008] For example, document US 20040209558 A1 discloses a centreless plunge grinding machine adapted to move the blade along a vertical direction to modify the working height, so as to minimise the occurrence of lobes on the workpiece profile.

[0009] Support blades for known centreless plunge grinding machines have a flat contact surface adapted to support the workpiece as it rotates.

[0010] In detail, the flat contact surface has a constant angle of inclination at every point and can be identified with the working angle.

[0011] Other examples of centreless plunge grinding machines are for instance reported in US2897636A and KR102028879B1.

[0012] In detail, document US2897636A discloses a centreless plunge grinding machine comprising a blade inclination mechanism adapted to allow for grinding processes with different working angles by a same blade. It is worth noting that the blade used in the machine described in document US2897636A is of the standard type and does not have any particular work profile to allow for grinding processes with different working angles.

[0013] Document KR102028879B1 discloses a centreless grinding machine comprising a support blade configured to contact the workpiece with a single working angle, and an auxiliary support blade adapted to accept the workpiece during automatic loading.

Problem of the state of the art

[0014] Disadvantageously, centreless grinding machines of the known type do not allow to easily modify the working angle, as this requires the replacement of the support blade or an automatic blade orientation system.

[0015] Disadvantageously, the grinding machine disclosed in US2897636A requires to modify the common machines by introducing a specific blade inclination mechanism in order to be able to carry out grinding processes with different working angles by the same support blade.

Object of the invention

[0016] In this context, the technical task underlying the present invention is to provide a grinding machine which overcomes the above described drawbacks of the prior art .

[0017] In particular, it is an object of the present invention to make available a grinding machine which is able to easily modify the working angle to minimise the formation of lobes on the profile of the workpiece.

SUMMARY OF THE INVENTION

[0018] The specified technical task and the specified objects are substantially achieved by a grinding machine according to claims 1 and 7, respectively.

[0019] In detail, the grinding machine comprises a first and a second grinding wheel separated by a gap and configured to contact a workpiece, in order to work thereupon as it rotates.

[0020] The grinding machine further comprises a support blade, arranged in the gap, and adapted to support the workpiece.

[0021] Such support blade has a contact surface adapted to support the workpiece and a work profile shaped to contact the workpiece at one and only one point at a time. In detail, the work profile is shaped to contact the workpiece with different angles in different respective working steps.

[0022] Advantageously, such working surface and profile of the support blade make it possible to easily vary the working angle. In particular, the work profile is shaped to contact the workpiece with at least two different working angles in at least two respective working steps, so that the formation of lobes on the work profile of the workpiece can be minimised by varying the working angle during the process.

LIST OF FIGURES

[0023] Further characteristics and advantages of the present invention will become more apparent from the indicative and thus non-limiting description of a preferred, but not exclusive, embodiment of a grinding structure, as shown in the accompanying drawings, wherein:

- Figure 1 shows a schematic representation of the working area of a grinding machine object of the present invention;
- Figure 2 shows a view from the side of the working area of figure 1;
- Figure 3 shows a schematic representation of a first embodiment of a component of the grinding machine and arranged in the working area of figure 1;
- Figure 4a shows a schematic representation of a second embodiment of the component of figure 3;
- Figure 4b shows a schematic representation of a third embodiment of the component of figure 3;
- Figure 5a shows the kinematics of the working area of figure 1 with the component of figure 4a;
- Figure 5b shows the kinematics of the working area of figure 1 with the component of figure 4b.

DETAILED DESCRIPTION

[0024] Even when not explicitly highlighted, the individual features described with reference to the specific embodiments must be considered as accessories and/or exchangeable with other features, described with reference to other embodiments.

[0025] With reference to the appended figures, the present invention relates to a grinding machine 1, in particular a centreless plunge grinding machine.

[0026] As shown in figure 1, the grinding machine 1 comprises a first and a second grinding wheel 2a, 2b separated by a gap 3 and configured to contact a workpiece 100 to perform a mechanical grinding operation.

[0027] The first and second grinding wheel 2a, 2b are respectively configured to rotate about a first and a second axis of rotation A-A, B-B to work the workpiece 100 as it rotates. In greater detail, the first and the second grinding wheel 2a, 2b are configured to both contact the workpiece 100 to rotate it about an axis of rotation while removing material from its surface.

[0028] In detail, as shown in figure 2, the first and the second grinding wheel 2a, 2b are arranged in such a way that the first and the second axis of rotation A-A, B-B are at an angle with each other, so that by rotating about their respective axes of rotation they push the workpiece 100 against an abutment pad 5 adapted to hold the workpiece in position while being worked.

[0029] The first and second grinding wheel 2a, 2b preferably have an axial-symmetric geometry, and extend along the first and second axis of rotation A-A, B-B respectively.

[0030] The extension of the grinding wheels 2a, 2b along their axis of rotation A-A, B-B is defined as the height of the grinding wheel. Explicitly, the height of the first grinding wheel h_{M1} is defined as the extension of the first grinding wheel 2a along the first axis of rotation A-A, the height of the second grinding wheel 2b h_{M2} is defined as the extension of the second grinding wheel 2b along the second axis of rotation B-B.

[0031] The first and second grinding wheel 2a, 2b are commonly referred to as the operating wheel and the driving wheel, typically, but not necessarily, the operating wheel has a larger diameter than the driving wheel.

[0032] As shown in Figure 1, the grinding machine further comprises a support blade 4 arranged in the gap 3, i.e. between the first and second grinding wheel 2a, 2b.

[0033] The support blade 4 has a contact surface 4a to support the workpiece 100 in order to impose a working angle γ.

[0034] In greater detail, the contact surface 4a of the support blade 4 has a work profile 40a shaped to contact the workpiece at one and only one point at a time.

[0035] In addition, the work profile 40a is shaped to allow contacting the workpiece 100 with different working angles γ in different respective working steps. The support blade 4 is therefore configured to arrange the workpiece 100 with at least a first and a second working angle γ_1, γ_2 respectively in a first and a second working step.

[0036] In the context of the present invention, the working angle γ means the inclination of the support blade at a contact point C with the workpiece. More precisely, the working angle γ is defined as the inclination of the tangent line T-T to the work profile 40a drawn at the contact point C of the workpiece 100 with the contact surface 4a. Preferably, the working angle γ is defined by the inclination of the tangent line T-T to the work profile 40a with respect to a plane containing the first axis of rotation A-A and the medium point of the second axis of rotation B-B.

[0037] The medium point of the second axis of rotation B-B is the medium point of the height of the second grinding wheel h_{M2} i.e. the point that divides the height of the second grinding wheel h_{M2} into two segments having equal length.

[0038] The support blade 3 also has the function of supporting the workpiece 100 while it's been worked by imposing a working height and a working height h_w.

[0039] Working height h_w means the distance of the centre of the workpiece from the plane containing the first axis of rotation A-A and the medium point of the second axis of rotation B-B.

[0040] With reference to figures 3, 4a and 4b, the support blade 4 extends mainly along a vertical direction X-X, and the work profile 40a has at least two tangent lines T-T having different inclinations with respect to the vertical direction X-X.

[0041] In a first embodiment shown in figure 3, the contact surface 4a comprises at least two flat surfaces having different inclinations. In greater detail, the work profile 40a has at least a first and a second rectilinear stretch 41a, 42a respectively corresponding to the first and second flat surfaces, and having different inclinations with respect to the vertical direction X-X.

[0042] Advantageously, the support blade 4 of figure 3 allows to easily modify the working angle γ by moving the contact point C of the workpiece 100 with the contact surface 4a from the first to the second flat surface and vice versa. Thus, the grinding machine 1 object of the present invention allows to modify the working angle γ without having to replace the support blade 4.

[0043] The first embodiment of the support blade 4 may comprise more than two flat surfaces, each one having a different inclination and corresponding to a rectilinear stretch of the work profile.

[0044] In a second and a third embodiment of the support blade 4 shown in figure 4a and figure 4b respectively, the contact surface 4a comprises a curved surface 43, and the work profile 40a comprises a curved stretch 43a corresponding to the curved surface 43.

[0045] Advantageously, by moving the contact point C of the workpiece 100 with the contact surface 4a on the curved surface 43 it is possible to vary the working angle γ continuously between a minimum working angle γ_{min} and a maximum working angle γ_{max}. The curved surface 43 therefore allows greater flexibility of use, as it allows to continuously vary the value of the working angle γ.

[0046] In addition, it can be seen that a variation in the working angle γ also corresponds to a variation in the working height h_w. In detail, by moving the contact point C of the workpiece 100 with the contact surface 4a on the curved surface 43, the working height h_w varies continuously between a maximum $h_{w,max}$ and a minimum working height $h_{w,min}$, as the working angle γ varies between the maximum γ_{max} and minimum working angle γ_{min}.

[0047] Each possible contact point C of the workpiece 100 with the contact surface 4a therefore corresponds to a certain working angle γ and a certain working height h_w. It is therefore possible to specifically design the contact surface 4a and the corresponding work profile 40a in order to have a certain range of variation of the working angle and height γ, h_w.

[0048] The curved surface 43, as a curve in itself, has a concavity and a radius of curvature.

[0049] In the second embodiment of the support blade 4 shown in figure 4a, the concavity of the curved surface 43 is turned the opposite way with respect to the workpiece 100, when the latter is resting on the contact surface 40a. For the sake of simplicity, we will hereinafter refer to the second embodiment of the support blade 4 calling it as convex support blade 4a due to the curvature of its contact surface 40a.

[0050] In the third embodiment of the support blade 4 shown in figure 4b, the concavity of the curved surface 43 is turned towards the workpiece 100, when the latter is resting on the contact surface 40a. For the sake of simplicity, we will hereinafter refer to the third embodiment of the support blade 4 calling it as concave support blade 4a due to the curvature of its contact surface 40a.

[0051] Advantageously, the convex support blade does not impose any lower limits on the radius of curvature of the curved surface 43, as the workpiece 100, regardless of its size, always rests on the contact surface 4a at a single point. Conversely, the concave support blade cannot have a curved surface 43 having a radius of curvature smaller than that of the workpiece 100, otherwise the workpiece 100 would be resting on the contact surface 4a at two separate points, thus making grinding impossible.

[0052] However, advantageously, the concave support blade allows grinding small workpieces 100 with large working angles without generating problems of interference of the first grinding wheel 2a with the support blade 4. In greater detail, and with reference to figures 5a and 5b, the concave support blade, unlike the convex support blade, allows to reach the greatest working angles when the contact point between the workpiece 100 and the curved surface 43 is at the first grinding wheel 2a, therefore the first grinding wheel 2a is well spaced apart from the support blade 4.

[0053] A method for operating a grinding machine, in particular the grinding machine 1 of the centreless plunge type described above, is also an object of the present invention.

[0054] Such method comprises a first working step in which the support blade 4, according to one of the previously described embodiments, is configured to arrange the workpiece 100 at a first working height h_{w1} with respect to the plane containing the first axis of rotation A-A and the medium point of the second axis of rotation B-B, according to what has been previously described.

[0055] The method further comprises a second working step in which the support blade 4 is configured to arrange the workpiece 100 at a second working height h_{w2}, which is different from the first working height h_{w1}, with respect to the plane containing the first axis of rotation A-A and the medium point of the second axis of rotation B-B.

[0056] The work profile 40a of the contact surface 4a of the support blade 4 is configured to arrange the workpiece 100 with a first working angle γ_1 in the first working step, and with a second working angle γ_2 other than the first working angle γ_1 in the second working step.

[0057] The method object of the present invention thus comprises at least two working steps characterised by different working heights and angles h_w, γ.

[0058] In detail, the contact surface 4a and the work profile 40a of the support blade 4 are configured to arrange the workpiece 100 in the first working step at the first working height h_{w1} with the first working angle γ_1 and in the second working step at the second working height h_{w2} with the second working angle γ_2.

[0059] Preferably, as shown in figures 5a and 5b, the first and second grinding wheel 2a, 2b can be neared/distanced to change the position of the workpiece 100 on the contact surface 4a, and thus the working height and/or angle of h_w, γ. The method comprises a transition step interposed between the first and second working steps, in which the distance between the first and second grinding wheel 2a, 2b varies so as to change the first working angle, the height γ_1 in the second working angle γ_2 and the first working height h_{w1} in the second working height h_{w2}.

[0060] The transition step can also take place without stopping the working process, i.e. during the grinding process the distance between the grinding wheels 2a, 2b varies gradually so that the working height and angle are continuously varied h_w, γ from the values of the first working step to those of the second working step.

[0061] In greater detail, in the first working step the workpiece 100 is resting on the contact surface 4a of the support blade 4 at a first contact point, while in the second working step the workpiece 100 is resting on the contact surface 4a of the support blade 4 at a second contact point other than the first contact point. The contact surface 4a at the first and second contact points is respectively configured to arrange the workpiece 100 at the first working height h_{w1} with the first working angle γ_1 and at the second working height h_{w2} with the second working angle γ_2.

[0062] The method object of the present invention therefore allows to easily carry out a working process with multiple steps, each one having different working angles and heights γ, h_w.

[0063] The method according to the present invention described above may be extended to a generic number "n" of steps, each of which differs from the others in at least the working angle and/or height γ, h_w.

[0064] Thus, advantageously, the method object of the present invention makes it possible to minimise the formation of lobes on the profile of the workpiece by easily varying the working angle γ without having to replace the support blade 4.

Claims

1. Grinding machine (1) comprising:

- a first and a second grinding wheel (2a, 2b) separated by a gap (3) and configured to both contact a workpiece (100) to work thereupon as it rotates;
- a support blade (4) arranged in the gap (3), extending mainly along a vertical direction (X-X), and having a contact surface (4a) adapted to support the workpiece (100) and impose a working angle (γ); said contact surface (4a) of said support blade (4) having a work profile (40a) shaped to contact at one and only one point at a time the workpiece (100), the work profile (40a) being also shaped to contact with different working angles (γ), in different respective working steps, said workpiece (100);

characterised in that the work profile (40a) has at least two tangent lines having a different inclination with respect to the vertical direction (X-X).

2. Grinding machine (1) according to the previous claim, wherein the contact surface (4a) comprises at least two flat surfaces respectively corresponding to a first and a second rectilinear stretch (41a, 42a) of the work profile (40a), the first and the second rectilinear stretch (41a, 42a) having different inclinations with respect to the vertical direction (X-X).

3. Grinding machine (1) according to any one of the previous claims, wherein the contact surface (4a) comprises a curved surface (43) corresponding to a curved stretch (43a) of the work profile (40a).

4. Grinding machine (1) according to the previous claim, wherein the curved surface (43) has the concavity turned towards the workpiece (100) when the workpiece (100) is resting on the contact surface (40a).

5. Grinding machine (1) according to the claim 3, wherein the curved surface (43) has the concavity turned the opposite way with respect to the workpiece (100) when the workpiece (100) is resting on the contact surface (40a).

6. Method for operating a grinding machine having a first and a second grinding wheel (2a, 2b) separated by a gap (3) and configured to both contact a workpiece (100), the first and the second grinding wheel (2a, 2b) being respectively configured to rotate about a first and a second axis of rotation (A-A, B-B), a support blade (4) positioned in the gap (3) and having a contact surface (4a) adapted to support the workpiece (100), said support blade (4) extending mainly along a vertical direction (X-X);
the method comprising at least:

- a first working step in which the support blade (4) is configured to arrange the workpiece (100) at a first working height (h_{w1}) with respect to a plane containing the first axis of rotation (A-A) and the medium point of the second axis of rotation (B-B);
- a second working step in which the support blade (4) is configured to arrange the workpiece (100) at a second working height (h_{w2}) with respect to the plane containing the first axis of rotation (A-A) and the medium point of the second axis of rotation (B-B);

characterised in that the contact surface (4a) has a work profile (40a) configured to arrange the workpiece (100) with a first working angle (γ_1) in the first working step, and with a second working angle (γ_2) in the second working step, the first working angle being different from the first working angle (γ_1), said working angle (40a) having at least two tangent lines having a different inclination than the vertical direction (X-X).

7. Method according to the previous claim wherein the first and the second grinding wheel (2a, 2b) can be respectively neared/distanced for modifying the position of the workpiece (100) on the contact surface (4a) and therefore the working height and/or the working angle (h_w, γ).

8. Method according to the previous claim wherein in the first working step the workpiece (100) rests on the contact surface (4a) of the support blade (4) at a first contact point, and in the second working step the workpiece (100) rests on the contact surface (4a) of the support blade (4) at a second contact point different from the first contact point, the contact surface (4a) at the first and the second contact point being respectively configured to arrange the workpiece (100) at the first working height (h_{w1}) with the first working angle (γ_1) and at the second working height (h_{w2}) with the second working angle (γ_2).

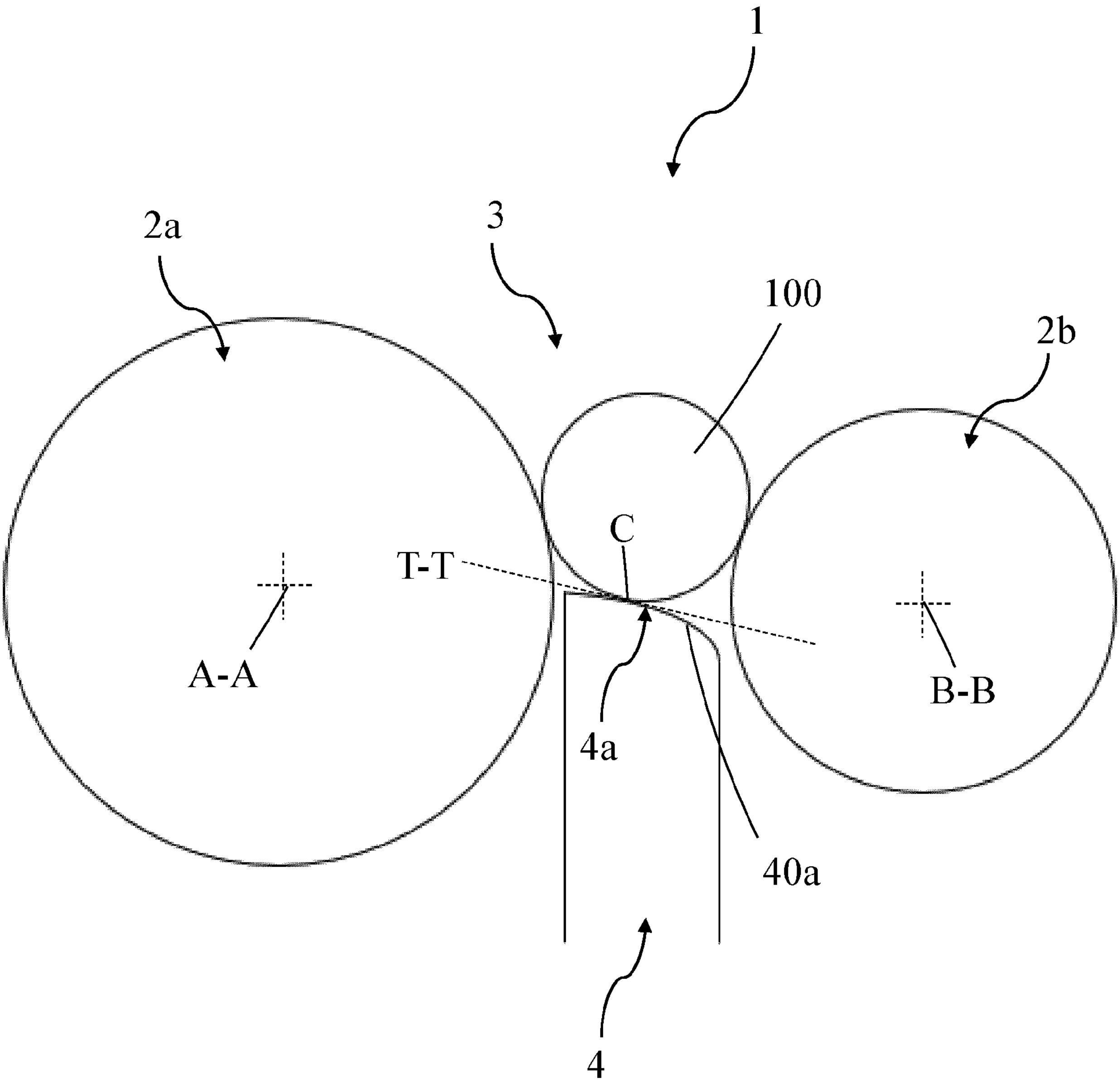

Fig. 1

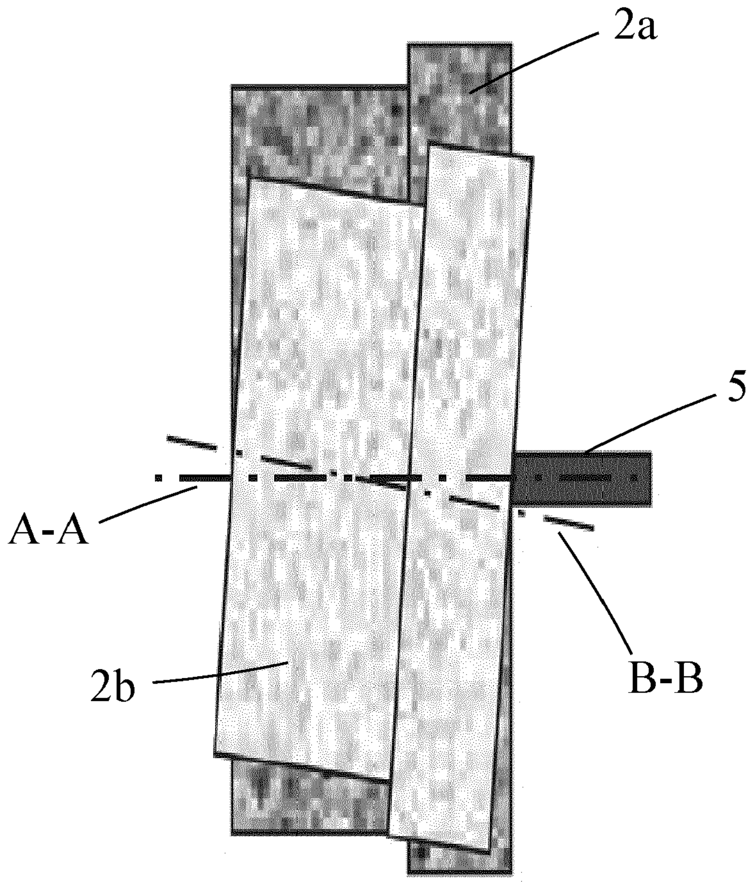

Fig. 2

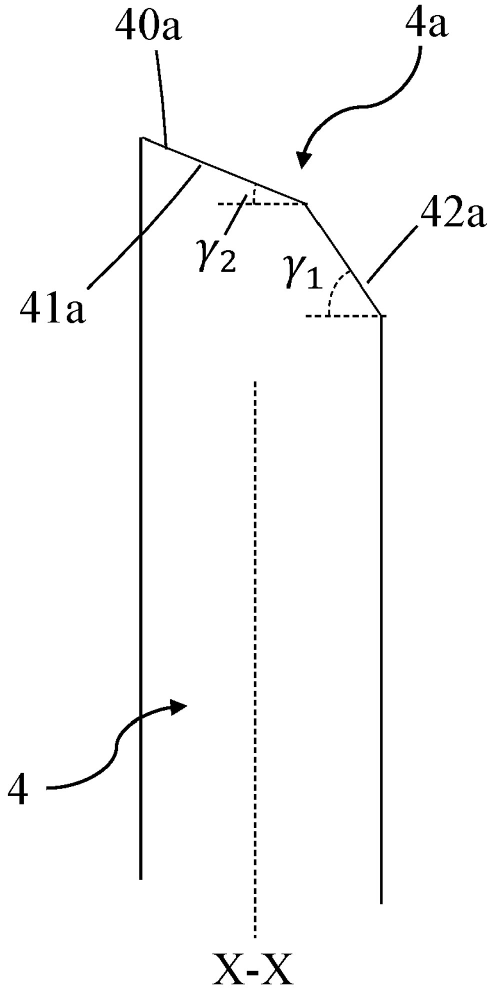

Fig. 3

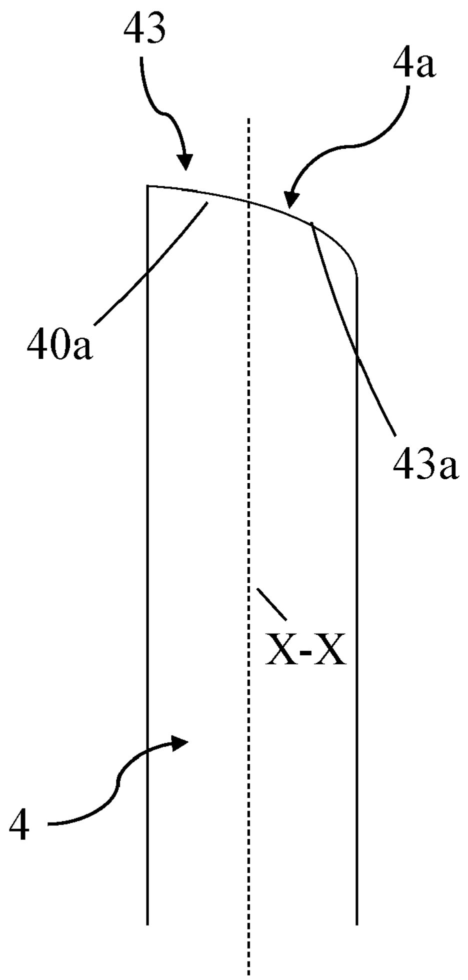

Fig. 4a

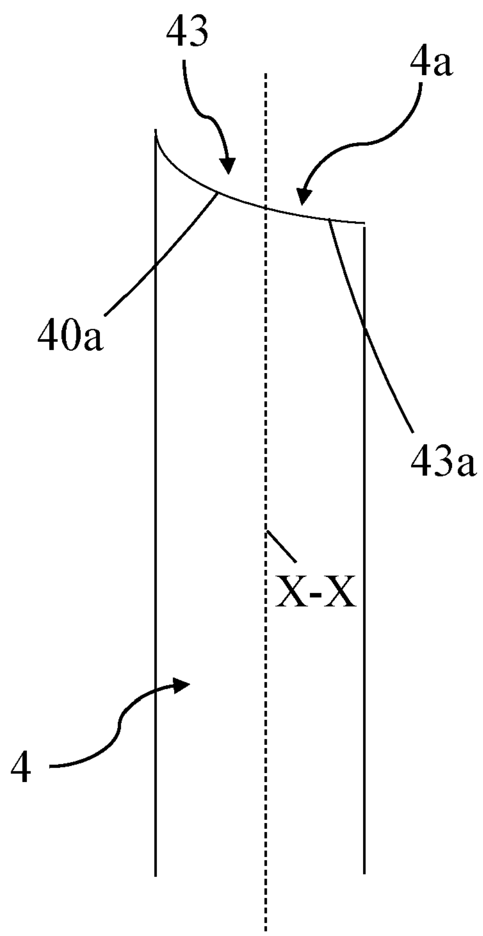

Fig. 4b

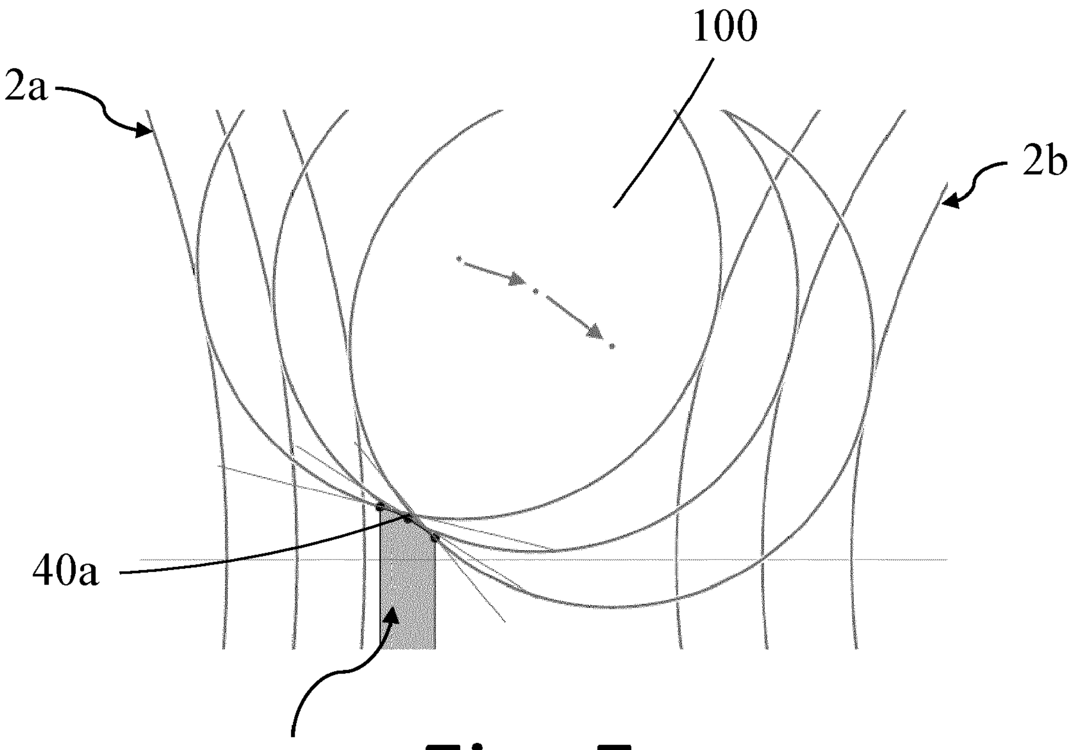

Fig. 5a

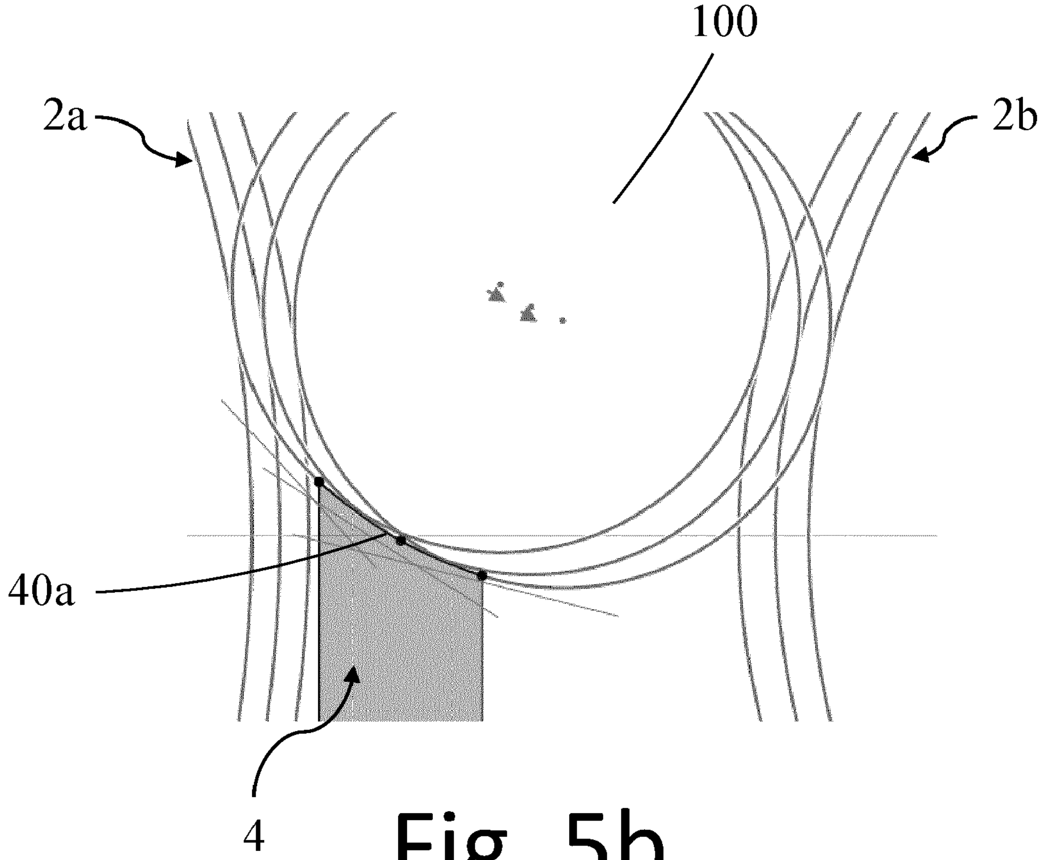

Fig. 5b

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EUROPEAN SEARCH REPORT

Application Number
EP 21 20 8976

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2 897 636 A (PYNE ROGER S ET AL) 4 August 1959 (1959-08-04) * figures 2, 7, 8 *	1-8	INV. B24B5/22 B24B5/307 B24B41/06
A	KR 102 028 879 B1 (CHO KI SUN [KR]) 4 October 2019 (2019-10-04) * paragraphs [0021] - [0035] * * figures 2-7 *	1-8	

TECHNICAL FIELDS SEARCHED (IPC)

B24B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	6 April 2022	Bermejo, Marco

CATEGORY OF CITED DOCUMENTS

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2897636	A	04-08-1959	NONE	
KR 102028879	B1	04-10-2019	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- US 2897636 A **[0011] [0012] [0015]**
- KR 102028879 B1 **[0011] [0013]**