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(54) COLD FORMING A COMPONENT

(57) The subject-matter of the present disclosure relates to a method of cold forming a component made from a metallic material. The method comprises: providing a tool having a mandrel and a die, wherein the die comprises a plurality of protrusions on a surface facing the mandrel; inserting the component between the die and the mandrel; reducing a distance between the plurality of protrusions and the mandrel such that the plurality of protrusions produces indentations on a surface of the component; and increasing the distance between the plurality of protrusions and the mandrel to induce bending in the component.

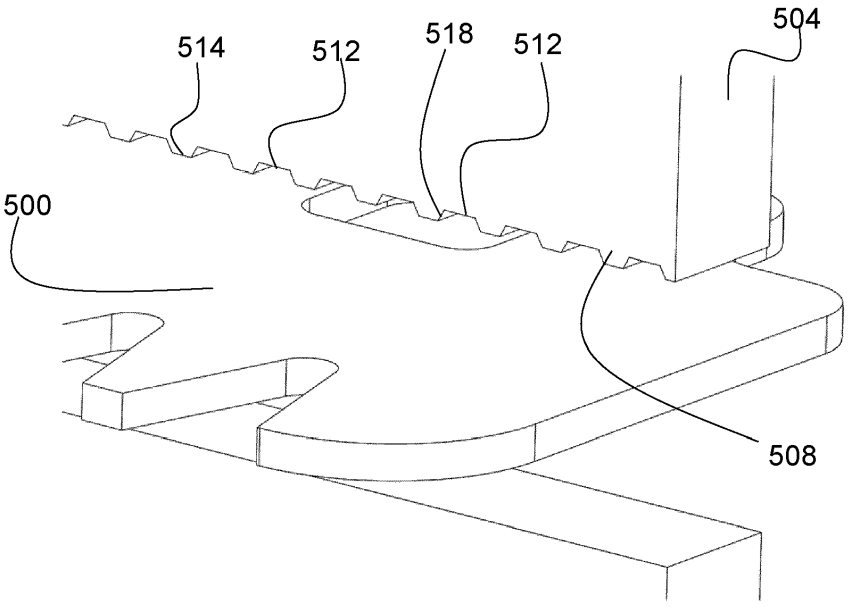

Figure 5

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Description

FIELD OF THE INVENTION

[0001] The subject-matter of the present disclosure relates to methods of cold forming components, more specifically, components made form metallic materials. The subject-matter of the present disclosure also relates to appliances including components made by cold forming and cold forming tools.

BACKGROUND OF THE INVENTION

[0002] Certain appliances have components which move relative to one another in operation.

[0003] With reference to Figs. 1 and 2, one such appliance is a personal care appliance 10 such as a hair cutting appliance. Hair cutting appliances have relative moving components like a cutter 12 and a guard 14. A frame 15 may also be provided to support the cutter 12 and guard 14 assembly. The contacting surfaces of these components need to be manufactured to a high degree of tolerance to avoid any deviations in their shape. For example, if they are both completely flat (as in Fig. 2), they can move relative to one another such that hairs can be caught between the respective teeth 17 of each component. In contrast, if one of the components exhibits any shape deformation (as shown in Fig. 1), gaps 16 will exist between the components meaning that they won't cut the hairs properly. It will be appreciated that the components do not have to be flat. For instance, they could both be curved, provided that they are both curved by the same radius, degree and direction of curvature. However, if they are not at the same radius, degree and direction of curvature, the components will not cooperate correctly to cut the hairs properly.

[0004] Typically, several post cold forming steps are required in order to achieve the correct shapes of the components. Those steps may include washing, hardening, grinding, deburring, and washing the components after cold forming them and before they are assembled together.

It is an aim of the subject-matter of the present disclosure to improve on the prior art.

SUMMARY OF THE INVENTION

[0005] According to a first aspect of the present invention, there is provided a method of cold forming a component made from a metallic material, the method comprising:

providing a tool having a mandrel and a die, wherein the die comprises a plurality of protrusions on a surface facing the mandrel; inserting the component between the die and the mandrel; reducing a distance between the plurality of protrusions and the mandrel such that the plurality of protrusions produces indentations on a surface of the component and increasing the distance between the plurality of protrusions and the mandrel to induce bending in the component. The indentations cause an increase in compressive stress on the surface of the component where the indentations occur. The compressive stress causes the component to bend away from the die. For example, a flat component will become concave on a side where the indentations occur and convex on an opposite side. A component may already have curvature with a convex and concave sides. If the die is applied to the convex side, the component will become less curved and can even become flat.

[0006] This method reduces the need for further non-cold forming steps since the shapes of the components will be controlled more accurately using the protrusions at desired locations. In addition, with conventional bending by cold forming, there is too much variation in curvature, e.g. flatness. After conventional bending, some components may have too little curvature and some components may have two much curvature. Such components may be out of tolerance and need to be removed from a production process. This requires a costly control plan during production (measurements/selecting parts/etc). Using the present method, the flatness tolerance of the resulting component will be better controlled.

[0007] In an embodiment, a surface of the mandrel facing the die is substantially flat.

[0008] In an embodiment, a virtual surface formed by tips of the protrusions has one or more substantially flat portions. The term virtual surface is used to mean an imaginary surface formed by contacting each tip. In other words, the tips *per se* may be flat or curved, whereas the virtual surface formed by the tips has one or more substantially flat portions.

[0009] In an embodiment, the protrusions do not cover a complete length of the component. In this way, the resulting component will be partly curved and partly flat, for example. In other words, the flatness will change along the length of the component depending on where the indentations are provided.

[0010] In an embodiment, the method further comprises: effect relative rotation between the die and the component; reducing the distance between the plurality of protrusions and the mandrel such that the plurality of protrusions indent into a surface of the component; and increasing the distance between the plurality of protrusions and the mandrel to induce bending in the component.

[0011] Again, the bending may be away from the die. The relative rotation may mean rotating the component and/or rotating the die provided the orientation between the two components is changed.

[0012] In an embodiment, the rotating the component is rotating the component substantially orthogonally. In this way, the indentations will be substantially orthogonal

to the initial indentations. This operation can cause the component to exhibit a substantially bowl shape.

[0013] In an embodiment, the method further comprises: flipping the component or the die and mandrel such that the surface with indentations is facing the mandrel; reducing the distance between the plurality of protrusions and the mandrel such that the plurality of protrusions indent into a surface of the component; and increasing the distance between the plurality of protrusions and the mandrel to induce bending in the component.

[0014] In an embodiment, the mandrel includes a plurality of protrusions for providing a plurality of indentations on an opposite surface of the component.

[0015] Again, the bending may be away from the die. The relative rotation may mean rotating the component and/or rotating the die provided the orientation between the two components is changed. Where the method includes effecting relative rotation substantially orthogonally, and flipping the component, the resulting component may have a substantially saddle shape.

[0016] In an embodiment, the protrusions form a set of teeth, each tooth of the teeth being separated from one another by a gap.

[0017] In an embodiment, the protrusions do not cover the complete length of the component so that the component is partly curved and partly straight in that direction.

[0018] In an embodiment, tips of the teeth are substantially flat, and wherein edges of the teeth between the tips and the gaps between adjacent teeth are substantially inclined.

[0019] In an embodiment, a width of the gaps is larger than a width of the tips. The gap may be the smallest distance between adjacent edges. In other words, the gaps are measured between base portions of adjacent teeth.

[0020] In an embodiment, the component is a cutter or a guard from a hair cutting appliance.

[0021] According to an aspect of the present disclosure, there is provided an appliance including a component curved using the method of any preceding aspect or embodiment.

[0022] According to an aspect of the present disclosure, there is provided a cold forming tool comprising: a mandrel; a die having a plurality of protrusions facing the mandrel; and an actuator arranged to: reduce a separation distance between the plurality of protrusions and the mandrel; and increase the separation distance between the plurality of protrusions and the mandrel to induce bending in the component.

[0023] These and other aspects of the present invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The embodiments of the present inventions may be best understood with reference to the accompanying figures, in which:

Fig. 1 shows two components in the form of a cutter and a guard, each cooperating to cut hair where the components do not have matching shapes, according to the prior art;

Fig. 2 shows two components in the form of a cutter and a guard, each cooperating to cut hair where the components have matching shapes, according to the prior art;

Figs. 3A to 3C show schematic cross-section views of a tool for cold forming a component according to one or more embodiments;

Fig. 4 shows a schematic cross-section view of a tool for cold forming a component according to one or more embodiments;

Fig. 5 shows a perspective view of the tool of Figs. 3A-3C being used on a component, according to one or more embodiments;

Fig. 6 shows a perspective view of another variation of the tool of Figs. 3A-3C being used on a component, according to one or more embodiments;

Fig. 7 shows a cross-section view of the tool form Fig. 5;

Fig. 8 shows a cross-section view of the tool from Fig. 6;

Fig. 9 shows a graph of flatness, F, versus indentation depth, I;

Fig. 10 shows a cross-section view of part of the component formed using the method from Figs. 3A-3C, to illustrate indentation depth;

Fig. 11 shows a similar view to Fig. 10 of the entire component to illustrate flatness, F;

Fig. 12 shows a component having been cold formed having been cold formed according to one or more embodiments; and

Fig. 13 shows a flow chart summarising a method of cold forming a component, according to one or more embodiments.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0025] With reference to Figs. 3A to 3C, a component 500, e.g. a cutter or a guard is provided together with a tool 502. The cutter and guard may be components of a personal care appliance such as a hair cutting appliance. The tool includes a die 504 and a mandrel 506. The die 504 has a plurality of protrusions 508 facing the mandrel 506. The tool includes an actuator 510. The actuator is arranged to reduce a separation distance, d, between the plurality of protrusions 508 and the mandrel 506 (Fig. 3B) such that the plurality of protrusions produces indentations 507 on a surface of the component. The actuator 510 is also arranged to increase separation distance, d, between the plurality of protrusions 508 and the mandrel 506.

[0026] In this embodiment, the mandrel has a surface facing the die that is substantially flat. In other embodi-

ments, the mandrel may itself have a plurality of protrusions. In this way, indentations are formed on an opposite surface of the component. In other words, indentations can be provided on opposing surfaces of the component simultaneously.

[0027] A virtual surface formed by tips of the protrusions has one or more substantially flat portions. For example, the virtual surface formed by the tips of the protrusions may be substantially, or entirely, flat. In this way, to change the separation distance, the actuator 510 moves the die 504. The term virtual surface is used to mean an imaginary surface formed by contacting each tip. The *tips per se* do not need to be flat, they may be curved, for example.

[0028] With reference to Fig. 4, in another embodiment, the die 604 may have a substantially circular cross-section. The plurality of protrusions 608 are provided around a perimeter of the die 604. To reduce the separation distance, d, the actuator 610 may be arranged to rotate the die 604 and move it laterally along the component 600. Otherwise, the tool 602 of Fig. 4 shares the same features as the tool of Figs. 3A to 3C.

[0029] Figs. 5 to 8 shows the die 504 from Figs. 3A to 3C.

[0030] With reference to Figs. 5 and 7, the plurality of protrusions 508 form a set of teeth. Each tooth of the teeth is separated from one another by a gap 512. In other words, there is a gap 512 between adjacent teeth. Tips 514 of the teeth are substantially flat. Edges 516 of the teeth between the tips 514 and the gaps 512 are substantially inclined or sloped. The width of the gaps 512 is substantially larger than the width of the tips 514. This profile provides compressive stress on the surface to bend the component with the indentations and is easy to remove from the component.

[0031] The teeth may have a height of between 0.01 and 0.15 mm. More specifically, the teeth may have a height of 0.02mm or 0.1mm. A width of the tips, W_{tip}, 514 may be between 0.03mm and 0.2 mm. More specifically, the teeth may have a tip width of 0.037mm and 0.1845mm. The gap widths, W_{gap}, may be between 0.025 and 0.4 mm. More specifically, the gap widths may be 0.04 mm or 0.3 mm. The angle of inclination, θ, of the sloped edges 516 may be between 20 and 45 degrees. More specifically, the angle of inclination may be 30 degrees. The specific dimensions may be selected to control the indentations. In particular, as described with reference to Fig. 9 below, the indentation dimensions, and in particular the indentation depths, controls a degree of curvature of the component.

[0032] With reference to Figs. 6 and 8, the plurality of protrusions 508 are shown in a similar fashion to those in Figs. 5 and 7. However, the sizes of the protrusions 508 are smaller to provide comparatively fine teeth.

[0033] In operation, there is provided a method of cold forming a component made from a metallic material. The method comprises providing the tool 502 having the mandrel 506 and the die 504 and inserting the component 500 between the die and the mandrel. The method also comprises reducing a distance, or separation distance, d, between the plurality of protrusions and the mandrel such that the plurality of protrusions produces the indentations on the surface of the component. The indentations increase compressive stresses on that surface. Then the distance, d, between the plurality of protrusions and the mandrel is increased to induce bending in the component. The bending may be bending away from the die 504. In other words, if the component was originally flat, after cold forming the component will become curved and the surface with the indentations will be concave, whereas the opposite surface will become convex. Similarly, if a surface having indentations made in it was previously convex, it will become less convex after cold forming, such that the final component will be less curved, e.g. less convex on a surface with the indentations, flat, or curved in an opposite direction, e.g. concave on a surface with the indentations.

[0034] With reference to Figs. 9 to 11, where the component is a cutter, the metal type may be stainless steel. For example, the alloy may be AISI301.

[0035] The indentation depth, I, is shown in Fig. 10 and Fig. 11 shows the resulting flatness, F. Indentation depth, I, is measured from a peak 1202 to a trough 1204. In other words, the indentation depth, I, describes a height of the indentation 507 in the component 500. The flatness, F, is a measure from a peak 1202 to a trough 1204 of a surface of the component 500 opposite to the indentations 507. In other words, the flatness, F, is a height of a bend of the component.

[0036] With specific reference to Fig. 9, flatness, F, is shown relative to indentation depth, I. The relationship is linear within this range of indentation depths. In other words, the flatness, F, is proportional to the indentation depth , I. For example, an indentation depth, I, of 0.0015 mm yields a flatness, F, of about 0.027 mm for the cutter. In contrast, an indentation depth, I, of 0.0025 mm yields a flatness of around 0.041 mm.

[0037] As alluded to above, the bending is induced because the indentations cause a change in compressive stress at the surface with the indentations. In this way, after pressing the indentations into the surface, the component bends away from the die.

[0038] With reference to Fig. 12, the method may further comprise effecting relative rotation between the die and the component; reducing the distance between the plurality of protrusions and the mandrel such that the plurality of protrusions indent into a surface of the component; and increasing the distance between the plurality of protrusions and the mandrel to induce bending in the component. The relative rotation may be achieved by rotating the component 500 and/or rotating the die such that the final position of the component after the rotation is rotated relative to the die. The rotation may be substantially orthogonal in some embodiments such as the one shown in Fig. 12. A first line of indentations 1402 may run substantially parallel to a line of teeth 1404 of the com-

ponent 500. A second line of indentations 1406 may run substantially perpendicular to the line of teeth 1404.

[0039] It will be appreciated that the component 500 in Fig. 12 has lines of indentations on opposite sides of the component 500. To achieve this, the method may further comprise flipping the component or the die and mandrel such that the surface with indentations is facing the mandrel; reducing the distance between the plurality of protrusions and the mandrel such that the plurality of protrusions indent into a surface of the component; and increasing the distance between the plurality of protrusions and the mandrel to induce bending in the component.

[0040] By having lines of indentations on opposing sides of the component and substantially orthogonal to one another, the component may be curved in a saddle shape. The degrees of rotation and the choice whether to flip the component or not can be adjusted to curve the component into a variety of shapes.

[0041] With reference to Fig. 13, the method of cold forming a component made from a metallic material can be summarised as including the steps of: providing 1500 a tool having a mandrel and a die, wherein the die comprises a plurality of protrusions on a surface facing the mandrel; inserting 1502 the component between the die and the mandrel; reducing 1504 a distance between the plurality of protrusions and the mandrel such that the plurality of protrusions produces indentations on a surface of the component; and increasing 1506 the distance between the plurality of protrusions and the mandrel to induce bending in the component.

[0042] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments.

[0043] Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfil the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A method of cold forming a component (500) made from a metallic material, the method comprising:

   providing (1500) a tool (502) having a mandrel (506) and a die (504), wherein the die comprises a plurality of protrusions (508) on a surface facing the mandrel;
   inserting (1502) the component between the die and the mandrel;
   reducing (1504) a distance, d, between the plurality of protrusions and the mandrel such that the plurality of protrusions produces indentations (507) on a surface of the component; and
   increasing (1506) the distance, d, between the plurality of protrusions and the mandrel to induce bending in the component.

2. The method of Claim 1, wherein a surface of the mandrel facing the die is substantially flat.

3. The method of Claim 1 or Claim 2, wherein a virtual surface formed by tips (514) of the protrusions has one or more substantially flat portions.

4. The method of any preceding claim, the protrusions do not cover a complete length of the component.

5. The method of any preceding claim, further comprising:

   effect relative rotation between the die and the component;
   reducing the distance between the plurality of protrusions and the mandrel such that the plurality of protrusions indent into a surface of the component; and
   increasing the distance between the plurality of protrusions and the mandrel to induce bending in the component.

6. The method of any Claim 5, wherein the rotating the component is rotating the component substantially orthogonally.

7. The method of any preceding claim, further comprising:

   flipping the component or the die and mandrel such that the surface with indentations is facing the mandrel;
   reducing the distance between the plurality of protrusions and the mandrel such that the plurality of protrusions indent into a surface of the component; and
   increasing the distance between the plurality of protrusions and the mandrel to induce bending in the component.

8. The method of any preceding claim, wherein the mandrel includes a plurality of protrusions for providing a plurality of indentations on an opposite surface of the component.

9. The method of any preceding claims, wherein the protrusions form a set of teeth, each tooth of the teeth being separated from one another by a gap (512).

10. The method of Claim 9, wherein tips of the teeth are substantially flat, and wherein edges (518) of the teeth between the tips and the gaps (512) between adjacent teeth are substantially inclined.

11. The method of Claim 10, wherein a width of the gaps is larger than a width of the tips.

12. The method of any preceding claim, wherein the component is a cutter or a guard from a hair cutting appliance.

13. An appliance including a component curved using the method of any preceding claim.

14. A cold forming tool (502) comprising:

a mandrel (506);
a die (504) having a plurality of protrusions (508) facing the mandrel; and
an actuator (510) arranged to:

reduce a separation distance, d, between the plurality of protrusions and the mandrel such that the plurality of protrusions produces indentations (507) on a surface of the component; and
increase the separation distance, d, between the plurality of protrusions and the mandrel to induce bending in the component.

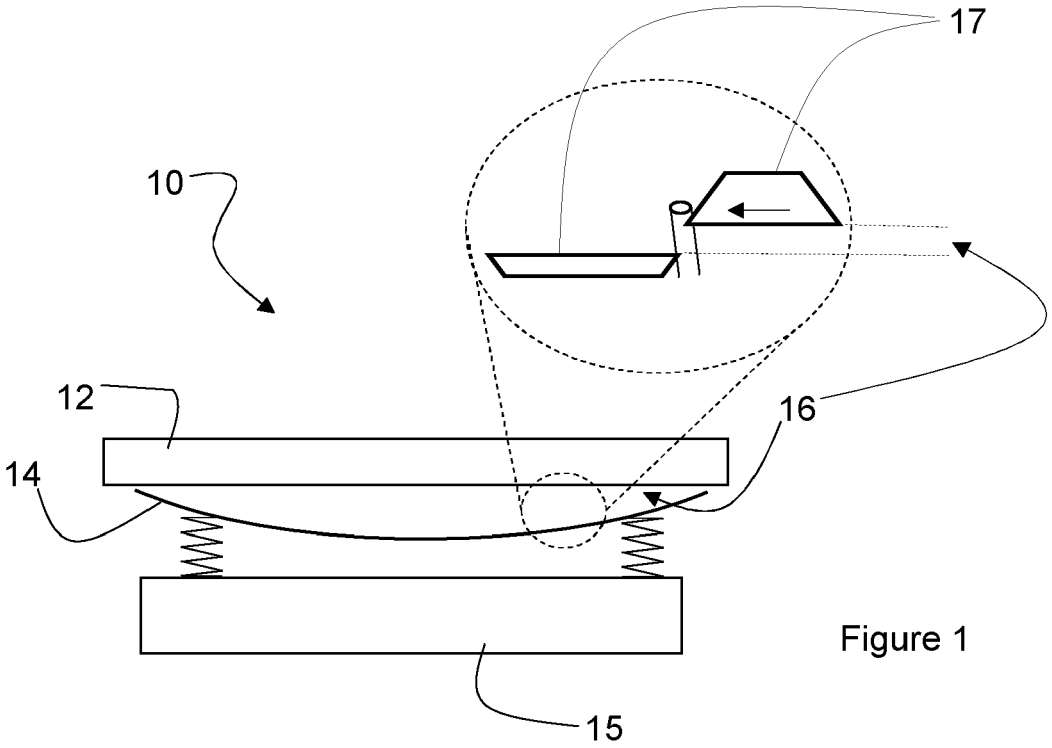


Figure 1

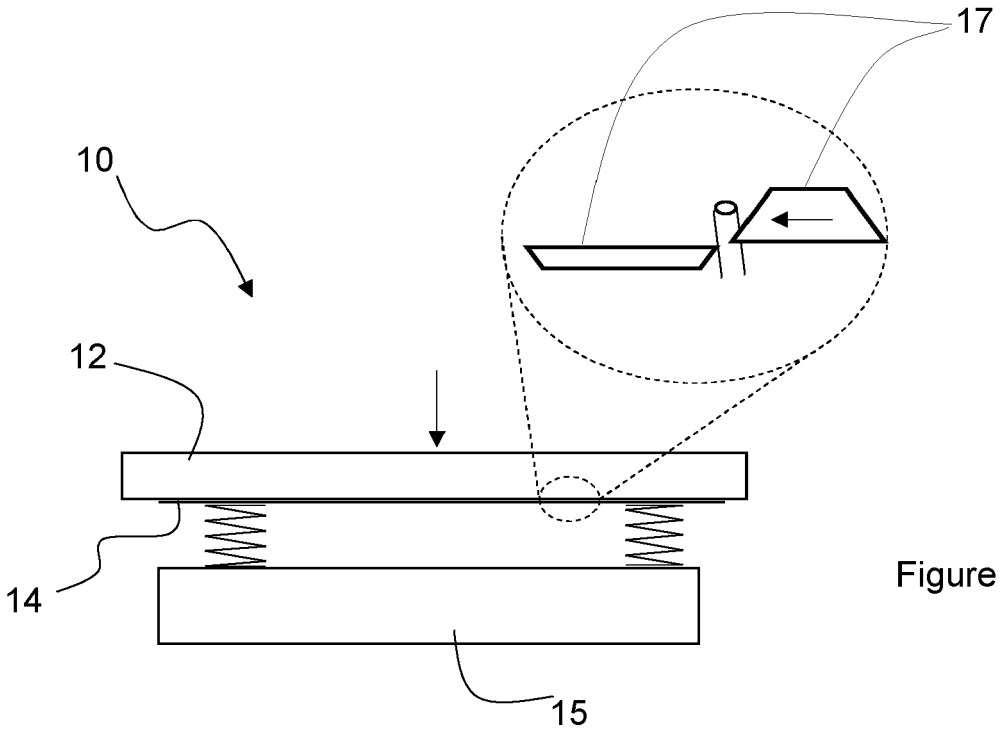


Figure 2

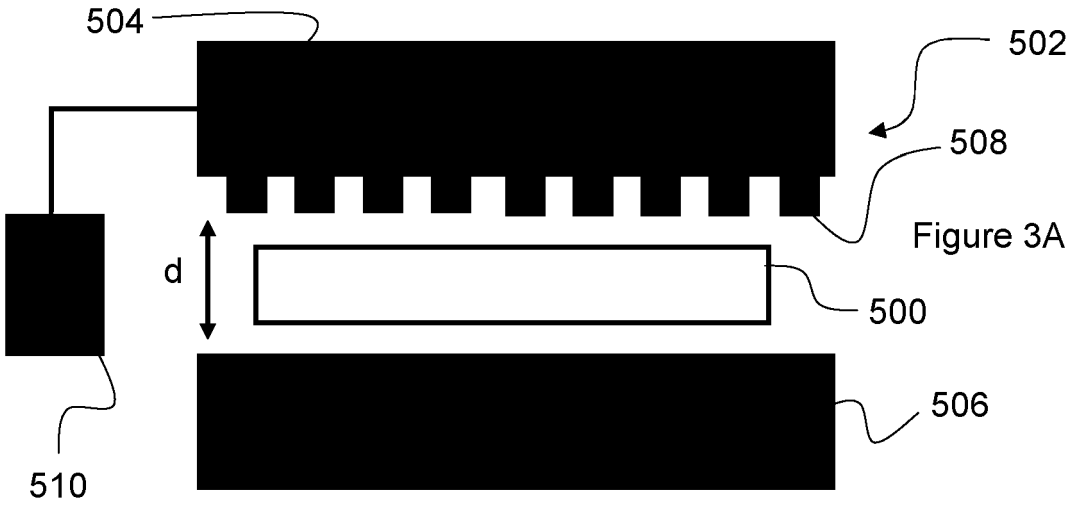


Figure 3A

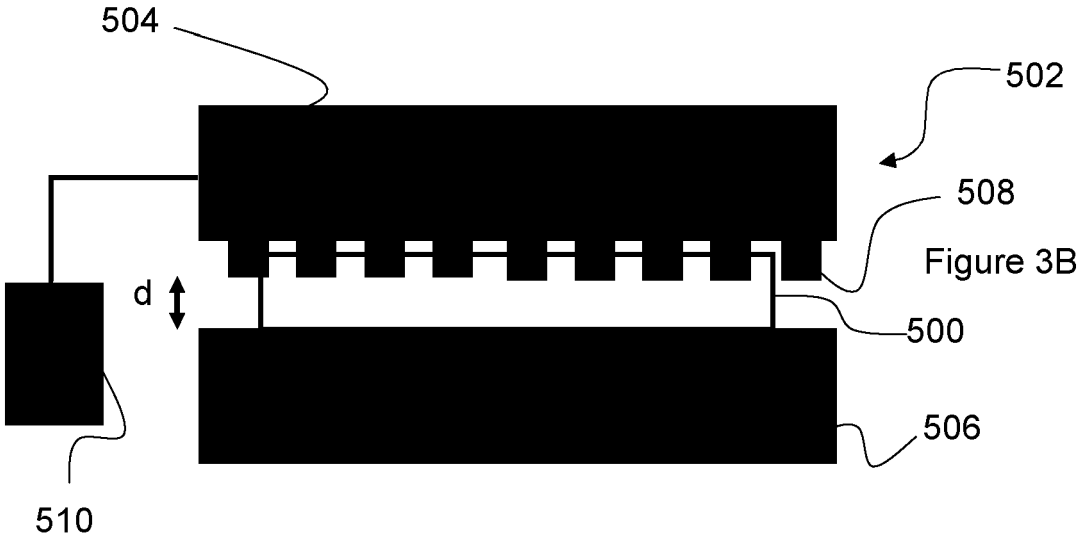


Figure 3B

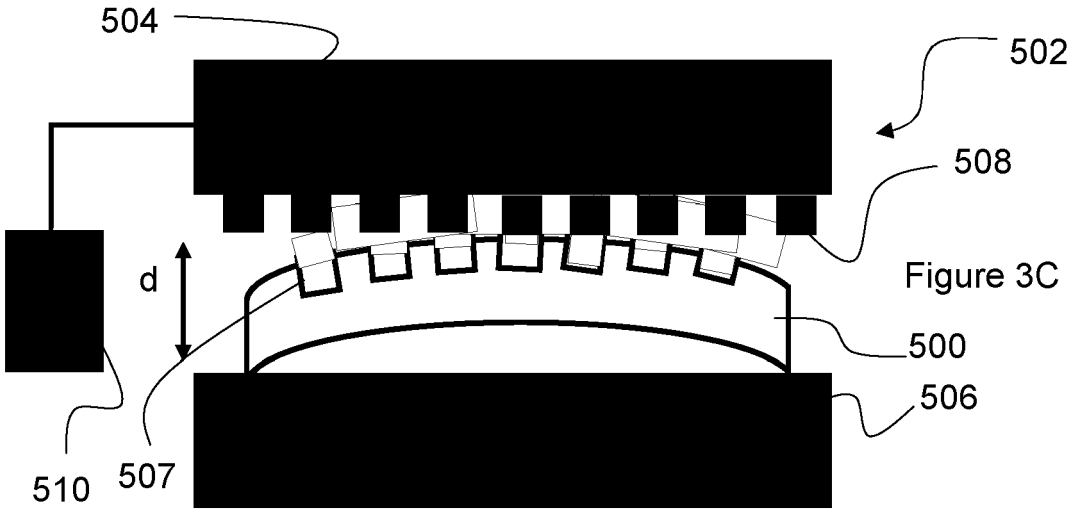


Figure 3C

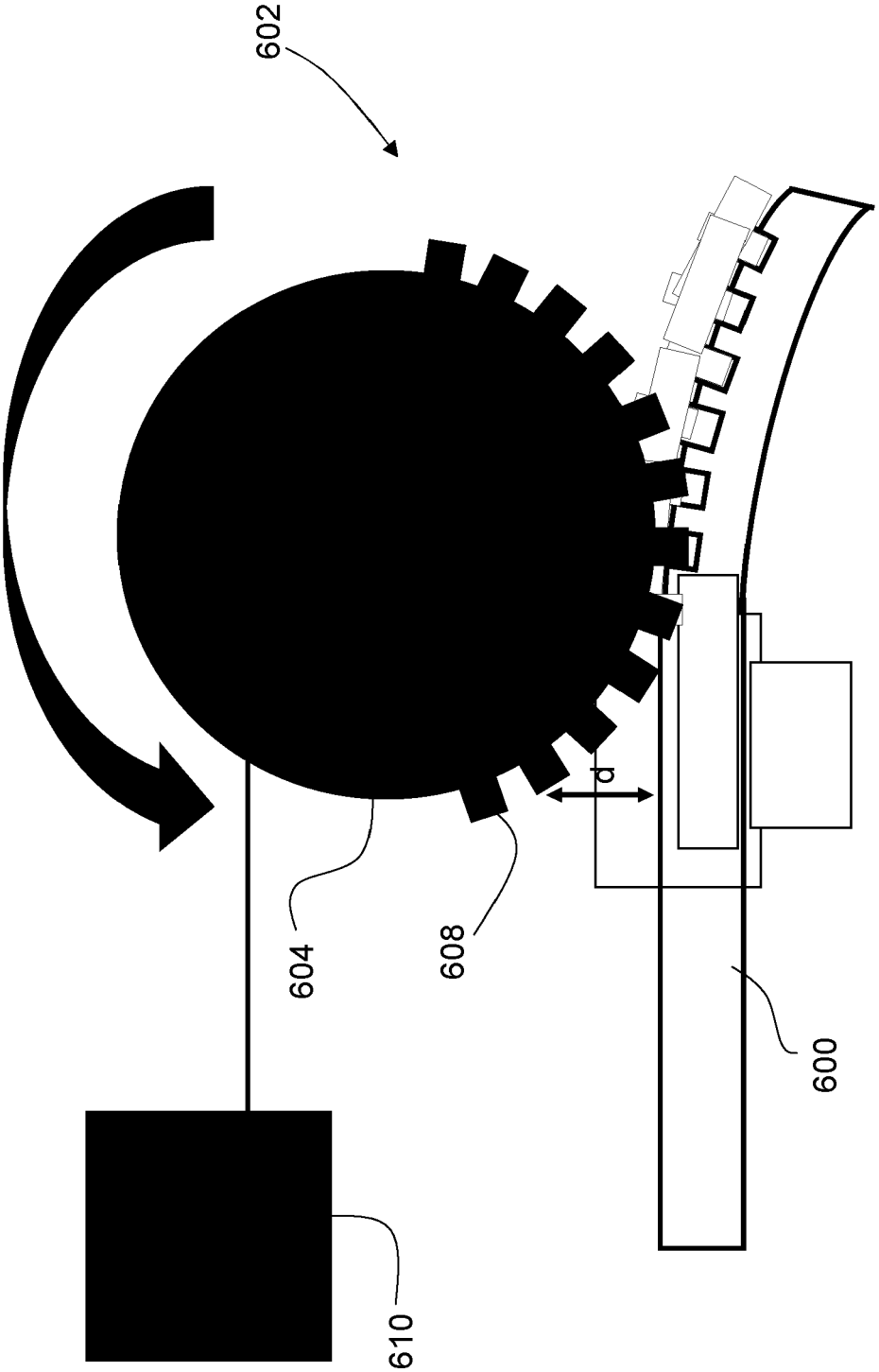


Figure 4

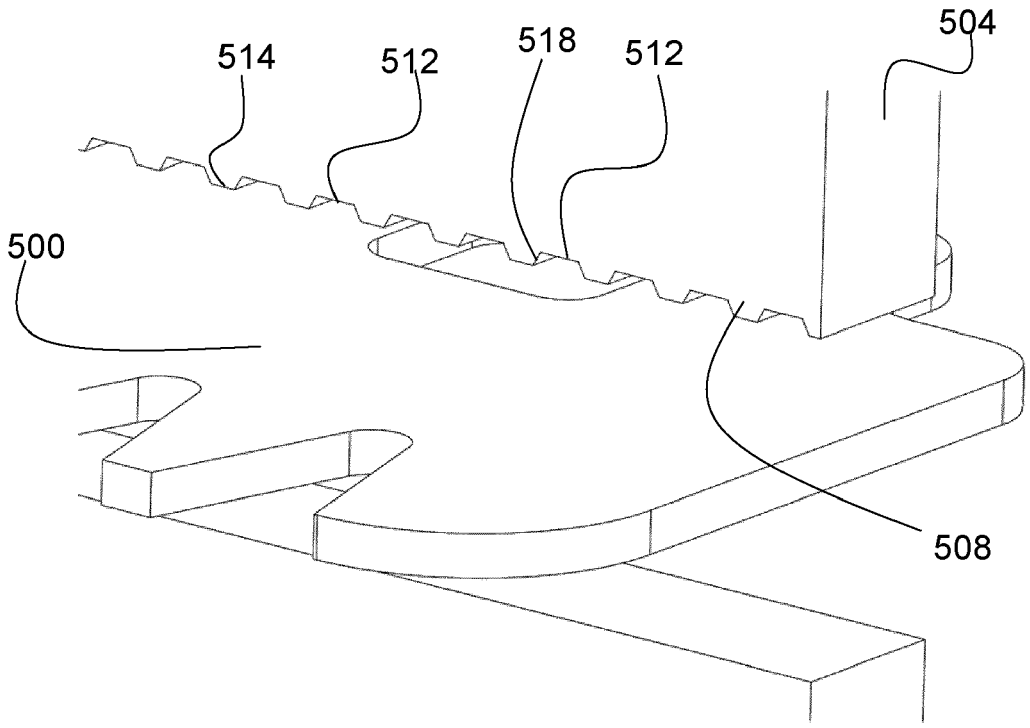


Figure 5

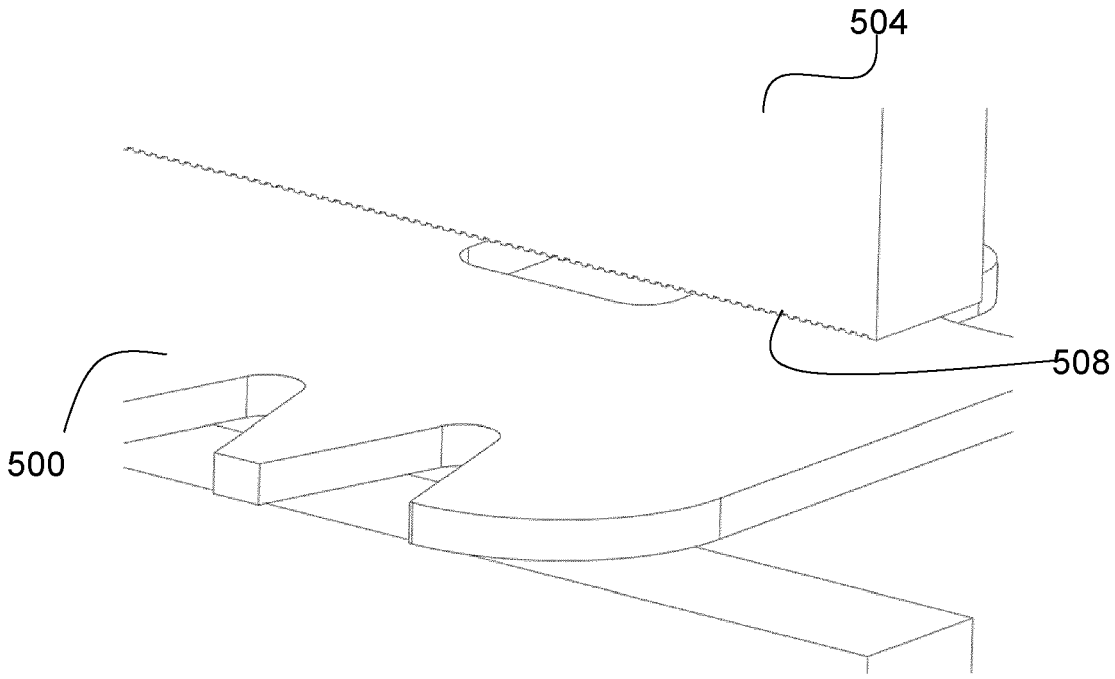


Figure 6

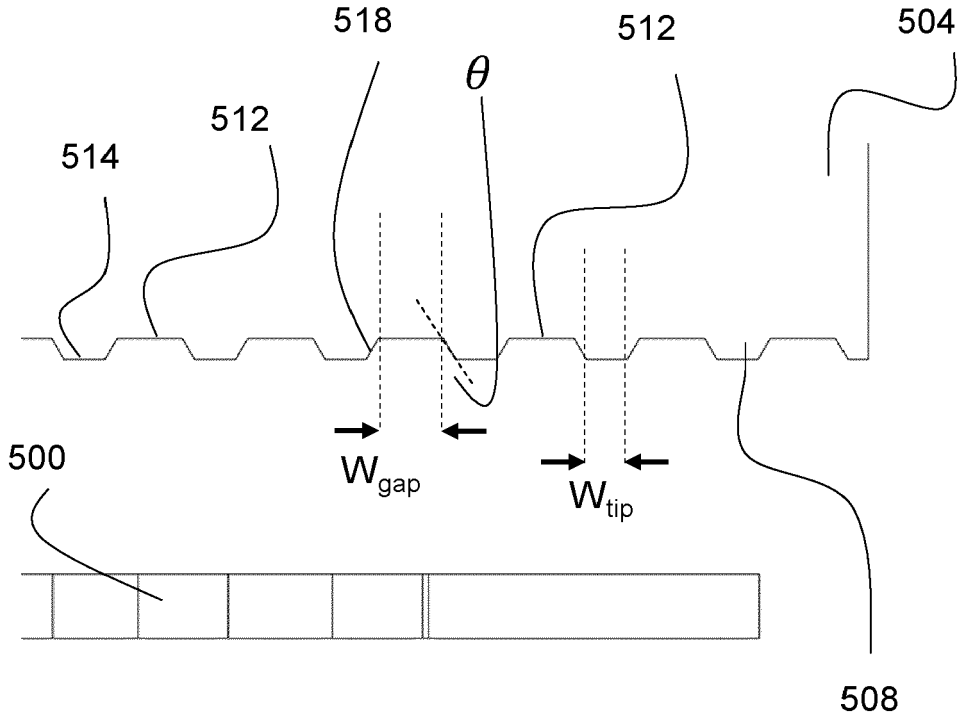


Figure 7

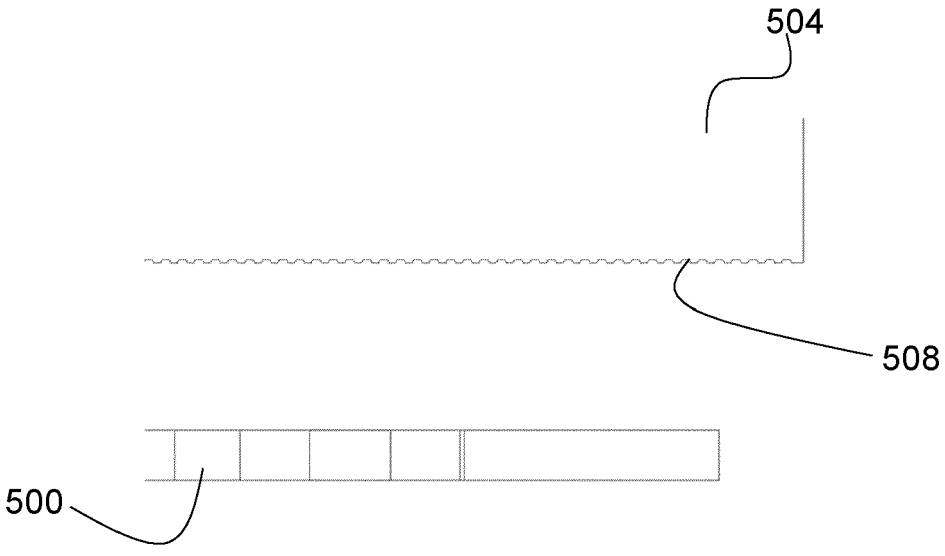


Figure 8

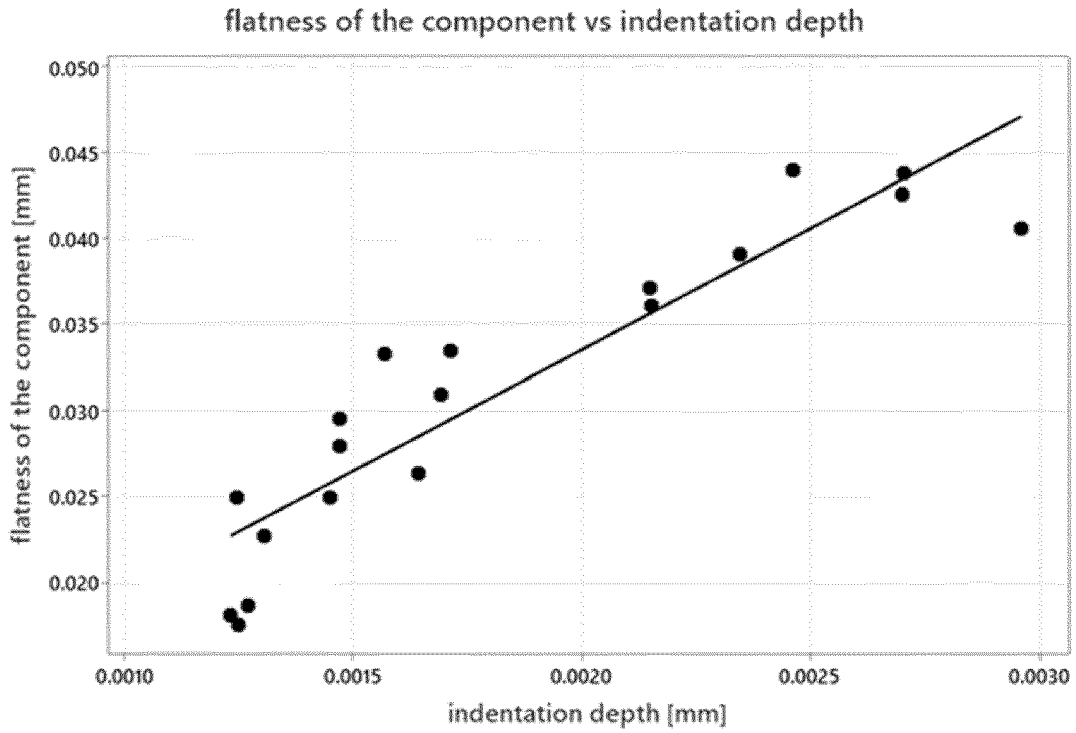


Figure 9

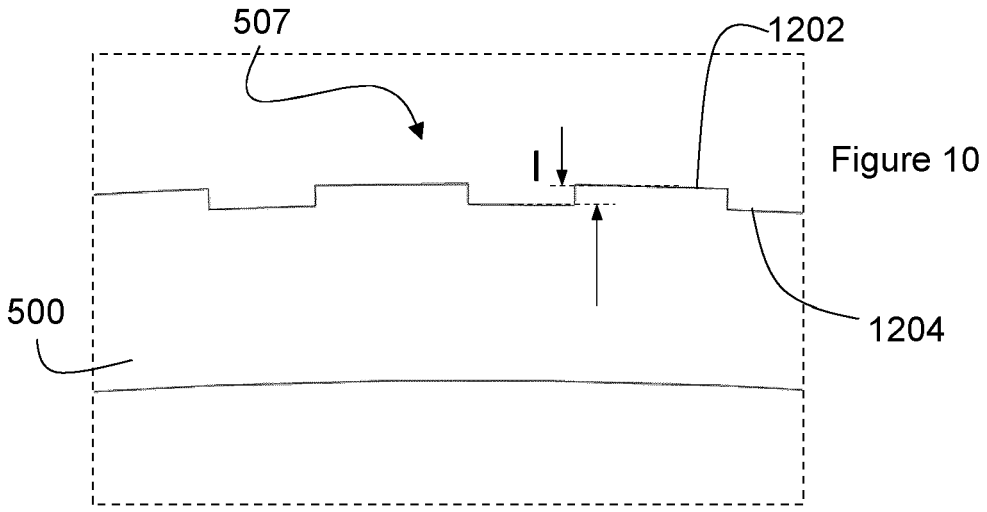


Figure 10

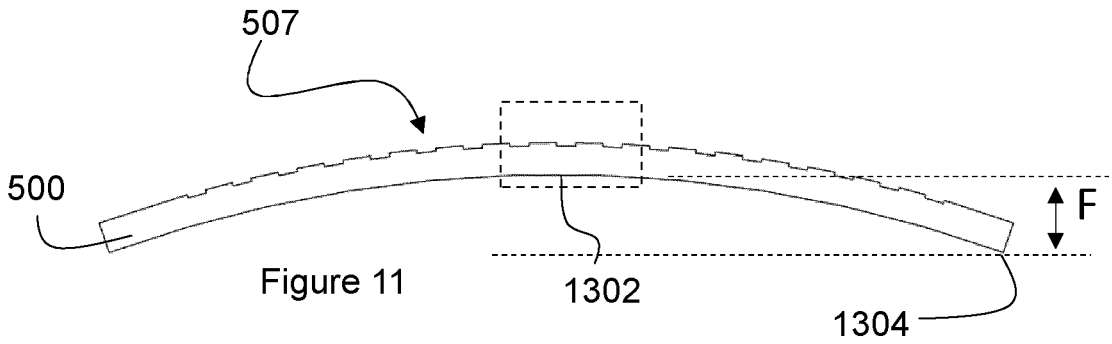


Figure 11

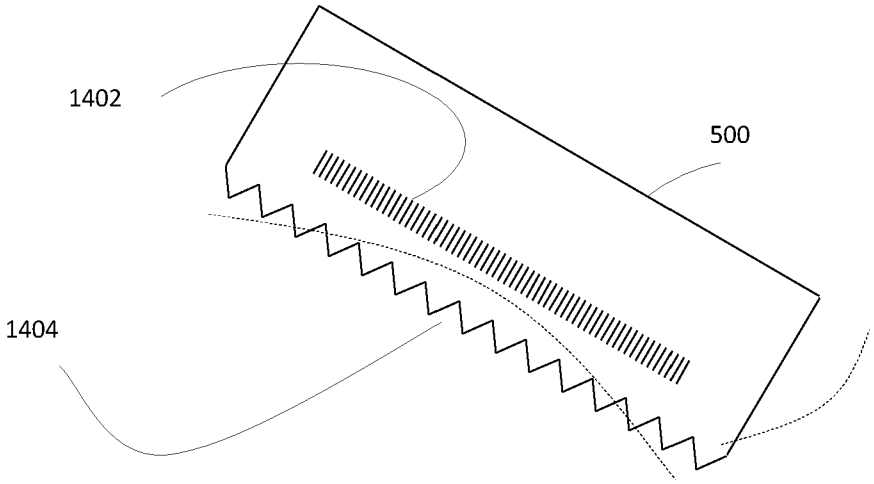
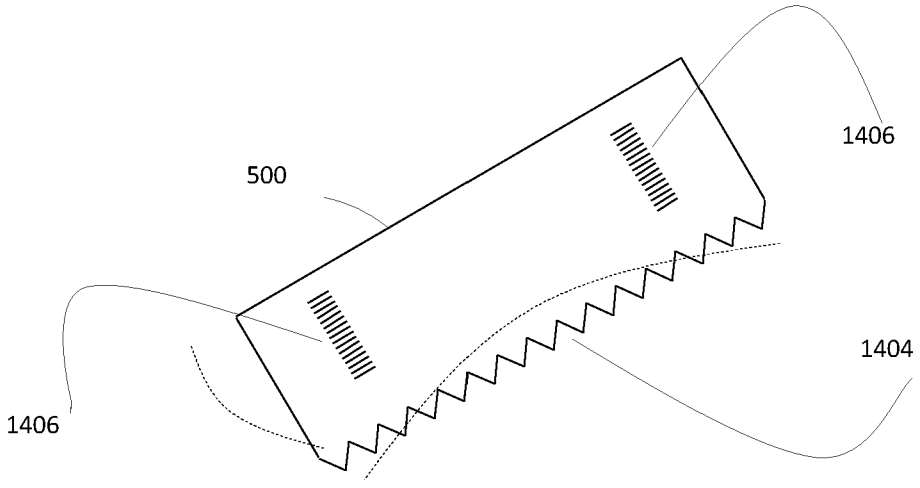


Figure 12



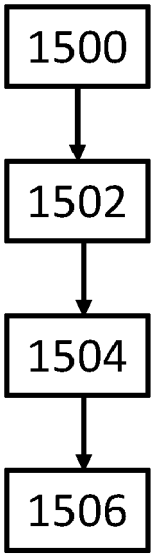


Figure 13

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 21 8909

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 360 673 A1 (LINDE AG [DE]) 15 August 2018 (2018-08-15) * figures 1, 3, 5, 9-11 *	1-14	INV. B21D5/01 B21D13/02 B21D13/04 B44B5/00 B26B19/04 B26B19/38
X	EP 1 637 247 A1 (ALCAN TECH & MAN LTD [CH]) 22 March 2006 (2006-03-22) * paragraph [0003] * * figures 1, 2 *	1-14	
X	CN 111 873 683 A (LIU PEITING) 3 November 2020 (2020-11-03) * figures 4, 5 *	1-14	
X	EP 2 026 979 B1 (AVANTONE OY [FI]) 28 October 2015 (2015-10-28) * figures 1-3 *	1-14	

TECHNICAL FIELDS SEARCHED (IPC)

B21D
B44F
B44B
B26B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 May 2024	Stanic, Franjo

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