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(54) ULTRASONIC SURGICAL BLADE WITH IMPROVED CUTTING AND COAGULATION FEATURES

CHIRURGISCHE ULTRASCHALLKLINGE MIT VERBESSERTER SCHNEID- UND KOAGULATIONSFUNKTION

LAME CHIRURGICALE À ULTRASONS À ÉLÉMENTS DE COUPE ET DE COAGULATION AMÉLIORÉS

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Description

INTRODUCTION

[0001] The present disclosure is related generally to ultrasonic blades for use in surgical instruments. In particular, the present disclosure is related to ultrasonic surgical blades for use in surgical instruments and, more particularly, to an ultrasonic surgical blade with improved cutting and coagulation features.

BACKGROUND

[0002] Ultrasonic instruments, including both hollow core and solid core instruments, are used for the safe and effective treatment of many medical conditions. Ultrasonic instruments, and particularly solid core ultrasonic instruments, are advantageous because they may be used to cut and/or coagulate organic tissue using energy in the form of mechanical vibrations transmitted to a surgical end-effector at ultrasonic frequencies. Ultrasonic vibrations, when transmitted to organic tissue at suitable energy levels and using a suitable end-effector, may be used to cut, dissect, or cauterize tissue. Ultrasonic instruments utilizing solid core technology are particularly advantageous because of the amount of ultrasonic energy that may be transmitted from the ultrasonic transducer, through the waveguide, to the surgical end-effector. Such instruments may be used for open procedures or minimally invasive procedures, such as endoscopic or laparoscopic procedures, wherein the end-effector is passed through a trocar to reach the surgical site.

[0003] Activating the end-effector (e.g., cutting blade) of such instruments at ultrasonic frequencies induces longitudinal vibratory movement that generates localized heat within adjacent tissue, facilitating both cutting and coagulation. Because of the nature of ultrasonic instruments, a particular ultrasonically actuated end-effector may be designed to perform numerous functions, including, for example, cutting and coagulation. The structural stress induced in such end-effectors by vibrating the blade at ultrasonic frequencies may have a number of undesirable effects. Such undesirable effects may include, for example, transverse motion in the instrument waveguide that may lead to, for example, excess heat generation in the waveguide or premature stress failure.

[0004] Although ultrasonic surgical instruments have been eminently successful, some areas of improvement still remain. For example, it would be desirable for improved ultrasonic blades to remove the gall bladder from the liver bed and for coagulation to facilitate the procedure. An ultrasonic blade that enables efficient dissection of the gall bladder from the liver bed using proximal and distal surfaces facilitates the surgical technique. An ultrasonic blade which has a hook or right angle or near right angle bend near the distal end would provide advantages for access and visibility. The challenges to providing such a configuration have been stress and balance related. An ultrasonic blade with such a configuration must be behave in a balanced manner and be sufficiently strong to endure the added stresses. It would, therefore, be desirable to design an improved ultrasonic surgical blade. It would further be advantageous to provide an ultrasonic surgical blade that cuts faster, while maintaining hemostasis desired by the surgeon. It would also be advantageous to provide an ultrasonic surgical blade that is more controllable and precise, to providing cutting where needed with significant control. An ultrasonic surgical instrument is described with improved cutting and coagulation features to provide these advantages and overcome the disadvantages of previous instruments.

[0005] US2010/106173A1 describes an ultrasonic surgical device. US2015/045701A1 describes an ultrasonic actuated unit and an ultrasonic treatment device. US2014/324084A1 describes a treatment assembly, a treatment device and a manufacturing method for a treatment device. US6309400B2 describes a curved ultrasonic blade having a trapezoidal cross section.

SUMMARY

[0006] The invention is as defined in claim 1.

[0007] Various embodiments of ultrasonic surgical blades are disclosed.

[0008] In one example, an ultrasonic surgical blade comprises a solid body; a longitudinal portion having a proximal end configured to couple to an ultrasonic transmission waveguide and a distal end configured to dissect and coagulate tissue, the longitudinal portion comprising: a substantially planar longitudinal surface; and a distal hemostasis surface located opposite of the substantially planar longitudinal surface; a transverse portion extending crosswise from the distal end of the longitudinal portion, the transverse portion defining a hook having a free end configured to pull and dissect tissue, the transverse portion comprising: a curved section extending from a distal end of the substantially planar longitudinal surface; a tip surface defined at the free end; a substantially planar proximal inner surface extending from the curved surface to the tip surface; and an outer concave distal surface extending from the tip surface to the distal hemostasis surface; and a distal dissection edge defined at a surface inflection of the outer concave distal surface and the distal hemostasis surface.

[0009] In another example, the ultrasonic surgical blade of example 1 is disclosed, wherein the longitudinal portion comprises a proximal hemostasis surface located opposite of the substantially planar longitudinal surface.

[0010] In another example, the ultrasonic surgical blade of example 2 is disclosed, comprising first and second lateral surfaces extending from the body to the proximal hemostasis surface defining first and second cutting edges defined at first and second surface inflections between the first and second lateral surfaces and the proximal hemostasis surface.

[0011] In another example, the ultrasonic surgical blade of example 2 is disclosed, wherein the distal hemostasis surface has a surface area S1 selected form a range of 3.226 mm^2 to 6.45 mm^2 (0.005 in^2 to 0.01 in^2).

[0012] In another example, the ultrasonic surgical blade of example 1 is disclosed, further comprising a beveled edge defined between the tip surface and the substantially planar proximal inner surface.

[0013] In another example, the ultrasonic surgical blade of example 1 is disclosed, further comprising an oblique tip surface extending from the tip surface to the outer concave distal surface.

[0014] In another example, the ultrasonic surgical blade of example 1 is disclosed, wherein the depth of the transverse portion measured from the tip surface to the proximal hemostasis surface is selected from a range of 1.8 mm to 3.0 mm (0.071 in to 0.1 18 in).

[0015] In another example, the ultrasonic surgical blade of example 1 is disclosed, wherein the proximal hemostasis surface has a surface area S2 selected form a range of 6.45 mm^2 to 12.90 mm^2 (0.01 in^2 to 0.02 in^2).

[0016] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

FIGURES

[0017]

FIG. 1 is an illustration of an ultrasonic instrument according to one embodiment.

FIG. 2 is an illustration of the ultrasonic instrument shown in FIG. 1, with the outer sheath removed to reveal the underlying ultrasonic transmission waveguide.

FIG. 3 is an illustration of the ultrasonic surgical instrument shown in FIG. 1 with the right and left shrouds removed.

FIG. 4 is an illustration of the handle assembly of the ultrasonic surgical instrument shown in FIG. 1 with the left shroud, the shaft assembly, and the nose cone removed.

FIG. 5 is a front view of the ultrasonic surgical instrument shown in FIG. 1 with the nose cone removed to show the underlying activation button assembly, the clutch plate, retainer, and support bushing.

FIG. 6 illustrates one embodiment of a surgical end-effector integrally formed with an ultrasonic transmission waveguide.

FIG. 7 is a perspective view of an ultrasonic surgical blade according to one embodiment.

FIG. 8 is a side view of the ultrasonic surgical blade shown in FIG. 7, according to one embodiment.

FIG. 9 is a perspective view of the ultrasonic surgical blade according to one embodiment.

FIG. 10 is an illustration of the distal and proximal hemostasis surface of the ultrasonic surgical blade shown in FIGS. 7-9, according to one embodiment.

FIG. 11 is a side view of the ultrasonic surgical blade in a neutral position illustrating the location of the distal antinode AN and the longitudinal axis L, according to one embodiment.

FIG. 12 is an illustration of the ultrasonic surgical blade shown in FIG. 11 in an intermediate position with no displacement.

FIG. 13 is an illustration of the ultrasonic surgical blade shown in FIG. 11 in a maximum proximal displacement, and

FIG. 14 is an illustration of the ultrasonic surgical blade shown in FIG. 11 in a maximum distal displacement.

FIG. 15 is a graphical representation of displacement (microns) along the vertical axis of the ultrasonic surgical blade shown in FIGS. 12-14 versus distance (in) along the ultrasonic surgical blade along the horizontal axis, according to one embodiment.

FIG. 16 is a side of the ultrasonic surgical blade shown in FIG. 7 illustrating the position of several sectional views shown in FIGS. 17-29, according to one embodiment.

FIG. 17 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line17--17, according to one embodiment.

FIG. 18 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line18--18, according to one embodiment.

FIG. 19 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line19--19, according to one embodiment.

FIG. 20 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line20--20, according to one embodiment.

FIG. 21 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line21--21, according to one embodiment.

FIG. 22 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line22--22, according to one embodiment.

FIG. 23 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line23--23, according to one embodiment.

FIG. 24 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line24--24, according to one embodiment.

FIG. 25 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line25--25, according to one embodiment.

FIG. 26 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line26--26, according to one embodiment.

FIG. 27 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line27--27, according to one embodiment.

FIG. 28 is a sectional view of the ultrasonic surgical blade shown in FIG. 16 taken along section line28--28, according to one embodiment.

FIG. 29 is an illustration of a bottom view of the ultrasonic surgical blade shown in FIG. 7 showing the distal and proximal hemostasis surfaces and lateral cutting edges.

FIG. 30 is a sectional view of the ultrasonic surgical blade shown in FIG. 29 taken along section line30--30, according to one embodiment.

FIG. 31 is a top view of the ultrasonic surgical blade shown in FIG.29, according to one embodiment.

FIG. 32 is an end view of the ultrasonic surgical instrument showing the ultrasonic surgical blade and the outer tube / sheath, according to one embodiment.

FIG. 33 is perspective view of the ultrasonic surgical blade, according to one embodiment.

FIG. 34 is a side view of the ultrasonic surgical blade shown in FIG.33, according to one embodiment.

FIG. 35 is an end view of the ultrasonic surgical blade shown in FIG.33, according to one embodiment.

FIG. 36 is another perspective view of the ultrasonic surgical blade shown in FIG.33, according to one embodiment.

FIG. 37 is a bottom view of the ultrasonic surgical blade shown in FIG.33, according to one embodiment.

FIG. 38 is an illustration of the distal and proximal hemostasis surface of the ultrasonic surgical blade shown in FIGS. 33-37, according to one embodiment.

FIG. 39 is a perspective view of the ultrasonic surgical blade shown in FIG. 39, according to one embodiment.

FIG. 40 is a side view of the ultrasonic surgical blade shown in FIG. 39, according to one embodiment.

FIG. 41 is an end view of the ultrasonic surgical blade shown in FIG. 39, according to one embodiment.

FIG. 42 is an end view of the ultrasonic surgical blade shown in FIGS. 39-41 illustrating a triangle shaped end mass, according to one embodiment.

FIG. 43 is an end view of the ultrasonic surgical blade shown in FIGS. 39-41 illustrating a suitable diameter for trocar entry, according to one embodiment.

FIG. 44 is a bottom view of the ultrasonic surgical blade shown in FIG. 39 in compression mode, according to one embodiment.

FIG. 45 is a bottom view of the ultrasonic surgical blade shown in FIG. 39 in tension mode, according to one embodiment.

FIG. 46 illustrates the ultrasonic surgical blade shown in FIG. 39 in a neutral unexcited state.

FIG. 47 illustrates the ultrasonic surgical blade shown in FIG. 46, as the vibration process initiates, where the blade hook is displaced distally under tension mode and the gap defined by the balance feature expands.

FIG. 48 illustrates the ultrasonic surgical blade shown in FIG. 47 as the blade continues to be displaced distally under tension until it reaches a point of maximum displacement under tension.

FIG. 49 illustrates the ultrasonic surgical blade shown in FIG. 48 as the blade is now in compression mode and has begun to contract.

FIG. 50 illustrates the ultrasonic surgical blade shown in FIG. 49 as the blade has reached a point of maximum compression where its overall displacement is at a minimum and the gap defined by the balance feature is at a minimum.

FIG. 51 illustrates a point of maximum displacement of the ultrasonic surgical blade shown in FIG. 39, according to one embodiment.

FIG. 52 illustrates a bottom view of the ultrasonic surgical blade shown in FIG. 51 under maximum displacement, according to one embodiment.

FIG. 53. Illustrates one embodiment of a right angle balance blade.

FIG. 54 is an illustration of a balanced displacement plot of a right angle balanced blade, similar to the blade shown FIG. 53, in a maximum displacement state, according to one embodiment.

FIG. 55 illustrates a right angle balanced ultrasonic blade driven in transverse mode to produce longitudinal motion at an end effector section, according to one embodiment.

FIG. 56 illustrates one configuration of a right angle balanced ultrasonic surgical blade.

FIG. 57 illustrates one configuration of a right angle balanced ultrasonic surgical blade.

FIG. 58 illustrates one configuration of a right angle balanced ultrasonic surgical blade.

FIG. 59 illustrates one configuration of a right angle balanced ultrasonic surgical blade.

FIG. 60 illustrates one configuration of a right angle balanced ultrasonic surgical blade.

DESCRIPTION

[0018] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols and reference characters typically identify similar components throughout the several views, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the scope of the subject matter presented here.

[0019] The following description of certain examples of the technology should not be used to limit its scope. Other examples, features, aspects, embodiments, and advantages of the technology will become apparent to those skilled in the art from the following description, which is by way of illustration, one of the best modes contemplated for carrying out the technology. As will be realized, the technology described herein is capable of other different and obvious aspects, all without departing from the technology. Accordingly, the drawings and descriptions should be regarded as illustrative in nature and not restrictive.

[0020] It is further understood that any one or more of the teachings, expressions, embodiments, examples, etc. described herein may be combined with any one or more of the other teachings, expressions, embodiments, examples, etc. that are described herein. The following-described teachings, expressions, embodiments, examples, etc. should therefore not be viewed in isolation relative to each other. Various suitable ways in which the teachings herein may be combined will be readily apparent to those of ordinary skill in the art in view of the teachings herein. Such modifications and variations are intended to be included within the scope of the claims.

[0021] In the following description, it is to be understood that terms such as front, back, inside, outside, top, bottom and the like are words of convenience and are not to be construed as limiting terms. Terminology used herein is not meant to be limiting insofar as devices described herein, or portions thereof, may be attached or utilized in other orientations. The various embodiments will be described in more detail with reference to the drawings.

[0022] The present disclosure provides an ultrasonic instrument comprising an ultrasonic blade with improved cutting and coagulation features. FIG. 1 is an illustration of an ultrasonic instrument 100 according to one embodiment. The ultrasonic instrument 100 comprises a handle assembly 102, a shaft assembly 104, and a surgical end-effector 106. The handle assembly 102 comprises right and left shrouds 108a, 108b, an activation button assembly 110, and a nose cone 112. The activation button assembly 110 comprises a plurality of activation buttons. Turning briefly to FIG. 5, which is a front view of the ultrasonic instrument, it can be seen that in one embodiment, the activation button assembly 110 comprises eight activation buttons 110a, 110b, 110c, 110d, 110e, 110f, 110g, 110h distributed about the handle assembly 102. Turning back to FIG. 1, the shaft assembly 104 comprises an outer sheath 114. The surgical end-effector 106 comprises an ultrasonic surgical blade 116 with improved cutting and coagulation features. The ultrasonic surgical blade 116 and ultrasonic transmission waveguide is isolated from the outer sheath 114 with multiple isolation spacers 118, which can be overmolded over the ultrasonic transmission waveguide.

[0023] The handle assembly 102 also comprises an ultrasonic transducer acoustically coupled to an ultrasonic transmission waveguide which is acoustically coupled to the surgical end-effector 106. The handle assembly 102 is electrically connected to an ultrasonic energy generator, which can be activated by one of the plurality of activation buttons 110a-110h, for example the activation button 110a. Depressing the activation button 110a activates the ultrasonic generator, and delivers electrical energy to an ultrasonic transducer located in the handle assembly 102. The ultrasonic transducer in the handle assembly 102 converts the electrical energy to ultrasonic motion, which is acoustically coupled to the ultrasonic transmission assembly and the treatment region of the surgical end-effector 106. The treatment region vibrates at an excursion magnitude of 20 micrometers to 150 micrometers, and at a frequency of approximately 55.5 kilohertz, although other frequencies may be employed, without departing from the scope of the present disclosure.

[0024] FIG. 2 is an illustration of the ultrasonic instrument 100 shown in FIG. 1, with the outer sheath 114 (FIG. 1) removed to reveal the underlying ultrasonic transmission waveguide 120. As shown, isolation spacers 118 are disposed over the ultrasonic transmission waveguide 120 to acoustically isolate the outer sheath 114 from the ultrasonic transmission waveguide 120. Accordingly, the plurality of isolation spacers 118 are located on respective nodes along the ultrasonic transmission waveguide 120 to minimize the vibrations acoustically coupled to the outer sheath 114. In one embodiment, the isolation spacers 118 may be overmolded over the ultrasonic transmission waveguide 120.

[0025] FIG. 3 is an illustration of the ultrasonic surgical instrument 100 shown in FIG. 1 with the right and left shrouds 108a, 108b removed. The handle assembly 102 includes a support base 122 located proximal to the activation button assembly 110.

[0026] FIG. 4 is an illustration of the handle assembly 102 of the ultrasonic surgical instrument 100 shown in FIG. 1 with the left shroud 108b (FIG. 1), the shaft assembly 102 (FIG. 1), and the nose cone 112 removed. As shown in FIG. 4, below the nose cone 112 is a bridge guide 132 operatively coupled to the activation button assembly 110. A clutch plate 134 and clutch spring 136 are disposed between the bridge guide 132 and a retainer 138. A support bushing 140 supports the shaft assembly 102.

[0027] FIG. 5 is a front view of the ultrasonic surgical instrument 100 shown in FIG. 1 with the nose cone 112 removed to show the underlying activation button assembly 110, the clutch plate 134, retainer 138, and support bushing 140. The activation button assembly 110 comprises a plurality activation buttons 110a-110h, that are individually programmable to perform a particular function. For example, the activation 110a is electrically coupled to the ultrasonic generator and is used to energize the ultrasonic transducer to activate the surgical end-effector 106.

[0028] Having described one embodiment of an ultrasonic surgical instrument 100 (FIGS. 1-5) that can be configured to operate a surgical end-effector 106, the present disclosure now turns to a description of one embodiment of a surgical end-effector 106 in connection with FIGS. 6-32.

Ultrasonic Blade for Tissue Dissection and Hemostasis (Embodiment 1)

[0029] FIGS. 6-32 illustrate one embodiment of the ultrasonic surgical blade 116 configured with edges and surfaces to optimize hemostasis and dissection. In one exemplary use, the distal portion allows access to surface tissue, such as the liver bed, for efficient hemostasis. Sharp edges disposed on the distal portion of the ultrasonic surgical blade 116 deliver quick dissection. Accordingly, the disclosed ultrasonic blade 116 enables efficient dissection of the gall bladder from the liver bed using proximal and distal surfaces for ease of surgeon technique.

[0030] FIG. 6 illustrates one embodiment of a surgical end-effector 106 integrally formed with an ultrasonic transmission waveguide 120. The surgical end-effector 106 comprises an ultrasonic surgical blade 116 having a neck 142 coupled to the ultrasonic transmission waveguide 120. The ultrasonic transmission waveguide 120 is a component of the shaft assembly 104 and is acoustically isolated from other components of the shaft assembly 104, such as the outer sheath 114 (FIG. 1), by the isolation spacer 118. The ultrasonic surgical blade 116 is configured to vibrate in response to ultrasonic energy applied thereto via the ultrasonic transmission waveguide 120. A balance feature 143 is defined as a cutout section in the ultrasonic transmission waveguide 120 to facilitate the expansion and contraction of the ultrasonic transmission waveguide 120 during the vibratory process.

[0031] FIG. 7 is a perspective view of an ultrasonic surgical blade 116 according to one embodiment. The distal portion of the ultrasonic surgical blade 116 has a curved or angular shape that defines a blade hook 150 having a free end configured for pulling and cutting tissue during use. The ultrasonic surgical blade 116 comprises a longitudinal portion 141 extending distally from the neck 142, where it couples to ultrasonic vibrations and a transverse portion 147 extending from a distal end of the longitudinal portion 141. The transverse portion 147 of the ultrasonic surgical blade 116 defines the blade hook 150. At the end of the transverse portion, the blade hook 150 defines a tip surface 144 optimized to access tissue planes. From the tip surface 144, extending outwardly and towards the longitudinal portion 141, the tip surface 144 transitions at a surface inflection 139 to an oblique tip surface 145 having a convex radius of curvature. Extending from the oblique tip surface 145, at another surface inflection 153, the blade hook 150 defines an outer distal surface 152 on a distal side of the blade hook 150, where the outer distal surface 152 defines a contour profile configured to facilitate access to tissue planes. The distal surface 152 has a concave radius of curvature that defines a reduced size contour profile to facilitate better access to tissue planes. An angle θ_1 is defined by the tip surface 144 and the oblique tip surface.

[0032] Extending from the outer distal surface 152 through yet another surface inflection is a distal hemostasis surface 148 defining a larger surface area. The distal hemostasis surface 148 has a convex radius of curvature. A dissection edge 146 is defined at the surface inflection between the outer distal surface 152 and the distal hemostasis surface 148. The dissection edge 146 is configured to improve the dissection or cutting speed. The contour profile of the outer distal surface 152 extends distally at the surface inflection defining the dissection edge 146 such that the transverse portion 147 of the hook 150 is tapered from the dissection edge 146 to the oblique tip surface 145. From the surface inflection 153, the oblique tip surface 145 extends at an angle to the tip surface 144. The proximal end of the tip surface 144 defines a beveled edge 182. The inner, proximal, portion of the blade hook 150 defines a substantially planar inner surface 149 on the proximal side of the blade hook 150 that extends along the transverse portion 147 from the beveled edge 182 of the tip surface 144 to a curved surface 151 having a concave radius of curvature r_1. The depth d_1 of the transverse portion 147 measured from the tip surface 144 to the planar longitudinal surface 161 may be optimized to pull tissue of various types. A proximal hemostasis surface 154 is provided on the longitudinal portion 141 of the ultrasonic surgical blade 116 and is sized to deliver suitable hemostasis while minimizing mass.

[0033] The ultrasonic surgical blade 116 also may comprise additional surfaces designed to acoustically balance the ultrasonic surgical blade 116. These surfaces include a first lateral surface 156, a second lateral surface 158, and a third lateral surface 160 located on one side of the ultrasonic surgical blade 116 and corresponding lateral surfaces on the other side of the ultrasonic surgical blade 116, which are labeled by a prime ('). The lateral surfaces 160, 160' are oblique and extend from a proximal body portion 159 of the blade 116 to the proximal hemostasis surface 154. Cutting edges 165, 165' are defined at the surface inflections of the proximal hemostasis surface 154 and the oblique lateral surfaces 160, 160'. The lateral surfaces 156, 156' 158, 158', 160, 160' are produced by removing mass from the blade body 159 and are contoured to balance the ultrasonic surgical blade 116 to provide stable ultrasonic vibrations when energized. The substantially planar longitudinal surface 161 is part of the longitudinal portion 141 of the ultrasonic surgical blade 116 extending from the neck 142 towards the curved surface 151 of the transverse portion 147 of the blade hook 150.

[0034] FIG. 8 is a side view of the ultrasonic surgical blade 116 shown in FIG. 7, according to one embodiment. As described in connection with FIG. 7, the depth d_1 of the hook 150 is optimized to pull tissue. The dimension d_1 is the depth of the hook 150 from the upper tip 144 to the substantially planar longitudinal surface 161. The depth d_1 is approximately 2.4 mm and may vary between 1.8 mm to 3.0 mm, without departing from the scope of the present disclosure. A cutting edge 165 is defined by a surface inflection between the proximal hemostasis surface 154 and the cutting surface 163. The upper tip surface 144 defines a beveled edge 182. The upper tip 144 surface has a slight convexity.

[0035] The dimension r_1 is the radius of curvature of the curved surface 151 that joins the lower section of the flat inner surface 149 to the substantially planar longitudinal surface 161. The radius of curvature r_1 is approximately 0.823 mm and may vary between 0.635 mm to 1.010 mm, without departing from the scope of the present disclosure.

[0036] The dimension d_2 is the width of the upper surface 144 extending from the inner surface 149 to the juncture of the upper surface 144 and the oblique tip surface 145 may vary based on the particular configuration of this embodiment. The dimension d_2 is approximately 0.5075 mm and may vary from 0.38 mm to 0.635 mm, but the embodiment is not limited in this context.

[0037] The dimension d_3 is the distance from the planar inner surface 149 to the juncture of the oblique tip surface 145 and the distal surface 152. The juncture of the of the distal surface 152 is the minimum length of the distal surface 152, which flares out distally at a radius of curvature r_3 to the juncture with the dissection edged 146. The dimension of d_3 is approximately 1.08 mm and may vary between 0.89 mm to 1.27 mm, without departing from the scope of the present disclosure. The dimension of r_3 given the same centerline is approximately 8.57 mm and may vary between 8.38 mm to 8.76 mm, without departing from the scope of the present disclosure.

[0038] The dimension r_2 is the radius of curvature of the oblique tip surface 145, which has a convex curvature. The radius of curvature r_2 is approximately 2.985 mm and may vary between 2.8 mm to 3.17 mm, without departing from the scope of the present disclosure.

[0039] The distance from the juncture of the tip surface 144 and the oblique tip surface 145 defines the degree of obliqueness of the oblique tip surface 145. This dimension may vary depending on the particular configuration of this embodiment.

[0040] The length extending orthogonally from a point where the curved surface 151 meets the longitudinal flat surface 161 to a point on the distal surface 152 defines the base of the transverse portion 147. This dimension may vary depending on the particular configuration of this embodiment.

[0041] The dimension d_4 is the length from the juncture of the tip surface 144 and the planar inner surface 149 to the most distal point defined by the dissection edge 146. The dimension of d_4 is approximately 1.58 mm may vary between 1.39 mm to 1.77 mm, without departing from the scope of the present disclosure.

[0042] The length of the distal surface 152 extends from the juncture with the oblique tip surface 145 to the juncture of the distal surface 152 and the dissection edge 146 at a radius of curvature of r_3. This dimension may vary depending on the particular configuration of this embodiment. The radius of curvature of the distal hemostasis surface 148, may vary depending on the particular configuration of this embodiment.

[0043] The length of the longitudinal hemostasis surface 154 extends from the surface inflection 155 between the proximal hemostasis surface 148 and the distal hemostasis surface 154 and the surface inflection 157 between the distal hemostasis surface 154 and the blade body 159. This dimension may vary depending on the particular configuration of this embodiment.

[0044] The dimension d_5 is the distance from the longitudinal surface 154 to the surface inflection between the blade body 159 and the substantially planar longitudinal surface 161. The dimension of d_5 is approximately 4.375 mm and can vary from 3.75 mm to 5.00 mm, without departing from the scope of the present disclosure.

[0045] FIG. 9 is a perspective view of the ultrasonic surgical blade 116 according to one embodiment. The view illustrated in FIG. 9 shows the width of the junctures 155, 157 of the distal and proximal hemostasis surfaces 148, 154, respectively, and the surface areas of each surface 148, 154. The sizes of the distal and proximal hemostasis surfaces 148, 154 are dimensioned to deliver suitable hemostasis while minimizing mass.

[0046] FIG. 10 is an illustration of the distal and proximal hemostasis surface 148, 154 of the ultrasonic surgical blade 116 shown in FIGS. 7-9, according to one embodiment. The distal hemostasis surface 148 defines a distal dissection edge 146 and lateral sharp cutting edges 172, 172'. The dimension d_6 is the maximum width of the distal hemostasis surface 148 and dimension d_7 is the minimum width of the distal hemostasis surface 148 and the minimum width of the proximal hemostasis surface 154. The dimension of d_6 may vary according to the particular configuration of this embodiment. The distal hemostasis surface 148 has an effective surface area S1 of approximately 4.838 mm^2 and may vary over a range of 3.226 mm^2 to 6.45 mm^2 (0.005 in^2 to 0.01 in^2). The proximal hemostasis surface 154 defines lateral sharp cutting edges 170, 170'. The dimension d_7 is the minimum width of the proximal hemostasis surface 154. The dimension d_8 is the maximum width of the proximal hemostasis surface 154. The dimension of d_8 may vary according to the particular configuration of this embodiment. The proximal hemostasis surface 154 has an effective surface area S2 of approximately 9.675 mm^2 and may vary over a range of 6.45 mm^2 to 12.90 mm^2 (0.01 in^2 to 0.02 in^2).

[0047] FIG. 11 is a side view of the ultrasonic surgical blade 116 in a neutral position illustrating the location of the distal antinode AN and the longitudinal axis L, according to one embodiment. It is well known that a standing wave that set up in the ultrasonic waveguide defines nodes and antinodes, where the nodes represent regions of minimal or no displacement and the antinodes represent regions of maximum displacement. The nodes and antinodes occur periodically based on the driving frequency of approximately 55.5 kilohertz, for example. The nodes and antinodes are located at one quarter wavelength apart. Accordingly, the transverse portion 147 of the blade hook 150 is located at the antinode AN, thus is located at a point of maximum displacement.

[0048] FIGS. 12-14 illustrate the ultrasonic surgical blade 116 in three states of motions, where FIG. 12 is an illustration of the ultrasonic surgical blade 116 shown in FIG. 11 in an intermediate position with no displacement, FIG. 13 is an illustration of the ultrasonic surgical blade 116 shown in FIG. 11 in a maximum proximal displacement, and FIG. 14 is an illustration of the ultrasonic surgical blade 116. FIG. 11 in a maximum distal displacement. Accordingly, with reference to FIGS.12-14, the ultrasonic surgical blade 116 moves between maximum and minimum displacement as the handle assembly 102 (FIG. 1) converts electrical energy into ultrasonic motion of ultrasonic transmission assembly 120 and the treatment region of the surgical ultrasonic surgical blade 116. The ultrasonic surgical blade 116 vibrates at an excursion magnitude of 20 micrometers to 150 micrometers, and at a frequency of approximately 55.5 kilohertz. As shown in FIGS. 13 and 14 the maximum displacement is represented by the tip surface 144 of the hook 150. Also, the balance feature 143 portion assists the ultrasonic transmission waveguide 120 to flex during the vibration process.

[0049] FIG. 15 is a graphical representation of displacement (microns) along the vertical axis of the ultrasonic surgical blade 116 shown in FIGS. 12-14 versus distance (in) along the ultrasonic surgical blade 116 along the horizontal axis, according to one embodiment. The distance along the blade indicated as 0.000 mm (0.000 in.) corresponds to the most proximal location where the ultrasonic transmission waveguide 120 and the distance along the blade indicated as 355.600 mm (14.000 in.) corresponds to the most distal location where the ultrasonic tip 144 of the ultrasonic surgical blade 116 is displaced. With reference now also to FIG.11, the blade displacement waveform 164 represented by the solid line is a standing waveform set up in the ultrasonic transmission waveguide and end effector ultrasonic surgical blade 116 along the longitudinal axil L as shown in FIG.11. The displacement waveform 164 includes periodic nodes 174 and antinodes 176, 176' at locations along the longitudinal axis L. The nodes 174 are locations along the standing waveform 164 where there is no displacement and antinodes 176 are locations where displacement is maximum positive, and antinodes 176' where displacement is maximum negative. In accordance with the periodic nature of the ultrasonic vibrations and the properties of a standing wave 164, the nodes 174 and antinodes 176, 176' are located at a distance equal to one quarter wavelength $\frac{\lambda}{4}$, where the wavelength λ proportional to the frequency of vibrations f_o and the speed c of sound in the material of the transmission waveguide and the ultrasonic surgical blade 116 according to the following relationship $f_o = \frac{2\pi\lambda}{c}$. Due to the design of the ultrasonic surgical blade 116, it can be seen that the absolute maximum displacement occurs at the distal antinode 178, which corresponds to the location of the antinode AN in FIG.11.

[0050] FIG. 16 is a side of the ultrasonic surgical blade 116 shown in FIG. 7 illustrating the position of several sectional views shown in FIGS. 17-29, according to one embodiment.

[0051] FIG. 17 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 17--17, according to one embodiment. The sectional view shows the cross-section of the neck 142. The diameter of the neck 142 increases from an initial diameter d_9 to a final diameter d_{10}. The isolation spacer 118 is disposed about the proximal neck 142' portion of the neck 142 to isolate the ultrasonic surgical blade 116 from the outer sheath 114. The isolation spacer 118 is located at a node of the ultrasonic transmission waveguide. The outer diameter d_{11} of the outer sheath 114 is sized to be slidably received within a trocar. The ultrasonic surgical blade 116 is sized to fit within the inner diameter d_{12} of the outer sheath 114.

[0052] FIG. 18 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line18--18, according to one embodiment. As shown in the view of FIG.18, the ultrasonic surgical blade 116 has an overall dimension to fit within the outer sheath 114. The junctures 157, 157' of the distal hemostasis surfaces 154, 154' and the cutting surface 163 section of the lateral surface 160 define din the blade body 159 define sharp edges that can be used to assist in dissection. The overall width d_{16} of the ultrasonic surgical blade 116 is defined as the distance between the cutting edges 165, 165'. The lateral surface 160, 160' also are shown as straight surfaces in FIG.18. The radius of curvature of the neck 142 is defined as r_4.

[0053] FIG. 19 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line19--19, according to one embodiment. As shown, the blade body 159 widens and defines flat sidewall portions of the lateral surfaces 160, 160'.

[0054] FIG. 20 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 20--20, according to one embodiment. The radius of curvature of the blade body 159 at section 20--20 is defined as r_5.

[0055] FIG. 21 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 21--21, according to one embodiment. At section line 21--21, the cross sectional are of the blade body 159 is less than the cross sectional are shown in FIGS.19 and 20. This is due to the lateral surfaces 158, 158' that are defined by the blade body 159 to balance the ultrasonic vibrations of the ultrasonic surgical blade 116. As shown, the lateral surfaces 158, 158' are contoured and define contoured lateral walls 180, 180' cut, ground, or otherwise formed in the blade body 159. Also, a gap d_{14} is defined between the proximal hemostasis surface 154 and the inner diameter of the outer sheath 114. The gap d_{14} enables the knife 116 to be slidably received and move within the outer sheath 114 as desired, and to fit within the diameter of a trocar. The flat portion 161' of the longitudinal surface 161 is also shown. The bottom surface 154 is the proximal hemostasis surface.

[0056] FIG. 22 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 22--22, according to one embodiment. This sectional view illustrates the contoured lateral walls 180, 180' of the respective lateral surfaces 158, 158' defined in the blade body 159. This view also shows the cutting surfaces 163, 163' that extend from the contoured lateral walls 180, 180' of the respective lateral surfaces 158, 158'. This view also shows the length of the dimension d_{15} of the planar inner surface 149 that extends from the tip surface 144 to the beginning of the curved surface 151 having a concave radius of curvature. This view also shows the dimension d_{16} of the beveled edge 182 defined in the upper tip 144. The dimension of d_{15} and the dimension of d_{16} may vary according to the particular configuration of this embodiment. The flat dimension of the planar longitudinal surface 161 is also shown. The bottom surface 154 is the proximal hemostasis surface.

[0057] FIG. 23 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 23--23, according to one embodiment. FIG. 23 shows the flat portion 161' of the longitudinal surface 161, the lateral surfaces 158, 158', and the contoured lateral walls 180, 180' of the lateral surfaces 158, 158'. The cutting surfaces 163, 163' flare out laterally from the blade body 159 to a surface inflection that defines cutting edges 165, 165'. The bottom surface 154 is the proximal hemostasis surface.

[0058] FIG. 24 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 24--24, according to one embodiment. The section line 24--24 is taken to show the full dimension d_{19} of the curved surface 151 portion of the blade hook 150. Also, shown is the full dimension d_{15} of the inner surface 149 portion of the blade hook 150 as well as the dimension d_{16} of the beveled edge 182 of the tip surface 144. This view also shows the flat portion 161' of the longitudinal surface 161, the straight lateral sidewalls of the blade hook 150 defined by the sidewalls of the beveled edge 182, the inner surface 149, and the curved surface 151. In this view, the dimension of the curved surface 151 is given by d_{17}. Extending below the flat portion 161' of the longitudinal surface 161 is the sectional view of the blade body 159 that defines the sidewalls of the lateral surfaces 158, 158' and the contoured lateral sidewalls 180, 180' of the lateral surfaces 158, 158' defined by the body 159. The bottom surface 154 is the proximal hemostasis surface. As previously discussed, the depth of the hook 150 is given by dimension d_1.

[0059] FIG. 25 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 25--25, according to one embodiment. The section view 25--25 is taken at the transition between the tip surface 144 and the oblique tip surface 145. This view shows the full dimension of the ultrasonic surgical blade 116 located within the outer tube / sheath 114. The straight sidewalls 184, 184' of the blade hook 150 and the contoured lateral sidewalls 180, 180' of the lateral surfaces 158, 158' defined by the body 159. The contoured lateral sidewalls 180, 180' define the juncture 155 of the distal and proximal hemostasis surfaces 148, 154. Also shown is the distal hemostasis bottom surface 148 relative to the straight sidewall 184, 184' of the blade hook 150.

[0060] FIG. 26 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 26--26, according to one embodiment. This view shows the straight sidewalls 184, 184' of the blade hook 150 which extends into the contoured lateral walls 180, 180' defined by the body 159. The contoured lateral walls 180, 180' define the juncture 155 of the distal and proximal hemostasis surfaces 148, 154. The distal hemostasis bottom surface 148 has a radius of curvature of r_6.

[0061] FIG. 27 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 27--27, according to one embodiment. As illustrated in the sectional view shown in FIG. 27, the lateral surfaces 158, 158' have a radius of curvature of r_8. The radius of curvature of r_8 may vary according to the particular configuration of this embodiment. Also shown is the longitudinal extending portion 141 of the blade hook 150.

[0062] FIG. 28 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 16 taken along section line 28--28, according to one embodiment. This view also shows the radius of curvature r_7 of the lateral surfaces 158, 158' and the cutting edges 165, 165' defined by the surface inflection between the proximal hemostasis surface 154 and the cutting surface 163 (FIG. 8).

[0063] FIGS. 29-32 provide additional views of the ultrasonic surgical blade 116 shown in FIG. 7, according to one embodiment. FIG. 29 is an illustration of a bottom view of the ultrasonic surgical blade 116 shown in FIG. 7 showing the distal and proximal hemostasis surfaces 148, 154 and lateral cutting edges 172, 172", 170, 170'. This view also shows the edges 155', 155" defined by the surface inflection 155 between the distal and proximal hemostasis surfaces 148, 154. The most distal portion of the distal hemostasis surface 148 defines the dissection edge 146, which is defined as the surface inflection between the distal hemostasis surface 148 and the distal surface 152 (FIG. 8). Another surface inflection 157 between the proximal hemostasis surface 154and the blade body 159 defines edges 157', 157" from which the cutting edges 165, 165' extend until they meet the lateral cutting edges 170, 170'. The blade body 159 transitions to the ultrasonic transmission waveguide 142 through surface loft 186. For completeness, the ultrasonic transmission waveguide 142 is shown extending proximally into the outer tube / sheath 114.

[0064] FIG. 30 is a sectional view of the ultrasonic surgical blade 116 shown in FIG. 29 taken along section line 30--30, according to one embodiment. This sectional view is taken along the longitudinal centerline to show the relevant features of the ultrasonic surgical blade 116 previously described. From right to left, as the blade body 159 extends from the blade neck 142, the ultrasonic surgical blade 116 defines a first surface inflection 168 between the blade body 159 and the planar longitudinal surface 161. The hook portion 150 is defined in part by the curved surface 151 and the inner surface 149 up to the beveled surface 182. The tip surface 144 transitions to the oblique tip surface 145 at surface inflection 139. The oblique tip surface 145 transitions to the distal surface 152 at surface inflection 153 and the distal surface 152 transitions to the distal hemostasis surface 148 at surface inflection 146, which also defines the dissection edge 146. For purposes of the present disclosure, the surface inflection 146 and the dissection edge 146 refer to the same elements. The distal hemostasis surface 148 transitions to the proximal hemostasis surface 154 at surface inflection 155. Moving to the right from there, the proximal hemostasis surface 154 transitions to the blade body 159 at surface inflection 165.

[0065] FIG. 31 is a top view of the ultrasonic surgical blade 116 shown in FIG. 29, according to one embodiment. The top view of FIG. 31 is the opposite of the bottom view of FIG. 29. From left to right, the ultrasonic transmission waveguide 142 extends distally from the outer tube / sheath 114 and transitions into the blade body 159 portion at surface inflection 186. The blade body 159 defines several surfaces for cutting and / or pulling tissue, applying hemostasis to the tissue, and / or acoustically balancing the ultrasonic surgical blade 116. The planar longitudinal surface 161 extends from a proximal end of the blade body 159 to the curved surface 151 of the blade hook 150. The inner surface 149 of the blade hook 150 extends from the curved surface 151 to the beveled surface 182 of the tip surface 144. The tip surface 144 transitions to the oblique tip surface 145 at surface inflection 139. The oblique tip surface 145 transitions to the distal surface 152 at surface inflection 153. The most distal portion of the distal surface 152 defines the dissection edge 146, which is also the surface inflection between the distal surface 152 and the distal hemostasis surface 148 (FIG.29). The top view of FIG. 31 also shows the lateral surfaces 158, 158' and the cutting edges 165, 165' defined by the surface inflection between the proximal hemostasis surface 154 and the lateral surfaces 160, 160'. The cutting edges 170, 170' are defined by the surface inflection of the proximal hemostasis surface 154 and the lateral surfaces 158, 158'.

[0066] FIG. 32 is an end view of the ultrasonic surgical instrument 100 showing the ultrasonic surgical blade 116 and the outer tube / sheath 114, according to one embodiment. As shown, the transverse portion 147 of the ultrasonic surgical blade 116 comprises a tip surface 144 that transitions into an oblique tip surface 145 at surface inflection 139. The distal surface 152 extends from the oblique tip surface 145 at surface inflection 153. The distal surface 152 defines the dissection edge 146 between the distal hemostasis surface 154 and the distal surface 152. The lateral surfaces 158, 158' extend proximally from the blade hook 150 and the walls define a radius of curvature r_8 on each side. The cutting edges 155', 155" are defined by the surface inflection 155 between the distal and proximal hemostasis surfaces 148, 154. The cutting edges 165. 165' are defined by the surface inflection between the proximal hemostasis surface 154 and the lateral surfaces 160, 160'. The lateral surfaces 160, 160' also define cutting surface 163, 163'. The ultrasonic surgical blade 116 extends distally from the outer tube / sheath 114. The isolation spacer 118 isolates the ultrasonic surgical blade 116 from the outer tube / sheath 114. The isolation spacer 118 is disposed about the proximal neck 142' portion of the ultrasonic surgical blade 116.

Ultrasonic Blade for Tissue Dissection and Hemostasis (Embodiment 2)

[0067] FIGS. 33-38 illustrate one embodiment of an ultrasonic surgical blade 200 configured with edges and surfaces to optimize hemostasis and dissection. In one exemplary use, the distal portion allows access to the surface of tissue, such as the liver bed, for efficient hemostasis. Sharp edges disposed on the distal portion of the ultrasonic surgical blade 200 deliver quick dissection. Accordingly, the disclosed ultrasonic blade 200 enables efficient dissection of the gall bladder from the liver bed using proximal and distal surfaces for ease of surgeon technique.

[0068] FIG. 33 is perspective view of the ultrasonic surgical blade 200, according to one embodiment. FIG. 34 is a side view of the ultrasonic surgical blade 200 shown in FIG. 33, according to one embodiment. FIG. 35 is an end view of the ultrasonic surgical blade 200 shown in FIG. 33, according to one embodiment. FIG. 36 is another perspective view of the ultrasonic surgical blade 200 shown in FIG. 33, according to one embodiment. FIG. 37 is a bottom view of the ultrasonic surgical blade 200 shown in FIG. 33, according to one embodiment.

[0069] With reference now to FIGS. 33-38, in one embodiment, the ultrasonic surgical blade 200 is configured and adapted to operate with the ultrasonic surgical instrument 100 shown and described connection with FIGS. 1-5. Accordingly, the ultrasonic surgical blade 200 comprises a blade body 218 that transitions into a blade neck 202 at surface inflection 232. The blade neck 202 extends proximally to form or couple to an ultrasonic transmission waveguide, having a proximal end configured to acoustically couple to an ultrasonic transducer piezoelectric stack. In the distal direction, the blade body 218 defines several surfaces suitable for cutting and / or pulling tissue, applying hemostasis to the tissue, and / or acoustically balancing the ultrasonic surgical blade 200.

[0070] Still with reference to FIGS. 33-38, the ultrasonic surgical blade 200 comprises a longitudinal portion 222 and a transverse portion 224. The longitudinal portion 222 extends distally from the blade body 218 and defines a substantially planar longitudinal surface 220 and multiple lateral surfaces 214, 216 are defined on each lateral portion of the blade body 218. The lateral surfaces 214, 214' extend from the substantially planar longitudinal surface 220 to a proximal hemostasis surface 212 and define sharp cutting edges 238, 238'. A portion of the lateral surfaces 214, 214' extend to the distal hemostasis surface 210 and define sharp cutting edges 208, 208'. The sharp cutting edges 208, 208', 238, 238' aid in fast dissection when using the side of the ultrasonic blade 200 and the distal surface 236. The lateral surfaces 216, 216' extend from the substantially planar longitudinal surface 220 and the transverse hook portion 204 of the ultrasonic surgical blade 200 to the distal surface 236 to define portions of the sharp cutting edges 208, 208'. The sharp cutting edges 208, 208" have a radius of curvature r_9 that may vary between 2.45 to 2.75 mm, without departing from the scope of the disclosure.

[0071] Still with reference to FIGS. 33-38, the transverse portion 224 of the ultrasonic surgical blade 200 defines the blade hook 204, which is suitable for pulling and cutting tissue and may be configured to access the tissue plane between the gull bladder and the liver. The blade hook 204 comprise a curved surface 230 having a radius of curvature r_{10} extending from the substantially planar longitudinal surface 220 to the inner surface 228. The radius of curvature r_{10} may vary between 0.635 mm to 1.010 mm, without departing from the scope of the disclosure. The inner surface 228 extends to a tip surface 206. The tip surface 206 extends towards the distal surface 236, which extends to the distal hemostasis surface 210. The distal hemostasis surface 210 defines a larger surface area on the bottom and distal side of the ultrasonic surgical blade 200 to aid hemostasis. The distal hemostasis surface 210 transitions to the proximal hemostasis surface 212 at surface inflection 226. The proximal hemostasis surface 212 transitions into the body portion 218 of the ultrasonic surgical blade 200 at surface inflection 234. The blade body 218 eventually transitions into the blade neck 202 at surface inflection 232. Other dimensions of the ultrasonic surgical blade 200 may be similar to the dimensions of the ultrasonic surgical blade 116 shown and described in connection with FIGS. 6-32, although the embodiments are not limited in this context.

[0072] FIG. 38 is an illustration of the distal and proximal hemostasis surface 210, 212 of the ultrasonic surgical blade 200 shown in FIGS. 33-37, according to one embodiment. The distal hemostasis surface 210 is continuous with the distal surface 236 and transitions to the proximal hemostasis surface 212 at surface inflection 226. The proximal hemostasis surface 212 transitions into the body portion 218 of the ultrasonic surgical blade 200 at surface inflection 234. The distal hemostasis surface 210 and the proximal hemostasis surface define a surface inflection 226 therebetween. The distal hemostasis surface 210 defines sharp cutting edges 208, 208'. The dimension d_{18} is the maximum width of the distal hemostasis surface 236 and dimension d_{19} is the minimum width of the distal hemostasis surface 212 and the minimum width of the proximal hemostasis surface 210. The dimension of d_{19} may vary according to the particular configuration of this embodiment. The dimension d_{19} is the minimum width of the proximal hemostasis surface 210. The dimension d_{20} is the maximum width of the proximal hemostasis surface 212. The dimension of d_{20} may vary according to the particular configuration of this embodiment. The distal hemostasis surface 210 has an effective surface area S1'of approximately 54.1935 mm^2 and may vary over a range of 3.226 mm^2 to 105.161 mm^2 (0.005 in^2 to 0.163 in^2). The proximal hemostasis surface 212 defines sharp cutting edges 238, 238'. The proximal hemostasis surface 212 has an effective surface area S2' of approximately 9.6765 mm^2 and may vary over a range of 6.45 mmm^2 to 12.903 mm^2 (0.01 in^2 to 0.02 in^2).

Ultrasonic Blade for Tissue Dissection and Hemostasis (Embodiment 3)

[0073] FIGS. 39-52 illustrate one embodiment of an ultrasonic surgical blade 300 configured with edges and surfaces to optimize hemostasis and dissection. In one exemplary use, the distal portion allows access to the surface of tissue, such as the liver bed, for efficient hemostasis. Sharp edges disposed on the distal portion of the ultrasonic surgical blade 300 deliver quick dissection. Accordingly, the disclosed ultrasonic blade 300 enables efficient dissection of the gall bladder from the liver bed using proximal and distal surfaces for ease of surgeon technique.

[0074] FIG. 39 is a perspective view of the ultrasonic surgical blade 300 shown in FIG. 39, according to one embodiment. FIG. 40 is a side view of the ultrasonic surgical blade 300 shown in FIG. 39, according to one embodiment. FIG. 41 is an end view of the ultrasonic surgical blade 300 shown in FIG. 39, according to one embodiment.

[0075] With reference now to FIGS. 39-41, in one embodiment the ultrasonic surgical blade 300 comprises a neck 302 configured to acoustically couple to an ultrasonic transmission waveguide which is configured and adapted to acoustically couple to a piezoelectric ultrasonic transducer. From the neck 302, the ultrasonic surgical blade 300 extends distally as a substantially longitudinal section 342, defined by dimension d_{21}, and transitions to a substantially transverse section 344 to define a blade hook 304. A sharp central ridge comprised of three distinct segments 306, 306', 306" extends from the neck 320 to a tip 312 of the hook 304 of the transverse section 344 defined by dimension d_{22}. As best seen in FIG. 40, a proximal segment 306 extends substantially longitudinally but has an arcuate component such that it extends downwardly from the neck 302 to an inflection point with an arcuate intermediate segment 306', which extends to a substantially linear distal segment 306". The substantially linear distal segment 306" extends from the junction of the arcuate intermediate section 306' to the tip 312 of the blade hook 304.

[0076] The proximal segment 306 of the sharp central ridge is defined by the junction of two proximal oblique surfaces 324, 330 that extend downwardly and outwardly from the proximal sharp central ridge 306. A first lateral sharp cutting edge 308 is defined by the junction of the proximal oblique surface 324 and the lateral surface 338. On the other side of the blade 300, a second lateral sharp cutting edge 310 is defined by the junction of the proximal oblique surface 330 and the other lateral surface 340 (FIG. 41).

[0077] The intermediate arcuate segment 306' of the sharp central ridge is defined by junction of intermediate arcuate oblique surfaces 326, 332 that extend downwardly and outwardly from the intermediate arcuate segment 306' of the sharp central ridge. A sharp cutting edge 308' is defined by the junction of the intermediate arcuate oblique arcuate surface 326 and an end mass 314 that is located below the transverse section 344 of the blade hook 304 and partially below the longitudinal section 342. An arcuate section of a sharp cutting edge 310' is defined by the junction of the intermediate arcuate oblique surface 332 and the end mass 314. The end mass 314 is used to acoustically balanced the ultrasonic surgical blade 300.

[0078] The distal linear segment 306" of the sharp central ridge is defined by junction of distal oblique surfaces 328, 334 that extend distally and outwardly from the distal linear segment 306" of the sharp central ridge. A sharp cutting edge 308" is defined by the junction of the distal oblique arcuate surface 328 and a body portion of the blade hook 304. A sharp cutting edge 310" is defined by the junction of the distal oblique surface 334 and a body portion of the blade hook 304.

[0079] As shown in FIG. 40, the depth or height of the blade hook 304 of the transverse section 344 defined by dimension d_{23} should be maximized so the surgeon can hook and drag tissue to dissect the tissue along a plane. The dimension d_{23} can be optimized to enable the surgeon to hook and drag to dissect the gall bladder from the liver bad, for example. The dimension d_{23} of the hook 304 is approximately 2.794 mm and may vary between 1.016 mm to 4.572 mm (0.040 in to 0.180 in), without departing from the scope of the disclosure. The dimension d_{21} of the longitudinal section 342 of the blade 300 is approximately 10.414 mm and may vary between 1.778 mm to 19.050 mm (0.070 in to 0.750 in), without departing from the scope of the disclosure. The end mass 314 extends proximally from the distal surface 336 of the hook 304 and has a dimension d_{25}. The dimension d_{25} of the end mass 314 is approximately 5.207 mm and may vary between 0.889 mm to 9.525 mm (0.035 in to 0.375 in), without departing from the scope of the disclosure. The dimension d_{22} of the transverse portion 344 of the blade hook 304 is approximately 4.2545 mm (0.1675 in) and may vary from 3.4036 mm to 5.1054 mm (0.1340 in to 0.2010 in). The dimension d_{24} is approximately 0.9525 mm (0.0375 in) and can vary from 0.762 mm to 1.143 mm (0.0300 in to 0.0450 in). A straight line segment extending from the tip 312 of the blade hook 304 to a point 313 toward the distal end of the end mass 314 has a dimension of approximately 4.3510 mm (0.1713 in) and can vary from 3.4808 mm to 5.2200 mm (0.1370 in to 0.2055 in).

[0080] FIG. 42 is an end view of the ultrasonic surgical blade 300 shown in FIGS. 39-41 illustrating a triangle shaped end mass 314, according to one embodiment. With reference now to FIGS. 40 and 42, the depth of the blade hook 304 of the transverse section 344 defined by transverse dimension d_{23} and longitudinal dimension d_{21} of the longitudinal section 342 creates a large overhung mass relative to the neutral axis L_N of the ultrasonic transmission waveguide that extends proximally from the neck section 302 of the ultrasonic surgical blade 300. To counteract the unbalancing effects of the large overhung mass, a local balance element is provided. In the illustrated embodiments, the local balance element is provided by the end mass 314. In one embodiment, balance is achieved locally via a triangle 316 shaped end mass 314 that extends proximally by a dimension of d_{25}. In one embodiment, the triangle 316 shaped end mass 314 is define by an angle θ_2. Increasing or deceasing the angle θ changes the local mass and thus alters the balance of the blade 300. Accordingly, the balance of the blade 300 can be adjusted by changing the angle θ_2. It will be appreciated that the balance end mass 314 element adjusts the acoustic balance of the ultrasonic surgical blade 300.

[0081] FIG. 43 is an end view of the ultrasonic surgical blade 300 shown in FIGS. 39-41 illustrating a suitable diameter 318 for trocar entry, according to one embodiment. As shown in FIG. 43, the total outer diameter 318 of the ultrasonic blade 300 is sized and configured to be slidably received in a trocar. In one embodiment, the maximum diameter 318 is about 5mm fro trocar entry.

[0082] FIG. 44 is a bottom view of the ultrasonic surgical blade 300 shown in FIG. 39 in compression mode, according to one embodiment. The bottom surface 320 of the end mass 314 can be employed as a spot coagulation surface, otherwise referred to as a hemostasis surface. Only about a 3% amplitude drop in ultrasonic vibration amplitude has been observer across the face of the coagulation surface 320. The illustrated geometry of the end mass 314 and the coagulation surface 320 provides positive tissue effects. When the blade 300 is excited by ultrasonic energy, it oscillates between a compression mode and an tension mode repeatedly. Such oscillation between compression and tension modes creates the displacement necessary to provide the desired tissue effects such as cutting and coagulating tissue. In compression mode, the blade 300 defines its most compact form along the longitudinal axis L_N. As shown in FIG. 44, in the compression mode, the blade 300 illustrated in FIG. 44 can be characterized by several dimensions. For example, in compression mode, the blade 300 defines length d_{26} between the neck section 302 and a proximal wall 348 of the end mass 314. The longitudinal section 342 of the blade 300 over the dimension d_{26} defines a radius of curvature r_{11}. The width of the longitudinal section 342 where it meets the proximal wall 348 of the end mass 314 is defined by dimension d_{27} and the width of the end mass 314 is defined by dimension d_{28}. The dimension d_{29} is the distance between the narrowest portion of the longitudinal section 342 to the outer diameter of the longitudinal section 342.

[0083] FIG. 45 is a bottom view of the ultrasonic surgical blade 300 shown in FIG. 39 in tension mode, according to one embodiment. The dimensions of the surgical blade 300 in tension mode are labeled by a prime (') as compared to the dimensions of the blade 300 in compression mode as shown in FIG. 44. As will be appreciated, when the blade 300 is in tension mode it defines its most elongated form along the longitudinal axis L_N. As shown in FIG. 45, in the tension mode, the blade 300 illustrated in FIG. 45 can be characterized by several dimensions. For example, in tension mode, the blade 300 defines length d_{26}' between the neck section 302 and the proximal wall 348 of the end mass 314. The longitudinal section 342 of the blade 300 over the distance defined by d_{26}' defines a radius of curvature r_{11}'. The width of the longitudinal section 342 where it meets the proximal wall 348 of the end mass 314 is defined by dimension d_{27}' and the width of the end mass 314 is defined by dimension d_{28}'. As the blade 300 transitions for the compression mode to the tension mode the dimensions of the blade 300 decrease in width and increase in length. Accordingly, with reference to FIGS. 44 and 45, the length $d_{26} < d_{26}'$ and $r_{11} < r_{11}'$. However, dimensions $d_{29} > d_{29}'$, $d_{27} > d_{27}'$, and $d_{28} > d_{28}'$.

[0084] FIGS. 46-50 illustrate a displacement cycle of the ultrasonic surgical blade 300, according to one embodiment. FIG. 46 illustrates the ultrasonic surgical blade shown in FIG. 39 in a neutral unexcited state. The longitudinal section 342 and the transverse section 344 are in a neutral state. A balance feature 322 is defined as a cutout portion in the ultrasonic transmission waveguide 350 to facilitate the expansion and contraction of the ultrasonic transmission waveguide 350 and the blade 300 during the vibratory process. As shown in FIG. 47, as the vibration process initiates, the blade 300 hook 304 is displaced distally under tension mode and the gap defined by the balance feature 322 expands. The blade 300 continues to be displaced distally under tension until it reaches a point of maximum displacement under tension as shown in FIG. 48. The diameter dimensions are at their minimum dimension, the length of the blade 300 is at a maximum or highest displacement, and the gap defined by the balance feature 322 is at a maximum. Once the blade 300 reaches the point of maximum displacement in tension mode as shown in FIG. 48, the blade 300 transitions to compression mode and begins to contract. As shown in FIG. 49, the blade 300 is now in compression mode and has begun to contract. The gap defined by the balance feature 322 has decreased in size to facilitate the compression process. As shown in FIG. 50, the blade 300 has reached a point of maximum compression where its overall displacement is at a minimum and the gap defined by the balance feature 322 is at a minimum. FIGS. 48 and 50 provide a good visual representation of the maximum and minimum longitudinal displacement of the blade hook 304 and how the blade hook 304 can be effectively used for dissecting tissue. Also, the longitudinal displacement of the blade 300 also displaces the end mass 314 to enable the coagulation surface 320 of the end mass 314 to be used to effectively coagulate tissue.

[0085] FIG. 51 illustrates a point of maximum displacement of the ultrasonic surgical blade 300, according to one embodiment. As shown in FIG. 51, the tip 312 of the blade hook 304 is at its point of maximum longitudinal displacement and the gap defined by the balance feature 322 is maximally expanded. A distal section 352 of the ultrasonic waveguide 350 has a reduced diameter.

[0086] FIG. 52 illustrates a bottom view of the ultrasonic surgical blade 300 shown in FIG. 51 under maximum displacement, according to one embodiment. As shown in FIG. 52, the maximum stress area 354 is located in the balance feature 322 of the ultrasonic transmission waveguide 350. In use, the balance feature 322 should be protected by the outer sheath of the instrument.

Right Angle Ultrasonic Surgical Blades (Embodiment 4)

[0087] The present disclosure now turns to various embodiments of an ultrasonic surgical blade comprising a right angle or near right angle bend near the distal end to provide advantages in tissue access and visibility. As previously discussed in connection with the foregoing embodiments, the challenges with a right angle ultrasonic blade or a hook-type ultrasonic blade include stress and balance. The embodiments disclosed in FIGS. 53-60 provide an ultrasonic blade with a mass distributed in such a manner that the blade behaves in a balanced fashion and is sufficiently strong to withstand the stresses.

[0088] FIG. 53. Illustrates one embodiment of a right angle balance blade 400. The right angle balance blade 400 comprises a longitudinal section 418 and a transverse section 412. The transverse section 412 of the blade 400 may be at or close to 90° relative to the longitudinal section 418. The longitudinal section 418 extends longitudinally along an ultrasonic waveguide section 402 of the blade 400. A centerline is defined along the longitudinal axis L_N of the blade 400. The distal end of the blade 400 defines a transverse section 412 relative to the longitudinal section 418. The distal end includes a working side defining a thin elongated right angle member 404 section and back side 414 defining a mass 406. A tip 408 having a relatively small surface area is employed for tissue dissection and a rounded end 410 having a larger surface area is employed for coagulation.

[0089] In the illustrated embodiment, the right angle balanced blade 400 comprises a mass distributed such that, at the distal end 412, the back side 414 of the blade 400 has a large mass 406 distributed relatively close to a centerline L_4 of the blade 400. The working side 416 of the blade 400 has a mass distributed in a relatively long, thin section right angle member 404 section when compared to the back side 414 mass 406. This may resemble some designs of golf putters, for example. Additionally, if necessary, balance features may be added, such as notches, to reduce the transverse motion accompanying the desired longitudinal mode.

[0090] FIG. 54 is an illustration of a balanced displacement plot 420 of a right angle balanced blade, similar to the blade 400 shown FIG. 53, in a maximum displacement state, according to one embodiment. As shown, the area of maximum stress 422 occurs at the tip of the blade 400 whereas the areas of minimum stress occur at the blade neck section 424 and the transition section 426 from the blade 400 to the ultrasonic transmission waveguide 402.

[0091] With reference to FIGS. 53 and 54, the right angle balanced blade 400 provides a waveguide 402 with the blade tip 408 extending at a right angle or near right angle relative to the longitudinal section 418. The blade 400 provides the same utility as derived from a simple monopolar RF hook. The technical challenges with the right angle balanced blade 400 includes transmitting longitudinal motion around the corner 428, defined as the point where the transverse section 412 extends from the longitudinal section 418, without creating transverse motion. The transverse motion in the distal right-angle end effector can be used to create hemostasis using the surface area 410 of the back end 414 of the blade 400.

[0092] In one embodiment, rather than driving the waveguide 402 in longitudinal motion and compensating for the ensuing transverse motion, the waveguide 402 is driven in transverse motion, and the whipping motion of the end drive the right angle member 404 section in longitudinal motion as shown in FIG. 54. One way to illustrate this concept is by analogy to a transversely vibrating rod with a free end such as end 408. In a transversely vibrating rod with a freed end, the end "whips" up and down and the slope of the end is relatively high. If a concentrated mass, such as mass 406, is added to the tip 408, it weighs down the free-end. If the mass is zero, the end acts as a free end, and for example has a positive slope. If the mass 406 is infinite, it acts as a pinned condition and the corresponding slope would be negative. A mass 406 can be selected such that the slope is zero, and then the end 408 moves up and down with near zero slope. If the right angle member 404 works as that mass, where the waveguide 402 and the right angle member 404 join at the corner 428, the loaded end 408 just pushes the right angle member 404 up and down in a longitudinal motion. In another aspect, when the right angle member 404 is a half wave resonator, it presents zero dynamic load (i.e., zero driving point impedance), so the end of the waveguide 403 just pulls the right angle member 404 up and down with it, because it experiences no load.

[0093] FIG. 55 illustrates a right angle balanced ultrasonic blade 430 driven in transverse mode to produce longitudinal motion at an end effector 434 section, according to one embodiment. The right angle balanced ultrasonic blade 430 comprises a longitudinal waveguide section 432 and a right angle end effector member 434 positioned transverse to the longitudinal waveguide section 432. As described above, driving the waveguide section 432 in transverse mode causes the transverse right angle end effector member 434 to be displaced from a proximal end to a distal end to effectively create longitudinal motion suitable for dissecting tissue with the tip 436 of the transverse right angle end effector member 434.

[0094] FIGS. 56-60 illustrate several embodiments of right angle balanced ultrasonic surgical blades. FIG. 56 illustrates one configuration of a right angle balanced ultrasonic surgical blade 440. The right angle balanced ultrasonic surgical blade 440 comprises a longitudinal waveguide section 442, a corner section 446, and an end effector section 444 positioned transverse to the longitudinal waveguide section 442 extending from the corner section 446. A tip section 448 may be used to dissect tissue. The tip section 448 moves longitudinally as the waveguide section 442 is excited transversely.

[0095] FIG. 57 illustrates one configuration of a right angle balanced ultrasonic surgical blade 450. The right angle balanced ultrasonic surgical blade 450 comprises a longitudinal waveguide section 452, a corner section 456, and an end effector section 454 positioned transverse to the longitudinal waveguide section 452 extending from the corner section 456. A balance feature 453 is positioned along the waveguide section 452 between the waveguide section 452 and the corner section 456. In the right angle balanced ultrasonic surgical blade 450, the balance feature 453 is a reduced mass portion of the longitudinal waveguide section 452. A tip section 458 may be used to dissect tissue. The tip section 458 moves longitudinally as the waveguide section 452 is excited transversely.

[0096] FIG. 58 illustrates one configuration of a right angle balanced ultrasonic surgical blade 460. The right angle balanced ultrasonic surgical blade 460 comprises a longitudinal waveguide section 462, a corner section 466, and an end effector section 464 positioned transverse to the longitudinal waveguide section 462 extending from the corner section 466. A balance feature 463 is positioned along the waveguide section 462 between the waveguide section 462 and the corner section 466. In the right angle balanced ultrasonic surgical blade 460, the balance feature 463 is an increased mass portion of the longitudinal waveguide section 462. The tip section 468 may be used to dissect tissue. The tip section 468 moves longitudinally as the waveguide section 462 is excited transversely.

[0097] FIG. 59 illustrates one configuration of a right angle balanced ultrasonic surgical blade 470. The right angle balanced ultrasonic surgical blade 470 comprises a longitudinal waveguide section 472, a corner section 476, and an end effector section 474 positioned transverse to the longitudinal waveguide section 472 extending from the corner section 476. A balance feature 473 is positioned on the end effector section 474 between the corner section 476 and the tip section 478. In the right angle balanced ultrasonic surgical blade 470, the balance feature 473 is a reduced mass portion of the end effector section 474. The tip section 478 may be used to dissect tissue. The tip section 478 moves longitudinally as the waveguide section 472 is excited transversely.

[0098] FIG. 60 illustrates one configuration of a right angle balanced ultrasonic surgical blade 480. The right angle balanced ultrasonic surgical blade 480 comprises a longitudinal waveguide section 482, a corner section 486, and an end effector section 484 positioned transverse to the longitudinal waveguide section 482 extending from the corner section 486. A balance feature 483 is positioned on the end effector section 484 between the corner section 486 and the tip section 488. In the right angle balanced ultrasonic surgical blade 480, the balance feature 483 is an increased mass portion of the end effector section 484. The tip section 488 may be used to dissect tissue. The tip section 488 moves longitudinally as the waveguide section 482 is excited transversely.

[0099] As discussed herein, any reference to "one aspect," "an aspect," "one embodiment," or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the aspect is included in at least one aspect. Thus, appearances of the phrases "in one aspect," "in an aspect," "in one embodiment," or "in an embodiment" in various places throughout the specification are not necessarily all referring to the same aspect. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner in one or more aspects.

[0100] Although various embodiments have been described herein, many modifications, variations, substitutions, changes, and equivalents to those embodiments may be implemented and will occur to those skilled in the art. Also, where materials are disclosed for certain components, other materials may be used. It is therefore to be understood that the foregoing description is intended to cover all such modifications and variations as falling within the scope of the appended claims.

Claims

1. An ultrasonic surgical blade (116), comprising:

    a solid body;
    a longitudinal portion (141) having a proximal end configured to couple to an ultrasonic transmission waveguide (120) and a distal end configured to dissect and coagulate tissue, the longitudinal portion (141) comprising:

        a substantially planar longitudinal surface (161); and
        a distal hemostasis surface (148) located opposite of the substantially planar longitudinal surface (161);

    a transverse portion (147) extending crosswise from the distal end of the longitudinal portion (141), the transverse portion (147) defining a hook (150) having a free end configured to pull and dissect tissue, the transverse portion (147) comprising:

        a curved surface (151) extending from a distal end of the substantially planar longitudinal surface;
        a tip surface (144) defined at the free end;
        a substantially planar proximal inner surface (149) extending from the curved surface (151) to the tip surface (144); and
        an outer concave distal surface (152) extending from the tip surface (144) to the distal hemostasis surface (148); and

    a distal dissection edge (146) defined at a surface inflection of the outer concave distal surface (152) and the distal hemostasis surface (148).

2. The ultrasonic surgical blade of claim 1, wherein the longitudinal portion (141) comprises a proximal hemostasis surface (154) located opposite of the substantially planar longitudinal surface.

3. The ultrasonic surgical blade of claim 2, comprising first and second lateral surfaces (158, 158') extending from the body to the proximal hemostasis surface (154) defining first and second cutting edges (170, 170') defined at first and second surface inflections between the first and second lateral surfaces (158, 158') and the proximal hemostasis surface (154).

4. The ultrasonic surgical blade of claim 2, wherein the distal hemostasis surface (148) has a surface area S1 selected form a range of 3.226 mm^2 to 6.45 mm^2.

5. The ultrasonic surgical blade of claim 1, further comprising a beveled edge (182) defined between the tip surface (144) and the substantially planar proximal inner surface (149).

6. The ultrasonic surgical blade of claim 1, further comprising an oblique tip surface (145) extending from the tip surface (144) to the outer concave distal surface (152).

7. The ultrasonic surgical blade of claim 1, wherein the depth of the transverse portion (147) measured from the tip surface (144) to the proximal hemostasis surface (154) is selected from a range of 1.8 mm to 3.0 mm.

8. The ultrasonic surgical blade of claim 1, wherein the proximal hemostasis surface (154) has a surface area S2 selected form a range of 6.45 mm^2 to 12.90 mm^2.

Patentansprüche

1. Chirurgische Ultraschallklinge (116), umfassend:

einen festen Körper;
einen Längsabschnitt (141) mit einem proximalen Ende, das dazu ausgelegt ist, an einen Ultraschallübertragungswellenleiter (120) zu koppeln, und einem distalen Ende, das dazu ausgelegt ist, Gewebe zu dissektieren und zu koagulieren,
wobei der Längsabschnitt (141) umfasst:

eine im Wesentlichen ebene Längsfläche (161); und
eine distale Hämostasefläche (148), die sich gegenüber der im Wesentlichen ebenen Längsfläche (161) befindet;

einen Querabschnitt (147), der sich quer von dem distalen Ende des Längsabschnitts (141) erstreckt, wobei der Querabschnitt (147) einen Haken (150) definiert, der ein freies Ende aufweist, das dazu ausgelegt ist, Gewebe zu ziehen und zu dissektieren, wobei der Querabschnitt (147) umfasst:

eine gekrümmte Fläche (151), die sich von einem distalen Ende der im Wesentlichen ebenen Längsfläche erstreckt;
eine Spitzenfläche (144), die an dem freien Ende definiert ist;
eine im Wesentlichen ebene proximale Innenfläche (149), die sich von der gekrümmten Fläche (151) bis zu der Spitzenfläche (144) erstreckt; und

eine konkave distale Außenfläche (152), die sich von der Spitzenfläche (144) bis zu der distalen Hämostasefläche (148) erstreckt; und
eine distale Dissektionskante (146), die an einer Oberflächenbeugung der konkaven distalen Außenfläche (152) und der distalen Hämostasefläche (148) definiert ist.

2. Chirurgische Ultraschallklinge nach Anspruch 1, wobei der Längsabschnitt (141) eine proximale Hämostasefläche (154) umfasst, die sich gegenüber der im Wesentlichen ebenen Längsfläche befindet.

3. Chirurgische Ultraschallklinge nach Anspruch 2, umfassend eine erste und eine zweite Seitenfläche (158, 158'), die sich von dem Körper bis zu der proximalen Hämostasefläche (154) erstreckt, die eine erste und eine zweite Schnittkante (170, 170') definiert, die an einer ersten und einer zweiten Oberflächenbeugung zwischen der ersten und der zweiten Seitenfläche (158, 158') und der proximalen Hämostasefläche (154) definiert sind.

4. Chirurgische Ultraschallklinge nach Anspruch 2, wobei die distale Hämostasefläche (148) eine Oberfläche S1 aufweist, die aus einem Bereich von 3,226 mm^2 bis 6,45 mm^2 ausgewählt ist.

5. Chirurgische Ultraschallklinge nach Anspruch 1, ferner umfassend eine abgeschrägte Kante (182), die zwischen der Spitzenfläche (144) und der im Wesentlichen ebenen proximalen Innenfläche (149) definiert ist.

6. Chirurgische Ultraschallklinge nach Anspruch 1, ferner umfassend eine schräge Spitzenfläche (145), die sich von der Spitzenfläche (144) bis zu der konkaven distalen Außenfläche (152) erstreckt.

7. Chirurgische Ultraschallklinge nach Anspruch 1, wobei die Tiefe des Schrägabschnitts (147) gemessen von der Spitzenfläche (144) bis zu der proximalen Hämostasefläche (154) aus einem Bereich von 1,8 mm bis 3,0 mm ausgewählt ist.

8. Chirurgische Ultraschallklinge nach Anspruch 1, wobei die proximale Hämostasefläche (154) eine Oberfläche S2 aufweist, die aus einem Bereich von 6,45 mm^2 bis 12,90 mm^2 ausgewählt ist.

Revendications

1. Lame chirurgicale (116) à ultra-sons, comprenant :

un corps solide ;
une partie longitudinale (141) comportant une extrémité proximale configurée pour s'accoupler à un guide d'ondes (120) d'émission d'ultrasons et une extrémité distale configurée pour disséquer et coaguler le tissu, la partie longitudinale (141) comprenant :

une surface longitudinale (161) sensiblement plane ; et
une surface distale (148) d'hémostase située à l'opposé de la surface longitudinale

(161) sensiblement plane ;

une partie transversale (147) s'étendant en travers depuis l'extrémité distale de la partie longitudinale (141), la partie transversale (147) définissant un crochet (150) comportant une extrémité libre configurée pour tirer et disséquer du tissu, la partie transversale (147) comprenant :

une surface courbe (151) s'étendant depuis l'extrémité distale de la surface longitudinale sensiblement plane ;
une surface de pointe (144) définie à l'extrémité libre ;
une surface intérieure proximale (149) sensiblement plane s'étendant de la surface courbe (151) à la surface de pointe (144) ; et
une surface extérieure distale (152) concave s'étendant de la surface de pointe (144) à la surface distale (148) d'hémostase ; et

un bord distal (146) de dissection défini au niveau d'une inflexion de surface entre la surface extérieure distale (152) concave et la surface distale (148) d'hémostase.

2. Lame chirurgicale à ultra-sons selon la revendication 1, dans laquelle la partie longitudinale (141) comprend une surface proximale (154) d'hémostase située à l'opposé de la surface longitudinale sensiblement plane.

3. Lame chirurgicale à ultra-sons selon la revendication 2, comprenant des première et seconde surfaces latérales (158, 158') s'étendant du corps à la surface proximale (154) d'hémostase et définissant des premier et second bords tranchants (170, 170') définis au niveau de première et seconde inflexions de surface entre les première et seconde surfaces latérales (158, 158') et la surface proximale (154) d'hémostase.

4. Lame chirurgicale à ultra-sons selon la revendication 2, dans laquelle la surface distale (148) d'hémostase a une superficie S1 choisie dans une plage allant de 3,226 mm^2 à 6,45 mm^2.

5. Lame chirurgicale à ultra-sons selon la revendication 1, comprenant en outre un bord (182) biseauté défini entre la surface de pointe (144) et la surface intérieure proximale (149) sensiblement plane.

6. Lame chirurgicale à ultra-sons selon la revendication 1, comprenant en outre une surface de pointe (145) oblique s'étendant de la surface de pointe (144) à la surface extérieure distale (152) concave.

7. Lame chirurgicale à ultra-sons selon la revendication 1, dans laquelle la profondeur de la partie transversale (147), mesurée de la surface de pointe (144) à la surface proximale (154) d'hémostase, est choisie dans une plage de 1,8 mm à 3,0 mm.

8. Lame chirurgicale à ultra-sons selon la revendication 1, dans laquelle la surface proximale (154) d'hémostase a une superficie S2 choisie dans une plage allant de 6,45 mm^2 à 12,90 mm^2.

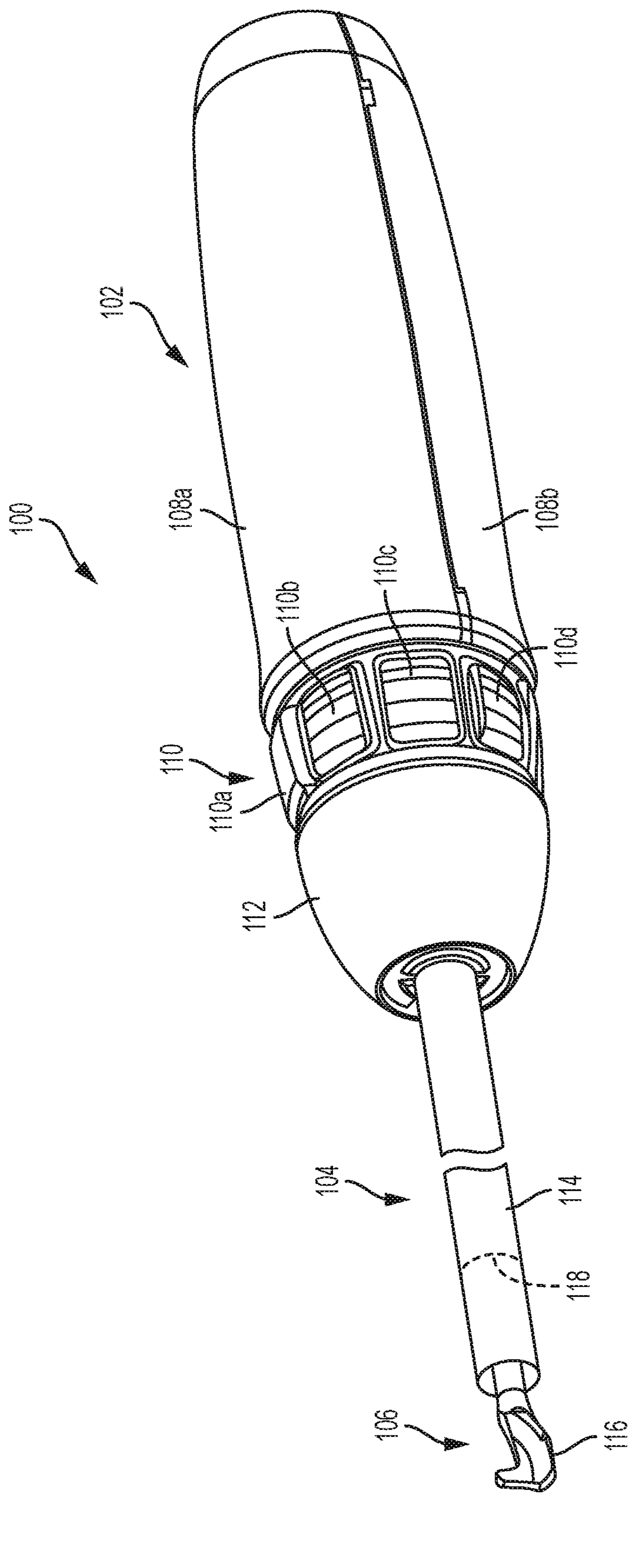
100
102
108a
108b
110b
110c
110d
110
110a
112
104
114
118
106
116

FIG. 1

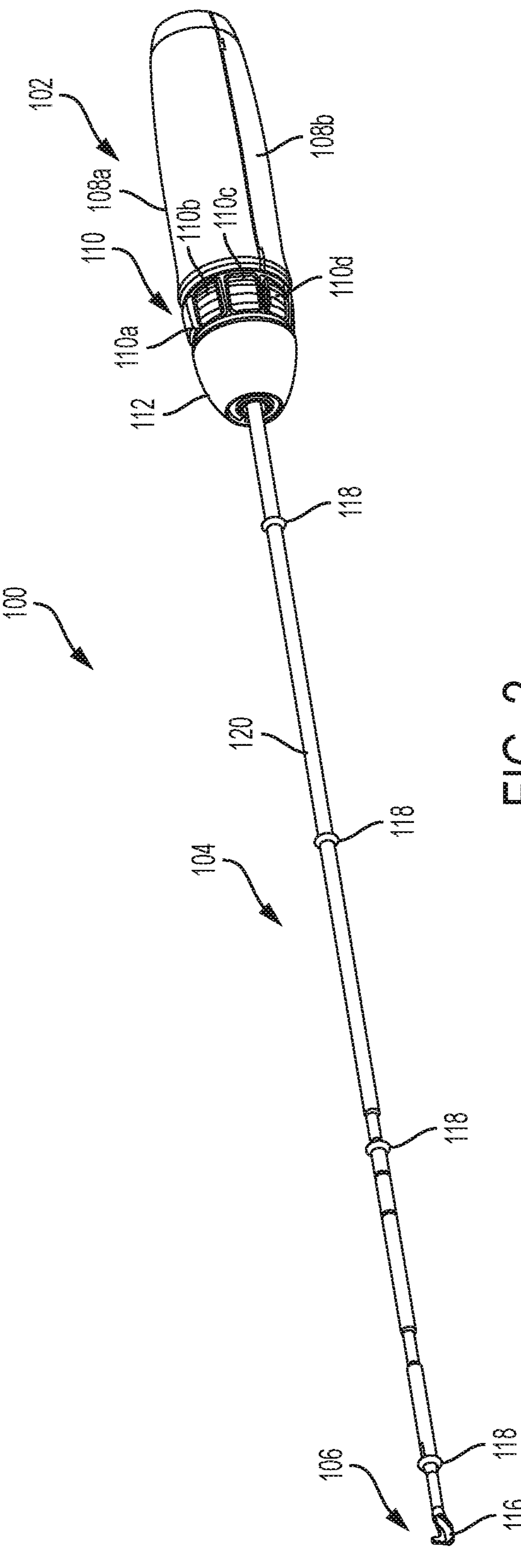
102
108a
108b
110
110a
110b
110c
110d
112
118
100
120
118
104
118
106
118
116

FIG. 2

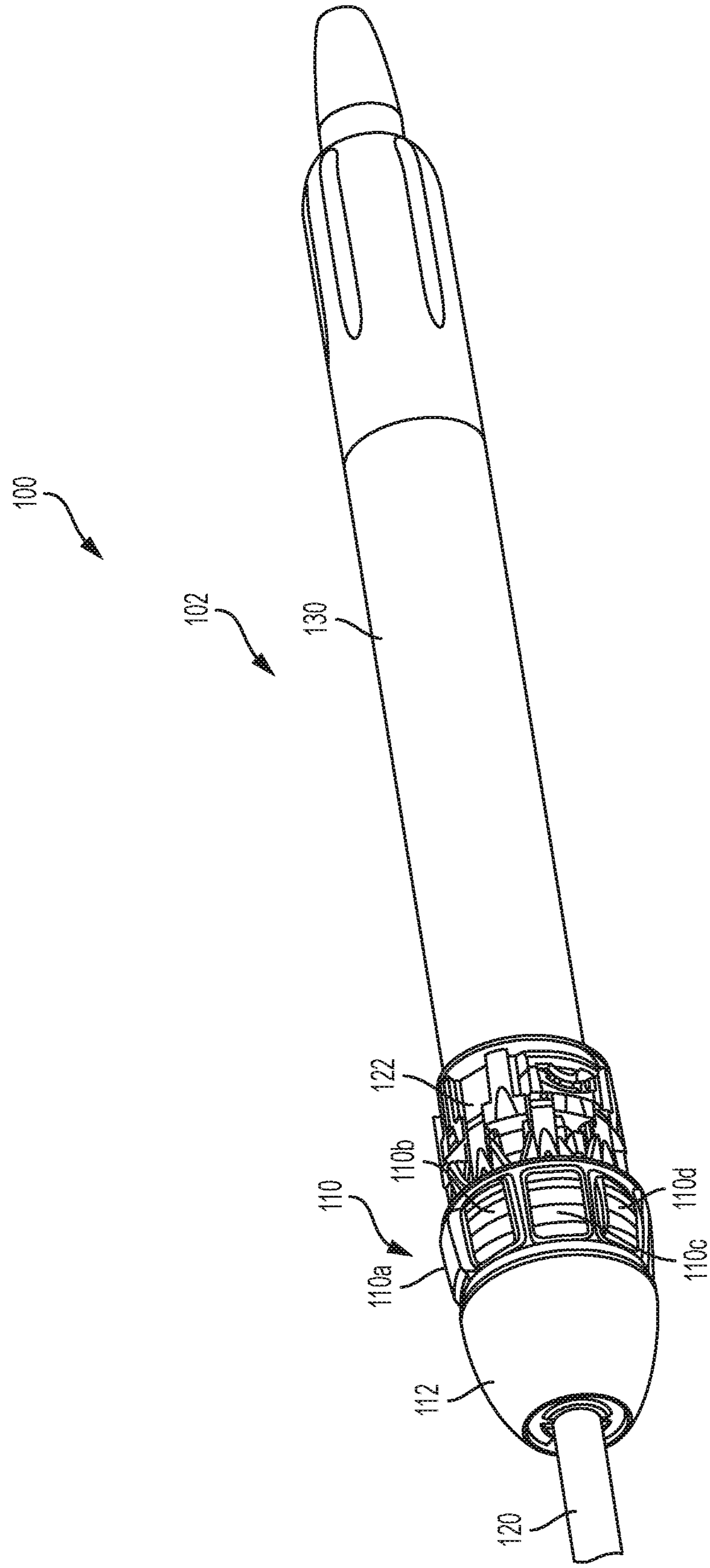

FIG. 3

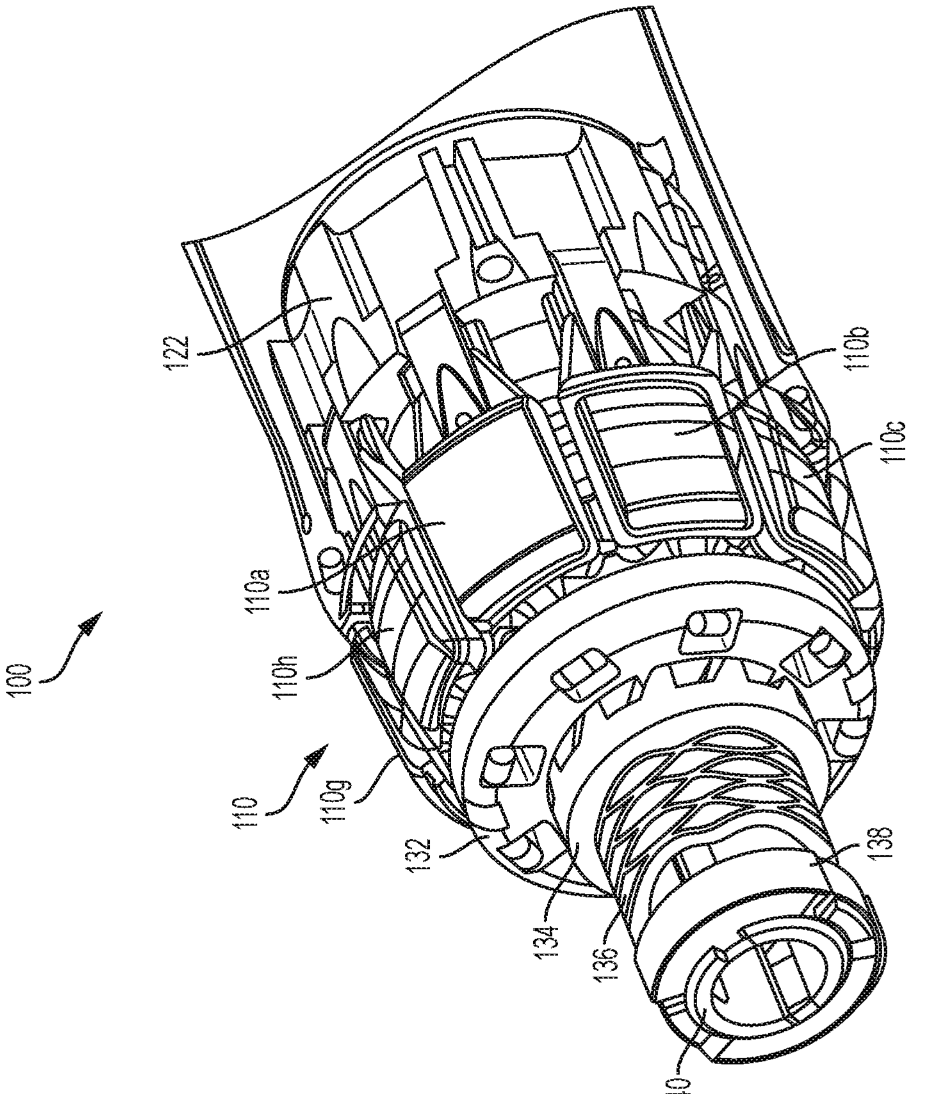

FIG. 4

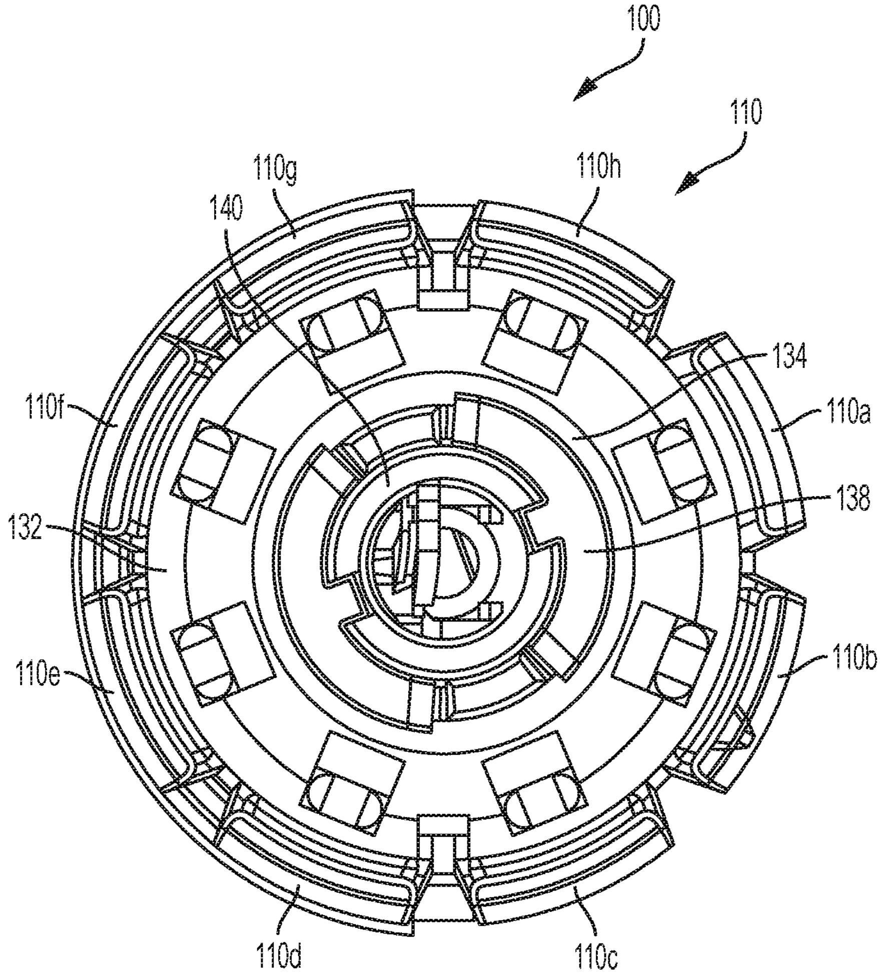
100
110
110g
110h
140
134
110f
110a
138
132
110e
110b
110d
110c

FIG. 5

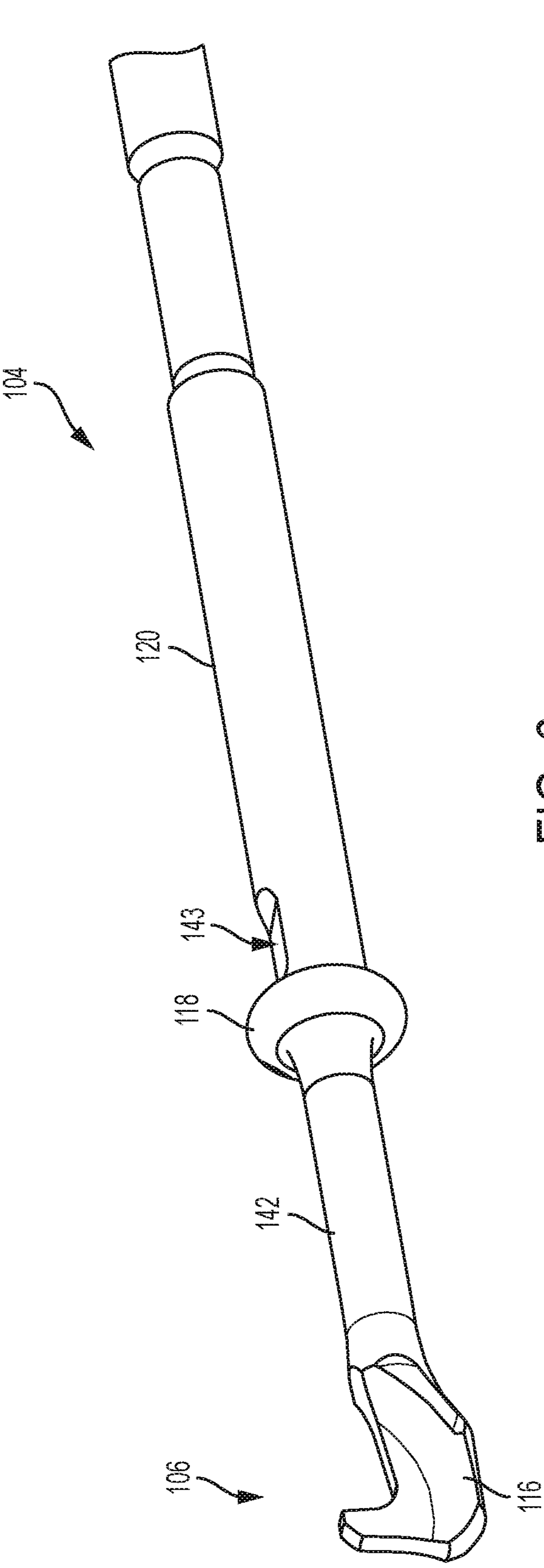

FIG. 6

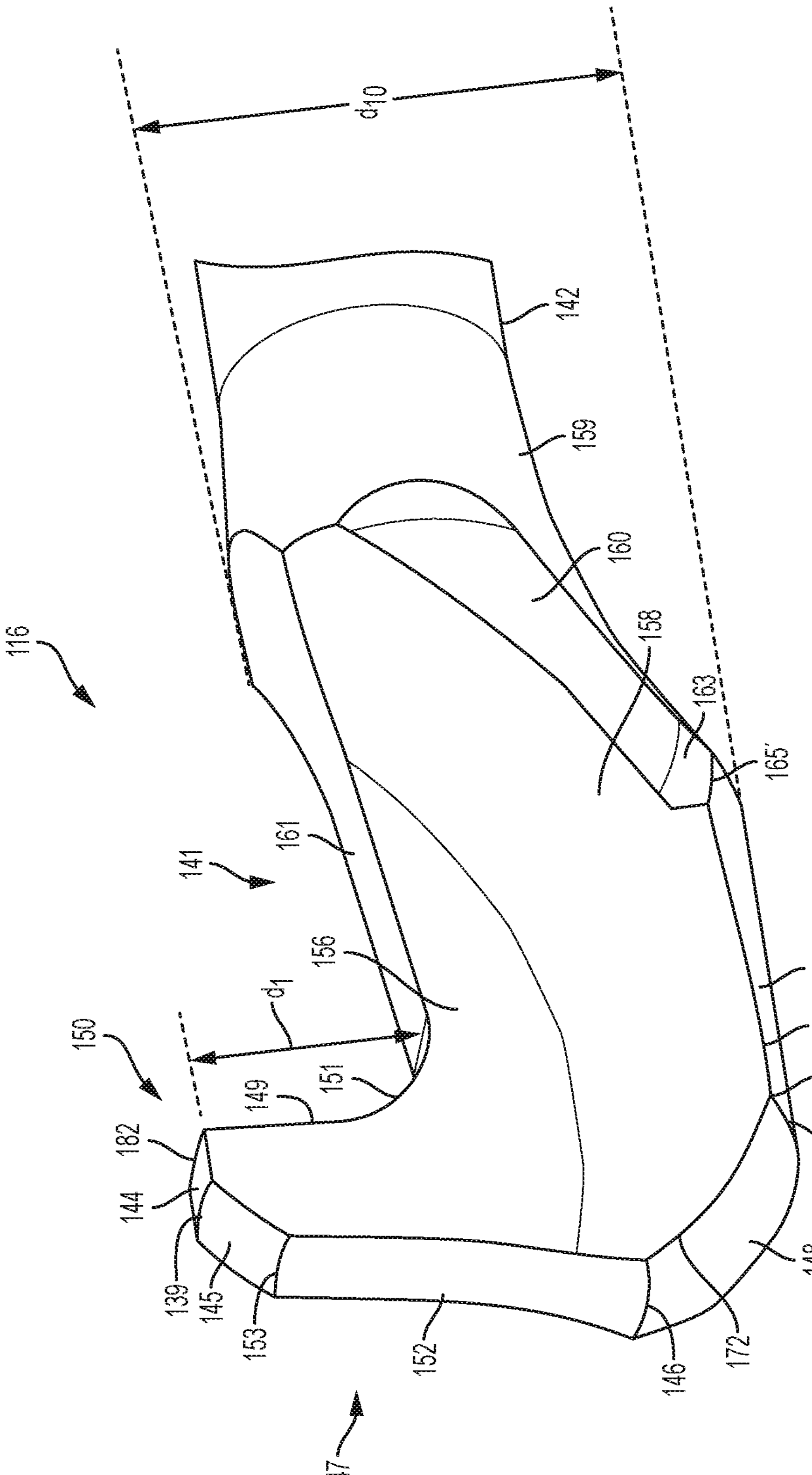
116
d_{10}
142
159
160
158
163
165'
141
161
156
150
d_1
149
151
182
144
139
145
153
152
146
172
148
155
155'
170'
154
147

FIG. 7

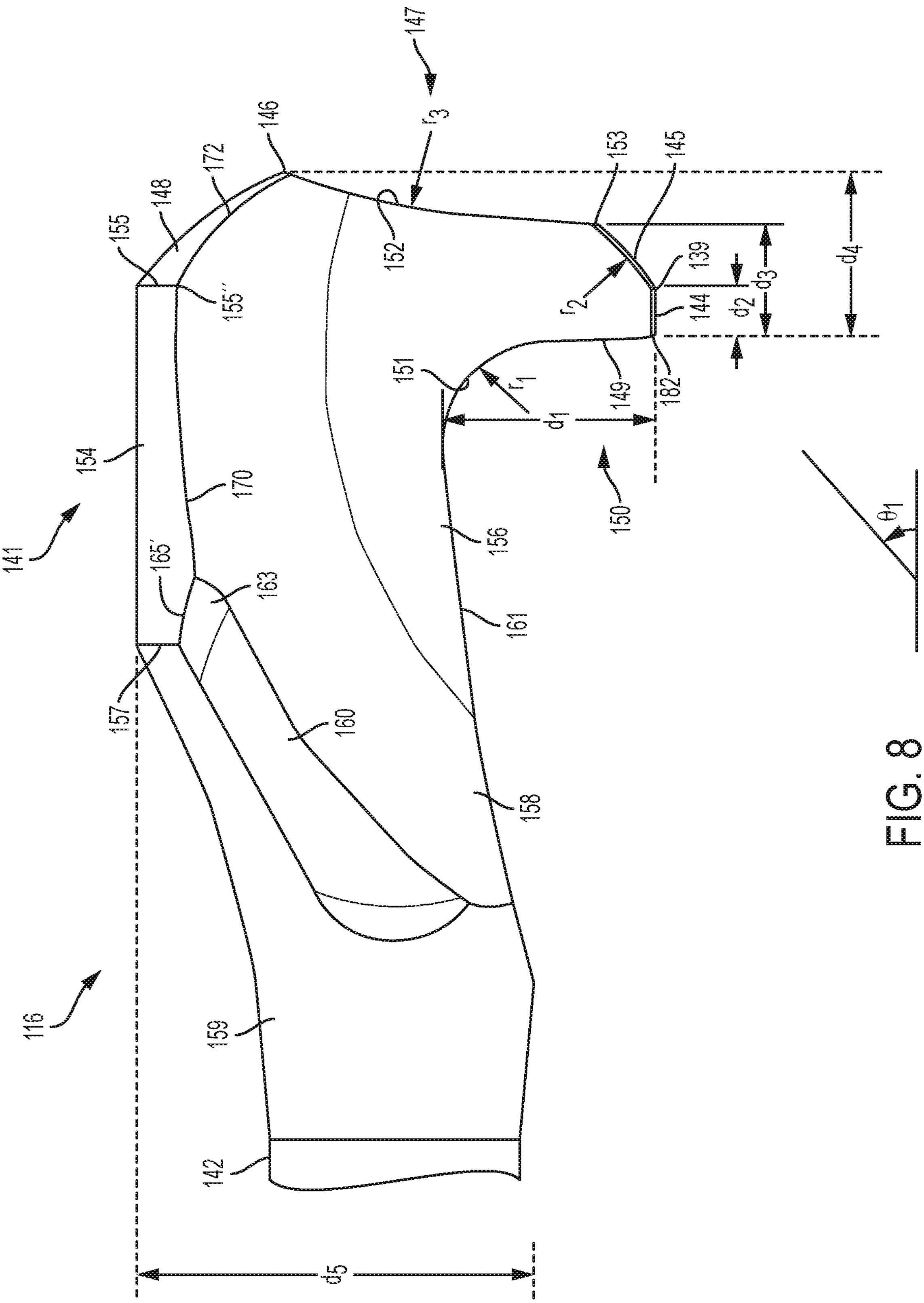
147
146
r_3
172
148
155
155''
152
153
145
139
r_2
144
d_2
d_3
d_4
151
r_1
149
182
d_1
154
170
150
141
165'
163
156
161
θ_1
157
160
158
116
159
142
d_5

FIG. 8

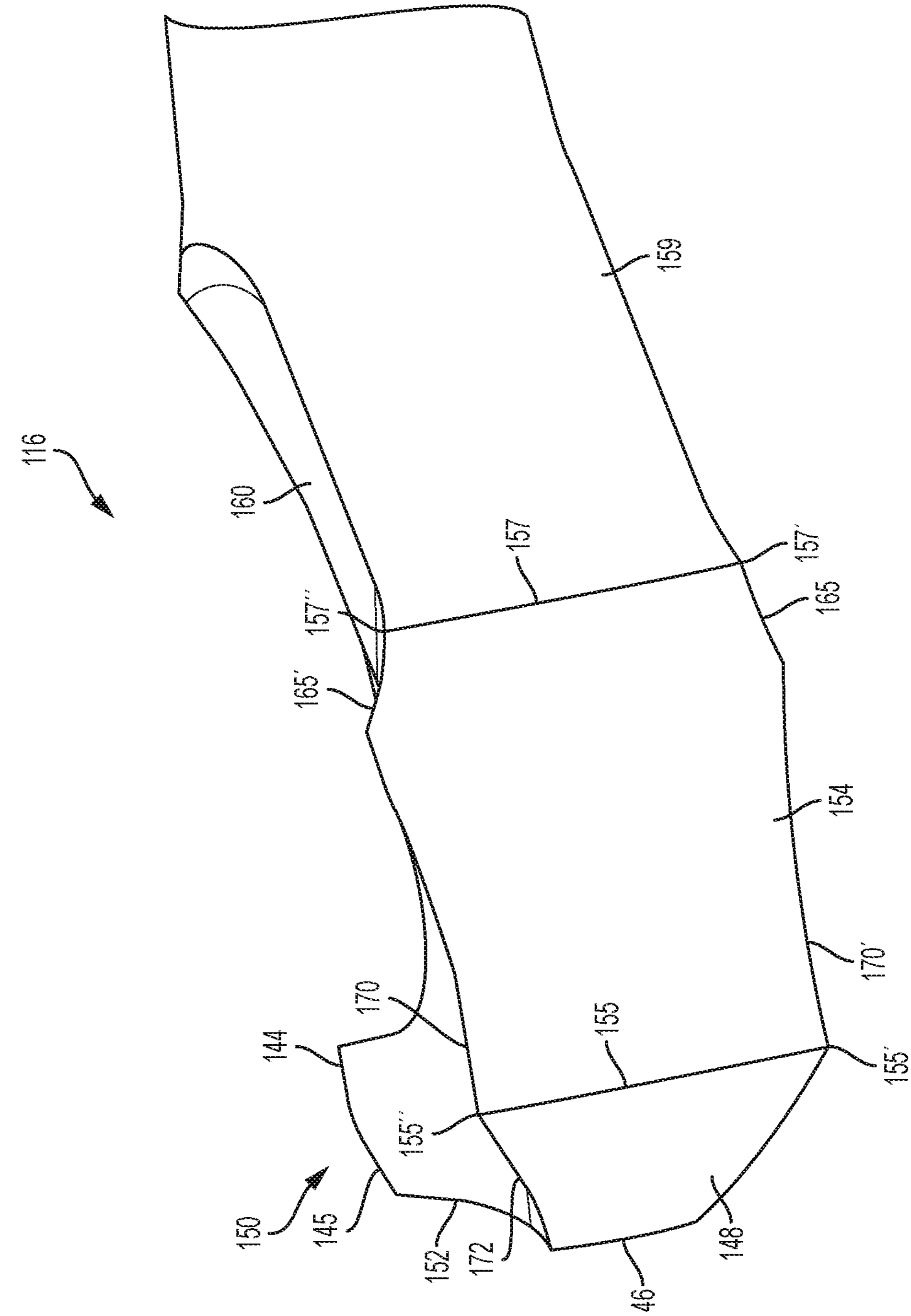
116
159
160
157
157'
157''
165
165'
154
170
170'
155
155'
155''
144
145
150
152
172
146
148

FIG. 9

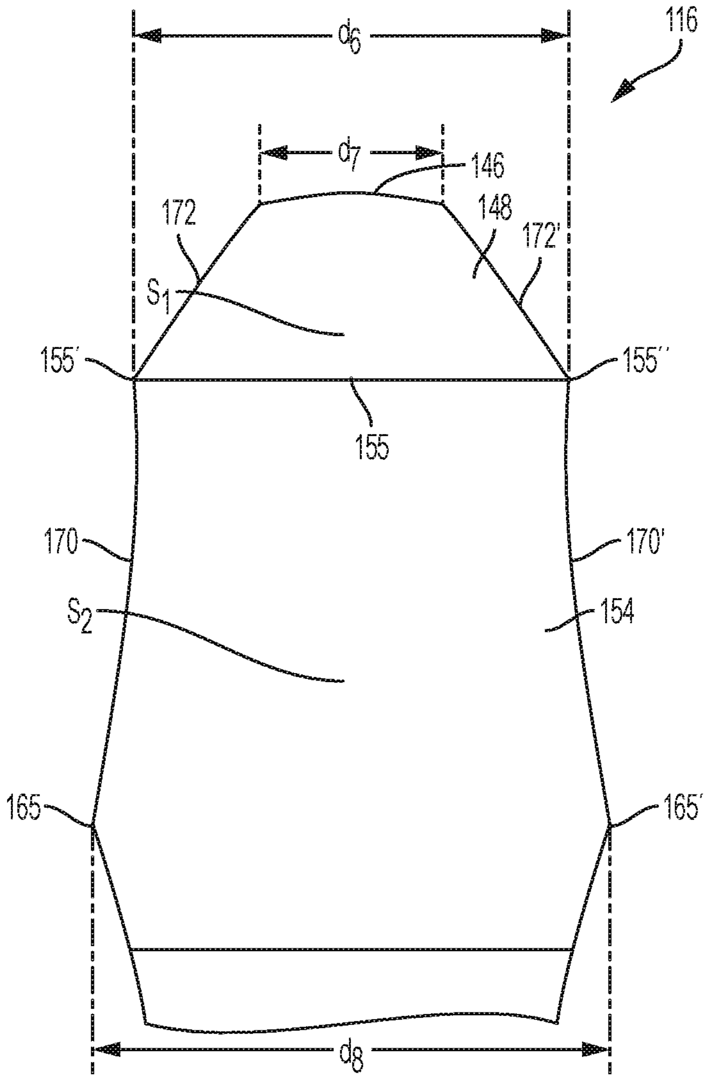

FIG. 10

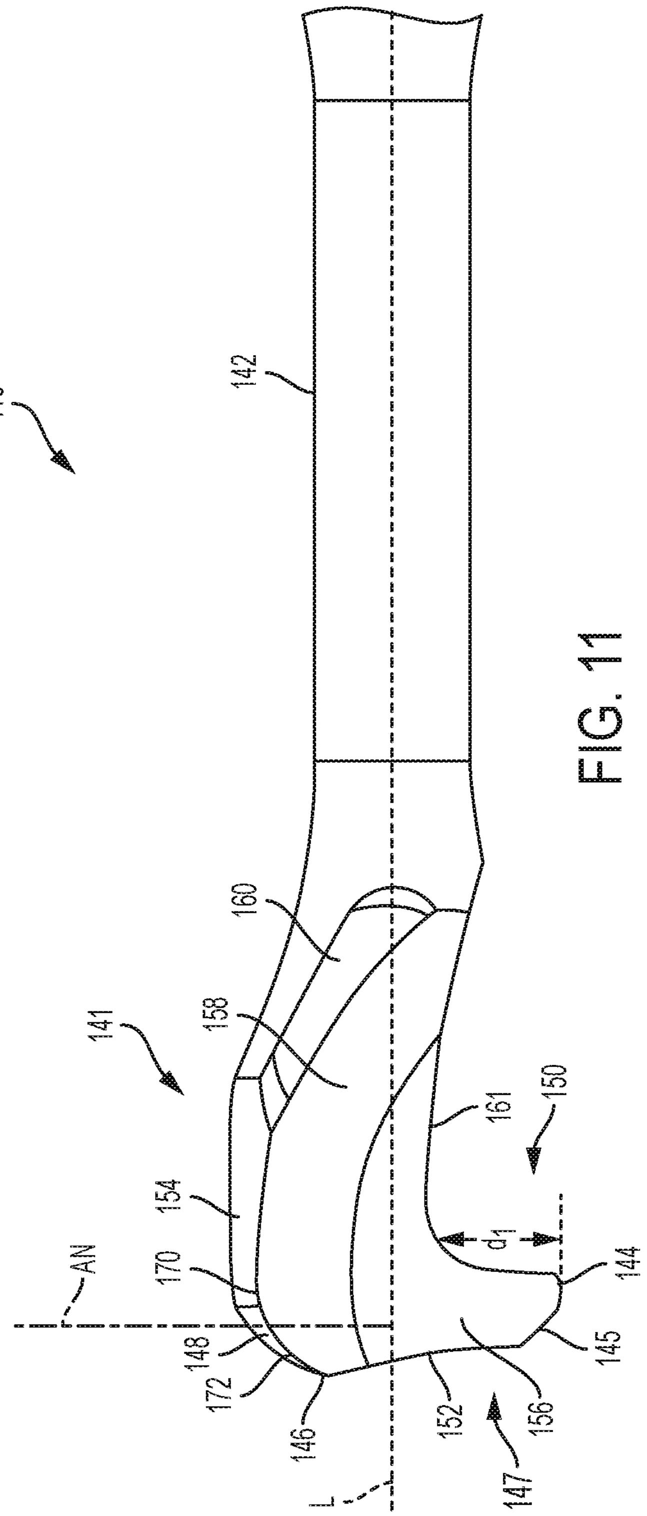
116
142
141
160
158
154
170
AN
148
172
146
L
152
147
156
145
144
d1
161
150

FIG. 11

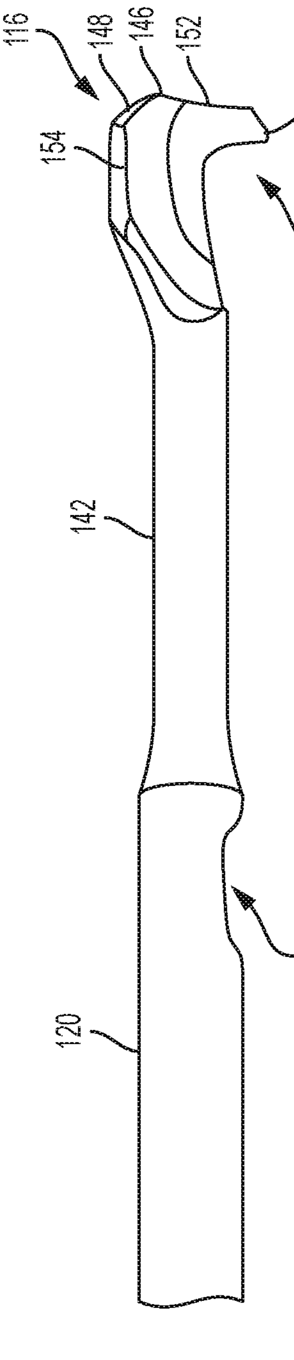

FIG. 12

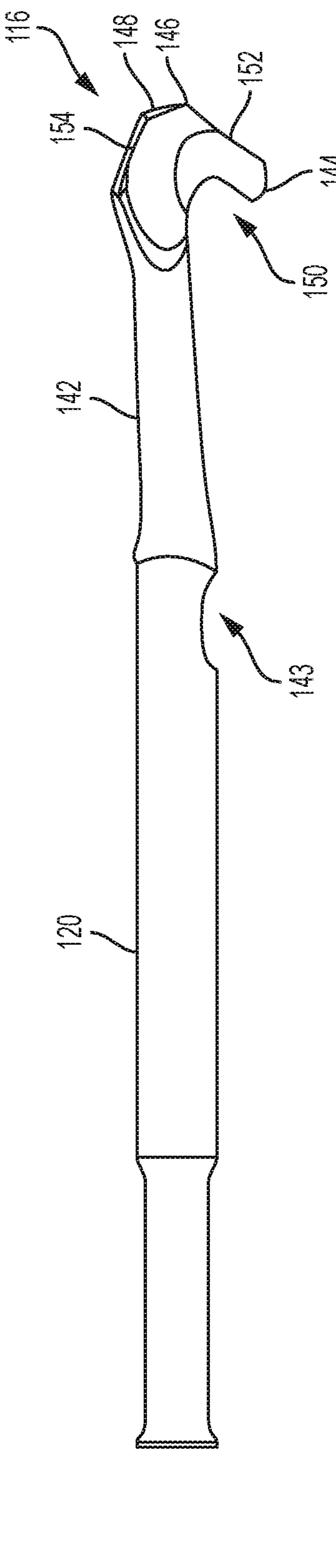

FIG. 13

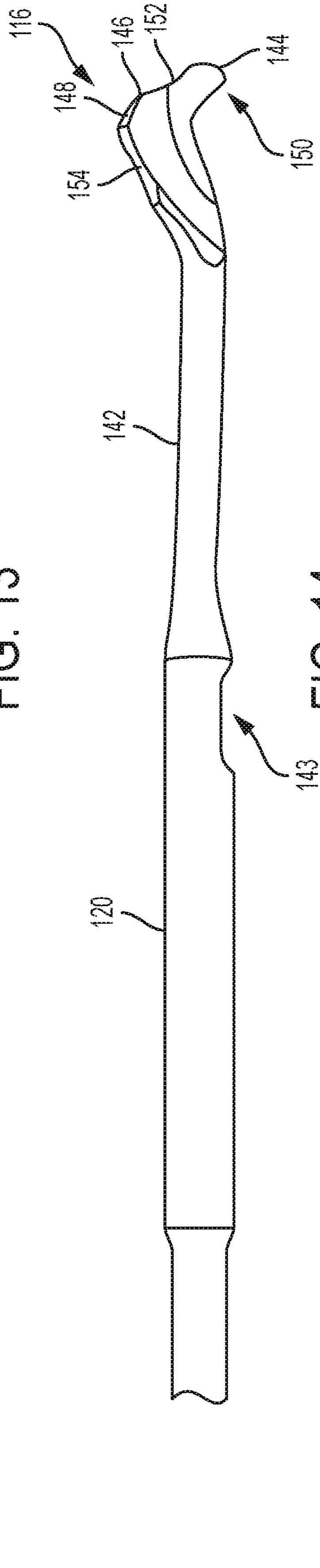

FIG. 14

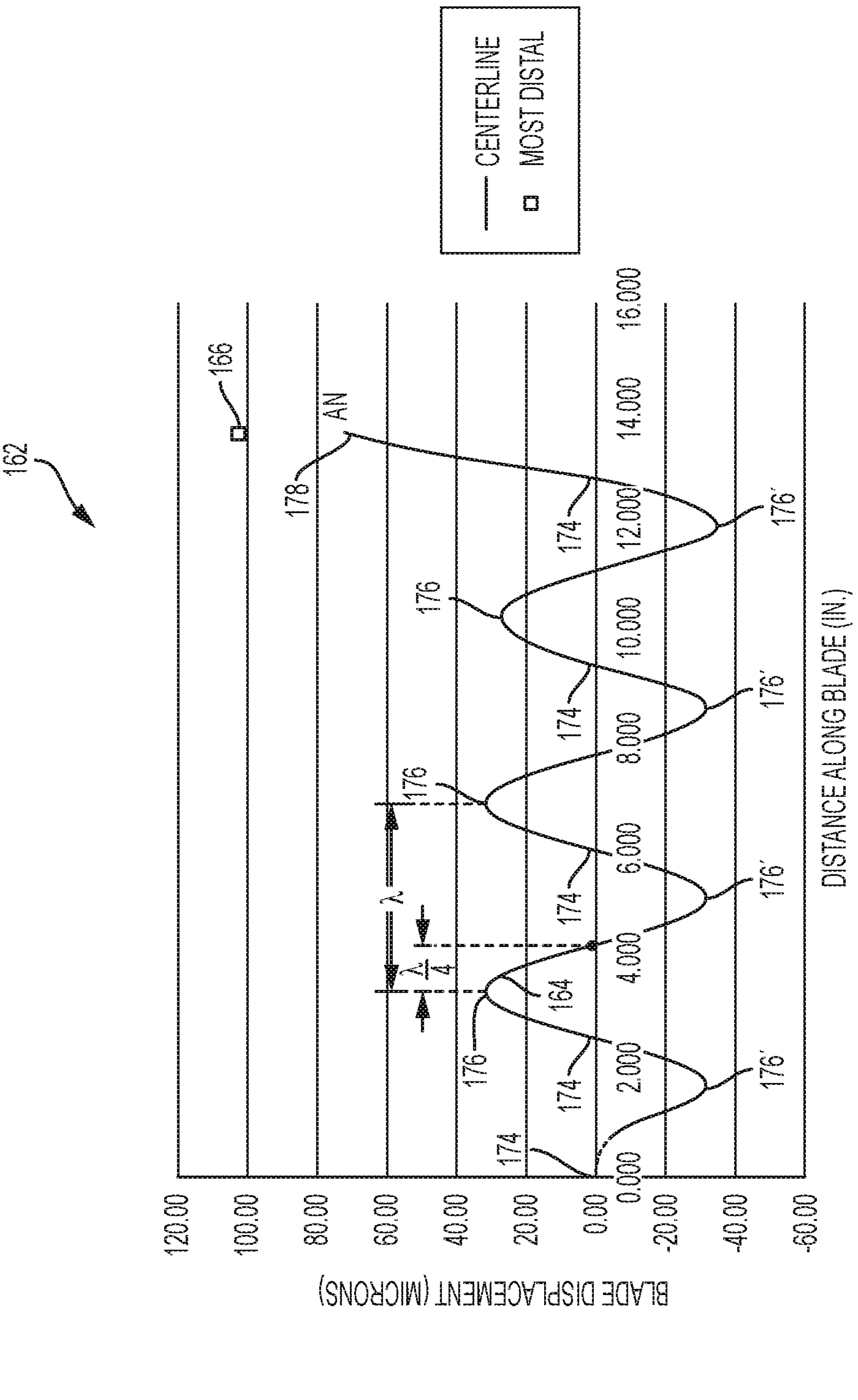
162
CENTERLINE
MOST DISTAL
166
AN
178
174
176
176′
164
λ
λ/4
120.00
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
-40.00
-60.00
BLADE DISPLACEMENT (MICRONS)
0.000
2.000
4.000
6.000
8.000
10.000
12.000
14.000
16.000
DISTANCE ALONG BLADE (IN.)

FIG. 15

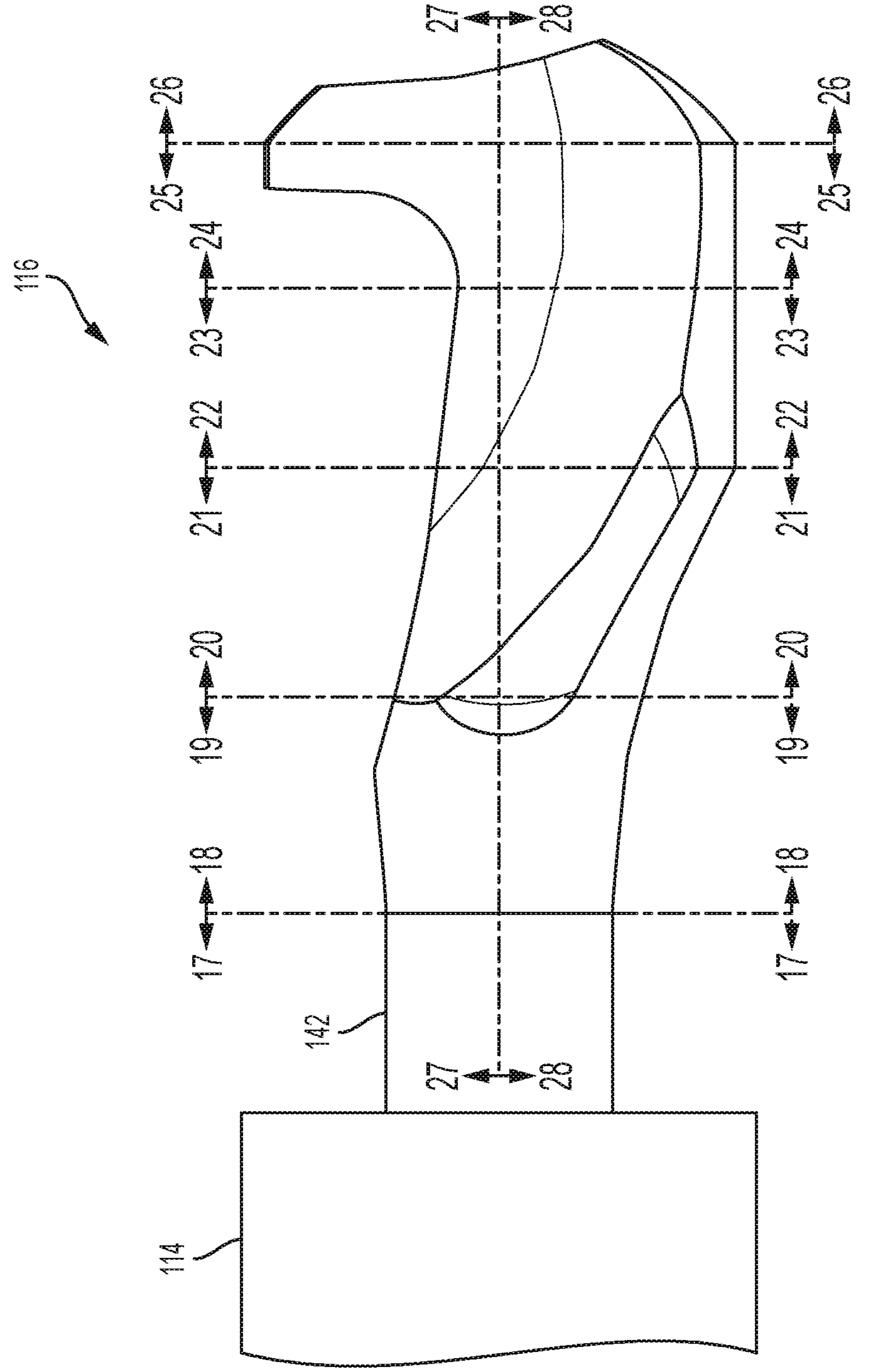

FIG. 16

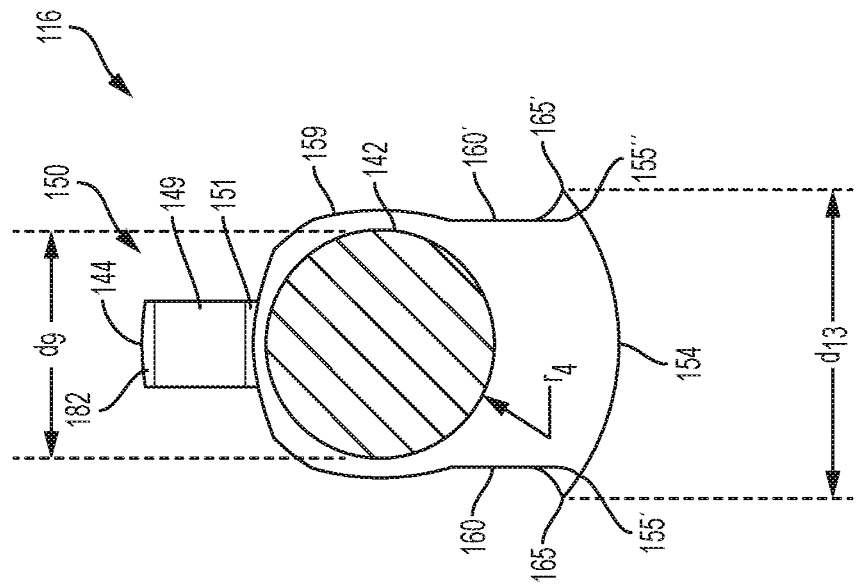
116
150
149
151
144
182
159
142
160'
165'
155''
154
160
165
155'
d_9
d_{13}
r_4

FIG. 18

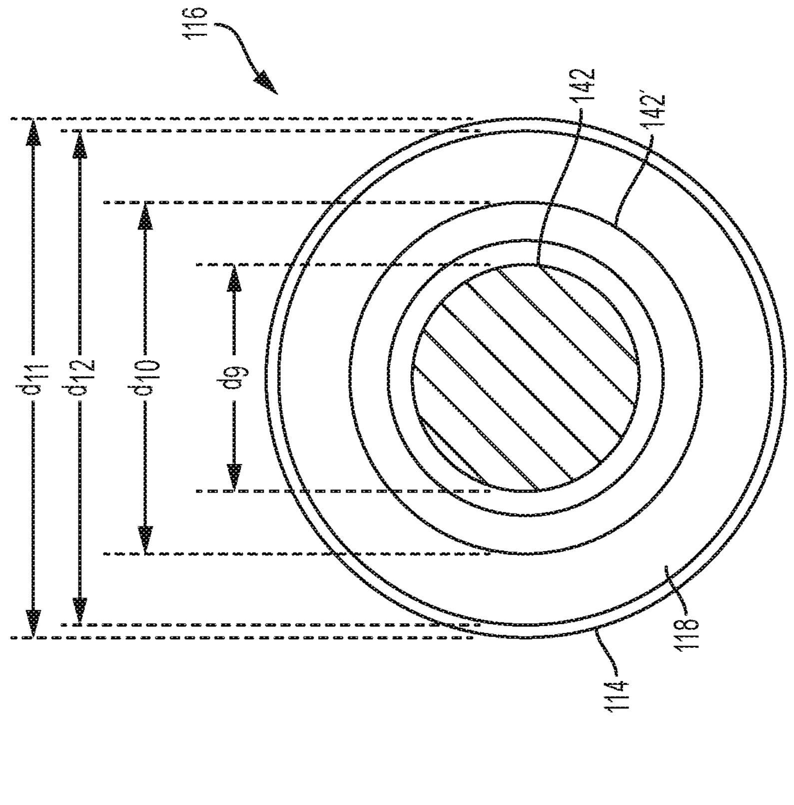
116
142
142'
118
114
d_{11}
d_{12}
d_{10}
d_9

FIG. 17

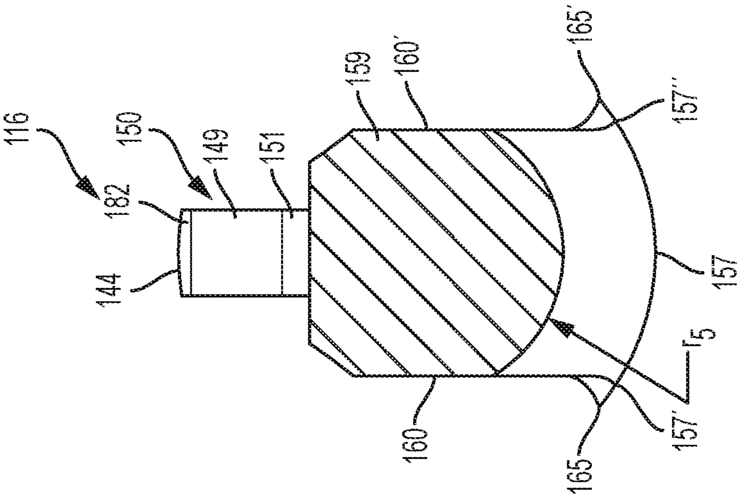
116
150
149
151
182
144
159
160′
165′
157′′
157
r_5
157′
165
160

FIG. 20

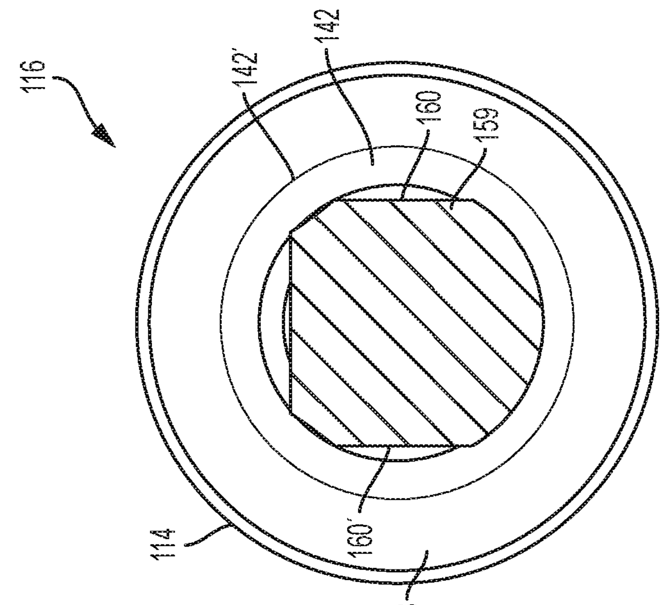
116
142′
142
160
159
114
160′
118

FIG. 19

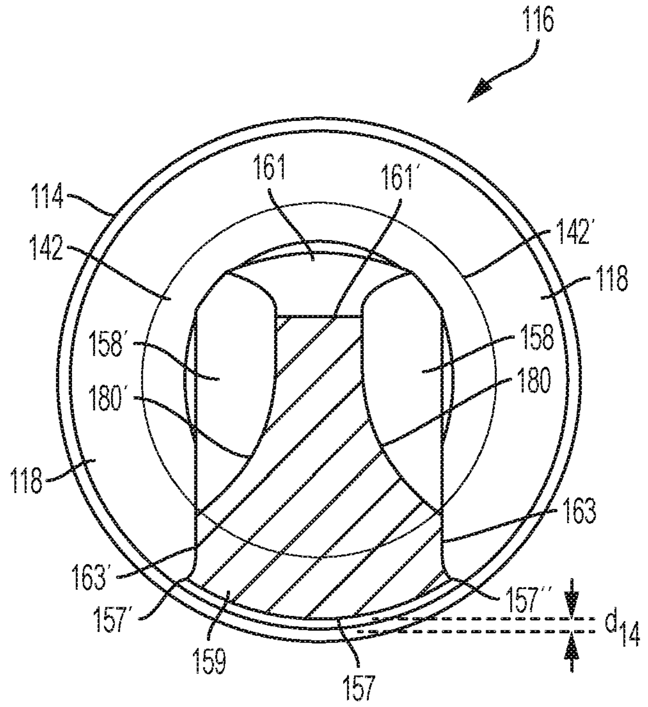
116
161
161′
114
142
142′
118
158′
158
180′
180
118
163
163′
157′
157′′
d14
159
157

FIG. 21

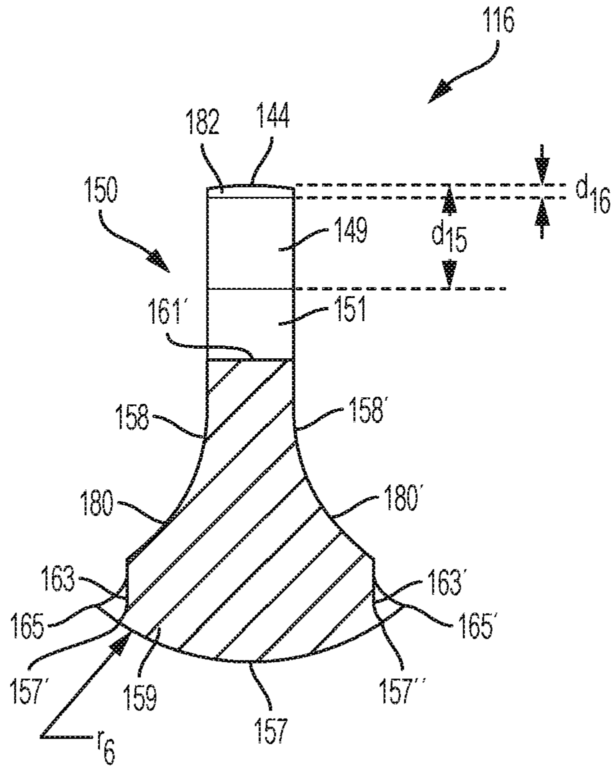
116
182
144
d16
150
149
d15
161′
151
158
158′
180
180′
163
163′
165
165′
157′
159
157
157′′
r6

FIG. 22

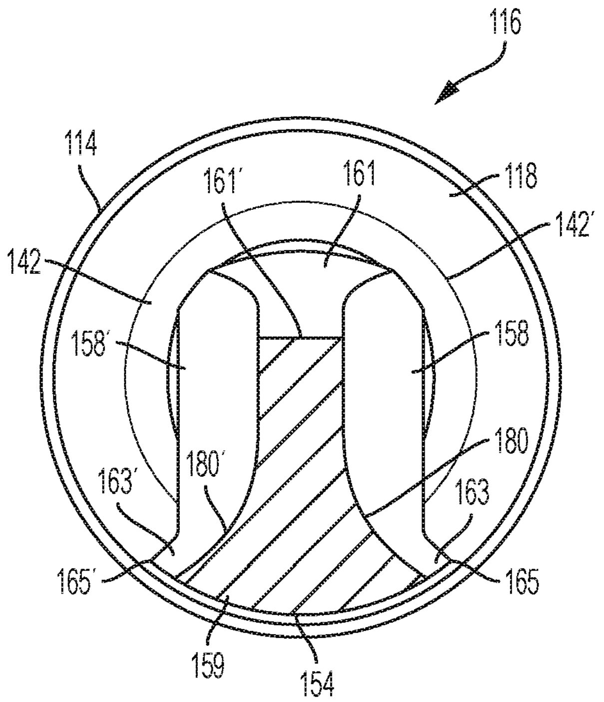
116
114
118
161′
161
142
142′
158′
158
180′
180
163′
163
165′
165
159
154

FIG. 23

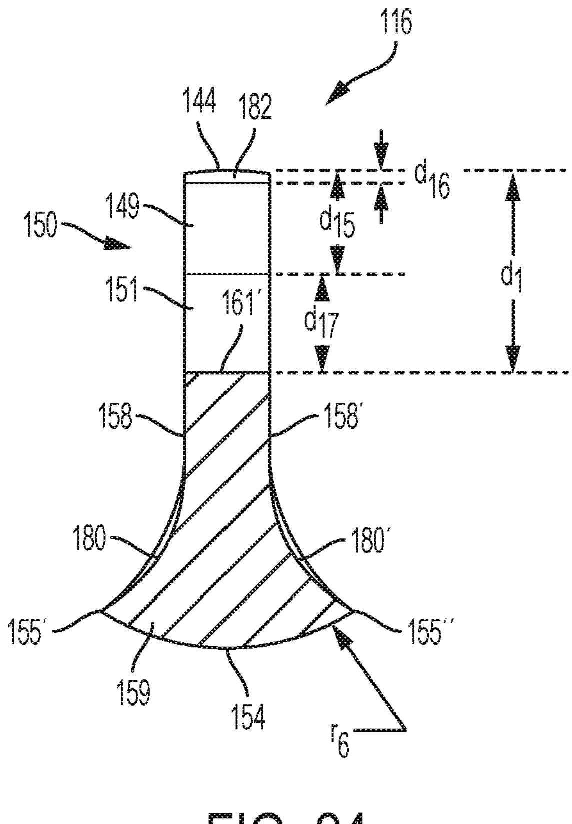
116
144
182
d16
150
149
d15
d1
151
161′
d17
158
158′
180
180′
155′
155′′
159
154
r6

FIG. 24

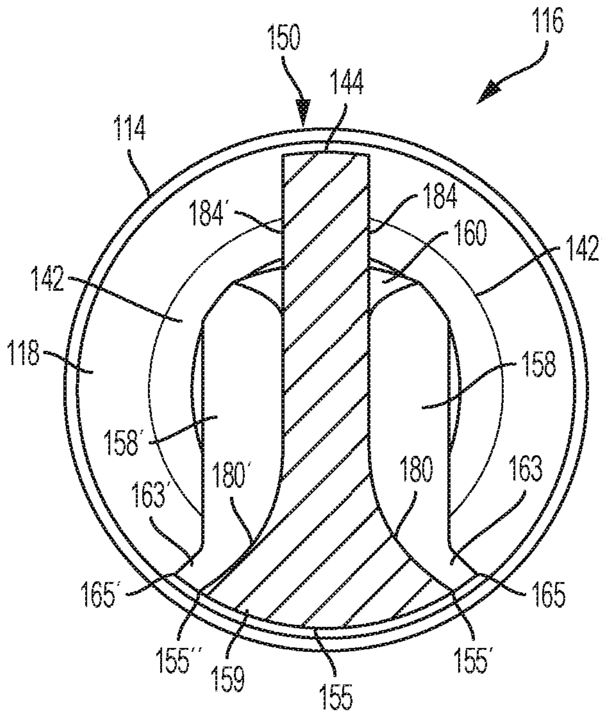
116
150
144
114
184′
184
160
142′
142
118
158
158′
180′
180
163
163′
165′
165
155′′
159
155
155′

FIG. 25

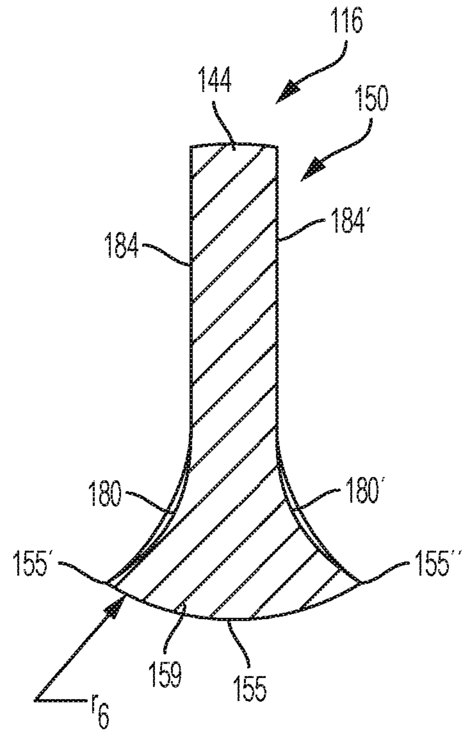
116
144
150
184
184′
180
180′
155′
155′′
159
155
r_6

FIG. 26

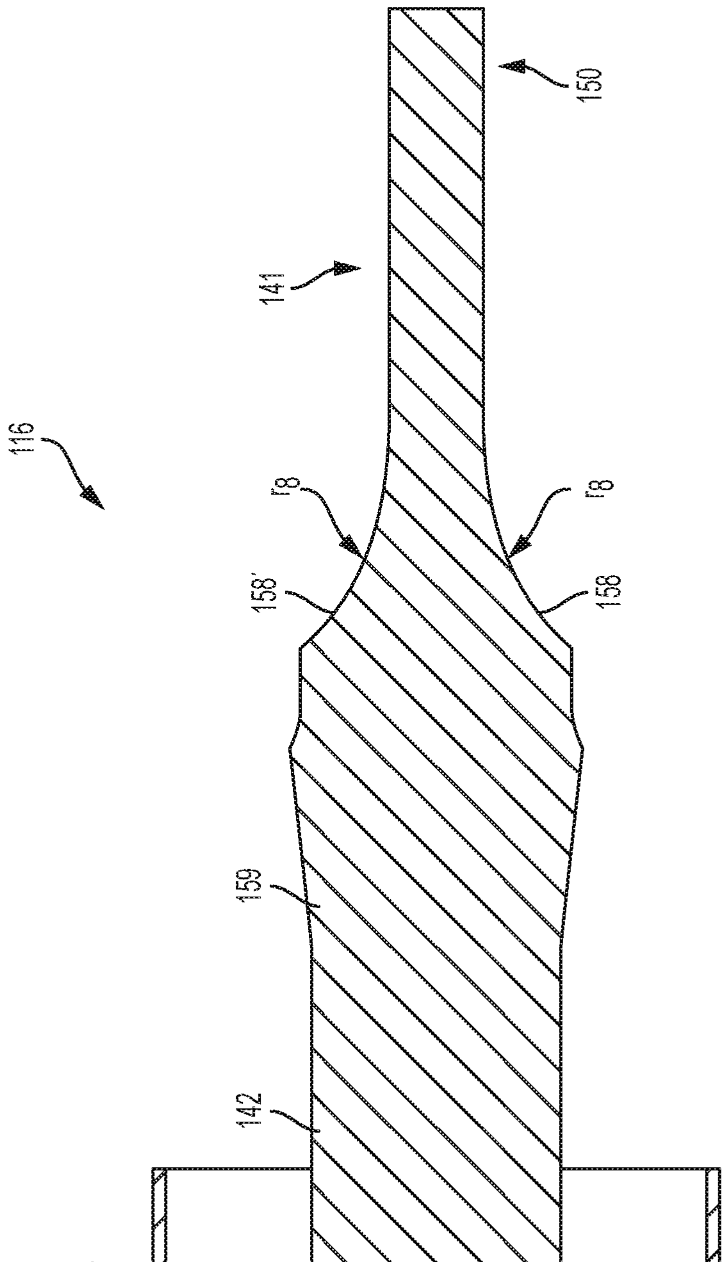

FIG. 27

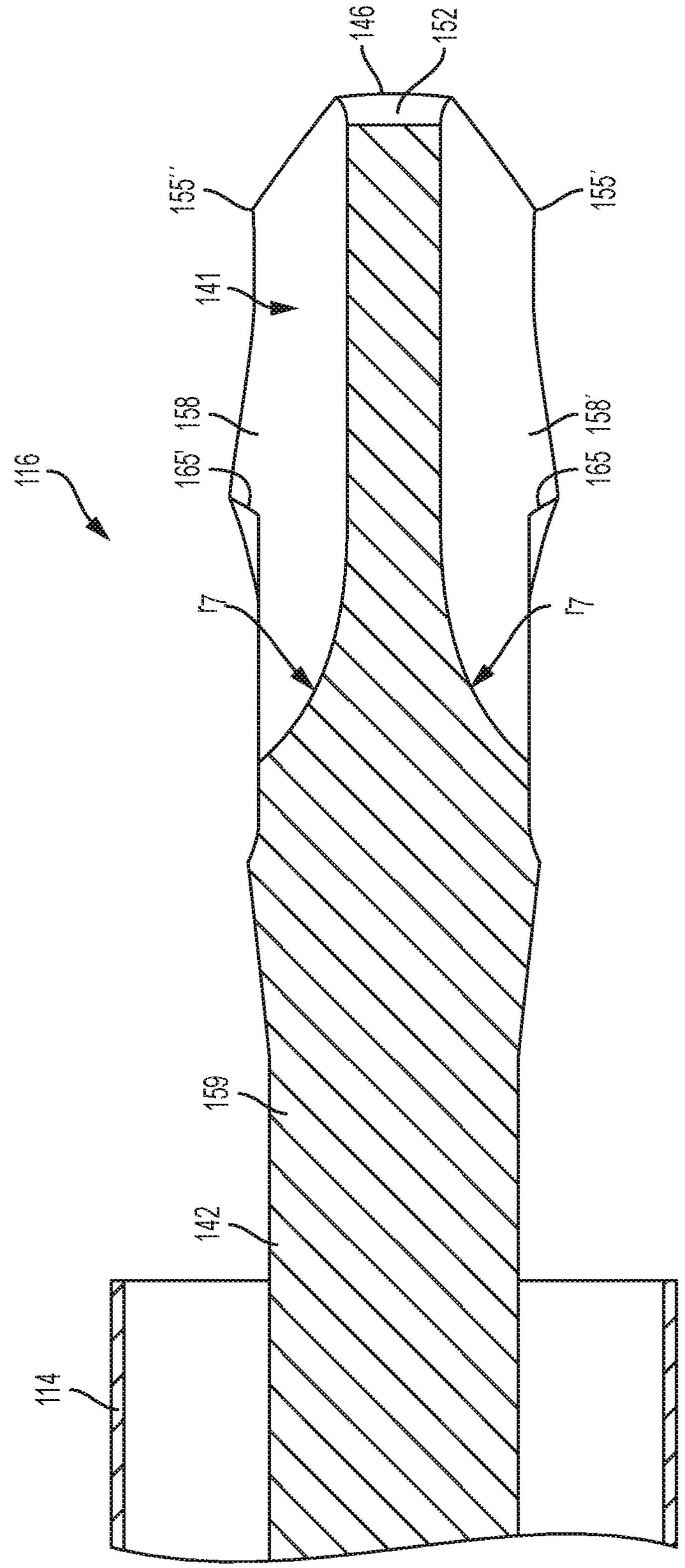

FIG. 28

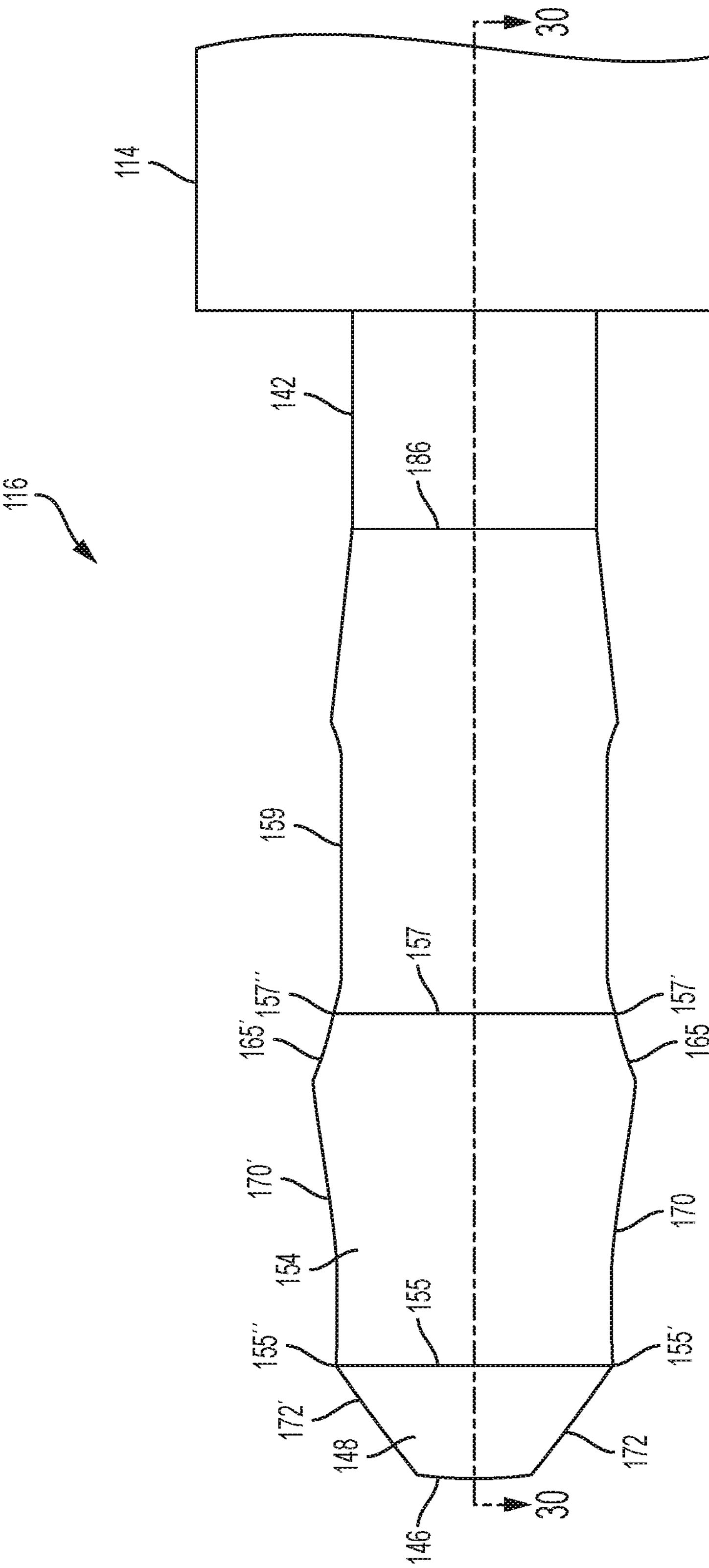
30
114
142
186
116
159
157
157''
157'
165'
165
170'
170
154
155
155''
155'
172'
148
172
146
30

FIG. 29

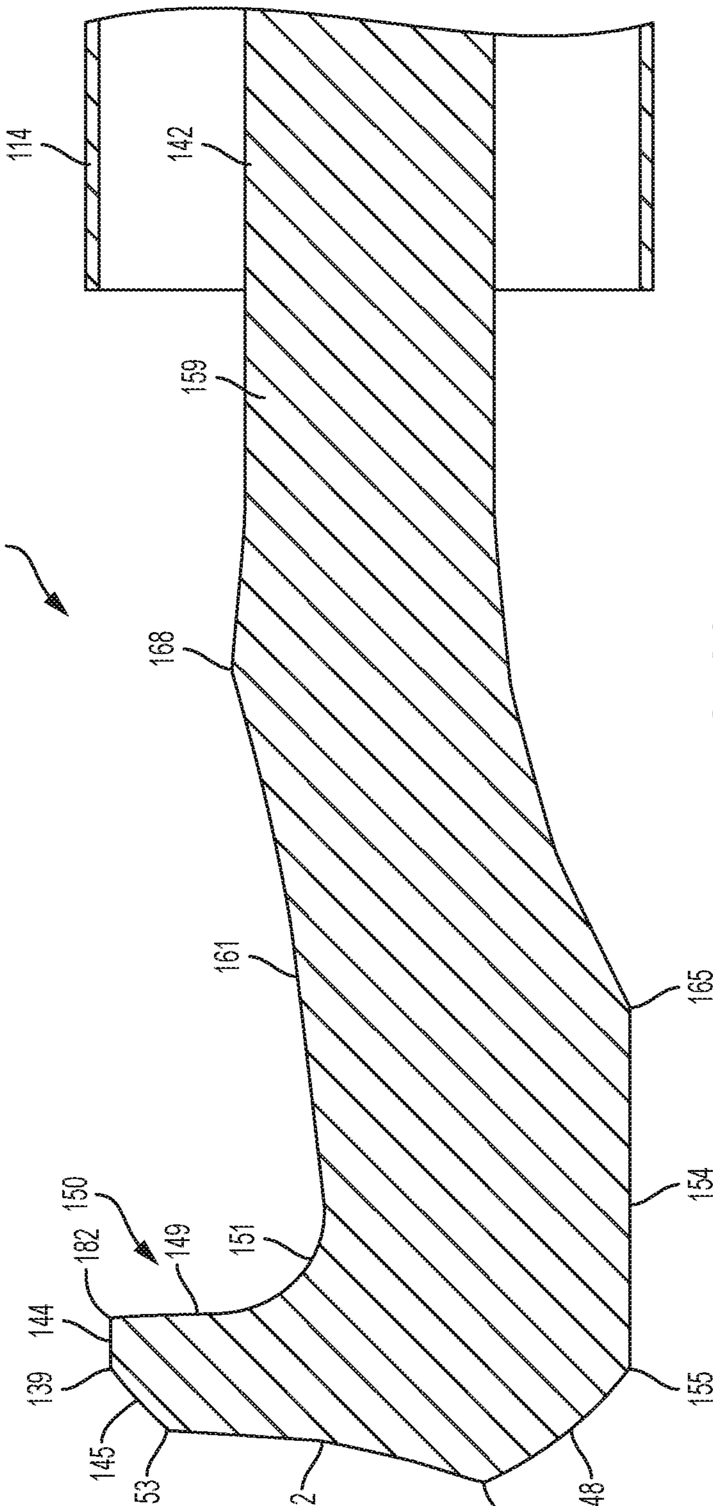
114
142
159
116
168
161
165
154
150
182
149
151
144
139
145
153
152
146
148
155

FIG. 30

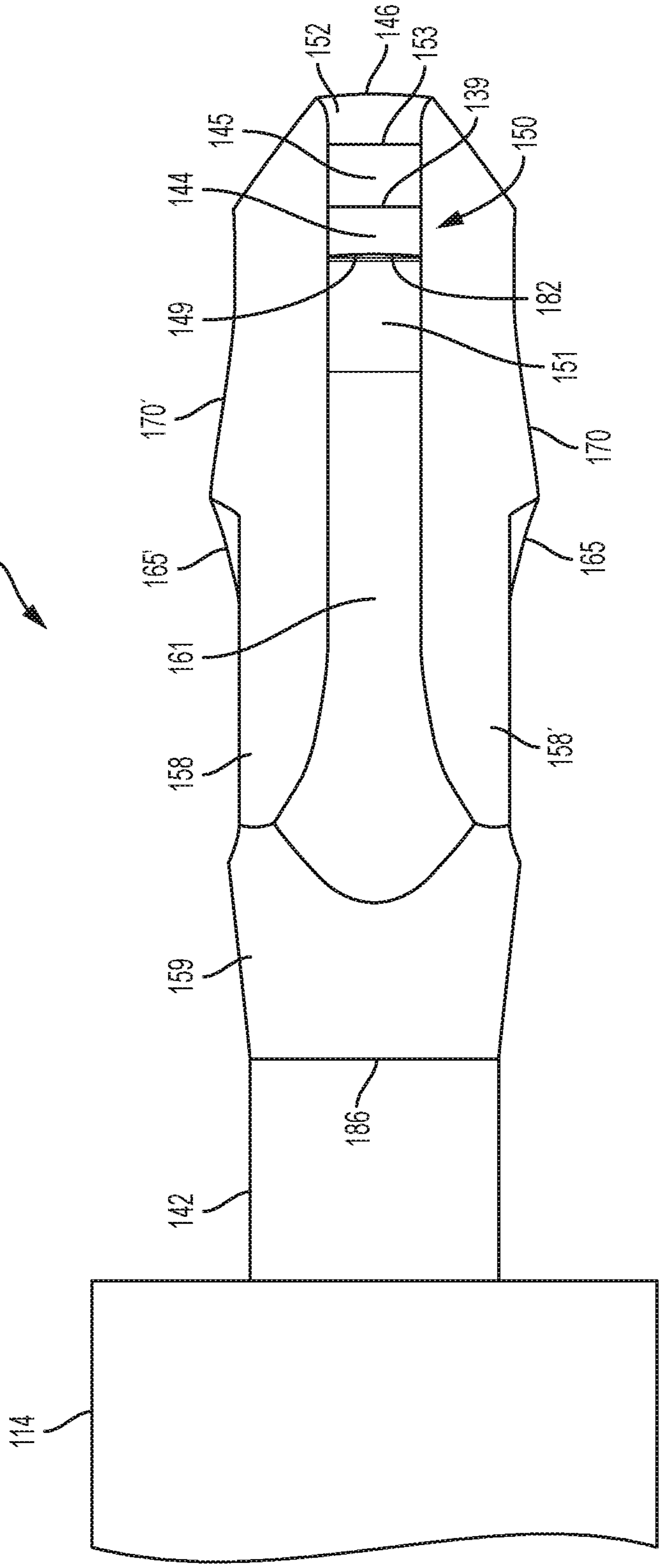
152
146
153
139
150
145
144
149
182
151
170'
170
165'
165
116
161
158
158'
159
186
142
114

FIG. 31

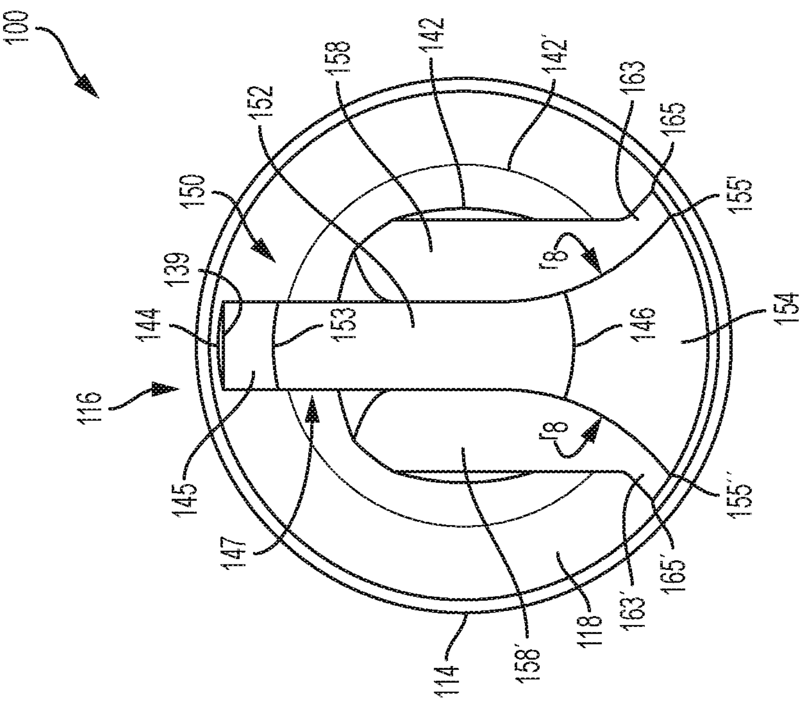
100
116
150
139
144
152
158
142
142'
163
165
155'
r8
153
146
154
r8
145
147
158'
118
163'
165'
155''
114

FIG. 32

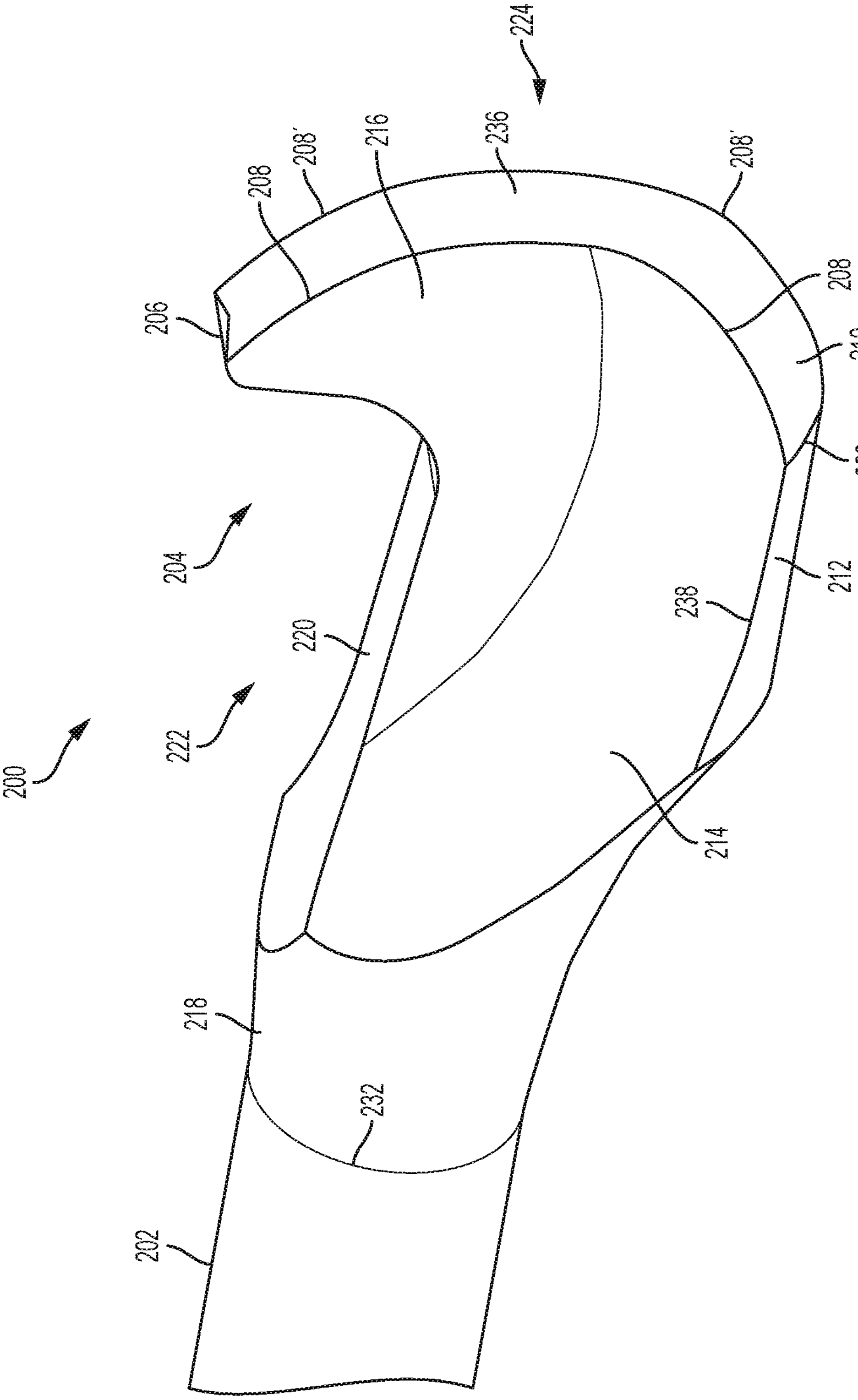
200
202
204
206
208
208'
210
212
214
216
218
220
222
224
226
232
236
238

FIG. 33

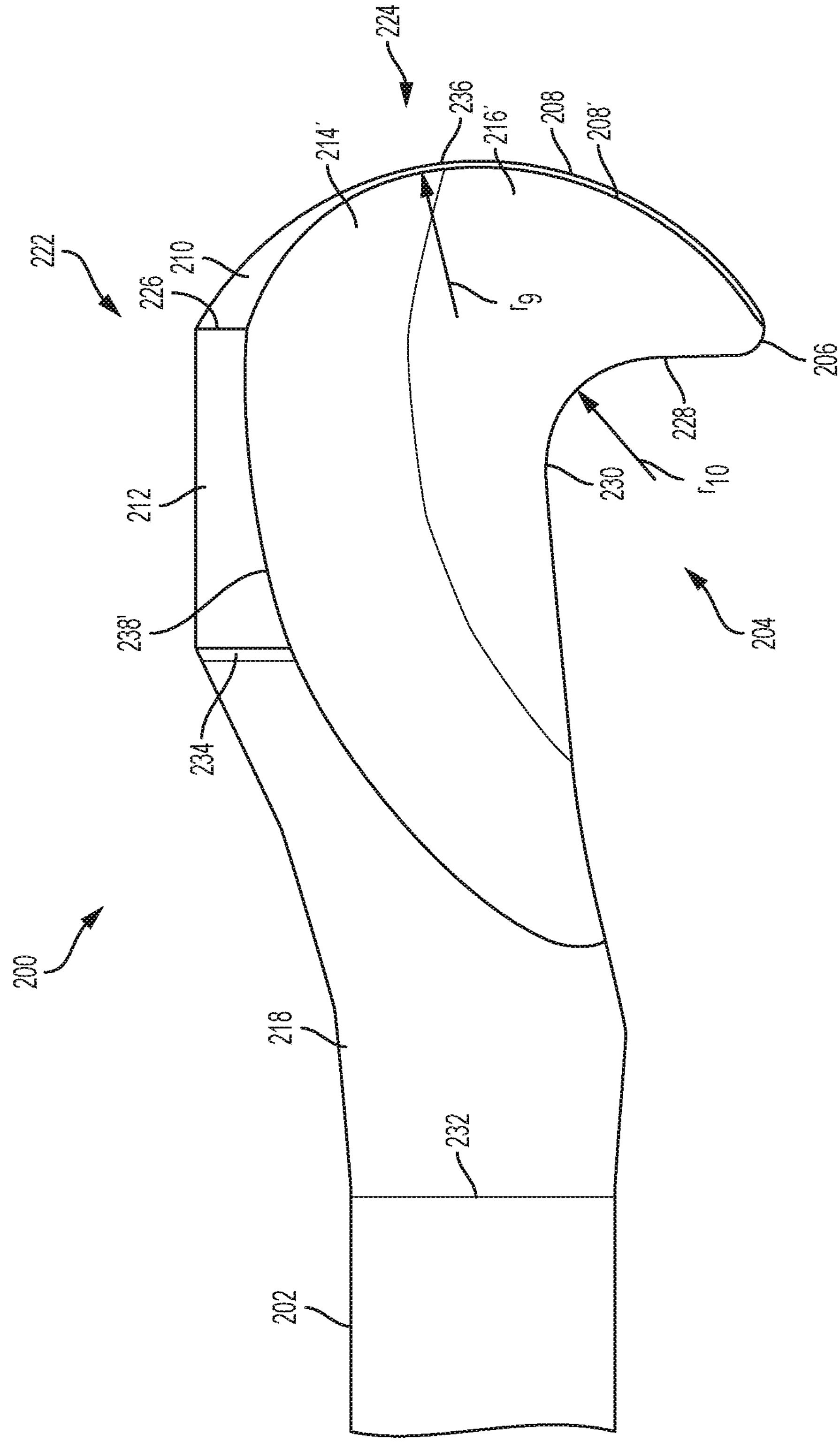
200
202
204
206
208
208'
210
212
214'
216'
218
222
224
226
228
230
232
234
236
238'
r9
r10

FIG. 34

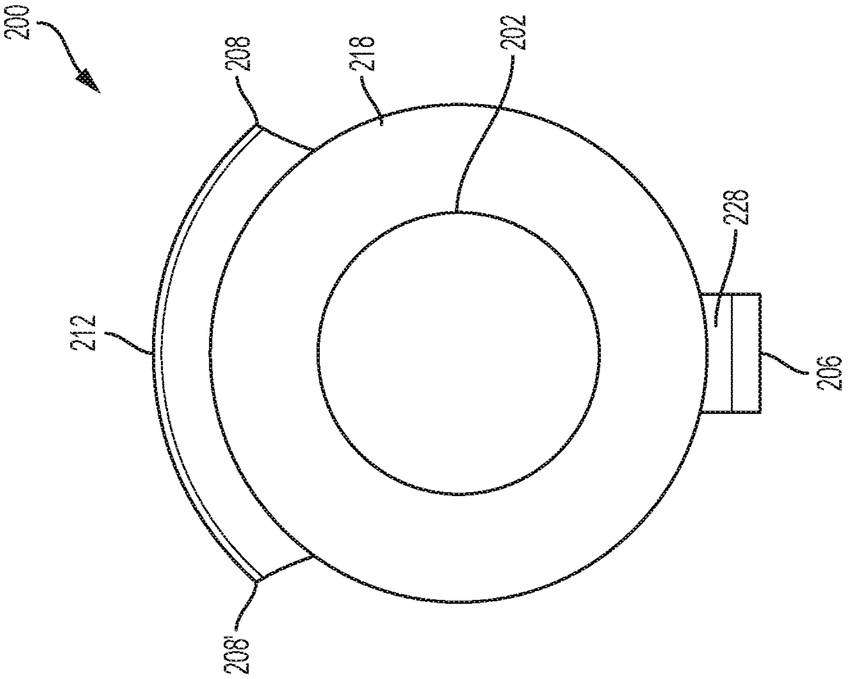

FIG. 35

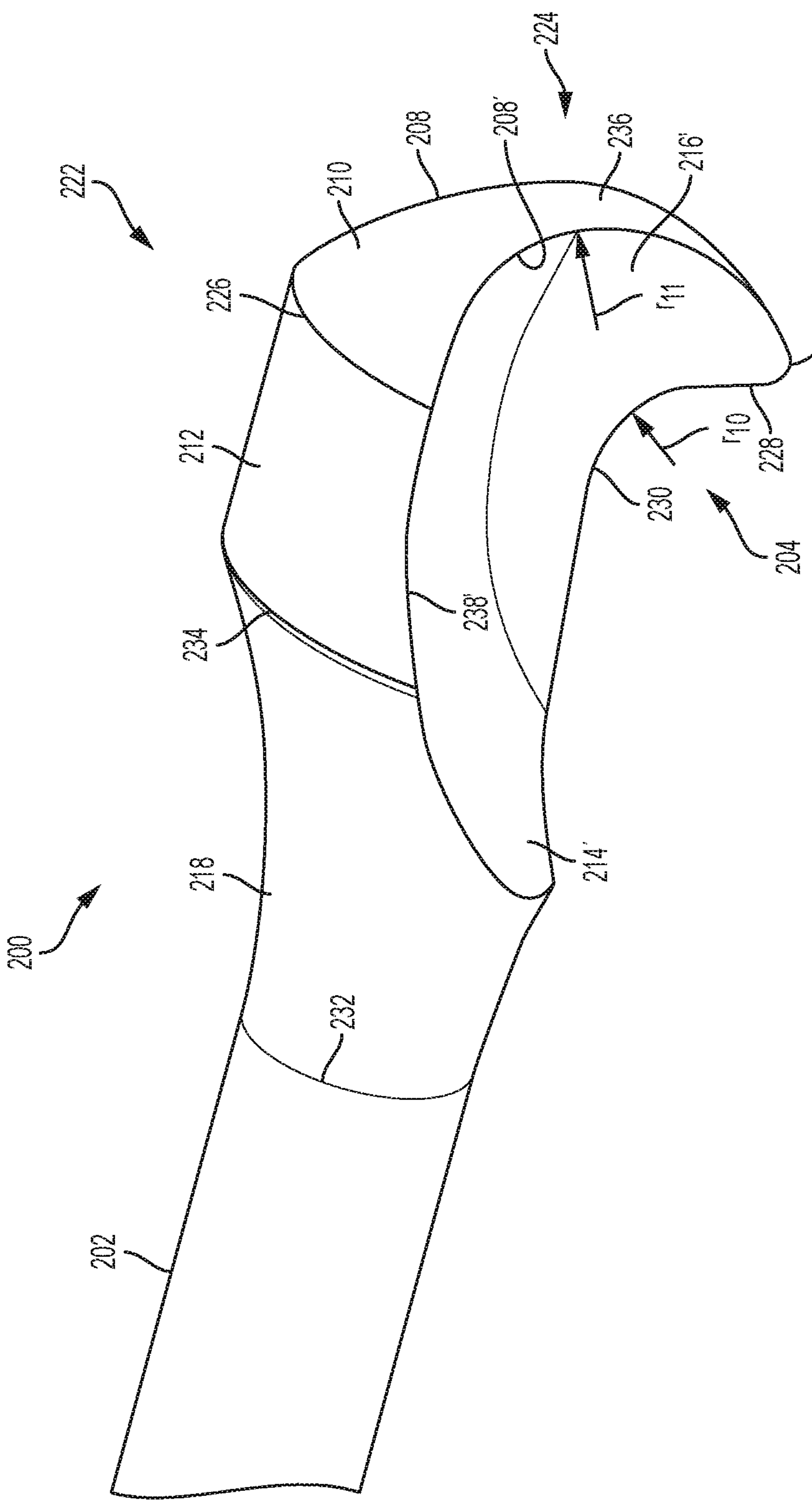
224
222
208
208'
236
216'
210
226
r_{11}
206
r_{10}
228
212
230
204
238'
234
214'
218
200
232
202

FIG. 36

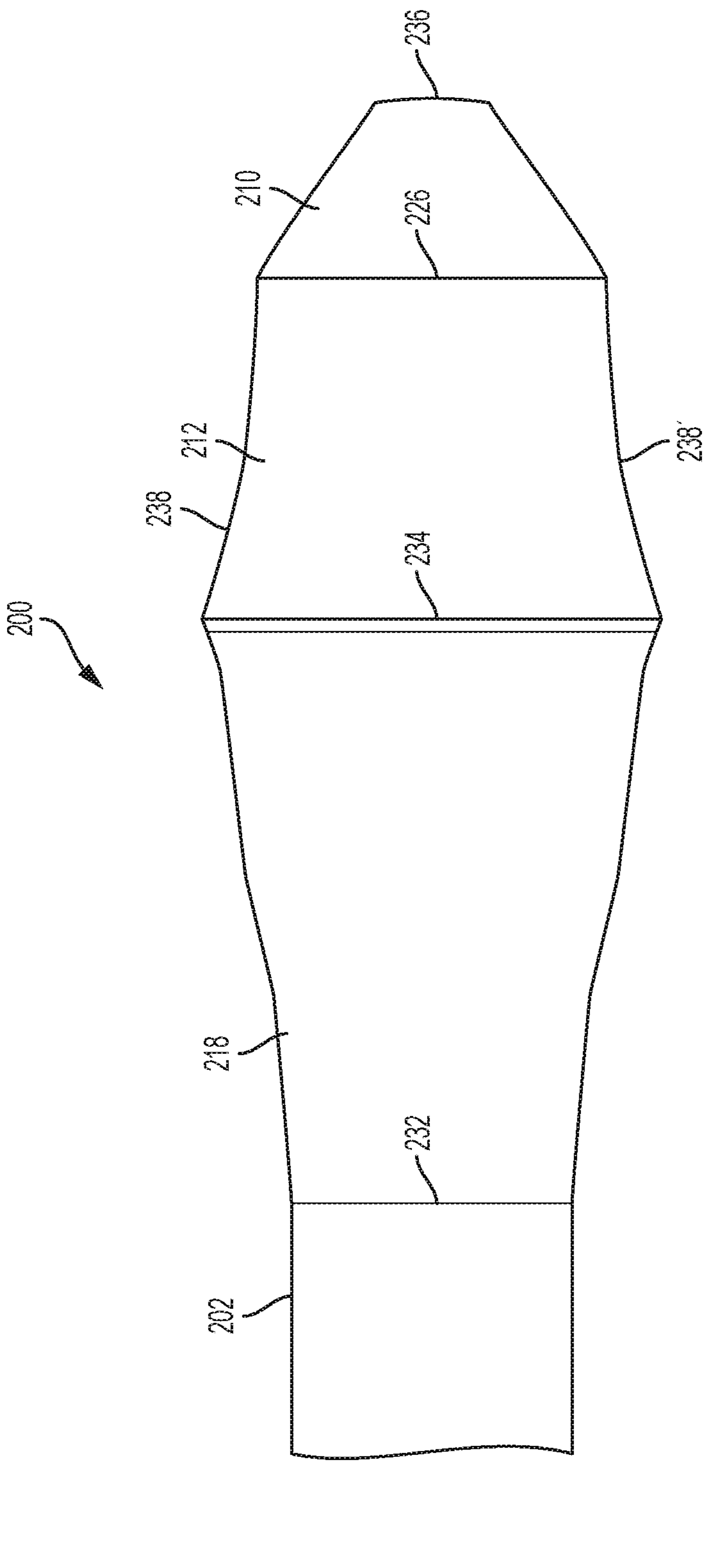

FIG. 37

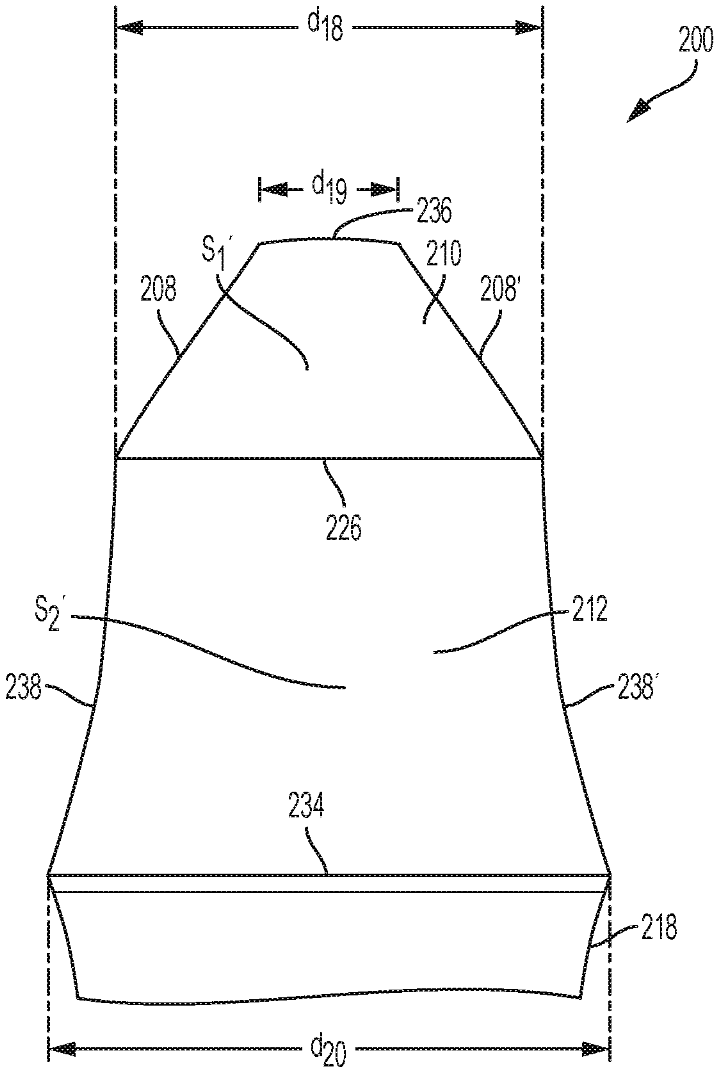

FIG. 38

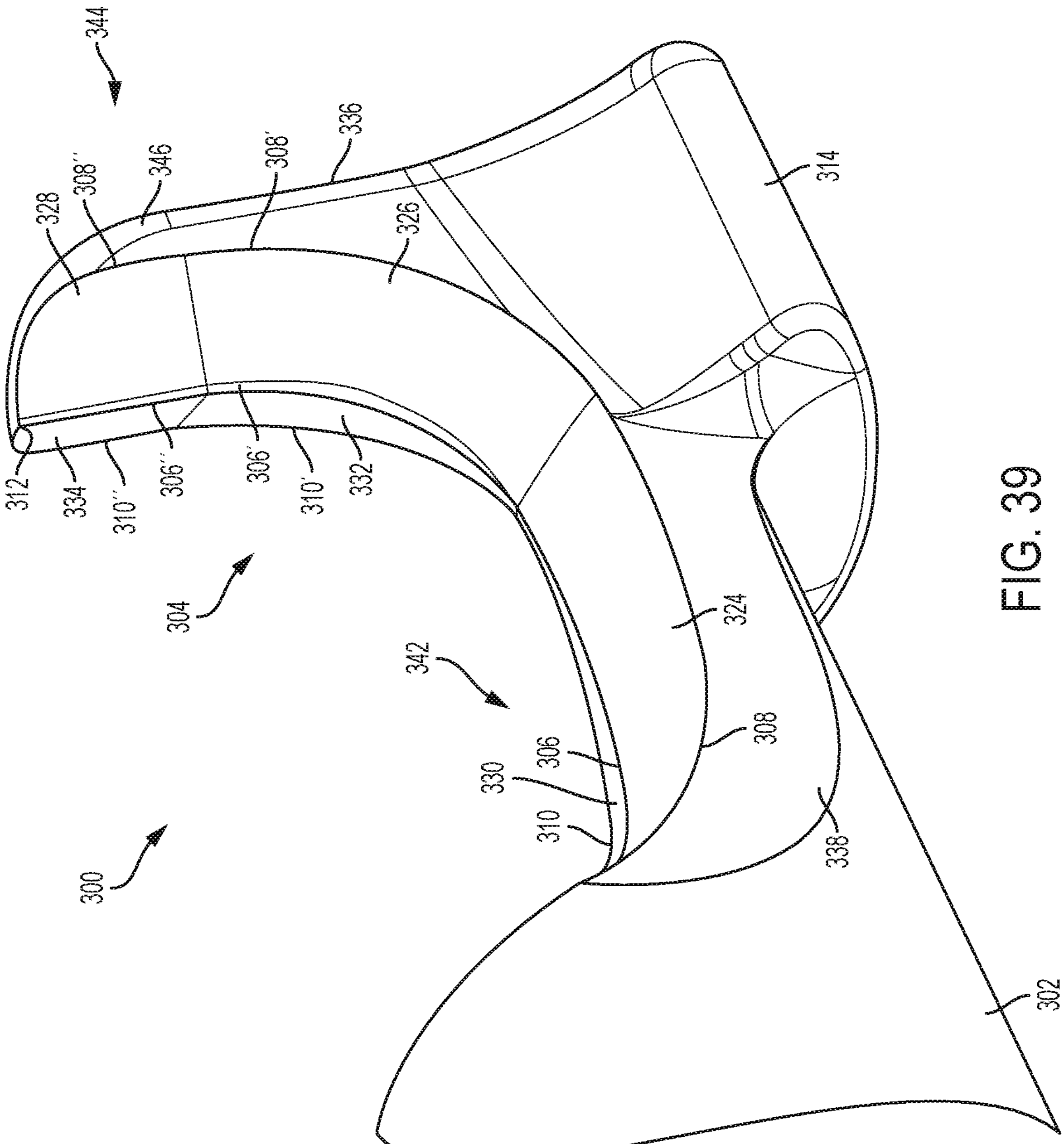
344
336
314
308'
346
308''
328
326
312
334
310''
306''
306'
310'
332
304
324
342
306
330
310
308
338
300
302

FIG. 39

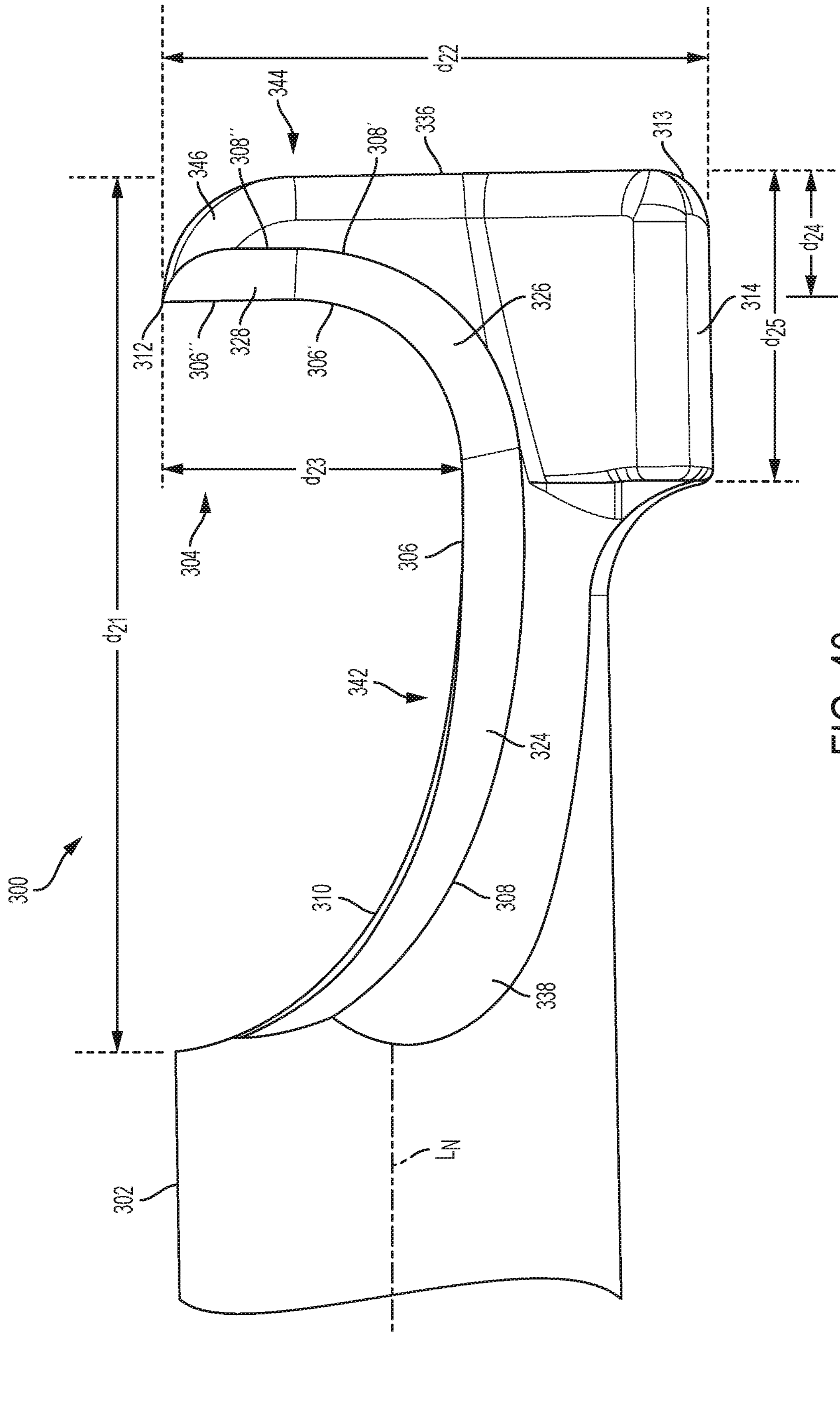
300
302
304
306
306'
306''
308
308'
308''
310
312
313
314
324
326
328
336
338
342
344
346
d21
d22
d23
d24
d25
LN

FIG. 40

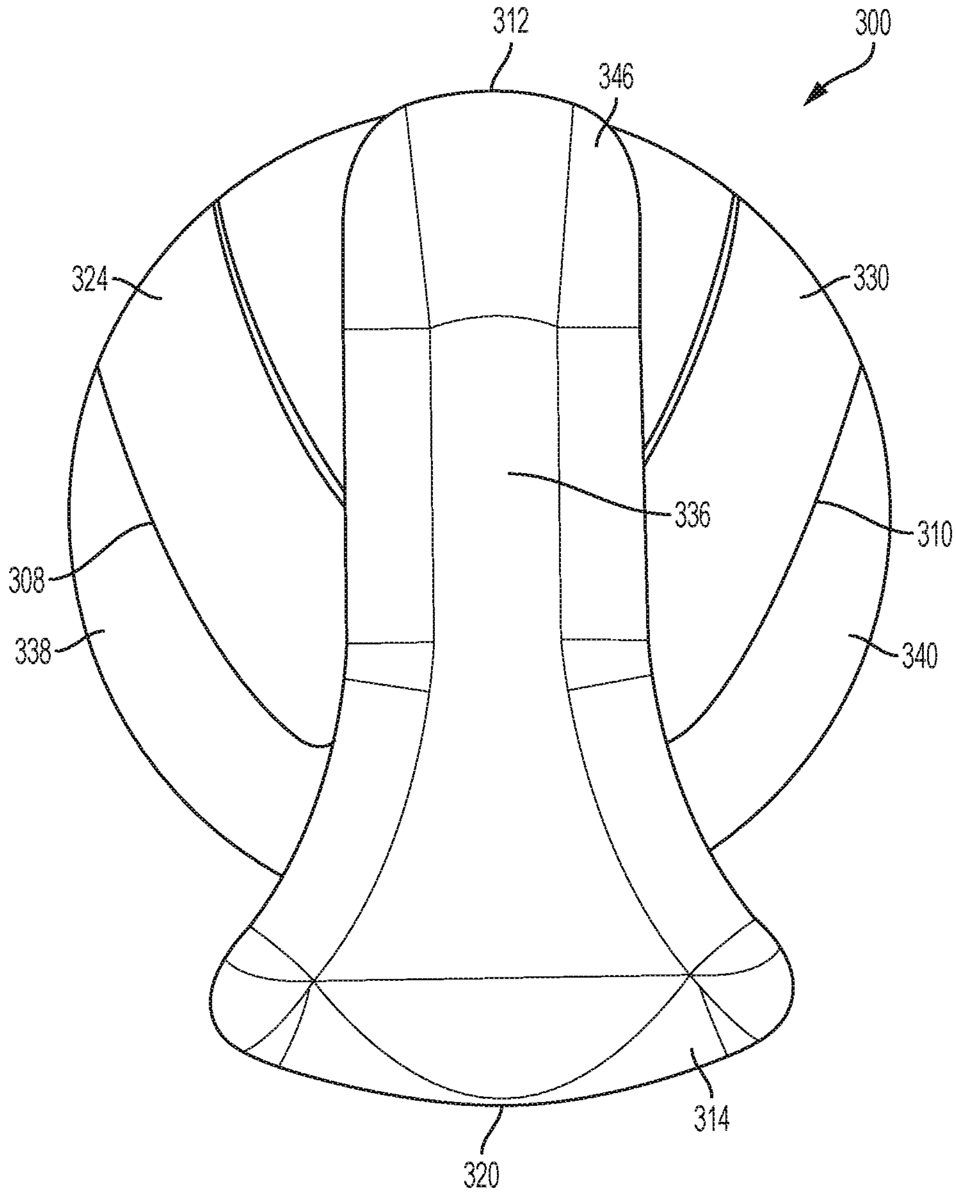

FIG. 41

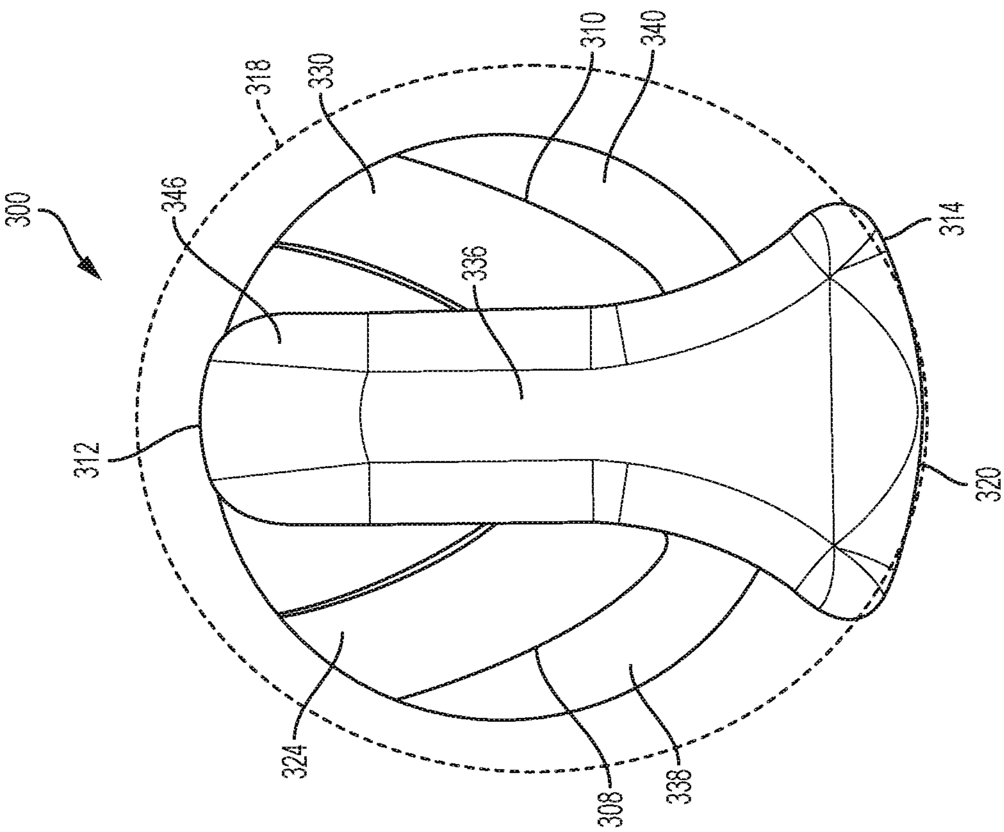
300
318
330
310
340
346
336
314
312
320
324
308
338

FIG. 43

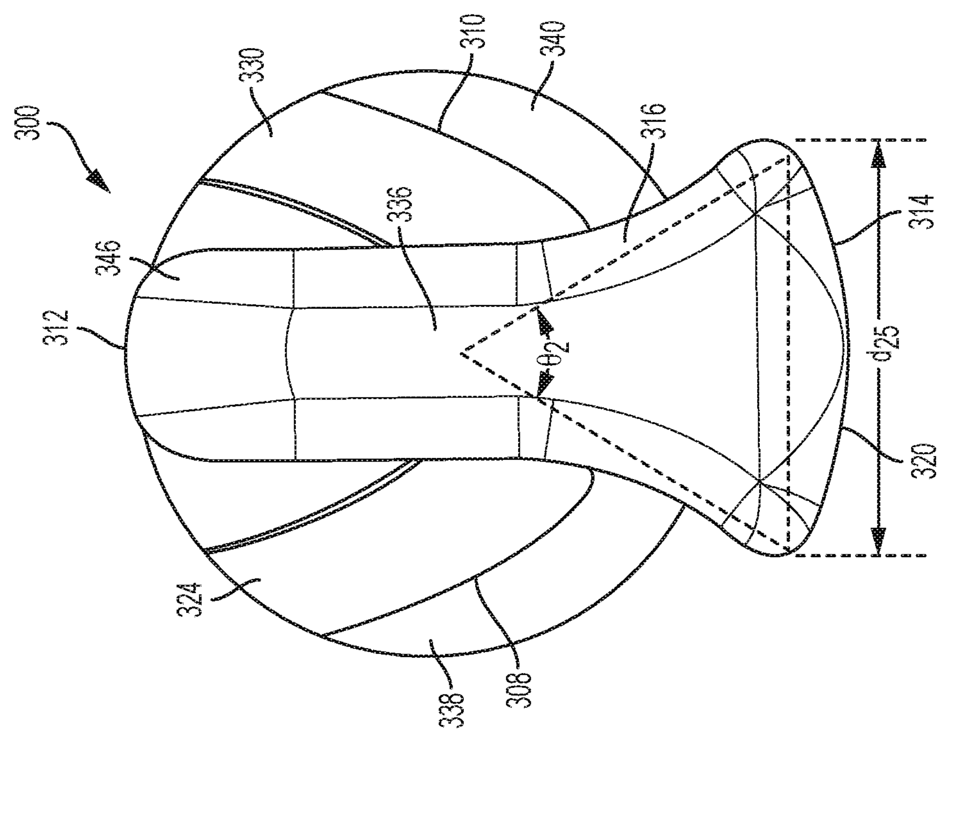
300
330
310
340
316
346
336
312
314
θ_2
d_{25}
320
324
338
308

FIG. 42

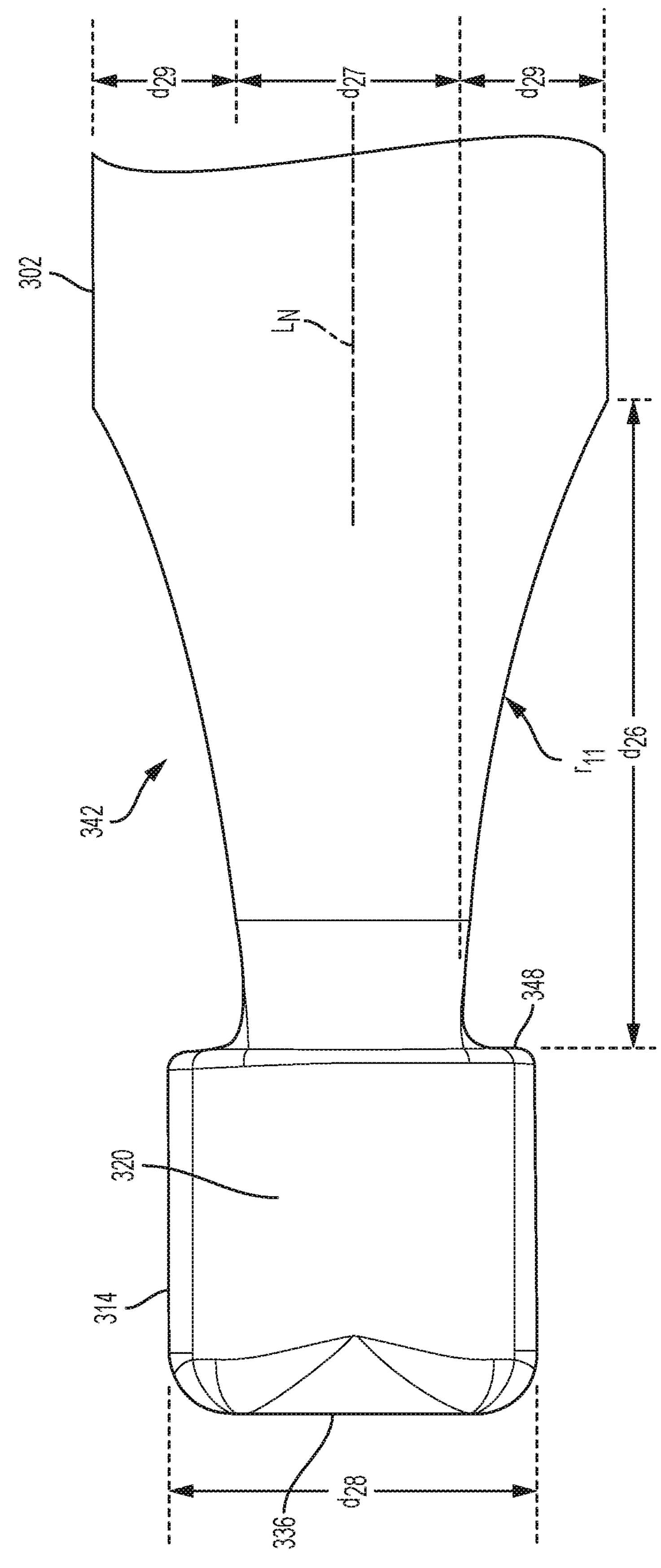

FIG. 44

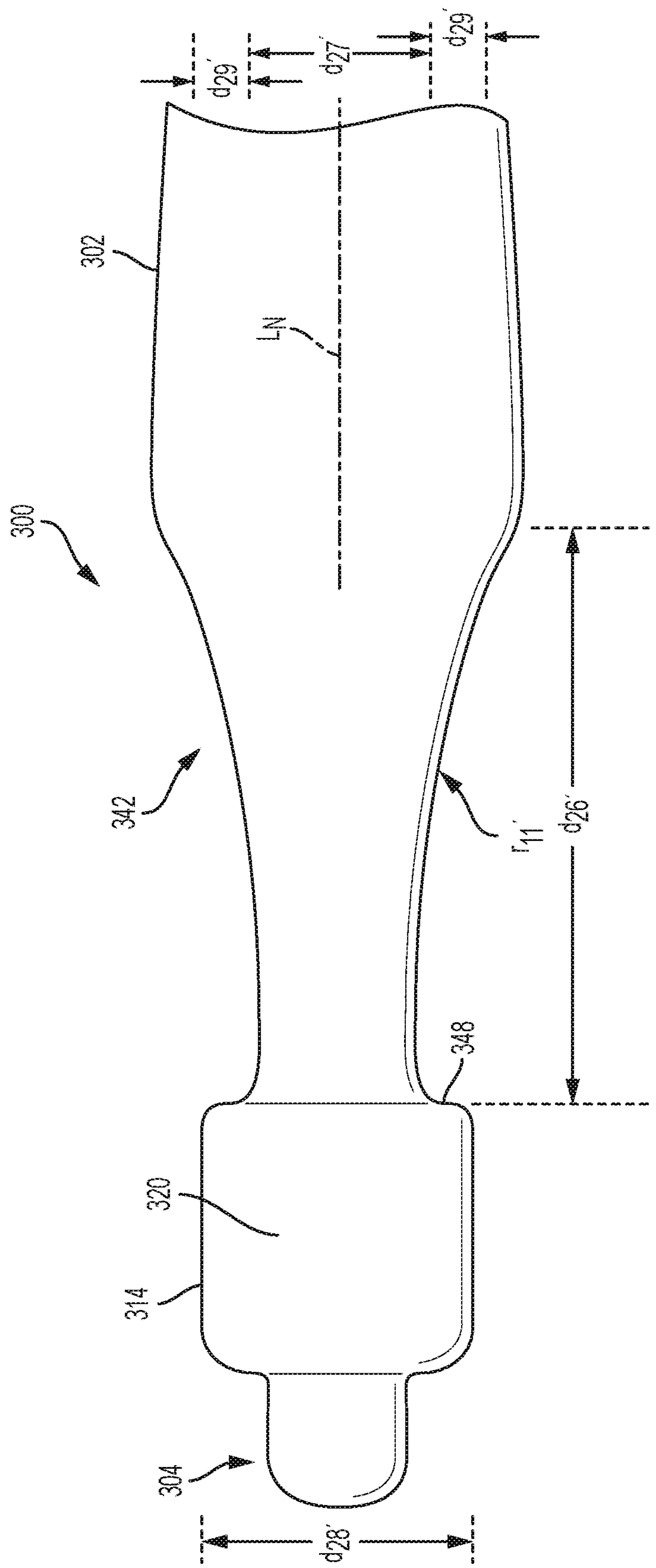

FIG. 45

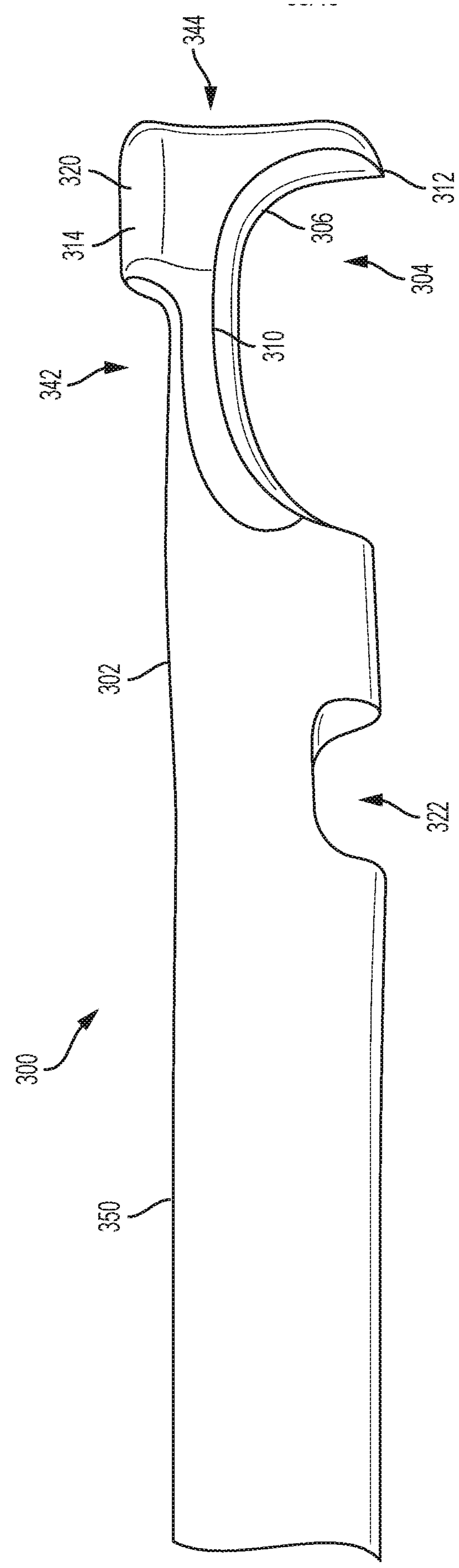

FIG. 46

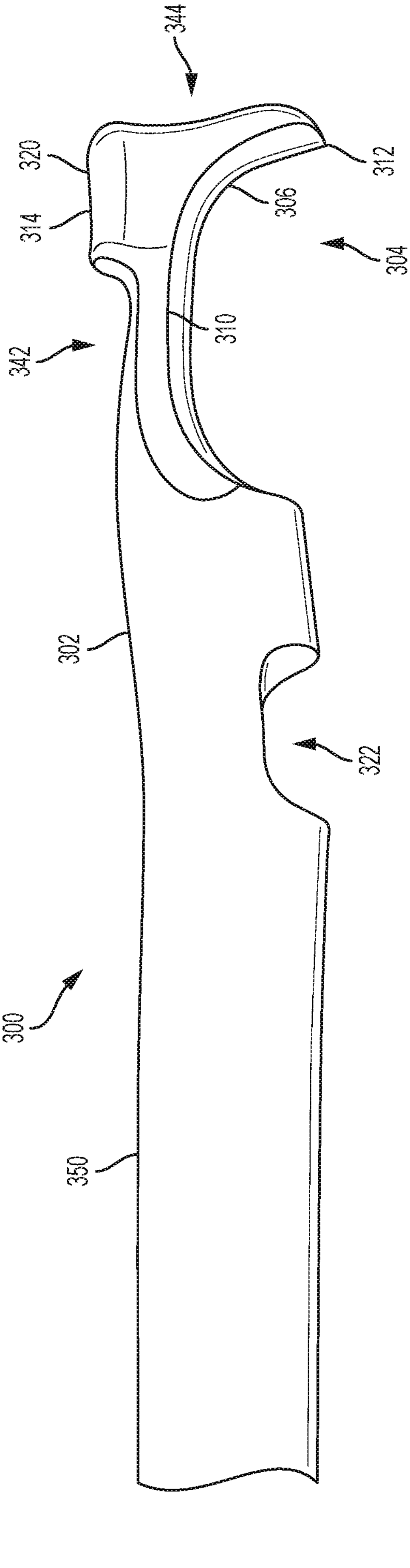

FIG. 47

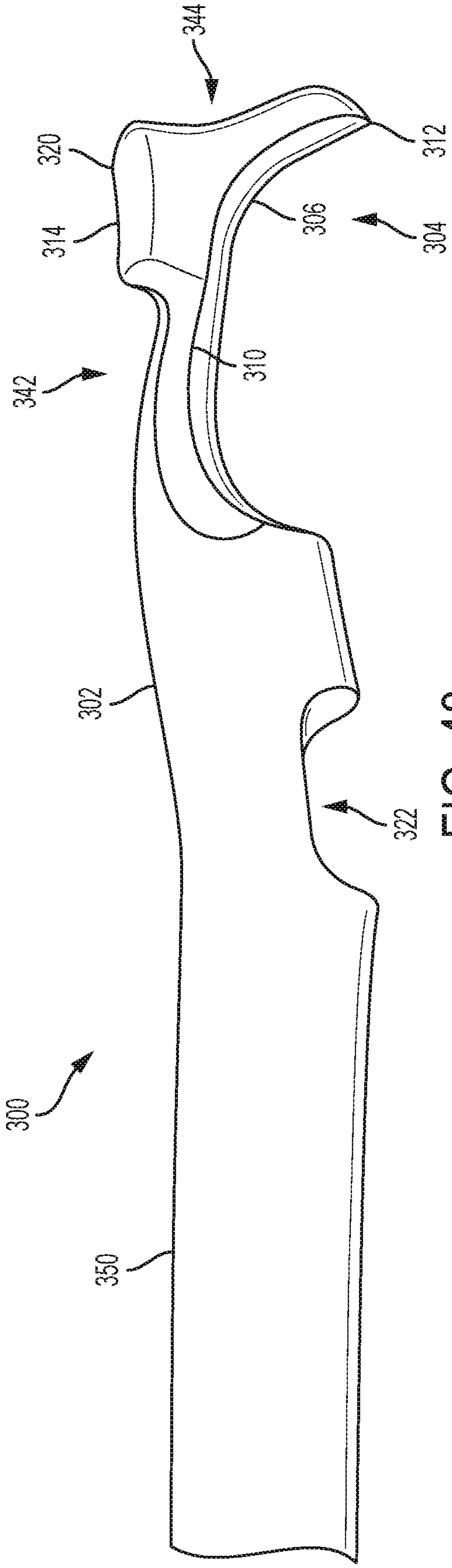

FIG. 48

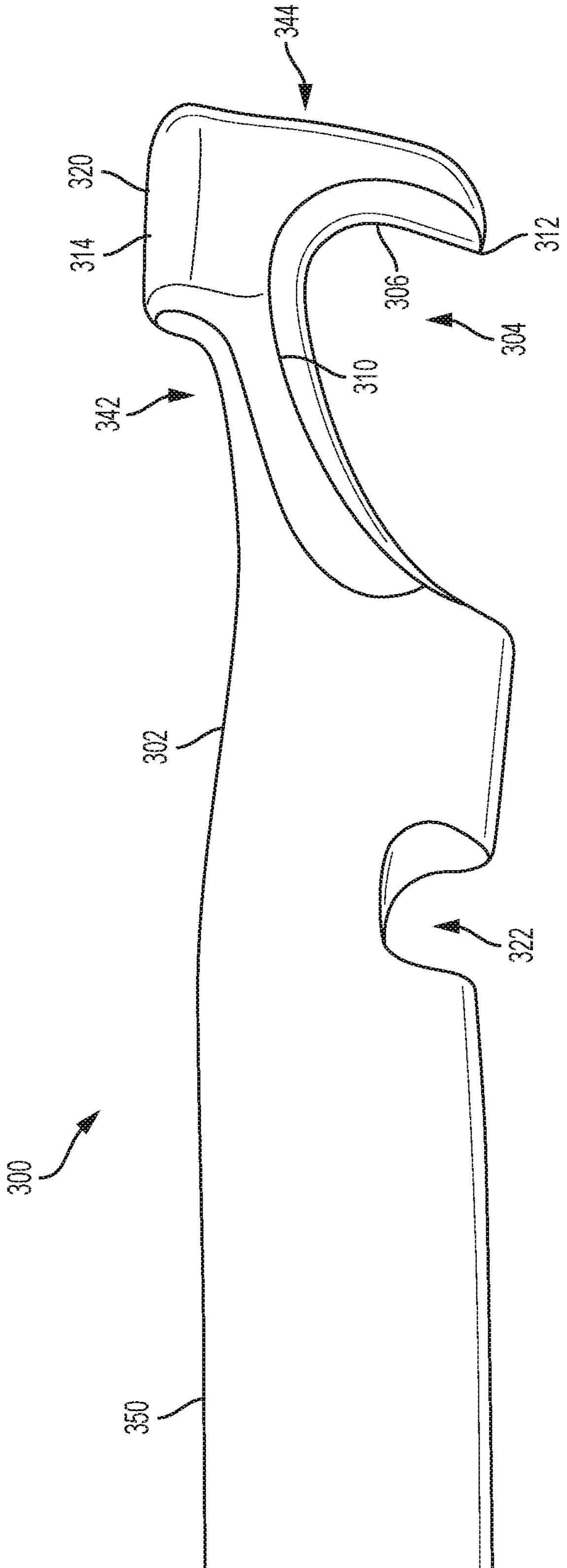

FIG. 49

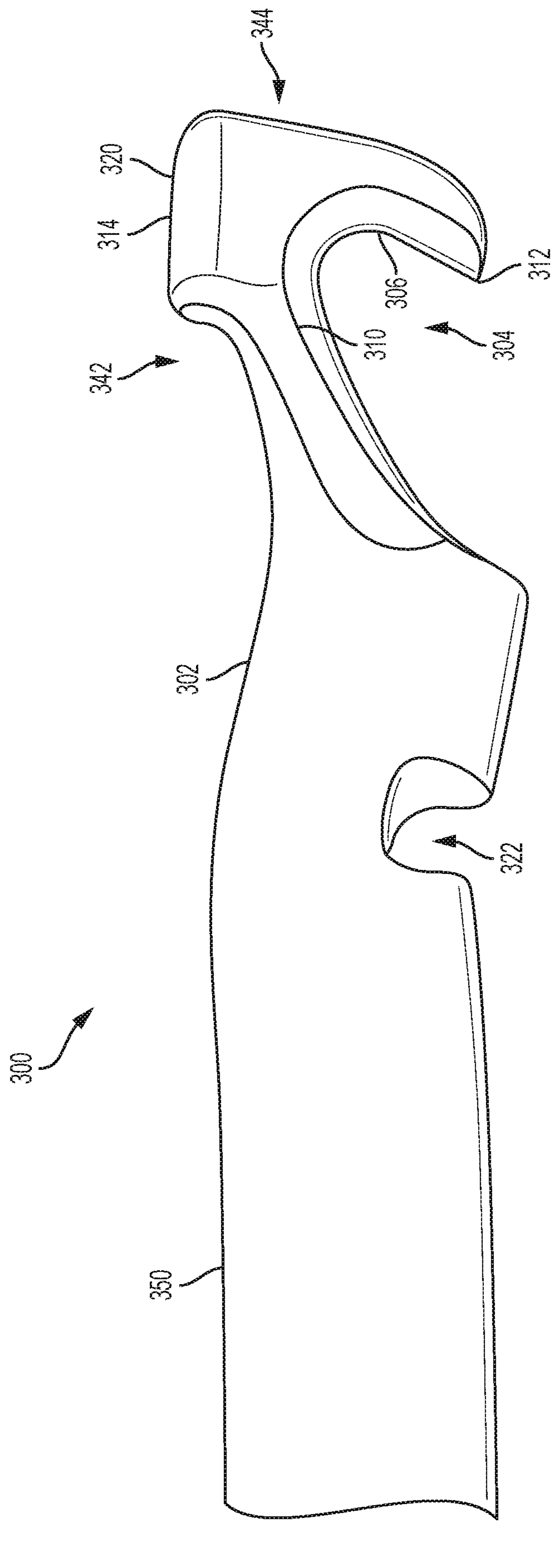

FIG. 50

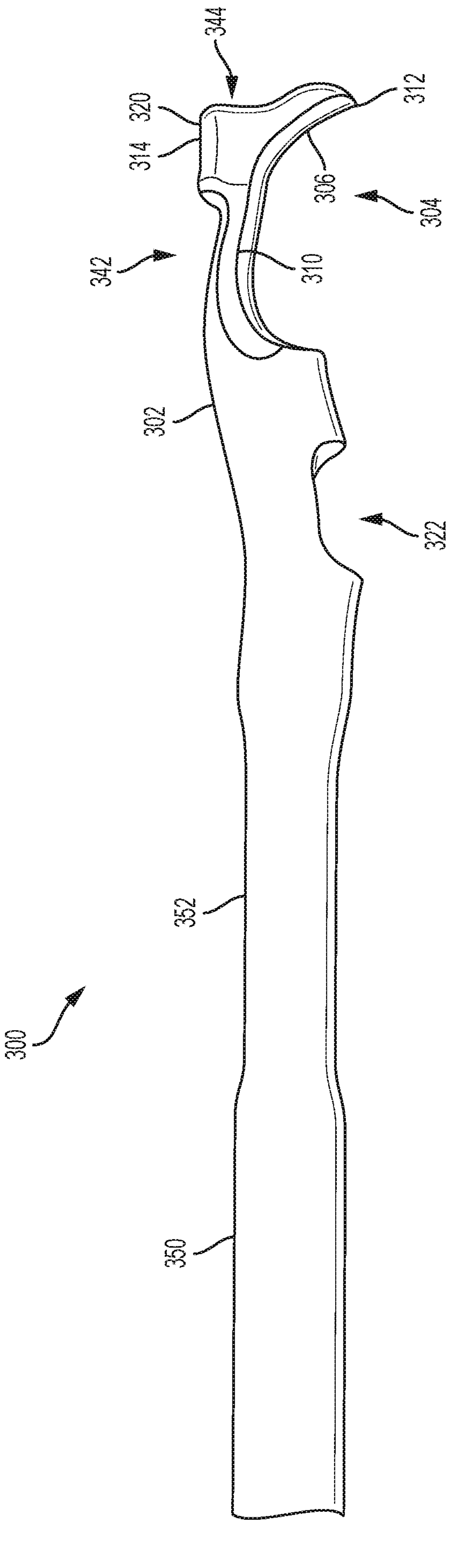

FIG. 51

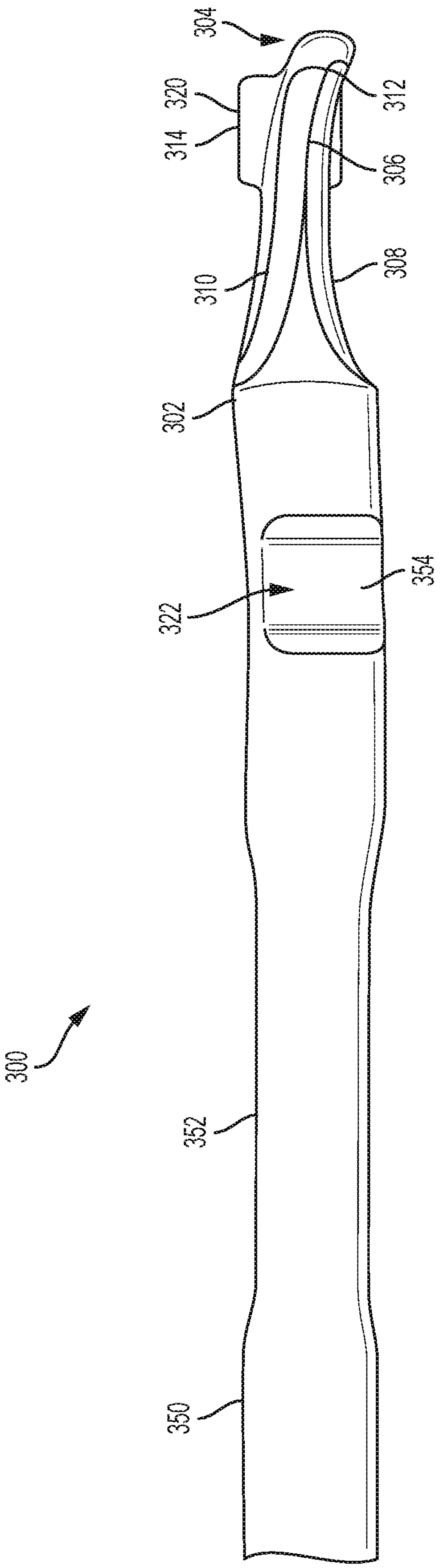

FIG. 52

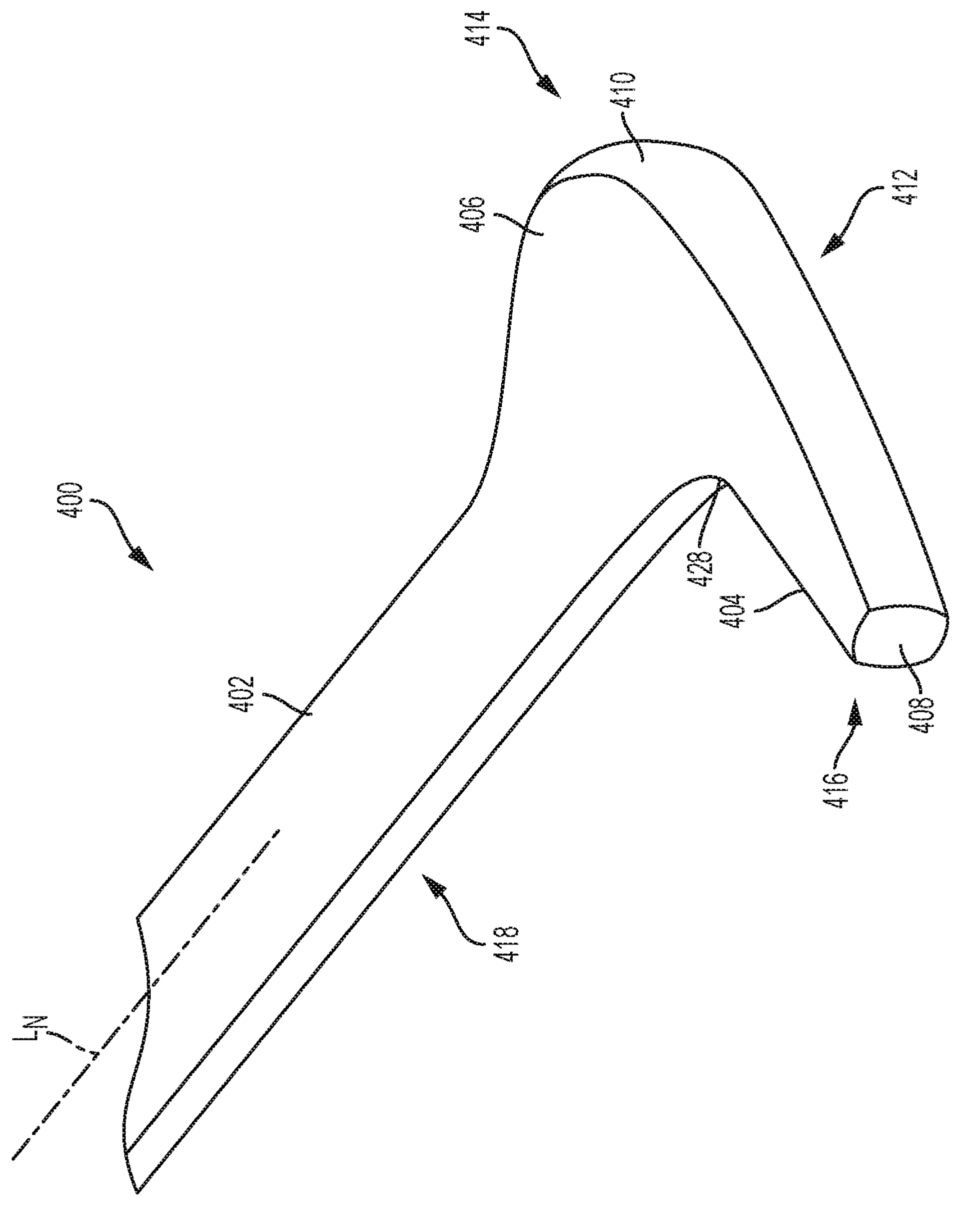

FIG. 53

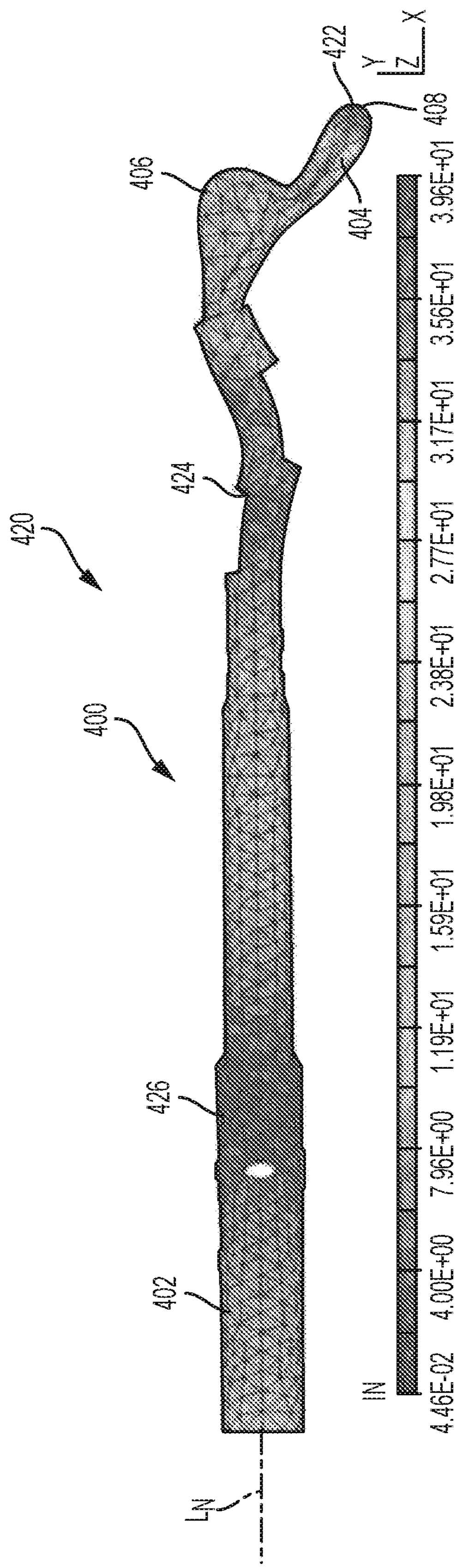
400
402
404
406
408
420
422
424
426
LN
X
Y
Z
IN
4.46E-02
4.00E+00
7.96E+00
1.19E+01
1.59E+01
1.98E+01
2.38E+01
2.77E+01
3.17E+01
3.56E+01
3.96E+01

FIG. 54

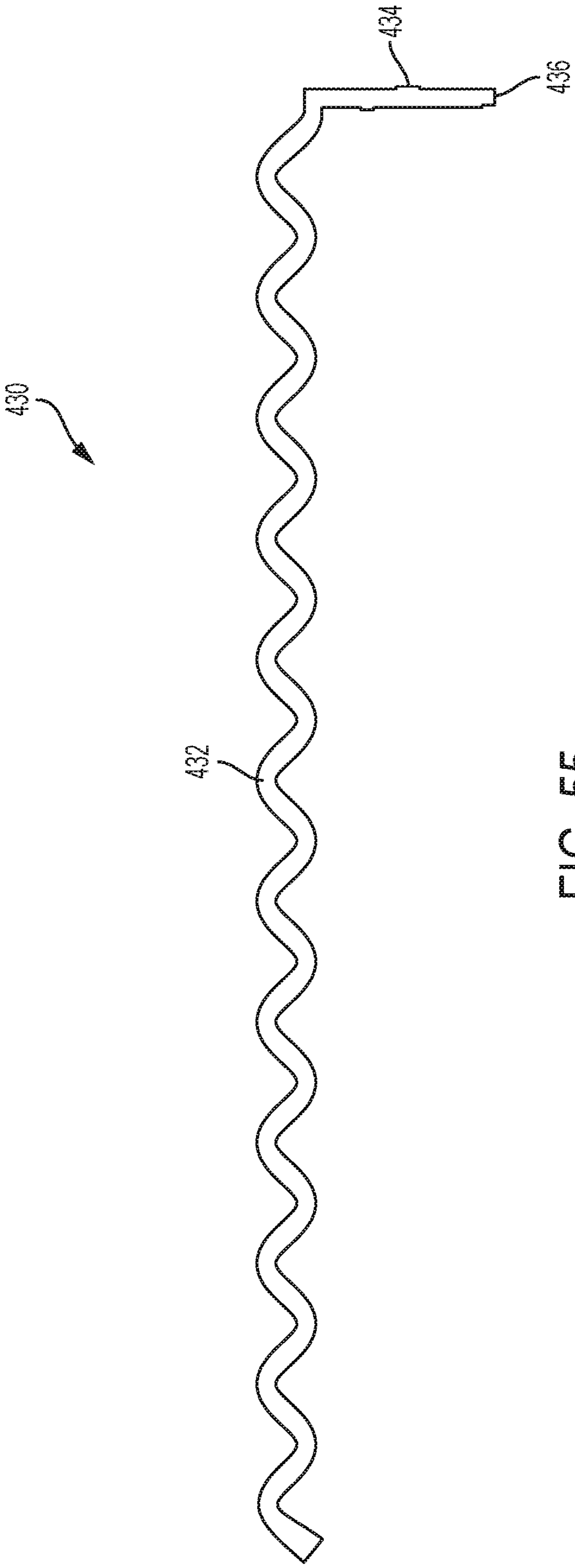

FIG. 55

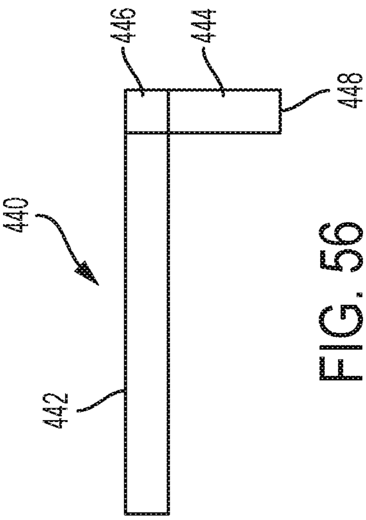

FIG. 56

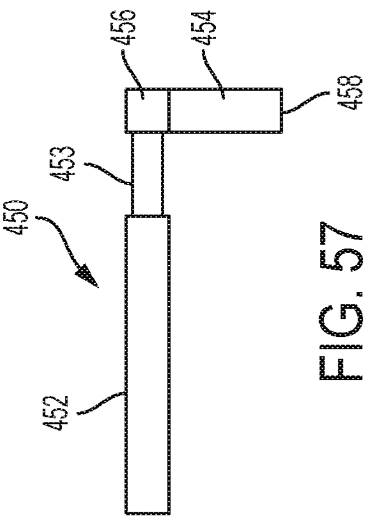

FIG. 57

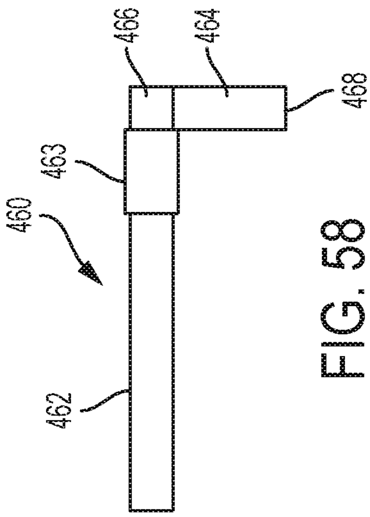

FIG. 58

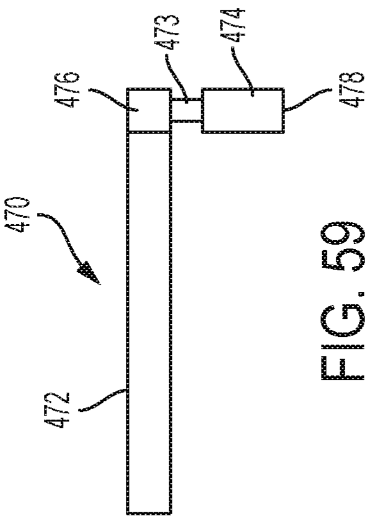

FIG. 59

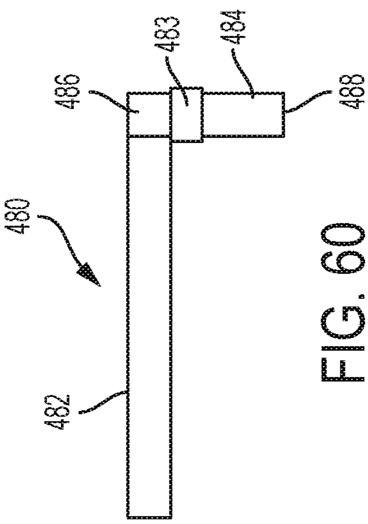

FIG. 60

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2010106173 A1 **[0005]**
- US 2015045701 A1 **[0005]**
- US 2014324084 A1 **[0005]**
- US 6309400 B2 **[0005]**

专利名称(译)	超声波手术刀片具有改进的切割和凝固功能		
公开(公告)号	EP3316803B1	公开(公告)日	2019-05-01
申请号	EP2016739352	申请日	2016-06-30
[标]申请(专利权)人(译)	ETHICON，LLC		
申请(专利权)人(译)	ETHICON LLC		
当前申请(专利权)人(译)	ETHICON LLC		
[标]发明人	CONLON SEAN P GEE JACOB S STULEN FOSTER B DANNAHER WILLIAM D OLSON WILLIAM A		
发明人	CONLON, SEAN P. GEE, JACOB S. STULEN, FOSTER B. DANNAHER, WILLIAM D. OLSON, WILLIAM A.		
IPC分类号	A61B17/32		
CPC分类号	A61B17/320068 A61B2017/320069 A61B2017/320071 A61B2017/320074 A61B2017/320075 A61B2017/320078 A61B2017/320089 A61B2017/00424		
优先权	14/789744 2015-07-01 US		
其他公开文献	EP3316803A2		
外部链接	Espacenet		

摘要(译)

公开了一种具有改进的切割和凝固特征的超声手术刀片。刀片包括实心主体，纵向部分，其具有配置成连接到超声波传输波导的近端和从纵向部分的远端横向延伸的横向部分。在刀片上设置至少一个解剖边缘和至少一个止血表面。横向部分限定了钩子，该钩子具有自由端，该自由端构造成拉动和切开组织。还公开了一种超声手术刀片，其还包括尖锐的中央脊和用于声学平衡的端部质量。

$$\frac{\lambda}{4},$$