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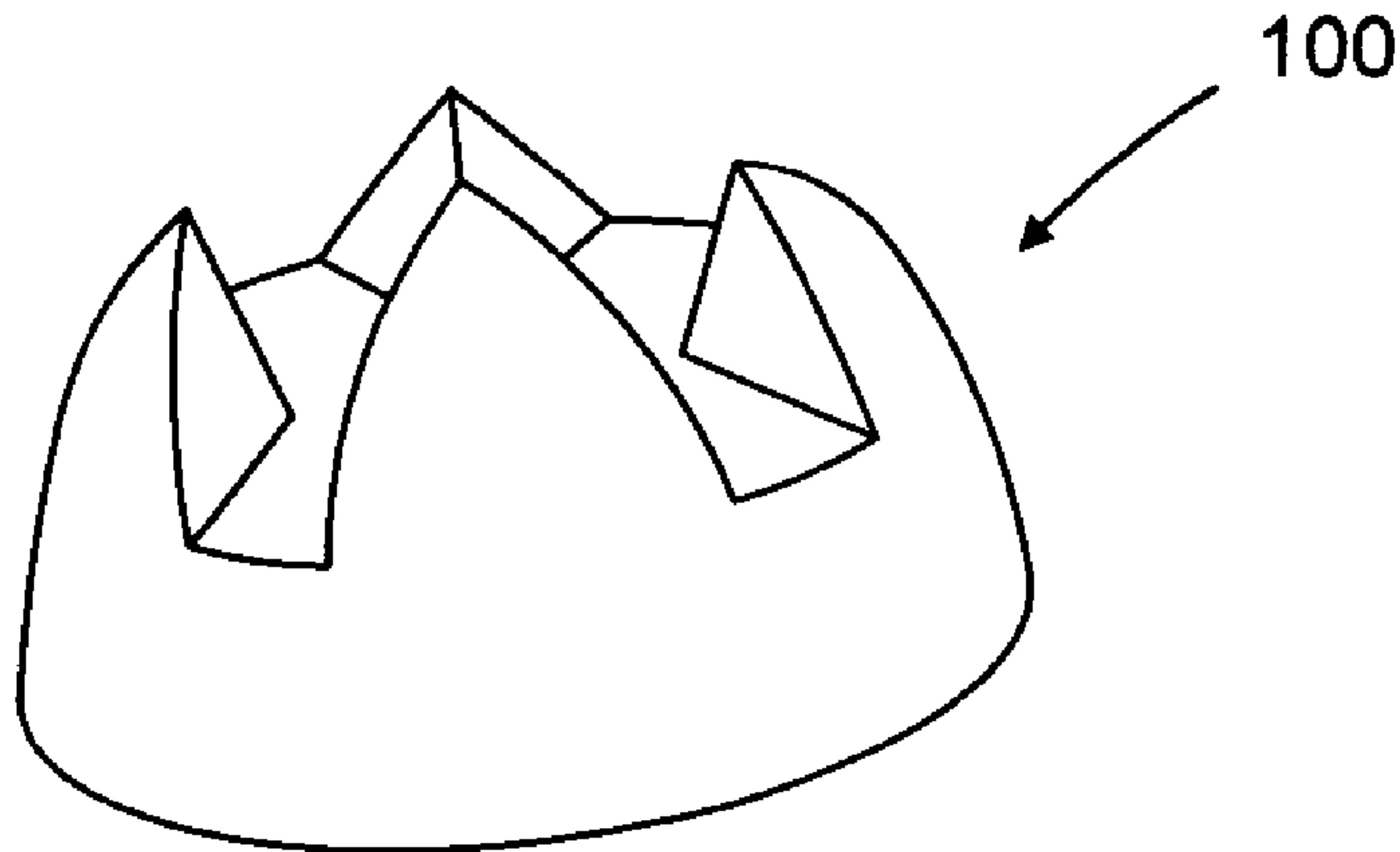
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(54) Title: SPIKE FOR HARVERSTER HEADS AND DEBARKER ROLLERS



A

(57) **Abrégé/Abstract:**

A feed roll spike for mounting to a surface, i.e. the outer surface of a feed roller of a harvester head or a debarking machine. The feed roll spike comprises a substantially truncated cone shape base having a top side, a bottom side and an axis; and evenly-spaced identical projections extending upwardly from the top side of the base. The space between the projections defines channels.

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ABSTRACT

A feed roll spike for mounting to a surface, i.e. the outer surface of a feed roller of a harvester head or a debarking machine. The feed roll spike comprises a substantially truncated cone shape base having a top side, a bottom side and an axis; and evenly-spaced identical projections extending upwardly from the top side of the base. The space between the projections defines channels.

SPIKE FOR HARVERSTER HEADS AND DEBARKER ROLLERS

BACKGROUND

(a) Field

[0001] The present disclosure generally relates to log handling machines and more particularly to improvements in feed rollers and feed roll spikes.

(b) Related Prior Art

[0002] Feed rollers for logs are used in various log handling applications such as feeding unbarked logs through a harvester head or a debarker, feeding logs through a sawing machine, and for feeding trees through a delimber. Each of these exemplary applications has different requirements with respect to the feed characteristics of the log and of the feed rollers. Two basic requirements are that the feed rollers provide sufficient motive force to carry the logs through the processing station and that they be transported through the rollers without undue damage to the log or tree.

[0003] One of the applications requiring a significant motive force in view of the reaction forces created by the process is the delimber. In order to provide the motive force traction must be developed between the feed roller and the log surface. Typically spikes extending radially outwardly from the surface of the feed roller would act to clutch the log surface and motivate it. With significant reaction forces created by the delimber knives, the spikes are required to penetrate the surface of the log causing damage. Such damage reduces the value of the log based upon the fact that fewer and/or lower value products are produced. As the logs become generally smaller in diameter, the problem of surface damage becomes even more significant.

[0004] In a typical delimbing application a pair of spiked feed rollers will act in unison to pull a log through a set of delimbing knives. Each roller can be driven by a gear and pinion arrangement that is housed in a case which pivots about the pinion shaft. This structure, as will be well understood by those skilled in the art,

allows the rollers to move laterally to adjust to the tree diameter. A suitable cross linkage provides simultaneous lateral motion and a hydraulic cylinder provides the opening and closing action allowing the rollers to continuously follow the surface of the tree. To develop the necessary traction, the spikes will penetrate the surface.

[0005] The significant forces involved in the delimbing application are the feed force acting parallel to the tree and a normal force forcing the feed roller spikes into the surface to generate the traction necessary to transmit the feed force. The normal force has several components. These forces acting through the spikes develop the required traction to overcome the reaction force from the knives and bring the trees through the knives at an adequate production rate.

[0006] Additionally, challenges exist in the processing of tree during different seasons, having the tree and the bark harden during the winter months. Such difference in the bark characteristics demands specific characteristics in the spikes to be operable in both conditions as to minimize the surface damages over the logs.

[0007] One known configuration of feed roll spikes consists in conical feed roll spikes. Rows of conical feed roll spikes are spaced about the circumference of the feed rollers to provide the best available feeding characteristics with the least amount of damage. Another typical configuration is the saw tooth where circumferentially spaced rows of saw tooth bars are affixed to the feed rollers surface.

[0008] It has been found that the known feed roll spike configurations could be improved to provide improved traction and less wood damage. Further desired advantage would be to have feed roll spikes debarking at least partially the logs without damaging the log. Furthermore, it would be desirable to also to provide feed roll spikes of simple construction and easy maintenance.

SUMMARY

[0009] According to an embodiment, there is disclosed a feed roll spike for mounting to a surface, the feed roll spike comprising: a substantially truncated cone shape base having a top side, a bottom side providing an interface with the surface; and evenly-spaced identical projections extending upwardly from the top side of the base, wherein space between the projections defines channels.

[0010] According to an aspect, the projections have a substantially pyramidal shape.

[0011] According to an aspect, the projections have an apex used for gripping.

[0012] According to an aspect, the projections have three faces.

[0013] According to an aspect, the base has an external face, and wherein one of the three faces of each projection expand seamlessly from the external face.

[0014] According to an aspect, the base has a center, and wherein the channels span from the center of the base to the external face of the base.

[0015] According to an aspect, two of the three faces of the projections are flat.

[0016] According to an aspect, one of the three faces is arc-shaped.

[0017] According to an aspect, the feed roll spike comprises a vertical axis which is substantially perpendicular to the top side and the bottom side, wherein at least one of the three faces is at an angle ALPHA of between about 5 degrees and 60 degrees relative to the vertical axis.

[0018] According to an aspect, the base has a circumference, wherein BETA is an angle between one of the faces of the projections facing toward an exterior of the feed roll spike and the vertical axis, wherein a ratio of the angles ALPHA over BETA is between about 2 over 3 and 3 over 2.

[0019] According to an aspect, the projections have an external face, a height and a width, and wherein a ratio of the height of the projections over the width of the projection is between about 1 over 1 and 1 over 3.

[0020] According to an aspect, the space of the top side between the projections and is substantially flat.

[0021] According to an aspect, a ratio of surface of the top side covered by the projections over surface of the top side covered by the channels is between about 2 over 5 and 4 over 5.

[0022] According to an aspect, each one of the channels comprises walls that are parallel to each other on an elevation plane parallel to the base for all distances of the elevation plane from the top side.

[0023] According to an aspect, the feed roll spike comprising an opening extending between the top side and the bottom side for fastening the gripping stud to the surface using a fastening means.

[0024] According to an aspect, the surface has a shape and wherein the bottom side comprises has a shape matching the shape of the mounting surface wherein the feed roll spike is fastened to the surface by welding.

[0025] According to an aspect, the projections are of an exact number of four (4).

[0026] According to an embodiment, there is disclosed a feed roll spike for mounting to a surface, the feed roll spike comprising: a base having a top side and a bottom side for mounting to the surface; evenly-spaced identical projections extending upwardly from the top side of the base; and channels have a width and a height, the channels extending radially between the projections over the top side, wherein the width of the channels between the projections is constant, and increases as a distance from the base increases.

[0027] According to an aspect, a ratio of surface of the top side covered by the projections over surface of the top side covered by the channels is between about 2 over 5 and 4 over 5.

[0028] According to an aspect, the projections have a substantially pyramidal shape and an apex.

[0029] According to an embodiment, there is disclosed a harvester head or debarking machine comprising a roll comprising a surface; and feed roll spikes for mounting to the surface roll, the feed roll spikes each comprising a substantially truncated cone shape base having a top side, a bottom side providing an interface with the surface; and evenly-spaced identical projections extending upwardly from the top side of the base, wherein space between the projections defines channels.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] Further features and advantages of the present disclosure will become apparent from the following detailed description, taken in combination with the appended drawings, in which:

[0031] FIG. 1 is a perspective side view of a harvesting head or a debarking machine using feed roll spikes in accordance with an embodiment;

[0032] FIG. 2 is a top view of a pair of feed rollers operating on a log in accordance with an embodiment;

[0033] FIGS. 3A to 3E are a perspective view, a top view, a side view, and side views according to cutting lines D-D and E-E of a feed roll spike in accordance with an embodiment;

[0034] FIGS. 4A to 4C are a perspective view, a top view and a side view of a feed roll spike in accordance with another embodiment; and

[0035] FIGS. 5A to 5C are a perspective view, a top view and a side view of a feed roll spike in accordance with another embodiment.

[0036] It will be noted that throughout the appended drawings, like features are identified by like reference numerals.

DETAILED DESCRIPTION

[0037] Referring now to the drawings, and more particularly to FIG. 1, there is shown therein a harvester head or a debarking machine, generally indicated at **10**, which has embodied therein the improvements of the present invention.

[0038] Referring additionally to FIG. 2, a feed roller assembly **15** comprising a pair of feed rollers **20** is illustrated. Each feed roller **20** is cylindrical and has inner end **24** and an outer end **26** and outer surface **28**. As an example only, representative dimensions for a delimber application will be a length from the inner end **24** to the outer end **26** of approximately 425 mm and an external diameter of approximately 400 mm for each feed roller **20**. Each feed roller **20** can be mounted on a pivotal base (not shown) over an upstanding shaft assembly (not shown) for easy removal. The feed rollers **20** are rotatable via suitable drive means (not shown). As previously pointed out the feed rollers **20** are moveable laterally in unison in order to contact two points on the surface of a log **40** or tree. A suitable means is provided (not shown) to force the feed rollers **20** into a tractive relationship with the log **40** and when power is applied to rotate the feed rollers **20** in opposite directions a tractive force will serve to feed the log **40** between the feed rollers **20** in the desired direction.

[0039] Mounted on the outer surface **28** of each feed roller **20** is a plurality of substantially uniformly spaced feed roll spikes **100**. Feed roll spikes **100** are circumferentially spaced apart on the outer surface **28** of a distance about equal. Such a distance according to a non-limiting embodiment is approximately 12 degrees of arc or with about the same space occupied by the feed roll spike **100** than spike-free between feed roll spikes **100**. According to an embodiment, the feed roll spikes **100** are mounted about straight mounting lines **50** surrounding the feed roller **20** and part of planes that are substantially perpendicular to the axis of rotation of the feed roller **20**. Feed roll spikes **100** are mounted on the feed roller

20 about a plurality of such mounting lines **50** parallel to each other. The feed roll spikes **100** mounted about a mounting line **50** are radially offset from the feed roll spikes **100** mounted about a first-neighbor mounting line **50**, so that feed roll spikes **100** mounted about a mounting line **50** and of a second-neighbor mounting line **50** have substantially aligned feed roll spikes **100** relative to the axis of rotation of the feed roller **20**.

[0040] According to an embodiment, the feed roll spikes **100** are mounted according to a same radial orientation, for instance with the cross-shaped interior floor surface **122** (FIGS. 3A-E) having channels **140** (FIGS. 3A-E) aligned with the mounting line **50**.

[0041] According to an embodiment, the feed roll spikes **100** are mounted in rows perpendicular to the direction of rotation of the feed roller **20** on which they are mounted. According to an embodiment, all feed roll spikes **100** in a row are mounted with their cross-shaped interior floor surface **122** in the same orientation.

[0042] According to an embodiment, all feed roll spikes **100** in two consecutive rows are mounted with their cross-shaped interior floor surface **122** in the same orientation.

[0043] According to an embodiment, all feed roll spikes **100** in a first set of two consecutive rows are mounted with their cross-shaped interior floor surface **122** in the same first orientation and all feed roll spikes **100** in a second set two consecutive rows are mounted with their cross-shaped interior floor surface **122** in the same second orientation, where the second orientation is at 45 degrees from the first orientation.

[0044] According to an embodiment, two neighboring feed roll spikes **100** mounted to the same mounting line **50** are radially offset from each other, the channels **140** of a feed roll spike **100** being at different angles from the neighboring feed roll spike **100** relative to their mounting line **50**.

[0045] According to an embodiment, the feed roll spikes **100** are mounted to the feed roller **20** at random radial orientations.

[0046] According to an embodiment, the feed roll spikes **100** are mounted to the feed rollers **20** about mounting lines **50** that are distant from neighbor mounting lines **50** of about or a slightly greater distance than the diameter **112** (FIGS. 3A-E) of the feed roll spikes **100**.

[0047] According to an embodiment, the feed roll spikes **100** are mounted to the feed rollers **20** about mounting lines **50** that are distant from neighbor mounting lines **50** of a smaller distance than the diameter **112** of the feed roll spikes **100**. According to an embodiment, the distance between neighbor mounting lines **50** is between about 0.5 and 0.8 times the diameter **112** of the feed roll spikes **100**.

[0048] Referring additionally to FIGS. 3A-E, the feed roll spikes **100** are of a substantially general truncated cone shape. According to embodiments, the truncated cone shape is defined as one among the group of a cone defined using a straight line revolving around a rotation axis, an inwardly curved line revolving around a rotation axis, and an outwardly curved line revolving around a rotation axis. In these embodiments, the top of the cone, including the apex, is truncated.

[0049] Accordingly, the feed roll spikes **100** comprises a base **110**. According to embodiments, the base is either of a substantially cylindrical shape or of a truncated cone shape. The base **110** comprise a top side **111** and a bottom side **109**. The bottom side **109** features a floor surface **116**, of a substantially circular area having a base diameter **112**. The base **110** has a thickness **114**. The base **110** further comprises at its top side **111** an interior floor surface **122**.

[0050] The feed roll spikes **100** are mounted to the outer surface **28** of the feed rollers **20** about the floor surface **116** using appropriate means selected among a group comprising welding, riveting, screwing, bolting, gluing, and clipping. It is worth mentioning that any solution to mount the feed roll spikes **100** to the outer surface **28** of the feed roller **20** providing the appropriate resistance between

the feed roll spikes **100** and the outer surface **28** for the feed roll spike mounting to hold when contacting logs **40** may be appropriate. Mounting means that are permanent or alternatively allowing release of the feed roll spikes **100** for maintenance and/or replacement are all intended to be covered by the present disclosure.

[0051] The feed roll spikes **100** further comprise a total height **118** from the surface of the floor surface **116** to the tip **124** of each of the four (4) projections **120** of each of the feed roll spikes **100**. Each feed roll spike **100** comprises four (4) identical projections **120**, extending from the top side **111** to their tip **124**. The interior floor surface **122** extending between the bases of the projections **120** defines a substantially flat cross-shaped surface. Four (4) arms or channels **140** extend outwardly unobstructed from the center of the feed roll spike **100** to the exterior of the base **110** with an increasing width as the height of the channel **140** increases.

[0052] The projections **120** each comprise three (3) faces, namely two interior faces **128** and one exterior face **130**. The exterior face **130** of the projections **120** provides a continuous surface expanding from the exterior of the base **110** and respecting the generally conic shape of the feed roll spike **100**. Thus, a continuous exterior surface covers the exterior of the feed roll spike **100** from the floor surface **116** and expanding seamlessly to the tips **124** of the projections **120**. Each of the interior faces **128** extends with an angle ALPHA relative to a vertical plane, a plane perpendicular to a plane defined by the base **110** of the feed roll spike **100** and with the axis of the conic shape being part of the plane. The intersection of the general conic shape and the interior faces **128** resulting in the tip **124**, namely an apex. The angle ALPHA is selected between about 5 degrees and about 60 degrees; the selected angle ALPHA providing a pair of interior faces **128** that are sloped to prevent bark of a log **40** from remaining stuck between the two interior faces **128**, while providing increasing pressure surface on a tree **40** as the projections **120** penetrate in the bark of the log **40**.

[0053] The configuration of the feed roll spikes **100**, and particularly the presence of three potential tree-contacting surfaces per projections **120**, namely the two interior faces **128** and the exterior face **130** each comprising a sloped contacting surface, makes the feed roll spikes **100** operable in any radial configuration and at any rotation angle of the feed rollers **120** as long as the feed roll spike **100** contacts the log **40**. The clearance between the projections **120** that the channels **140** provide with their symmetrical sloped parallel walls prevents the clearance from being filled with bark during operation. The walls are parallel on all distances of the channels **140** from the top side **111**. The cross shape of the channels **140** further allows bark to flow out of the channels **140** both tangentially and radially relative to the feed roller **20**.

[0054] This non-limiting embodiment of a feed roll spike **100** features a diameter **112** of about 38 mm (1.5 inch), a total height **118** of about 19 mm (0.75 inch) and a base height **114** / projection height of about 38 mm (0.375 inch) each; these dimensions being well adapted for operation during all seasons and normal conditions with typical North-American tree species.

[0055] According to an embodiment, the angle ALPHA is selected between about 5 degrees and 60 degrees relative to a vertical plane parallel to the base of the interior face **128** and perpendicular to the floor surface **116**. According to an embodiment, the angle ALPHA is selected between about 10 degrees and 50 degrees. According to an embodiment, the angle ALPHA is selected between about 20 degrees and 45 degrees. According to an embodiment, the angle ALPHA is selected between about 25 degrees and 40 degrees. According to an embodiment, the angle ALPHA is about 30 degrees.

[0056] According to an embodiment, the average exterior angle BETA of the conic shape, thus the average slope of the exterior face **130** over the height of the feed roll spike **100**, or the angle relative to a plane perpendicular to the base **110** and tangential to the cone circumference, is about of the same order as the angle

ALPHA. According to an embodiment, the ratio of the angles ALPHA over BETA is between about 2 over 3 and 3 over 2.

[0057] According to an embodiment, the angle BETA is selected between about 5 degrees and 45 degrees relative to a plane perpendicular to the base **110** and tangential to the cone circumference. According to an embodiment, the angle BETA is selected between about 10 degrees and 40 degrees. According to an embodiment, the angle BETA is selected between about 15 degrees and 30 degrees. According to an embodiment, the angle BETA is about 20 degrees.

[0058] According to an embodiment, the conic shape of the feed roll spike **100** is about a radius of curvature toward the center of the feed roll spike **100**. According to an embodiment, the ratio of the radius of curvature of the conic shape over the diameter **112** is between about 100 over 1 and 1 over 2. According to an embodiment, the ratio of the radius of curvature of the conic shape over the diameter **112** is between about 5 over 1 and 2 over 3. According to an embodiment, the radius of curvature of the conic shape is about the same as the diameter **112**.

[0059] According to an embodiment, the ratio of the surface covered by the projections **120** over the surface covered by the channels **140** at the level of the top side **111** is between about 2 over 5 and 4 over 5. According to an embodiment, the ratio is about 3 over 5. Therefore, according to the previous embodiment, the surface of the feed roll spike **100** contacting a log **40** would increase abruptly from about three (3) square units to about eight (8) square units when the projections **120** penetrate of their whole height in the bark of the log **40**.

[0060] According to an embodiment, the width of a projection **120** is measured through the length of a straight line joining the extremities of the exterior face **130** of the projection **120** at the level of the top side **111**. The ratio of the projection height over the projection width is between about 1 over 1 and 1 over 3. According to an embodiment, the ratio of the projection height over the projection width is between about 4 over 5.

[0061] According to an embodiment, the exterior face **130** has a different finish than the interior face **128** of the projections **120**. The interior faces **128** have a smooth surface easing removed bark to slip out of the channels **140**. The exterior face **130** has a rough surface favoring to catch the bark and thus debarking the log **40**.

[0062] According to an embodiment, the edge joining the interior floor surface **122** and the base of the projections **120** is chamfered to aid in flow of sap and ice.

[0063] Now referring to FIGS. 4A-C and 5A-C, these are alternative embodiments of feed roll spikes **200**, **300** that features a distinct number of projections **120**. FIGS. 4A-C show a feed roll spike **200** having three (3) projections **220**. The interior floor surface **222** is this embodiment features three (3) channels **240** evenly distributed in-between. FIGS. 5A-C show a feed roll spike **300** having five (5) projections **220** with a corresponding shape of interior floor surface **322**.

[0064] It is worth mentioning that regardless of the number of projections **120**, **220**, **320** of an embodiment, the above-discussed ratios are to be respected to reach the objectives in contact surface between the feed roll spike **100**, **200**, **300** and the log **40**, as easiness for clearance of bark from the channels **140**, **240**, **340**.

[0065] It should also be noted that the channels **240**, **340** feature parallel walls through the interior faces **228**, **328** of the projections **220**, **320** for efficiently allow material to move freely out of the channels **240**, **340** both radially and tangentially.

[0066] The feed roll spike **200** of FIGS. 4A-C feature a slightly arched floor surface **216** for efficient coupling to the outer surface **28** of a feed roller **20**. The feed roll spike **200** also features a slightly arched interior floor surface **222**. It is worth noting that the degrees of curvature of the arched floor surface **116** and the

arched interior floor surface **222** have been exaggerated on the drawing for illustration purposes.

[0067] The feed roll spike **200** of FIGS. 4A-C features a straight-revolving-line conic shape. The feed roll spike **300** of FIGS. 5A-C features an inwardly-curved-revolving-line conic shape providing a different change in the increase of contact surface as the projections **320** enters the bark of a log **40**.

[0068] The feed roll spike **300** of FIGS. 5A-C features projections **320** comprising arch-shapes interior faces **328**. The arch-shape interior faces **328** provide a non-linear increase of the contact surface of the feed roll spike **300** as the projections **320** penetrate the bark of a log **40**. The ratio of radius of curvature of the arch-shapes interior faces **328** over the diameter **312** of the feed roll spike **300** is set over about 3 over 1 to provide a gripping apex and efficient slope at the bottom of the channels **340**.

[0069] The feed roll spike **200** of FIGS. 4A-C further features a central hole **260** for a bolt or screw (i.e., a fastening means) to be used to fasten the feed roll spike **200** to the feed roller **20**. The central hole **260** is shaped for the bolt or screw to be housed within the feed roll spike **200** with its top almost flat to the interior floor surface **222**. According to another embodiment (not shown), the bolt or screw is covered with a cap to provide a flat top side of the base to ease bark material moving out of the channels **240**.

[0070] Furthermore, feed roll spikes **100**, **200**, **300** having a generally conic shape are easily manufactured through molding, providing a low-cost high-volume manufacturing solution. The feed roll spikes **100**, **200**, **300** are typically made of a highly resistant material, such as metal and particularly steel, that is well adapted for extended use periods as for mounting to the feed rollers **20** using a welding process.

[0071] While preferred embodiments have been described above and illustrated in the accompanying drawings, it will be evident to those skilled in the

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art that modifications may be made without departing from this disclosure. Such modifications are considered as possible variants comprised in the scope of the disclosure.

CLAIMS:

1. A feed roll spike for mounting to a surface, the feed roll spike comprising:
 - a substantially truncated cone shape base having a top side, a bottom side providing an interface with the surface; and
 - evenly-spaced identical projections extending upwardly from the top side of the base, wherein space between the projections defines channels.
2. The feed roll spike of claim 1, wherein the projections have a substantially pyramidal shape.
3. The feed roll spike of claim 1, wherein the projections have an apex used for gripping.
4. The feed roll spike of claim 1, wherein the projections have three faces.
5. The feed roll spike of claim 4, wherein the base has an external face, and wherein one of the three faces of each projection expand seamlessly from the external face.
6. The feed roll spike of claim 5, wherein the base has a center, and wherein the channels span from the center of the base to the external face of the base.
7. The feed roll spike of claim 4, wherein two of the three faces of the projections are flat.
8. The feed roll spike of claim 4, wherein one of the three faces is arc-shaped.

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9. The feed roll spike of claim 4, comprising a vertical axis which is substantially perpendicular to the top side and the bottom side, wherein at least one of the three faces is at an angle ALPHA of between about 5 degrees and 60 degrees relative to the vertical axis.

10. The feed roll spike of claim 9, wherein the base has a circumference, wherein BETA is an angle between one of the faces of the projections facing toward an exterior of the feed roll spike and the vertical axis, wherein a ratio of the angles ALPHA over BETA is between about 2 over 3 and 3 over 2.

11. The feed roll spike of claim 4, wherein the projections have an external face, a height and a width, and wherein a ratio of the height of the projections over the width of the projection is between about 1 over 1 and 1 over 3.

12. The feed roll spike of claim 1, wherein the space of the top side between the projections and is substantially flat.

13. The feed roll spike of claim 1, wherein a ratio of surface of the top side covered by the projections over surface of the top side covered by the channels is between about 2 over 5 and 4 over 5.

14. The feed roll spike of claim 1, wherein each one of the channels comprises walls that are parallel to each other on an elevation plane parallel to the base for all distances of the elevation plane from the top side.

15. The feed roll spike of claim 1, further comprising an opening extending between the top side and the bottom side for fastening the gripping stud to the surface using a fastening means.

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16. The feed roll spike of claim 1, wherein the surface has a shape and wherein the bottom side comprises has a shape matching the shape of the mounting surface wherein the feed roll spike is fastened to the surface by welding.

17. The feed roll spike of claim 1, wherein the projections are of an exact number of four (4).

18. A feed roll spike for mounting to a surface, the feed roll spike comprising:
- a base having a top side and a bottom side for mounting to the surface;
- evenly-spaced identical projections extending upwardly from the top side of the base; and
- channels have a width and a height, the channels extending radially between the projections over the top side,
wherein the width of the channels between the projections is constant, and increases as a distance from the base increases.

19. The feed roll spike of claim 18, wherein a ratio of surface of the top side covered by the projections over surface of the top side covered by the channels is between about 2 over 5 and 4 over 5.

20. The feed roll spike of claim 18, wherein the projections have a substantially pyramidal shape and an apex.

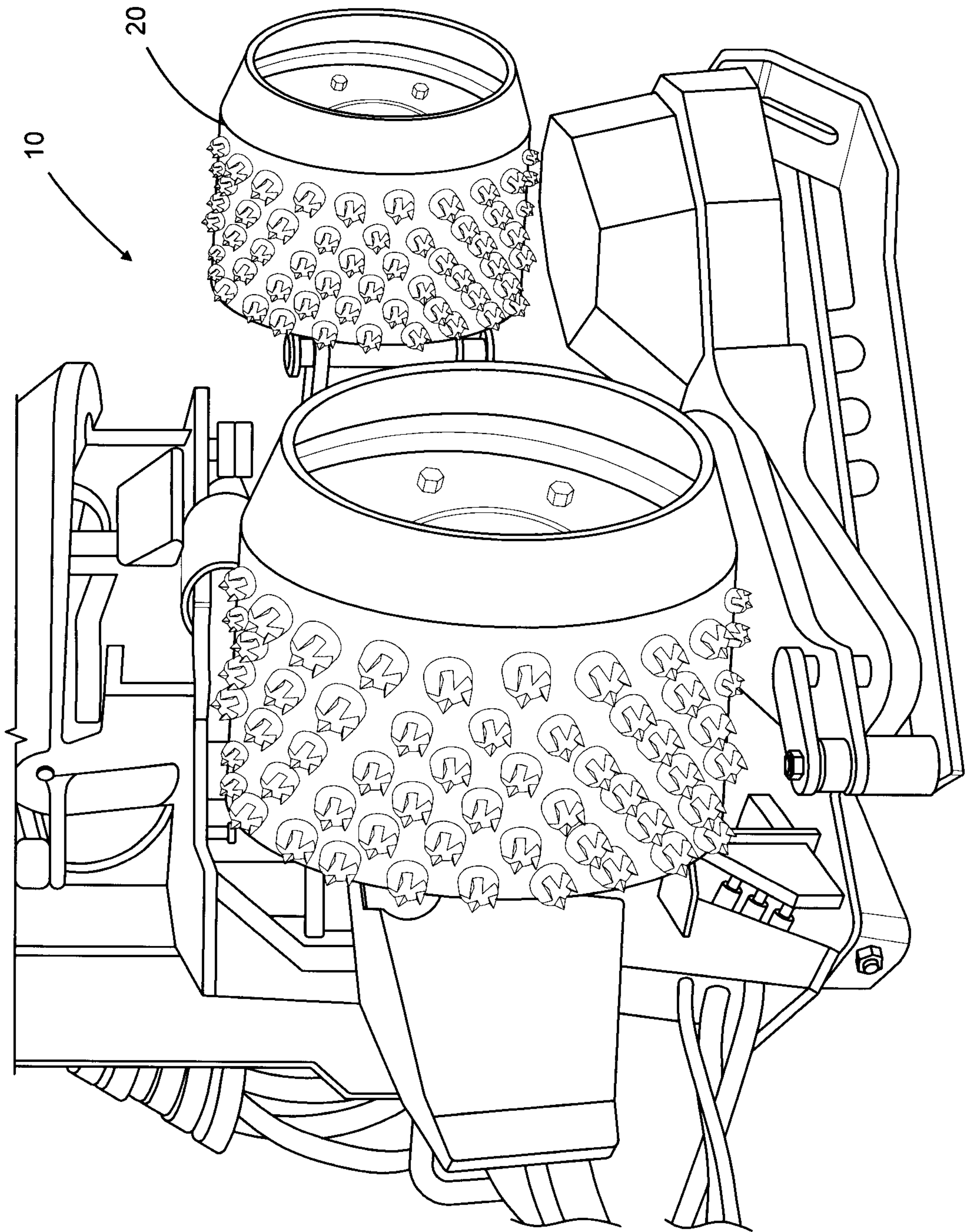


FIG. 1

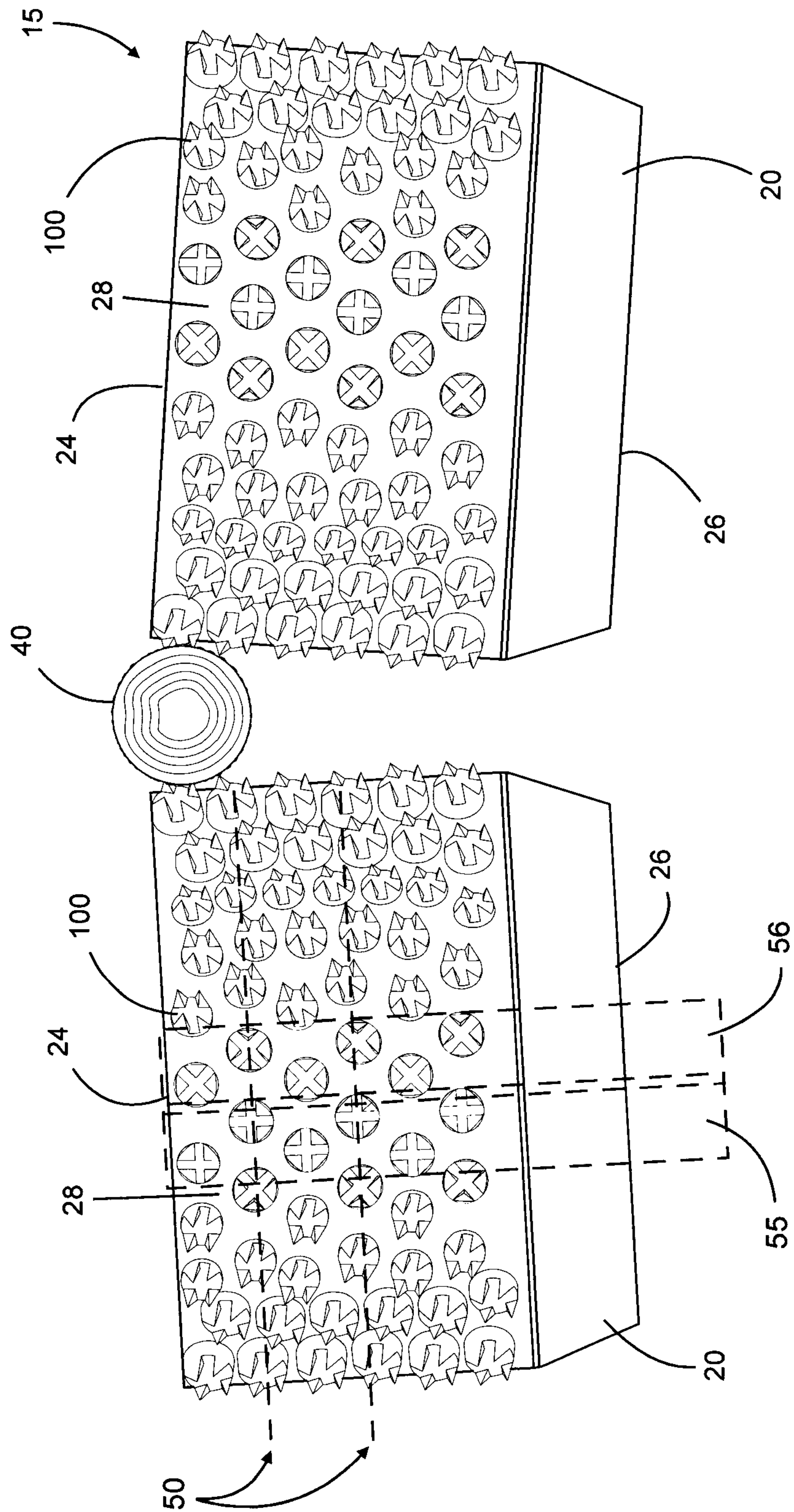


FIG. 2

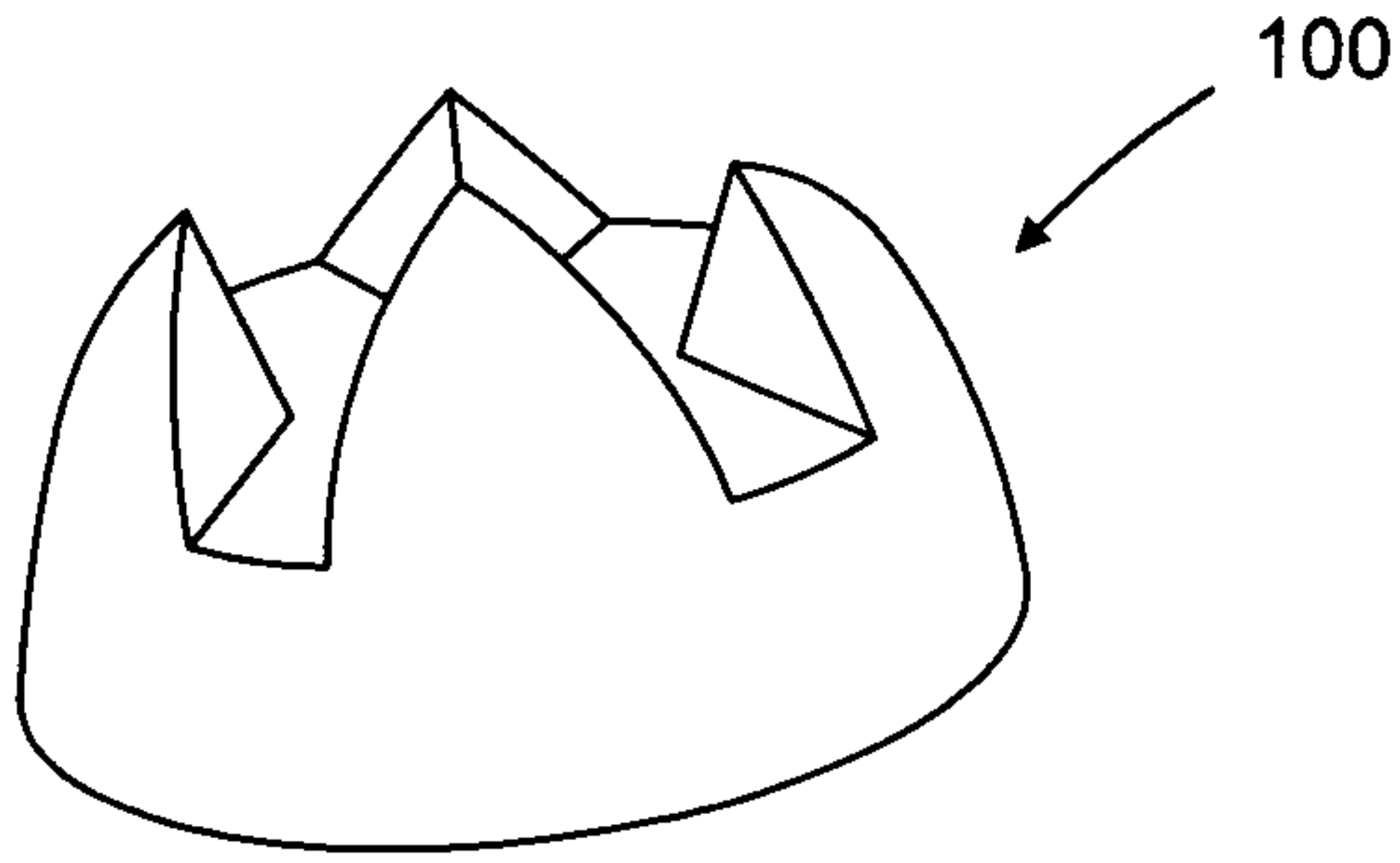


FIG. 3A

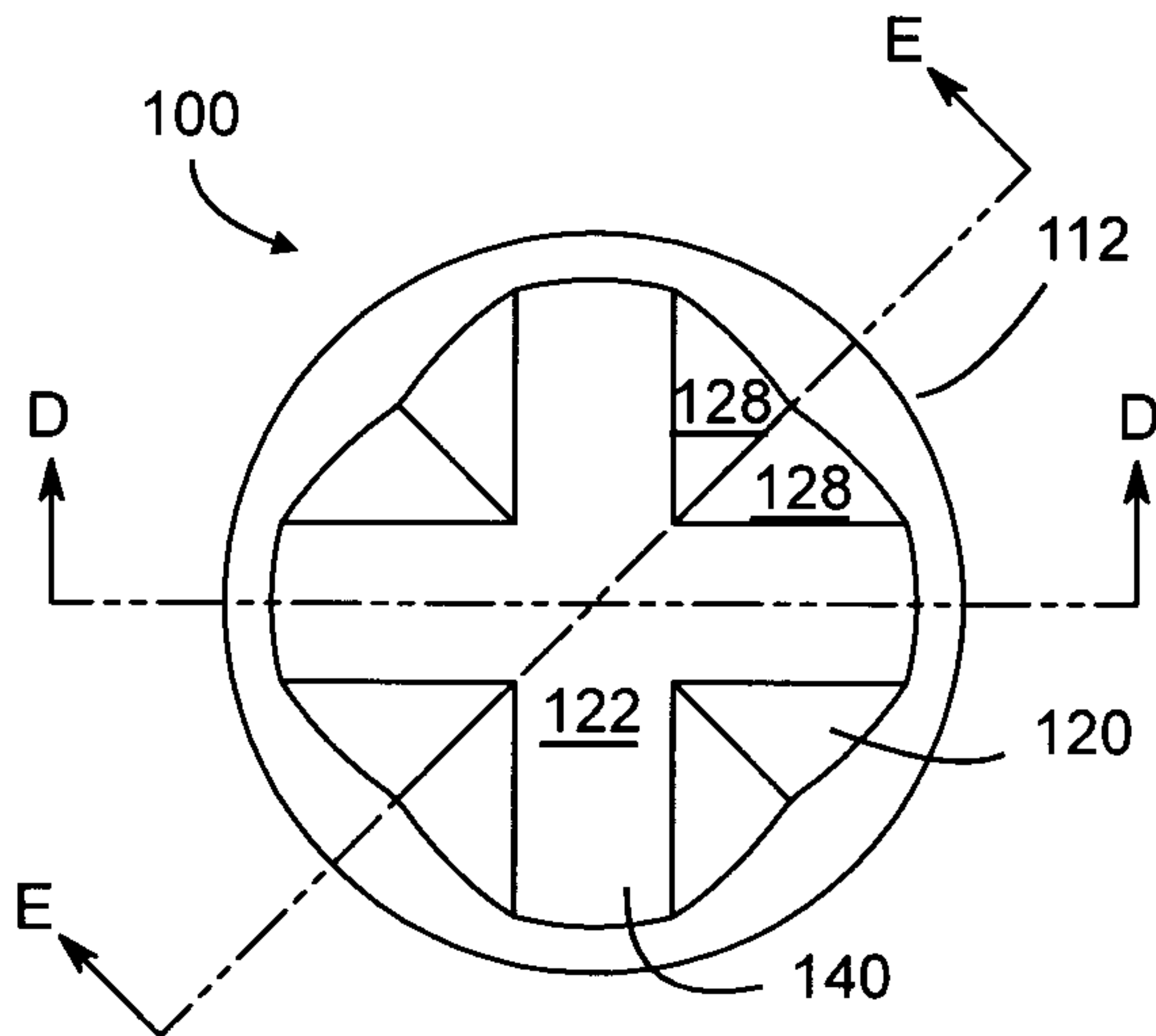


FIG. 3B

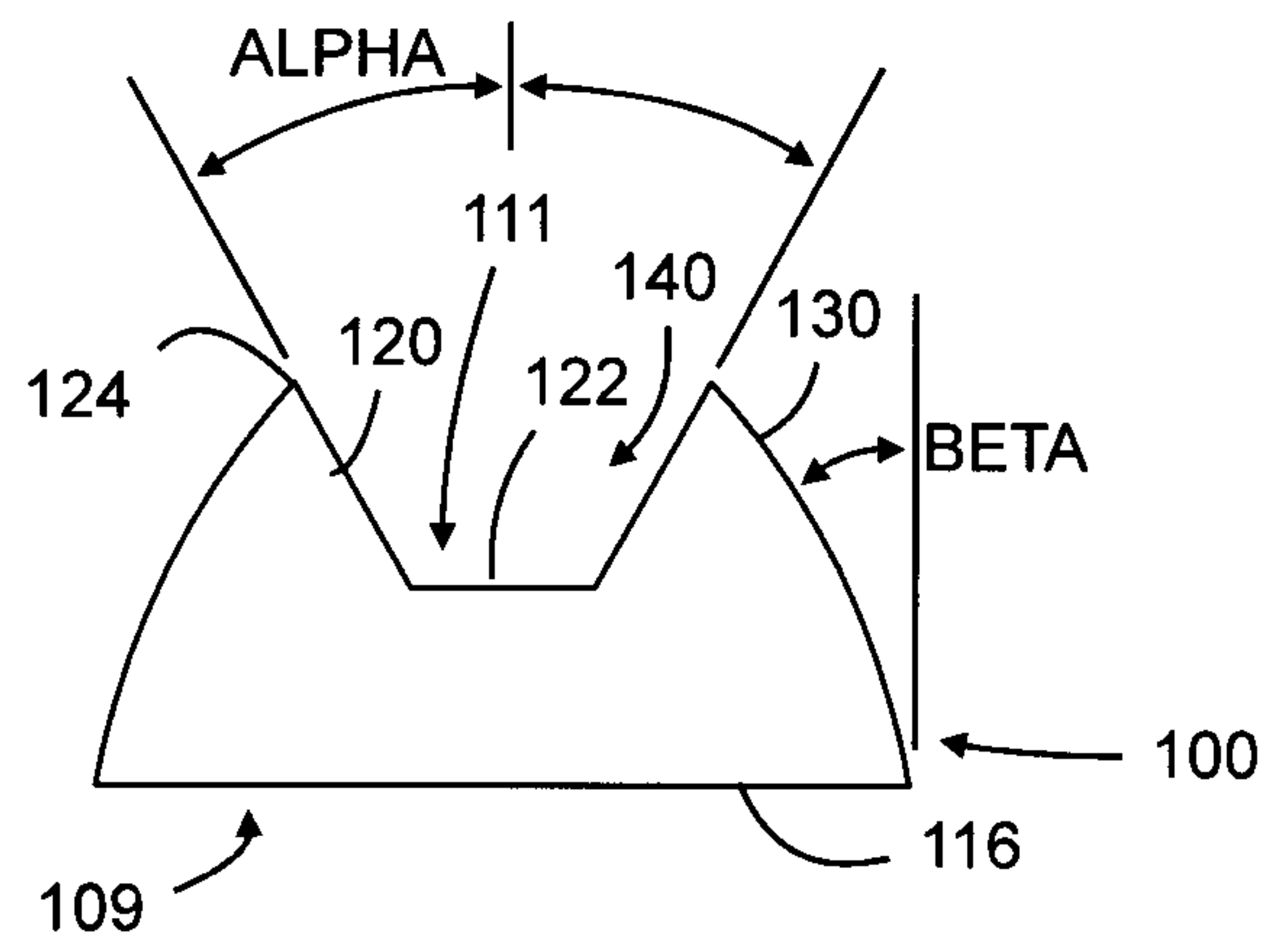


FIG. 3C

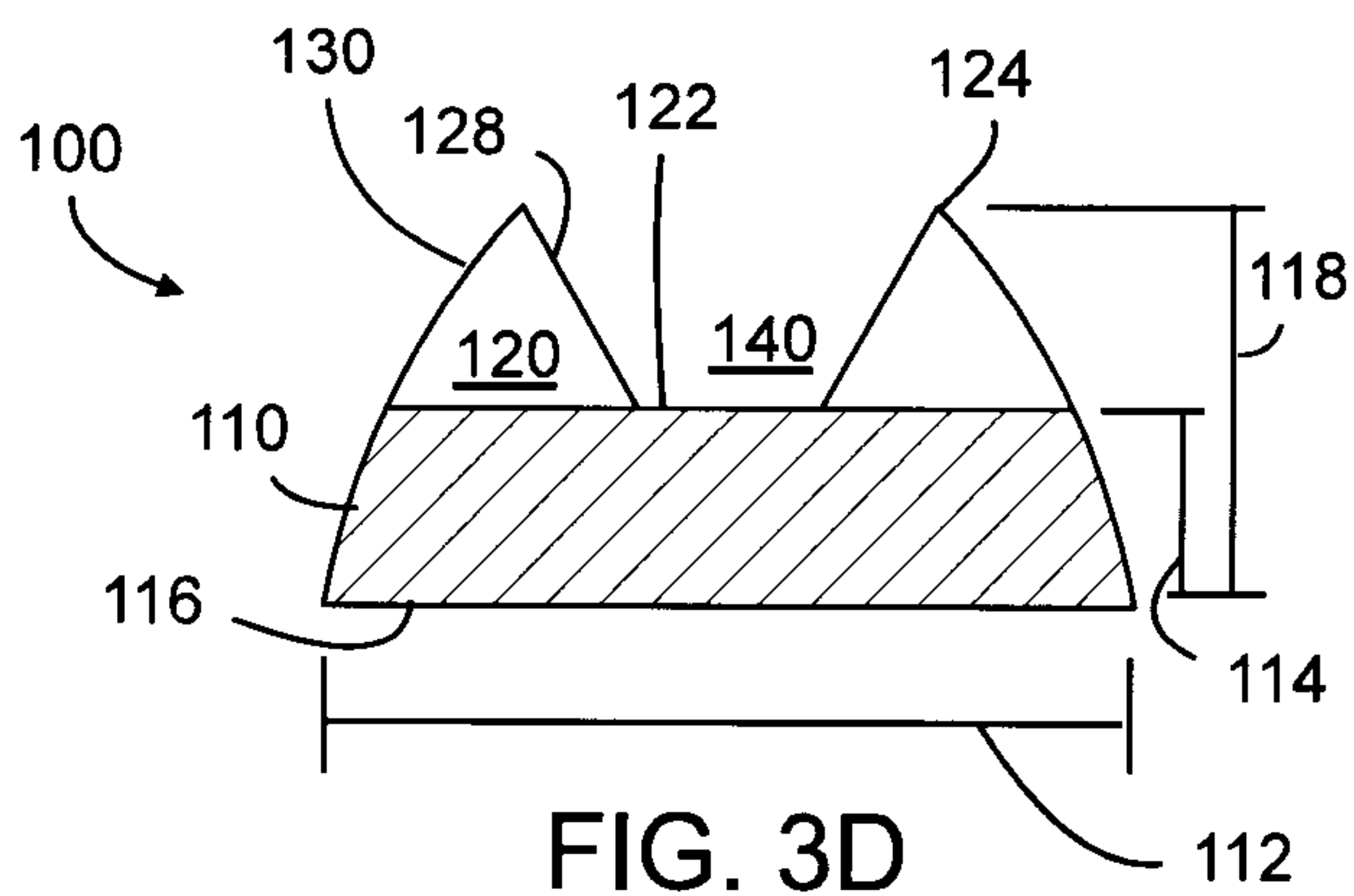


FIG. 3D

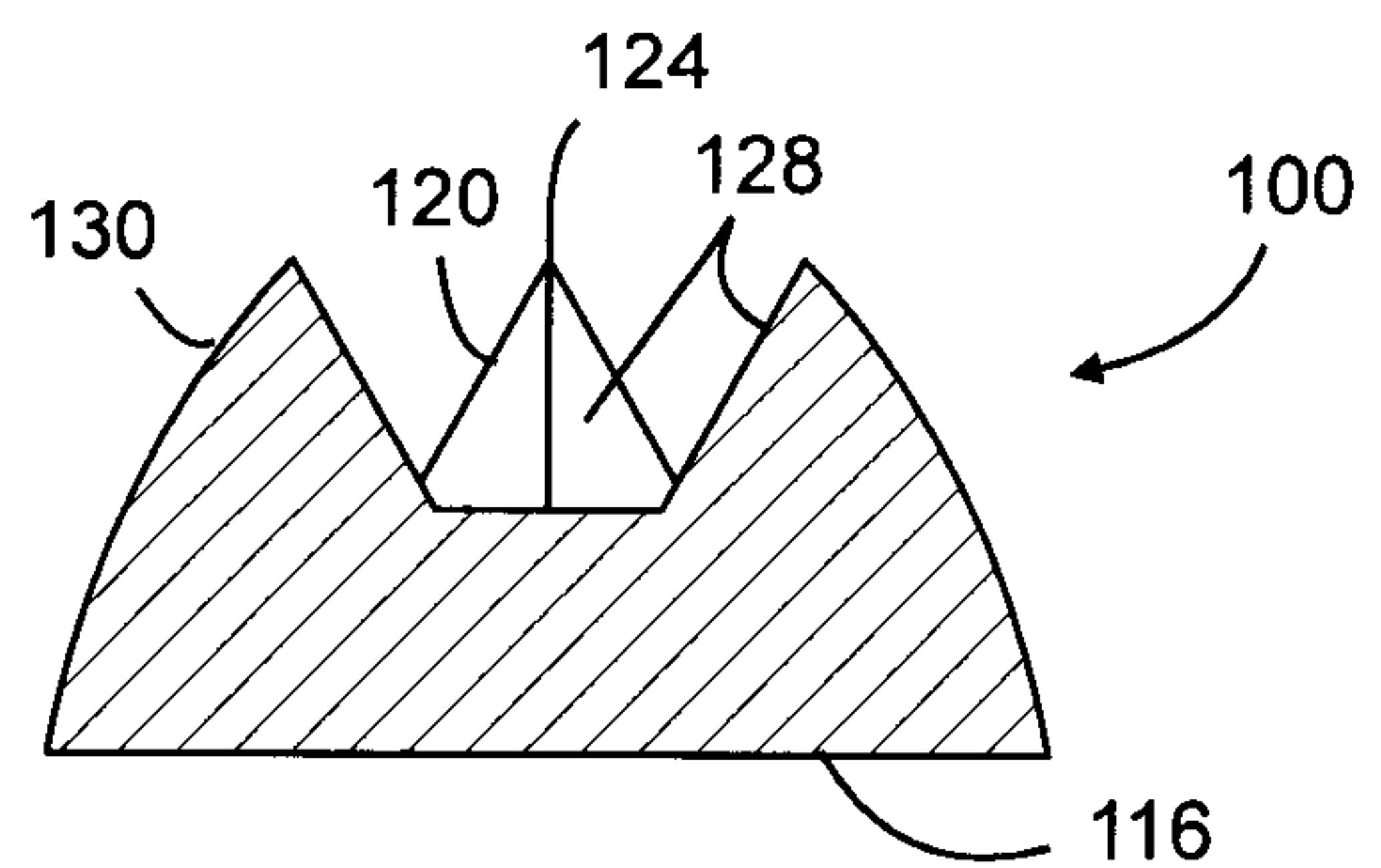


FIG. 3E

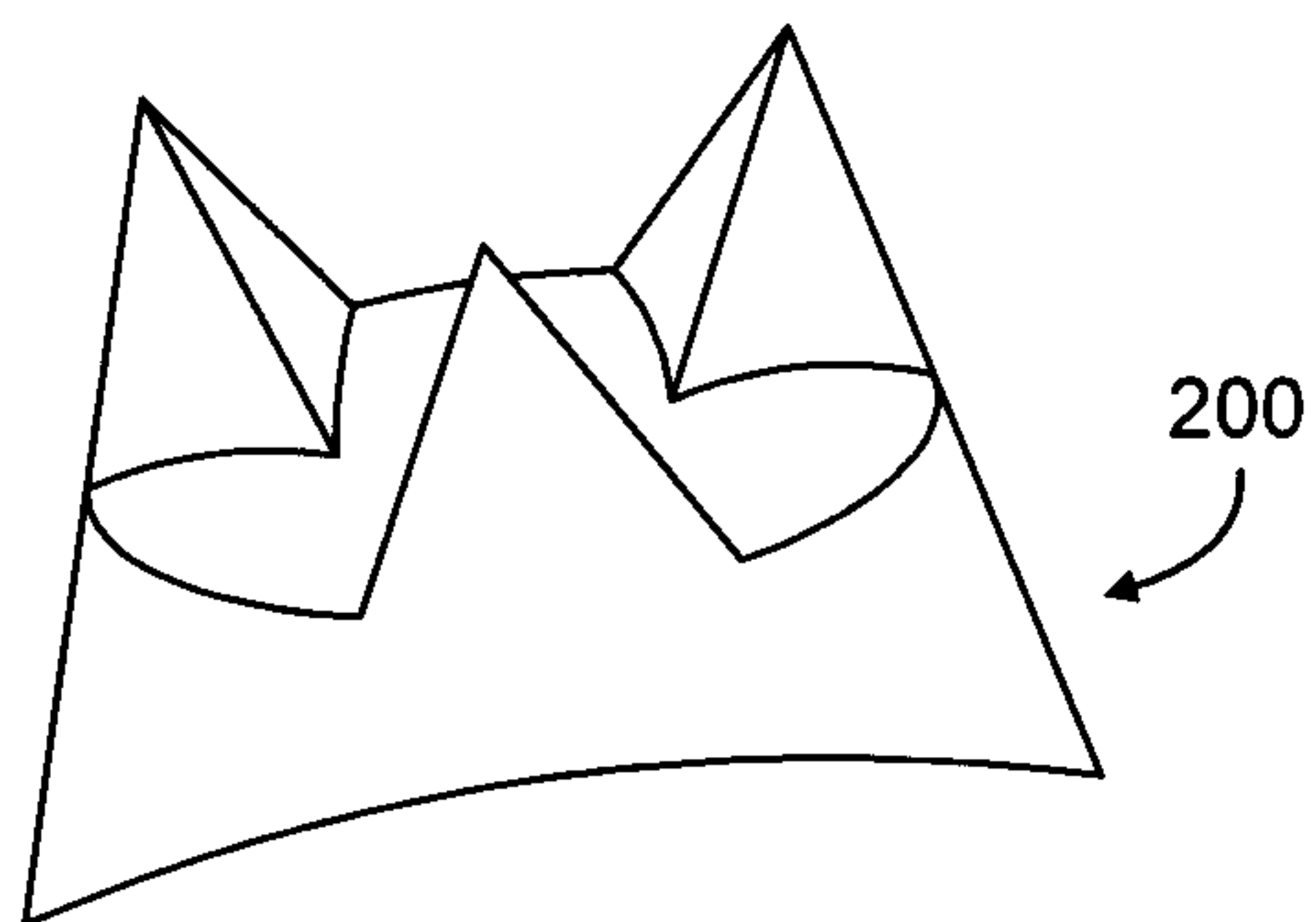


FIG. 4A

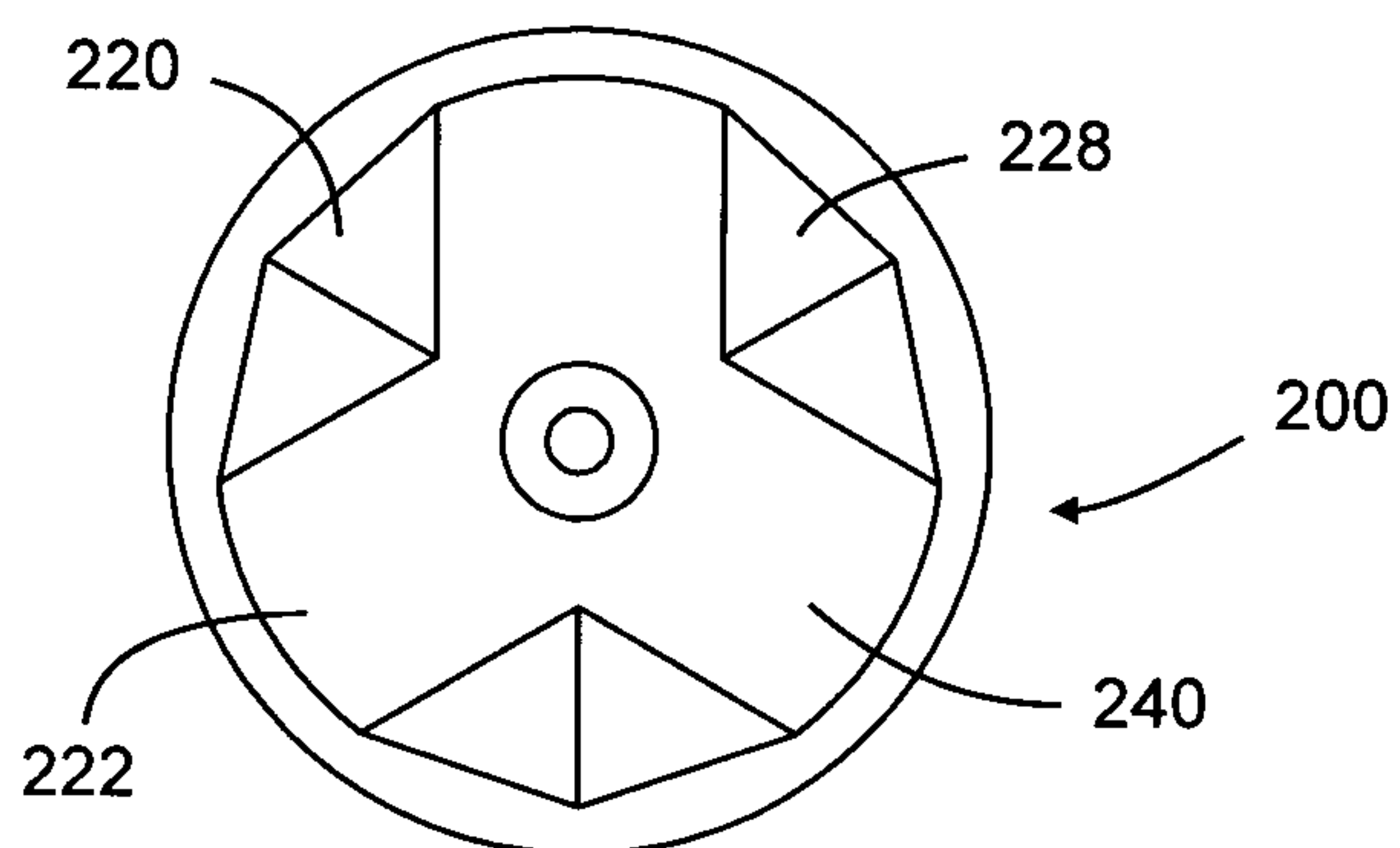


FIG. 4B

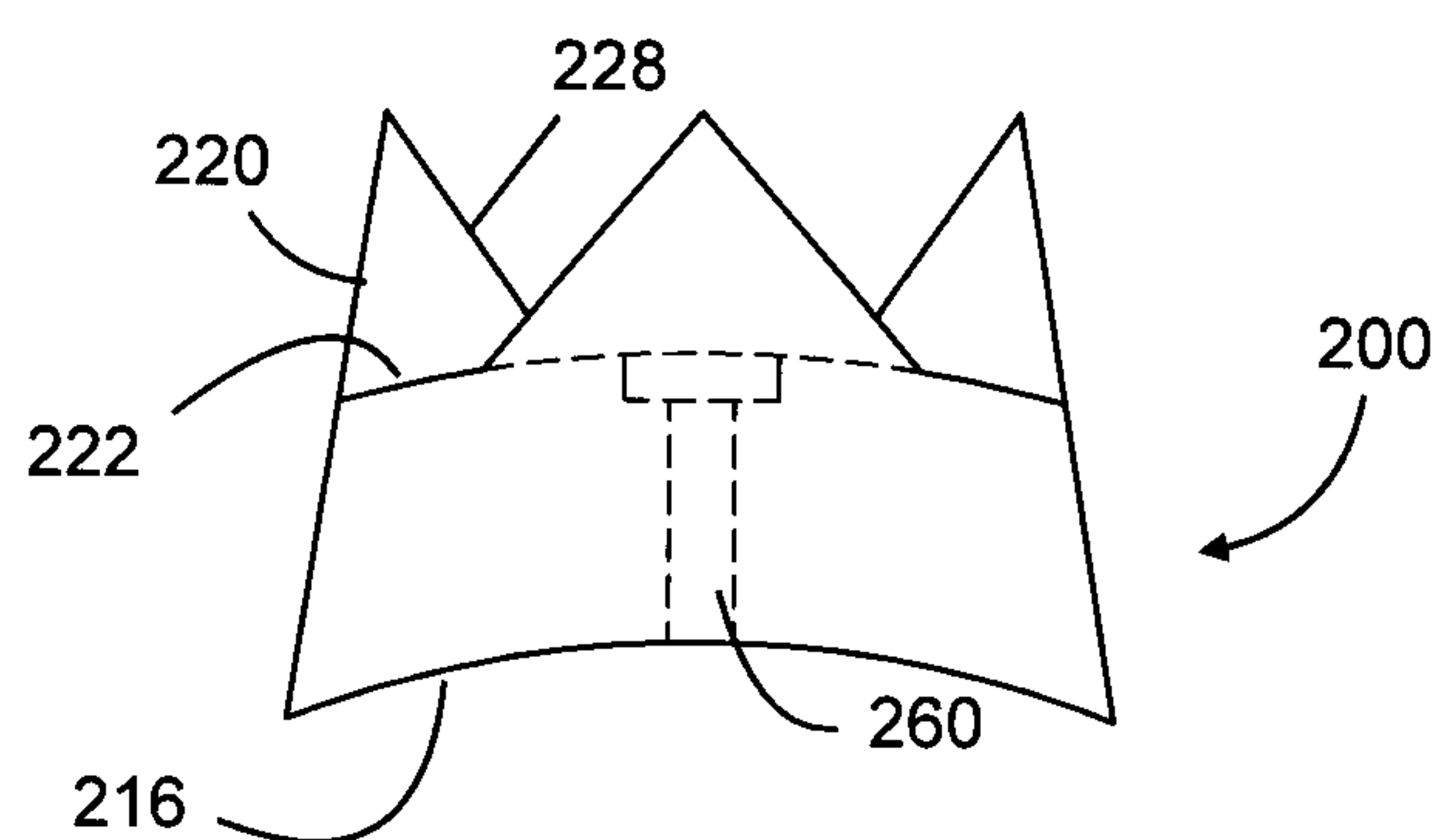


FIG. 4C

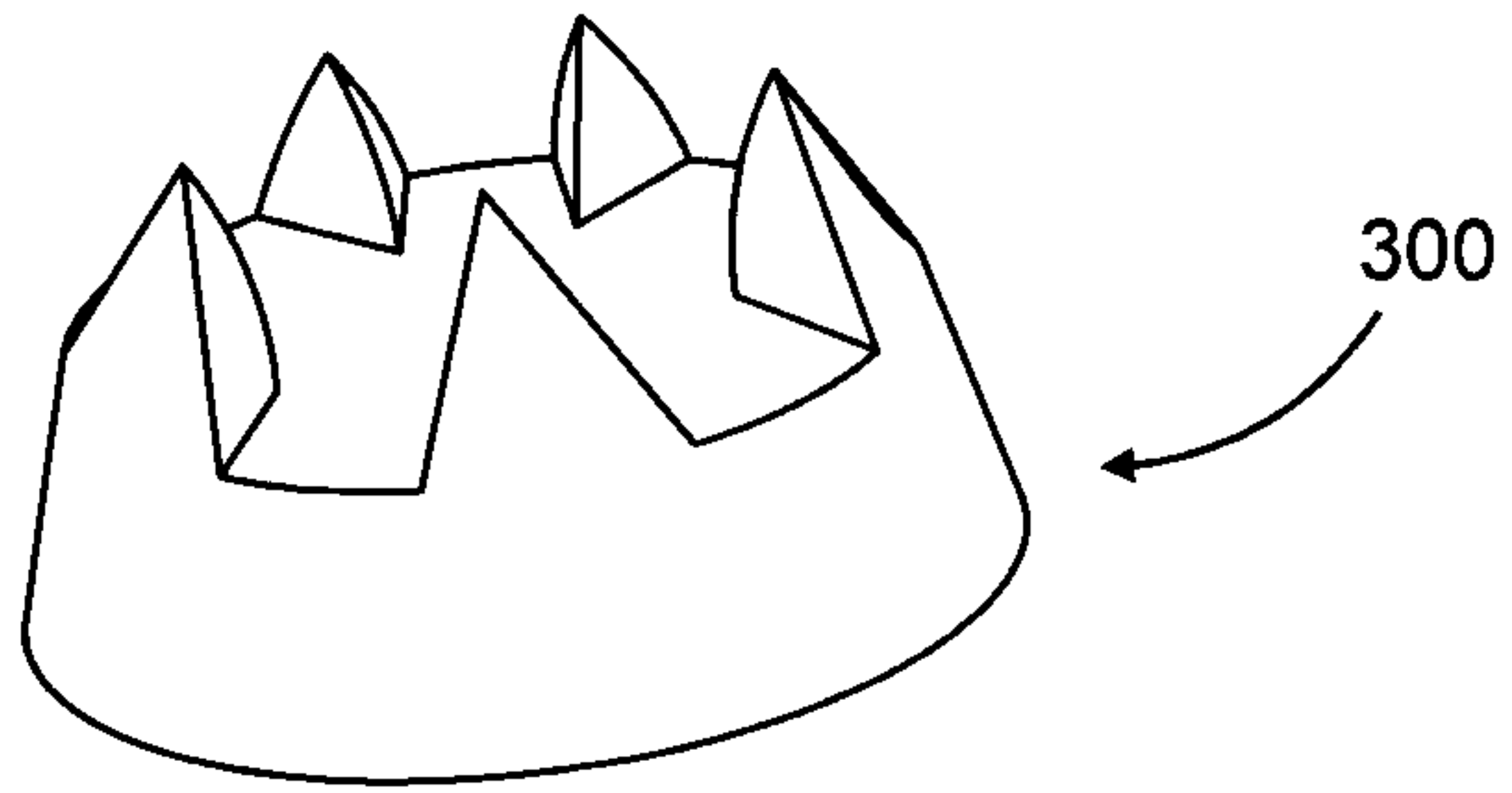


FIG. 5A

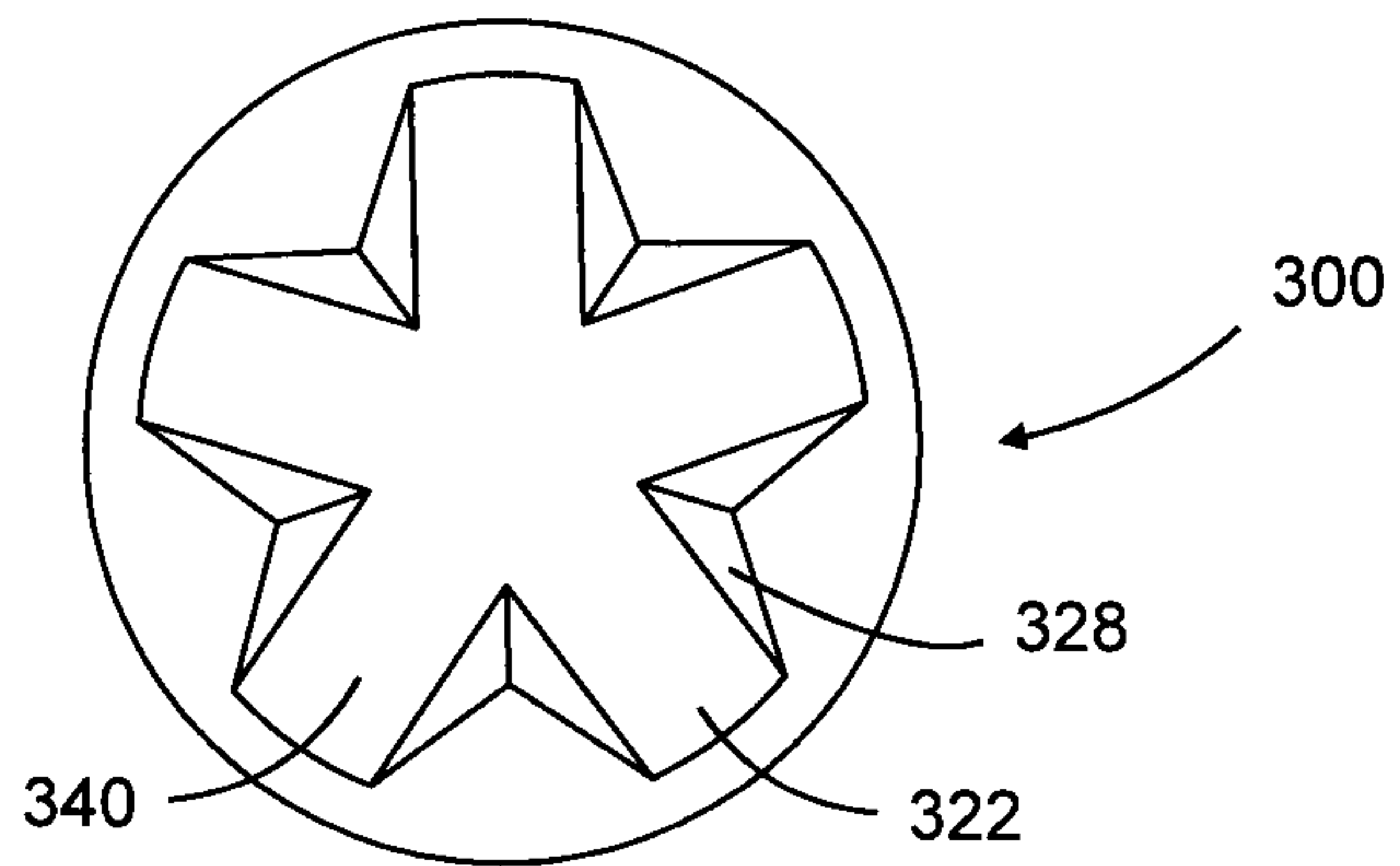


FIG. 5B

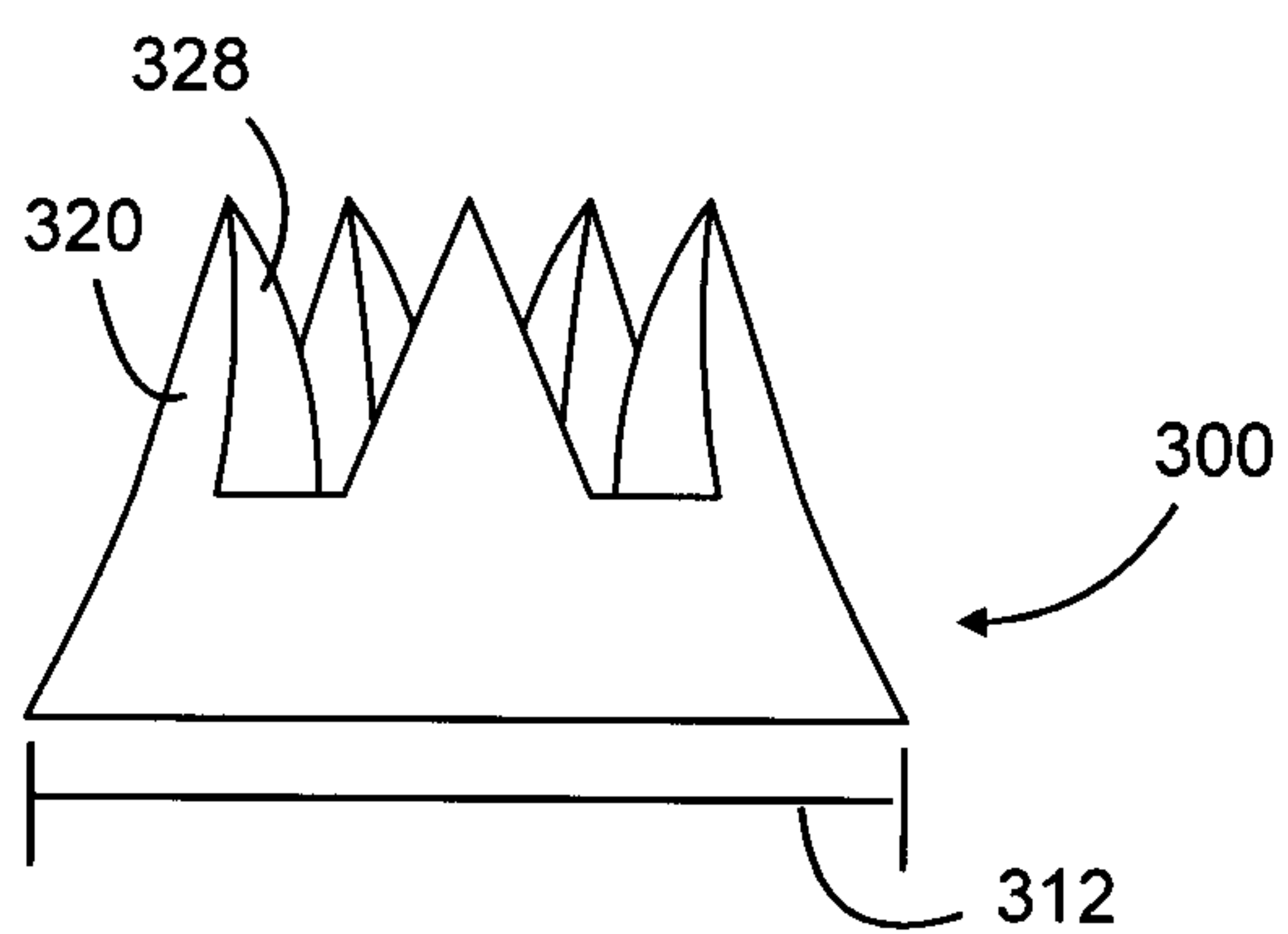
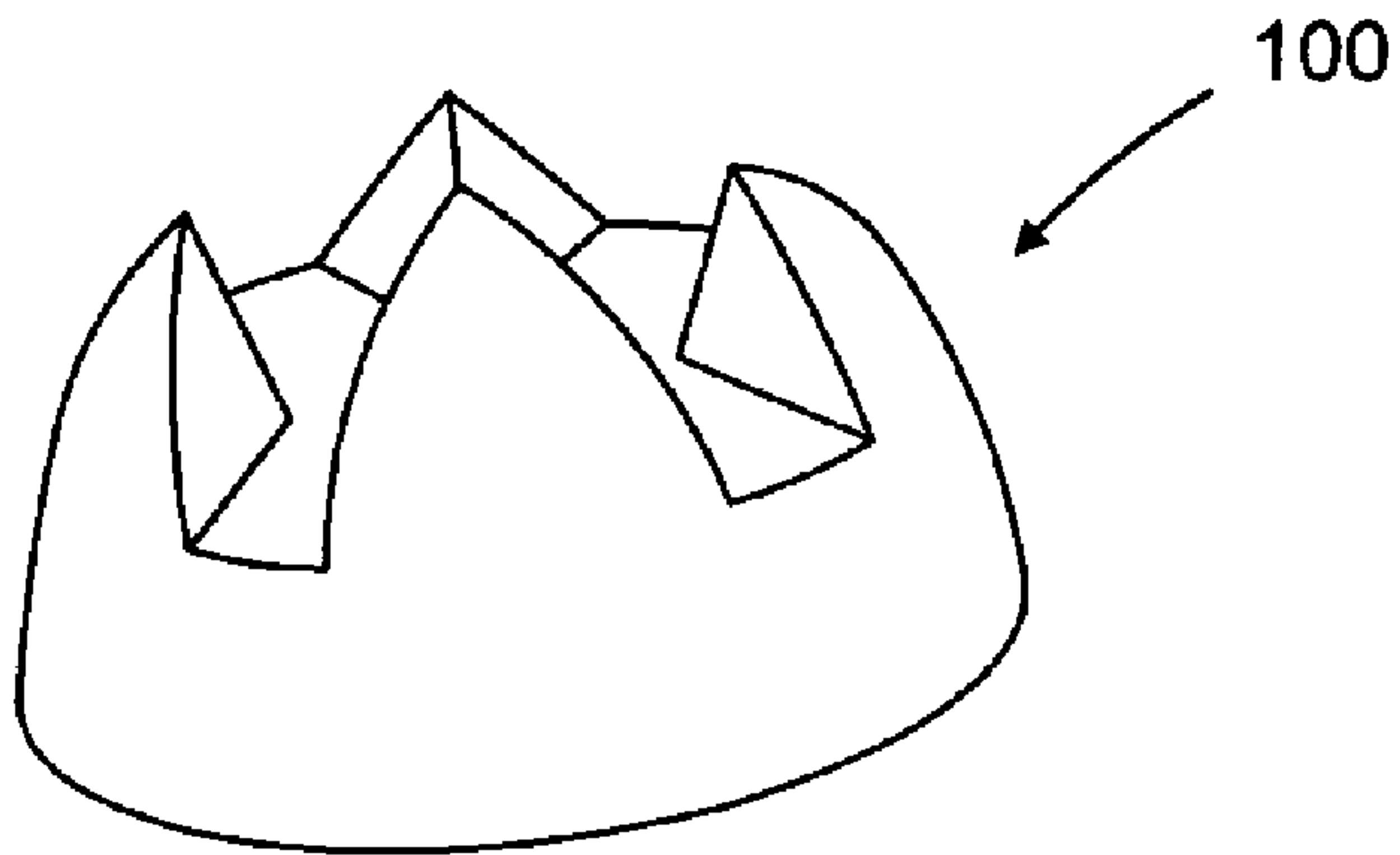


FIG. 5C



A