



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 649 906 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.04.2006 Bulletin 2006/17

(51) Int Cl.:
A63B 53/04^(2006.01)

(21) Application number: **05022374.2**

(22) Date of filing: **13.10.2005**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR**
Designated Extension States:
AL BA HR MK YU

(30) Priority: **13.10.2004 US 617659 P
25.03.2005 US 665653 P**

(71) Applicant: **Roger CLEVELAND Golf Company Inc.
Huntington Beach CA 92647 (US)**

(72) Inventors:
• **Rae, John J.
Westminster, CA 92683 (US)**
• **Radcliffe, Nathaniel J.
Huntington Beach, CA 92648 (US)**

• **Stone, Daniel J.
Long Beach, CA 90814 (US)**
• **Garner, Trent E.
Champaign, IL 61821 (US)**
• **Hooley, Brad S.
Huntington Beach, CA 92648 (US)**
• **Horacek, Robert J.
Hermosa Beach, CA 90254 (US)**
• **Wallans, Michael J.
Huntington Beach, CA 92649 (US)**

(74) Representative: **Bardehle, Heinz
Patent- und Rechtsanwälte
Bardehle . Pagenberg . Dost .
Altenburg . Geissler
Postfach 86 06 20
81633 München (DE)**

(54) **Golf club head having a displaced crown portion**

(57) A hollow wood-type golf club head having an increased weight budget and improved mass characteristics at minimum structural mass is disclosed. The club head has a striking face portion, a sole portion, a skirt portion, and a crown portion having a total surface area. A hosel portion joins the club head for connecting a shaft to the club head. The crown portion has a major crown portion and a minor crown portion, the major portion having greater surface area than the minor portion, and the

major portion being displaced vertically lower relative to the minor crown portion. The major crown portion may have a generally concave curvature and the minor crown portion may have a generally convex curvature such that the major crown portion is in effect inverted with respect to the minor crown portion. The major crown portion may be upwardly inclined from the heel to the toe of the head. The head may exhibit a parabolic top view silhouette.

EP 1 649 906 A1

Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Applications Nos. 60/617,659 and 60/665,653 which are hereby incorporated by reference in their entireties.

BACKGROUND

[0002] This invention pertains generally to improved metal wood type golf club heads and more particularly to a golf club head having an improved crown configuration incorporating high specific-strength materials. A recent trend in golf club head design has been to increase the size of such heads to generate increased performance and create more "forgiving" golf clubs. Although this can be said to be true for golf clubs in general, it may be observed that wood type club heads in particular have increased in size dramatically over the past few years. This has presented a number of challenges to designers of modern "metal wood" golf clubs.

[0003] Traditional wood type golf club heads generally comprise four primary surfaces that form a solid with predominantly convex outer surfaces. These four primary surfaces are referred to as the striking face (front surface), crown (top surface), skirt (side surface), and sole (bottom surface). In the case of modern metal woods, these surfaces form the exterior of thin metallic walls that are joined or integrally formed to create a thin-walled solid structure. A hosel is typically attached to at least one of the primary surfaces, and serves as a coupling member for attachment of a shaft to the club head. Such metal woods have nominal mass properties including a target mass, a center of gravity, and moments of inertia about a set of axes originating from a reference location (typically the center of gravity, or a point along the hosel axis).

[0004] The target mass refers to the ideal total mass for a finished club head, and must be differentiated from a minimum structural mass of a club head. Each club head must have a finished mass that yields a minimum desired swingweight value when assembled to a shaft fitted with a grip. The target mass will depend on the expected maximum length of shaft that may be assembled to the head, and taking into consideration the selection of grips that may be fitted thereto. The swingweight value may then be increased throughout a desired range of values for that shaft length, preferably by adding minor amounts of ballast. For shafts of lesser lengths, the minimum swingweight, and subsequently larger swingweights, may also be achieved by adding more ballast. Therefore the target mass of the head is dictated by the club type, shaft materials and maximum length, as well as the selection of grips which may be fitted thereto.

[0005] The minimum structural mass of a club head refers to the minimum mass of all structural components required to produce a club head having a desired shape

and geometry that can withstand the loads experienced during normal use. If the minimum structural mass achieved for a given design is less than the target mass, the difference is known as discretionary mass. This amount of discretionary mass may be strategically positioned throughout the club head to fine tune its performance characteristics. Parameters such as center of gravity location, principal axes and the magnitudes of the moments of inertia about them, may all be manipulated through strategic placement of discretionary mass. Thus, it is highly desirable for a club head design to achieve the absolute minimum structural mass to maximize the amount of discretionary mass available to the designer. This amount of discretionary mass available to the designer is also known as the weight budget.

[0006] It is known that a low and deep center of gravity generally provides beneficial launch conditions at the moment of impact between a golf club head and ball. Specifically, the combination of a high launch angle and a low ball spinning speed provides increased carry and therefore greater overall distance. Displacing the center of gravity lower in the head (closer to the sole) yields a higher launch angle to the ball at impact, accompanied by increased back spin. Positioning the center of gravity deeper in the club head (farther rearward from the face) will reduce the amount of back spin imparted to the ball at impact. Therefore, for optimum launch conditions of a metal wood, a low and deep club head center of gravity is sought.

[0007] A recent trend in metal wood design has been to increase head size in an effort to maximize moments of inertia, thereby minimizing distance loss when a ball is struck other than in the sweet spot of the striking face. However, increased head sizes have generated metal woods with commensurately larger and taller striking faces, which in turn increases the vertical distance between the crown and sole walls. Skirt walls have become correspondingly taller to bridge the larger distances between crown and sole. Therefore, at the minimum structural mass, center of gravity heights have increased in modern club heads.

[0008] Further, since the striking face must withstand the greatest loads compared to a remainder of the club head under normal use, it is generally the thickest wall of a metal wood head, and therefore the heaviest. Thus, increases in striking face size have also displaced center of gravity positions farther forward within modern metal wood heads at their minimum structural mass.

[0009] Still further, increasing the overall size of modern metal wood club heads has been accompanied by an increase in the volume of material required to form the head, therefore increasing the minimum structural mass, whereas target masses have remained constant. Increasing head volume while maintaining traditional head shapes has therefore resulted in decreased weight budget and a correspondingly reduced ability to improve the mass properties of modern metal wood club heads.

[0010] Recent attempts to mitigate increased structur-

al mass have included the advancement of thin-walled casting techniques for metal wood head portions such as the crown, sole, or skirt that may previously have had thicknesses that were greater than necessary for the structural loads placed on them during use. The result has been the achievement of the thinnest possible casting thicknesses for such portions with significant gains in weight budget and therefore the ability to better define the mass properties of metal wood heads. However, it has been demonstrated that there is room for further improvement upon these results, and that it is possible to produce metal wood heads with still more superior performance.

[0011] Accordingly, club head manufacturers have advanced club performance by fabricating select head portions from materials having a specific strength (ultimate tensile strength divided by specific gravity) that is greater than conventional head materials such as steel or titanium, while fabricating the rest of the head using conventional metal wood techniques and materials. These types of club heads are generally expensive to manufacture. The head portions are typically attached using various techniques, for example bonding. They can experience reduced durability, and produce a less satisfying sound at impact than a hollow metal wood of advanced thin-wall construction. The sound produced by any golf club at impact has a great deal of influence on a golfer's perception of the quality and performance of the club as a whole, and golfers are particularly demanding of a quality sound produced at impact by metal wood clubs.

[0012] Alternative attempts to achieve a minimum structural mass and hence increased weight budget over conventional metal wood head configurations have included the use of composite materials to form the head, e.g. carbon fiber reinforced epoxy or carbon fiber reinforced polymer, in place of traditional materials such as aluminum, steel, and titanium. A primary benefit of using composite materials to construct a head is their improved strength to weight ratios in comparison to traditional materials, permitting a reduction in the head's minimum structural mass, thereby increasing the weight budget available for strategic placement. However, such heads have suffered from durability, performance, and manufacturing issues associated with composite materials. These include higher labor costs in manufacture, undesirable acoustic properties, shearing and separation of composite plies used to form the striking surface of the club head, and comparatively low coefficients of restitution.

[0013] In such heads made from composite materials, the areas subject to greatest wear, e.g. the face and sole, have been provided with a metal plate in one or both regions in an attempt at reinforcing those regions. Integrated metal face and hosel constructions have also been attempted with the remainder being formed of composite material, and in several instances such constructions have also included a metal skirt portion. These hybrid constructions have remedied many of the durability

issues associated with heads formed entirely of composites while retaining some of the weight budget increase afforded by replacing metal components with a composite material. Furthermore, when a metal is used for the striking face, coefficients of restitution generally similar to those of wood type heads having all-metal construction have been achieved. However, such hybrid constructions are still bound by the inherent disadvantages of a traditional metal wood head shape, including the substantial mass of the crown and skirt portions being concentrated high within the head.

[0014] Still other attempts at improving club performance have included the elimination of certain portions of the club head as a whole, most notably the crown, in an attempt to eliminate the contribution of that component's mass from the overall head weight and thereby lower the center of gravity. Such club heads require a great deal of reinforcement in other areas of the head to compensate for the reduced structural integrity due to an open section, which virtually eliminates the possibility of achieving an increased weight budget. Further, such heads have also produced a displeasing sound at impact.

[0015] Additionally, club heads which are combinations of the above themes have been manufactured. Such combinations have included club heads where a portion, such as the crown, has been eliminated and certain components, for example the face, have been fabricated from higher specific strength materials. Such variations have yielded disadvantages consistent with the designs mentioned above.

[0016] Hence, there exists a need in the art of golf club design for improved metal wood head configurations that provide an improved center of gravity location at the minimum structural mass, and an increased weight budget. In addition, there exists a further need for an additional improvement including use of hybrid material construction, thereby advancing the performance standard of club heads of the metal wood variety to a level not previously attained in the industry.

SUMMARY OF THE INVENTION

[0017] The present invention comprises a novel hollow metal wood golf club head having an increased weight budget and improved mass characteristics at minimum structural mass. In one embodiment of the invention the club head includes a striking face portion, a sole portion, a skirt portion, and a crown portion having a total surface area. A hosel portion joins the club head for connecting a shaft to the club head. The crown portion comprises a major crown portion and a minor crown portion, the major portion having greater surface area than the minor portion, and the major portion being displaced vertically lower relative to the minor portion.

[0018] The major crown portion may have a generally concave curvature and the minor crown portion may have a generally convex curvature.

[0019] These and other features, aspects, and advan-

tages of the club head in its various embodiments will become apparent after consideration of the ensuing description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Embodiments of the present invention will now be described, by way of example only, with reference to the following drawings in which:

Figure 1 is a perspective view of an embodiment of a club head in accordance with the present invention; Figure 2 is a view taken from the top and parallel to the face of the club head of Figure 1;

Figure 3 is a heel view of the club head of Figure 1;

Figure 4 is a toe view of the club head of Figure 1;

Figure 5 is a front or face view of the club head of Figure 1;

Figure 6 is a heel view of the club head of Figure 1 depicting horizontal datum plane positions relative to a maximum face height;

Figure 7 (a) is a top view of the club head of Figure 1 showing the location VII(b) - VII(b) of a transverse cross section;

Figure 7 (b) is a rear cross-sectional view of the club head of Figure 1 with the section taken along the line VII(b) - VII(b) of Figure 7 (a);

Figure 8 (a) is a further top view of the club head of Figure 1 showing the location VIII(a) - VIII(a) of a longitudinal cross section;

Figure 8 (b) is a cross-sectional view from the toe of the club head of Figure 1 with the section taken along the line VIII(b) - VIII(b) of Figure 8 (a);

Figure 9 (a) is a longitudinal cross-sectional area at plane VIII(b)-VIII(b) of the club head of Figure 1;

Figure 9 (b) is a transverse cross-sectional area VIII(a)-VIII(a) of the club head of Figure 1;

Figure 10 is a further top view of the club head of Figure 1 depicting the locations of longitudinal cross-sections used in the analysis of said club head;

Figure 11 is a graphical representation of the data retrieved from analysis of the cross-sections taken from the club head of Figure 1 and depicted in Figure 10;

Figure 12 is a further top view of the club head of Figure 1;

Figure 13 is a perspective view of a further embodiment of a head like that shown in Figure 1;

Figure 14 (a) is a perspective view of still another embodiment of a head like that shown in Figure 1;

Figure 14 (b) is a perspective view of yet another embodiment of a head like that shown in Figure 1;

Figure 15 (a) is a perspective view of a further embodiment of a head like that shown in Figure 1;

Figure 15 (b) is a perspective view of a yet further embodiment of a head like that shown in Figure 1;

Figure 16 (a) is a rear perspective view of the head

shown in Figure 15 (a);

Figure 16 (b) is a rear perspective view of the head shown in Figure 15 (b);

Figure 17 (a) is a perspective view of yet another further embodiment of a head like that shown in Figure 1;

Figure 17 (b) is a perspective view of yet another further embodiment of a head like that shown in Figure 1;

Figure 18 (a) is a cross-sectional view of a first exemplary bonded joint type for joining two thin sheets; Figure 18 (b) is a cross-sectional view of a second exemplary bonded joint type for joining two thin sheets;

Figure 18 (c) is a cross-sectional view of a third exemplary bonded joint type for joining two thin sheets; Figure 18 (d) is a cross-sectional view of a fourth exemplary bonded joint type for joining two thin sheets;

Figure 18 (e) is a cross-sectional view of a fifth exemplary bonded joint type for joining two thin sheets; Figure 19 (a) is a cross-sectional view of one variation of the fourth exemplary joint configuration as adapted to the head of Figure 13, where the section is taken at line XIX - XIX;

Figure 19 (b) is a cross-sectional view of a further variation of the fourth exemplary joint configuration as adapted to the head of Figure 13, where the section is taken at line XIX - XIX;

Figure 19 (c) is a cross-sectional view of another further variation of the fourth exemplary joint configuration as adapted to the head of Figure 13, where the section is taken at line XIX - XIX;

Figure 19 (d) is a cross-sectional view of yet another further variation of the fourth exemplary joint configuration as adapted to the head of Figure 13, where the section is taken at line XIX - XIX;

Figure 20 (a) is an enlarged sectional view showing more detail of the exemplary joint configuration shown in Figure 18 (d);

Figure 20 (b) is an enlarged sectional view showing more detail of the exemplary joint configuration shown in Figure 18 (e);

Figure 20 (c) is an enlarged sectional view showing a variation of the exemplary joint configuration shown in Figure 20 (b);

Figure 21 is a perspective view of a further embodiment of the exemplary head of Figure 13, including a channel feature;

Figure 22 is a cross-sectional view of the exemplary head of Figure 21, taken at line XXII - XXII;

Figure 23 is an exploded perspective view of the exemplary head of Figure 13, shown with a channel feature as well as reinforcement material;

Figure 24 is an exploded perspective view of the exemplary head of Figure 15 (a), shown with a channel feature as well as reinforcement material;

Figure 25 is an exploded perspective view of the ex-

emplary head of Figure 16 (b), shown with a channel feature as well as reinforcement material;

Figure 26 is a perspective view of one more further embodiment of a head like that shown in Figure 1;

Figure 27 (a) is a cross-sectional view of an exemplary head in accordance with the present invention., showing internal features;

Figure 27 (b) is a further cross-sectional view of an exemplary head in accordance with the present invention, showing internal features;

Figure 27 (c) is yet another further cross-sectional view of an exemplary head in accordance with the present invention, showing internal features; and

Figure 27 (d) is still another further cross-sectional view of an exemplary head in accordance with the present invention, showing internal features.

[0021] For purposes of illustration these figures are not necessarily drawn to scale. In all of the figures, like components are designated by like reference numerals.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Throughout the following description, specific details are stated in order to provide a more thorough understanding of the invention. However, the invention may be practiced without these particulars. In other instances, well known elements have not been shown or described to avoid unnecessarily obscuring the invention. Accordingly, the detailed description and drawings are to be regarded in an illustrative rather than a restrictive sense.

[0023] A golf club head 200 is shown in Figure 1 depicting an exemplary embodiment of the present invention. The head has five primary surfaces, each defining a portion of the club head 200, namely, a front surface defining a striking face portion 202, a bottom surface defining a sole portion 204 (see Figures 3 and 4), a side surface defining a skirt portion 206, a first top surface defining a major crown portion 208, and a second top surface defining a minor crown portion 210. Major crown portion 208 and minor crown portion 210 together form crown 211. A hosel 212 is provided for receiving a shaft (not shown).

[0024] Striking face portion 202 has a loft angle, which defines the angle striking face portion 202 forms relative to vertical when head 200 is resting in an address position.

[0025] The extremities of crown 211 may be determined by viewing the club head from a top-down direction in a plane that is generally parallel to the face, as illustrated in Figure 2. The perimeter of the shape visible in this perspective, and represented by a crown perimeter edge 214, generally demarcates crown 211 from striking face portion 202 and skirt portion 206, both of which are not visible from this perspective. Crown perimeter edge 214 may comprise a top-line edge 218 that delimits crown

211 from face portion 202 and a tail edge 220 that delimits crown 211 from skirt portion 206. Minor crown portion 210 may have a surface contour generally consistent with contemporary metal wood crowns, and may be generally delimited from major crown portion 208 by a major crown portion perimeter edge 216. Either or both of edges 214 and 216 may not necessarily be represented by sharp or linear edges, but may be embodied as radiused or contoured transitions between the respective portions. In such instances, the line that passes through the approximate apex(es) along the radiused surface that joins the portions may be substituted for either or both of edges 214 and 216.

[0026] Major crown portion 208 may be generally characterized as being displaced vertically lower than a corresponding adjacent portion of minor crown portion 210. Major crown portion 208 may be further characterized as having a surface contour that does not follow the surface contour of minor crown portion 210, whereby the bulk of major crown portion 208 is displaced vertically downward relative to corresponding adjacent portions of minor crown portion 210. As seen for example in Figure 4, when viewed from the toe of the club head 200, the major crown portion 208 is not visible because the surface contour thereof is inverted with respect to the surface contour of minor crown portion 210. In one embodiment of the invention, major crown portion 208 may be characterized further still as having a concave surface contour while minor crown portion 210 may be characterized as having a generally convex curvature, whereby the bulk of major crown portion 208 is displaced vertically downward relative to adjacent portions of minor crown portion 210. Thus, head 200 may maintain similar or even identical sole and striking face proportions to that of modern metal wood heads with a reduction in volume of about 15 to about 40 percent, depending on the surface contour selected for major crown portion 208. Further, an appreciable amount of minimum structural mass of club head 200 is relocated vertically lower, which improves the mass characteristics of head 200 and allows for an improved center of gravity position and therefore improves launch characteristics. Additionally, there is a significant reduction in the amount of material required to form skirt 206. This reduction in material mass equates to a corresponding increase in the weight budget for head 200.

[0027] Major crown portion 208 may comprise anywhere from about 51 to about 90 percent of the surface area of crown 211. Major crown portion 208 is entirely visible from a golfer's perspective when head 200 is attached to a shaft to form a club and the club is held at an address position by the golfer.

[0028] As illustrated in Figure 6, the vertical position of major crown portion 208 may be related to the face height of club head 200, whereby certain percentages of the major crown portion's total surface area reside below corresponding threshold ratios of the maximum face height, $H_{f_{max}}$. For example, in general about 95% or more of major crown portion 208 may reside below a height of

$H_{f_{max}}$, about 80% or more may reside below a height of $0.80H_{f_{max}}$, about 60% or more may reside below a height of $0.65H_{f_{max}}$, and about 30% or more may reside below a height of $0.50H_{f_{max}}$. In a more extreme configuration, it may be expected that about 98% or more of major crown portion 208 may reside below a height of $H_{f_{max}}$, about 85% or more may reside below a height of $0.80H_{f_{max}}$, about 70% or more may reside below a height of $0.65H_{f_{max}}$, about 50% or more may reside below a height of $0.50H_{f_{max}}$, and about 25% or more may reside below a height of $0.35H_{f_{max}}$. The above percentages may be computed with club head 200 in the address position, with horizontal datum planes intersecting the head at the designated vertical positions relative the maximum face height, $H_{f_{max}}$. The surface area of major crown portion 208 lying below the respective horizontal datum planes may then be measured and compared against the total surface area of major crown portion 208 and the resulting percentage calculated.

[0029] Since the distribution of surface area of major crown portion 208 requires that the surface shape of crown 211 is a departure from one that golfers may be accustomed to, it may be beneficial to shape major crown portion 208 to minimize distraction of the user's attention. A conventional club silhouette at address is advantageous due to negative effects a more radical club head appearance may have on the mental performance of certain golfers. For such golfers, a departure from traditional head shapes may unduly distract their attention or render it difficult to frame the ball at address, and may therefore adversely affect their ability to strike the ball well. A conventional club head silhouette is generally characterized by crown perimeter edge 214 defining a slightly convex top-line edge 218 and a generally parabolic tail edge 220, as shown in Figure 2.

[0030] The surface shape of major crown portion 208 may be conveniently described in two directions; transverse and longitudinal. The longitudinal direction refers to the front-to-back and/or back-to-front directions of club head 200, whereas the transverse direction refers to the heel-to-toe and/or toe-to-heel directions of club head 200. The transverse direction is therefore perpendicular to the longitudinal direction, and vice-versa. Figures 7 (b) and 8 (b) illustrate exemplary sections taken in the longitudinal and transverse directions of Figures 7 (a) and 8 (a), respectively.

[0031] Achieving a well-balanced surface contour for major crown portion 208 involves a consideration of major crown portion 208 on its own, and also the interaction of the contour with the shape and proportions of head 200 as a whole. It is therefore useful to express the contour of major crown portion 208 as a function of the entire head geometry. Since head 200 maintains the shape and proportions of a conventional metal wood, with the exception of its distinct crown configuration, an analysis was performed which is descriptive of the unique topography of major crown portion 208. A set of longitudinal co-planar cross-sections, a single example of which is

shown in Figure 9 (a), was taken from an exemplary embodiment of club head 200. Each section has a perimeter length, L_p , and a cross-sectional area, A_x (shown as shaded), whose values are presented in Table 1, below.

For comparison, Table 1 also includes values corresponding to a conventionally shaped club head of commensurately greater volumetric displacement, but similar to identical proportions and dimensions in all portions except the crown. Each section was incrementally taken across the transverse span of major crown portion 208, as shown in Figure 10. The distance at which each section was taken was referenced to the heel-most extremity of exemplary head 200, and each corresponding section of the exemplary conventional metal wood head was taken at the same transverse position. The position at which each section was taken is represented in Figure 10 by a unique section denoted by a numeral, and each numeral corresponds to the section number assigned in Table 1.

[0032] Since a majority of the crown 211 of club head 200 is displaced vertically lower than in a conventional wood head, the cross-sectional areas taken from head 200 are significantly reduced, whereas the perimeter lengths of the sections are generally increased a slight amount. Thus, the L_p/A_x ratios across the major crown portion's transverse span are significantly increased versus those taken from a corresponding span of a conventional metal wood head's crown portion. The ratios of L_p/A_x in the transverse direction therefore distinguish head 200 from typical metal wood heads, and analyzing their change along the transverse direction is a useful way to quantitatively describe contour variation in relation to the entire head shape of major crown portion 208.

Table 1

Section	Transverse Distance	Exemplary Embodiment			Conventional Metal Wood Head		
		L _p (cm)	A _x (cm ²)	L _p /A _x	L _p (cm)	A _x (cm ²)	L _p /A _x
1	0.4	19.39	21.63	0.90	19.33	26.48	0.73
2	0.8	23.03	27.33	0.84	22.88	36.22	0.63
3	1.2	25.48	32.03	0.80	25.24	43.48	0.58
4	1.6	26.91	35.50	0.76	26.62	47.99	0.55
5	2.0	27.44	37.57	0.73	27.22	50.09	0.54
6	2.4	27.19	38.16	0.71	27.10	49.75	0.54
7	2.8	26.20	37.25	0.70	26.23	46.81	0.56
8	3.2	24.43	34.81	0.70	24.44	41.21	0.59
9	3.6	21.54	30.03	0.72	21.37	32.58	0.66

[0033] Figure 11 graphically represents the L_p/A_x values from Table 1 plotted according to their transverse position. The results demonstrate greater L_p/A_x ratios for exemplary club head 200, a reflection of the major crown portion's vertical displacement. It is not possible to achieve this distribution of L_p/A_x values in a club head utilizing a conventional, convex crown contour configu-

ration while at the same time maintaining conventional dimensions and proportions in the face and sole. Thus, a metal wood head may achieve the aforementioned performance benefits of increased weight budget and an improved center of gravity location at minimum structural mass by displacing the crown vertically to achieve augmented L_p/A_x values across its transverse span. While all longitudinal sections of the club head according to the above-described exemplary embodiment of the present invention maintain an L_p/A_x ratio above 0.70, adequate performance benefits may be realized by maintaining a minimum L_p/A_x ratio of at least about 0.65. Additionally, a longitudinal section of the club head according to the above-described exemplary embodiment of the present invention reaches an L_p/A_x ratio of about 0.90.

[0034] Although there are a series of nine transverse sections used for purposes of comparison between the exemplary club head of the present invention and a selected conventional metal wood, it should be appreciated that an applicable comparison may be performed for virtually any selected conventional metal wood. For example, comparison sections may be modified to include heel, toe, and a transverse midpoint between the heel and toe, such points of reference being available for virtually any metal type wood.

[0035] To achieve a crown contour that ensures encourages confident performance from all types of golfers, including those easily distracted and whose confidence may thereby be readily compromised, it may be desirable to take into consideration more than just the absolute minimum value of the L_p/A_x ratio in the transverse direction. The values of the L_p/A_x ratios in the heel-to-toe direction contribute to the overall confidence some golfers have in club head 200 and enable them to obtain maximum performance from its use. Major crown portion 208's contour yields minimally increasing L_p/A_x ratio values in the transverse direction from the approximate transverse midpoint of head 200 towards the toe. Referring to Figure 12, the transverse midpoint of head 200 may be represented by a plane 221, which runs longitudinally through head 200 at half the maximum club head width, W_h . It should be noted that the measurement of the width W_h does not include the hosel portion 212, but is a measurement from the heel-most to the toe-most extremes of skirt portion 206.

[0036] Major crown portion 208 may be gradually inclined in the heel-to-toe direction with its lowest point, represented in Figure 12 as point 222, located generally between the heel-most extremity of head 200 and axis 221. Progressively raising major crown portion 208 in the heel-to-toe direction causes the outer silhouette of head 200 to remain substantially identical in shape to the outer silhouette of a conventional metal wood head when viewed from a golfer's vantage point at address, and therefore serves to keep head 200 as familiar and appealing to golfers as possible. If all of major crown portion 208 were maintained at a lower vertical position, the resulting silhouette of head 200 might not resemble that of

a conventional metal wood head at address. Therefore, this contour of major crown portion 208 may be desirable since it permits a balance between an improved center of gravity location at minimum structural mass, increased weight budget, and a confidence-inspiring head shape.

[0037] Referring again to Figure 12, minor crown portion 210 may further comprise a return portion 224 running between top-line edge 218 and the front-most edge of major crown perimeter edge 216. Return portion 224 may have a length, L_r , which varies along the transverse direction, and which may have values in the range of about 1 cm to about 4 cm. The size of the return portion 224 aids in providing a more conventional looking crown portion to the club head 220 while enabling a maximum area for major crown portion 208.

[0038] Still further, with the exception of at least a portion of crown 211, the remainder of head 200 comprising a primary body 230 (see Figures 13-17 (b)) may be formed primarily of a metallic material. Any metal or alloy may be used to form the individual portions of the primary body, and furthermore, it may be advantageous for more than one of the portions to be formed integrally of the same metal. Portions of body 230 that experience elevated stress levels, for example face 202, may be formed of a different alloy or metal having superior strength characteristics than that which may be used to form the remaining metallic portions of the primary body. Any combination of cold or hot forming, casting, machining, or other known manufacturing techniques may be used to form the portions of body 230 individually, integrally, or as a one piece construction. Should one or more portion (s) of the primary body be formed separately from the others, suitable joining techniques may be used to affix them together including, by way of example, welding, adhesive bonding, press fitting, mechanical fastening, and the like.

[0039] As shown in Figure 13, crown 211 includes a material dissimilar to the material(s) used to form primary body 230 at least in that the specific strength of the dissimilar material is appreciably greater than the specific strength of the material forming face 202 and/or the remaining portions of the primary body. That portion of the club head utilizing the dissimilar material is defined as an auxiliary body 232. Specific strength is defined as the ultimate tensile strength of a given material divided by that material's density, and for values presented herein may have units of MPa/g/cm^3 . In one exemplary embodiment, the entire major crown portion 208 is formed from a material having a specific strength that is greater than that of the remainder of the club head.

[0040] Alternatively, both major crown portion 208 and at least a part of minor crown portion 210 may be made from the dissimilar material, as shown by way of example in Figures 14 (a) and 14 (b). Further, the dissimilar material may be used to form all or a part of skirt portion 206 in addition to the major crown portion 208 and at least a part of the minor crown portion 210, as shown by way of example in Figures 15 (a), 15 (b), 1.6 (a) and 16 (b).

Further still, the dissimilar material may additionally be used to form all or part of sole portion 204, as shown, for example, in Figures 17 (a) and 17 (b). Regardless of the specific configuration, in all embodiments the portions integrally formed of the dissimilar material constitute at least one auxiliary body 232.

[0041] If steel alloy is used to form the striking face portion of club head 200, exemplary materials for auxiliary body 232 include titanium alloys, aluminum alloys, magnesium alloys, fiber reinforced plastics (FRP), or metal matrix composites. In the case of striking face portions formed from high-strength titanium alloys, which may have specific strengths approaching about 360 MPa/g/cm^3 , FRP materials may be particularly well suited for use as the dissimilar material. For example, woven fiber cloth pre-impregnated with a thermosetting epoxy resin matrix, or "prepreg", may have specific strengths ranging from about 400 to well over 1000 MPa/g/cm^3 , depending on the type of weave (e.g. unidirectional, bidirectional), the type of fiber used (e.g. nylon, carbon, glass), the fiber areal weight, type of matrix resin and/or curing process, as well as the ratio of resin to fiber.

[0042] In all embodiments, since auxiliary body 232 is formed of a material that is different than the material(s) used to form primary body 230, mechanical fastening and/or adhesive bonding is employed to interconnect the bodies and thus form a unitary body, i.e. head 200. The principles of joining thin sheets by means of adhesive bonding are well-known, and may be employed to join the primary and auxiliary bodies. Exemplary bonded joint types include simple lap joints (see Figure 18 (a)), scarf joints (see Figure 18 (b)), single- and double-step lap joints, (see Figure 18 (c) and (d), respectively), as well as reinforced stepped lap joints (see Figure 18 (e)).

[0043] In the exemplary case of a single-step lap joint (see Figure 20 (a)), which provides excellent bond strength, either the primary body or the auxiliary body is provided with a step 234, comprising a first abutment surface 236 and a first lap surface 238 that are generally perpendicular to each other. A corresponding second lap surface 240 and a second abutment surface 242 are formed in the other body, where the second abutment surface may be the surface that separates the interior and exterior surfaces of said other body. Step 234 may be formed into the outwardly facing surface of the primary body or auxiliary body, as shown in Figures 19 (a) and 19 (b), or the inwardly facing surface of the primary or auxiliary bodies as shown in Figures 19 (c) and 19 (d), respectively. As seen in these figures, the second lap surface may conveniently comprise a portion of the inwardly or outwardly facing surfaces of the body that is not provided with said step. Alternatively, a double-step lap joint generally illustrated in Figure 18 (c) may be utilized. However this adds complexity to the design, and may be used at the discretion of the designer after weighing the costs and benefits of its implementation.

[0044] Adhesive, for example Hysol™ two part epoxy 9460 or 3M™ DP460NS may be applied to either lap

surface, or the body portions may be affixed together by the application of a force generally normal to the lap surface. For example, if the step is provided in the outwardly facing surface of the primary body 230 or the inwardly facing surface of the auxiliary body 232, the generally normal force may be applied through the use of cellophane wrap, heat shrink wrap, or elastic band(s) (not shown) wrapped around the exterior surface of head 200. If the step is provided in the inwardly facing surface of the primary body 230 or the outwardly facing surface of the auxiliary body 232, an inflatable bladder may be inserted through an access port formed in either body (not shown), and inflated to the desired pressure. In any of the preceding exemplary techniques, a normal force may thus be applied for any time required to cure the adhesive may require, thereby ensuring maximum reliability of the bond.

[0045] The adhesive separates the primary and secondary bodies by its application thickness, which is known as the bondline thickness, t_b . For the exemplary adhesives given above, bondline thickness t_b may generally be in a range from about 5 mil (0.1270 mm) to about 10 mil (0.254 mm). For an exemplary lap surface width, w_1 , of 7 mm, this would result in an average 0.175g of adhesive for every centimeter of bondline length. Typically, about 0.5g to about 1.0g of adhesive will be required to adhere the auxiliary body to the primary body, depending on the adhesive used, the specific joint design, as well as the bondline thickness recommended by the manufacturer. Regardless of the adhesive selected, the specific bondline thickness will ultimately depend on the material types chosen by the club head designer for primary body 230 and auxiliary body 232.

[0046] Prior to bonding the auxiliary body 232 to the primary body 230, lap surfaces 238 and 240 may be prepared using a variety of techniques. The metallic primary body and the auxiliary body may be cleaned with solvents or alcohols, and subsequently subjected to a chemical etching process, sandblasting, or manual etching using an abrasive cloth or paper. Etching the surface using any of the above three techniques will increase the adhesive's effectiveness, thereby reducing the likelihood of failure at the bonded joint. It should be noted that, given the inherent disparity between the materials of the primary and auxiliary bodies, not all solvents and chemical etching processes will be compatible for use on both lap surfaces 238 and 240,

[0047] The lap joint may be continuously formed along the entire interface between the primary and auxiliary bodies, or may be manifested as a series of spaced tabs (not shown), provided such tabs afford sufficient bonding area to withstand the loads imposed by the impact of striking surface portion 202 with a golf ball. If the lap joint is continuous along the entire interface of the primary and auxiliary bodies and referring again to Figure 20 (a), by way of example only, the lap surfaces may have a width, w_1 , of at least about 5 mm, and generally not greater than about 20 mm. The abutment surface has a height,

h_1 , which generally corresponds to a thickness, t_a , less bondline thickness t_b , where thickness t_a is the thickness of the body portion bonded to lap surface 238.

[0048] While step lap joints provide good bond characteristics, reinforced step lap joints provide superior resistance to cracking of surface treatments (e.g. paint, clear coat, etc.) applied to the exterior surface of head 200, particularly along the interface between the primary and auxiliary bodies. In addition, reinforced lap joints have greater overall bond reliability in comparison to the other bonded joint types considered herein. For these reasons, reinforced lap joints may be particularly well-suited for use in bonding the auxiliary body 232 to the primary body 230. A reinforced step lap joint is shown in Figure 20 (b) having the same elements as the stepped lap joint configuration considered above, and wherein a first bevel 244 is provided on the surface of the body into which step 234 is formed. A complementary second bevel 246 may be provided on the other body such that the two bevels form a channel 248 extending along the entire interface of the primary and auxiliary bodies, as shown in Figures 21 and 22. Referring back to Figure 20 (b), the two bevels generally form an included angle, α , having a value that is greater than about 90 degrees and less than about 160 degrees, and may have a channel width, w_c , ranging from about 5mm to about 15mm. The reinforced step lap joint may be configured such that channel 248 is located either on the exterior or the interior of the club head. Moreover, a step joint having both interior and exterior channels may be utilized (see Figure 20 (c)). Referring to Figures 20 (a), 20 (b), and 20 (c), channel 248 may be provided with a reinforcement material 250, for example an epoxy resin reinforced with at least one layer of a glass, nylon, or carbon fiber tape. Once the reinforcement material has been applied and allowed to cure (if necessary), sanding and/or grinding may be carried out to achieve a smooth, continuous look to the exterior surface of the golf club head 200. The head may then be prepared for finishing, if desired.

[0049] Typical wall thicknesses for various regions of the primary and auxiliary bodies may generally be between about 0.6 mm and about 2 mm, depending on the locations, and the structural requirements of said regions, as well as the respective materials used to fabricate the bodies. Striking face portion 202 is subjected to the greatest loads, and may therefore be an exception to the general thickness range given above. The striking face portion may typically have a thickness ranging from about 1.5 mm to about 4.0 mm. Another exception to the aforementioned range of thicknesses may arise should the club head designer choose to increase the thickness at a particular region of head 200 to provide a local mass concentration, thereby expending some or all of the weight budget. This method may be particularly effective if the thickened region is provided on a portion of the body made from a metallic material, i.e., on primary body 230. For example, the club head designer may provide a thickened region (not shown) in a part of sole portion

204 distal from striking face portion 202, in an attempt to displace the club head's center of gravity deeper and lower within the head.

[0050] Alternative means for expending weight budget within head 200 include the use of weight members made from relatively high-density materials in relation to those used to construct the remaining portions of head 200. Such weight members may be strategically placed on internal or external surfaces of the head, or may be used to replace sections of any portion of the head. Weighting of metal wood club heads is commonly practiced in the art of golf club construction, and any and all compatible weighting techniques may be used to expend weight budget afforded by the head configurations taught herein.

[0051] An exemplary club head, according to the additional principles outlined herein, may have a volumetric displacement of about 337 cm³, and proportions generally consistent with those of a conventional metal wood head displacing about 420 cm³. In this embodiment of the invention, illustrated in Figure 23, major crown portion 208 may be manufactured entirely from a carbon fiber reinforced plastic material, which includes three plies of high fracture toughness, uni-directional prepreg roving oriented at +45°, -45°, and 0°, an exterior-most ply of a light-weight bi-directional prepreg weave oriented at 0°/90°, and a thermosetting epoxy-resin matrix comprising about 40% and about 55% of the above-mentioned prepreg types, respectively, by weight. In this embodiment, the major crown portion forms the auxiliary body 232 of club head 200 and, when constructed using the aforementioned exemplary lay-up schedule and a compression molding process, may have a finished thickness that is generally uniform at about 1.0 mm. Striking face portion 202 (not shown) may be manufactured from a high-strength titanium alloy including about 4.5% aluminum, about 3% vanadium, about 2% molybdenum, about 2% iron, and up to about 0.15% oxygen, and may have a constant thickness of about 2.9 mm. To form primary body 230, the striking face portion may be welded to the remaining portions, which may be integrally cast from, e.g., a Ti 6Al 4V alloy using thin wall casting techniques to yield a generally uniform thickness of about 1.2 mm throughout. In this embodiment, major crown portion 208 may occupy about 60 cm² of the exterior surface area of the club head and have a mass of about 8 g. If made from the same Ti 6Al 4V alloy as the primary body, major crown portion 208 would have a mass of about 33 g. As shown in Figure 23, a reinforced step lap joint configuration may be employed to join the composite major crown portion 208 to primary body 230, additionally requiring about 9 g of titanium to form lap surface 238. Further, about 1.3 g of thermosetting epoxy resin and carbon fiber tape may be additionally provided in channel 248 to reinforce the stepped lap joint. Thus, a net savings of about 15 g may be realized and added to the weight budget of head 200, thereby enabling further improvements to the finished club head's mass properties.

[0052] Another exemplary club head in accordance

with the principles outlined herein may have a volumetric displacement of about 337 cm³, and proportions generally consistent with those of a conventional metal wood head displacing about 420 cm³. In this embodiment of the invention, illustrated in Figure 24, all of major crown portion 208, and parts of minor crown portion 210 and skirt portion 206 may form auxiliary body 232, which may be manufactured entirely from a carbon fiber reinforced plastic material including three plies of high fracture toughness, uni-directional prepreg roving oriented at +45°, -45°, and 0°, an exterior-most ply of a light-weight bi-directional prepreg weave oriented at 0°/90°, and a thermosetting epoxy-resin matrix comprising about 40% and about 55% of the above-mentioned prepreg types, respectively, by weight. Using this lay-up schedule and a compression-molding process, auxiliary body 230 may have a finished thickness that may be generally uniform at about 1.0 mm. Striking face portion 202 may be manufactured from a high-strength titanium alloy including about 4.5% aluminum, about 3% vanadium, about 2% molybdenum, about 2% iron, and up to about 0.15% oxygen, and may have a constant thickness of about 2.9 mm. To form primary body 230, the striking face portion may be welded to the remaining portions, which may be integrally cast from, e.g., a Ti 6Al 4V alloy using thin wall casting techniques to yield a generally uniform thickness of about 1.2 mm throughout. In this embodiment, auxiliary body 232 may occupy about 154 cm² of the exterior surface area of the club head and has a mass of about 22.2 g. If made from the same Ti 6Al 4V alloy used in the primary body, the auxiliary body would have a mass of about 84 g. As shown in Figure 24, a reinforced step lap joint configuration may be employed to join the auxiliary body 232 to primary body 230, additionally requiring about 13 g of titanium to form lap surface 238. Further, about 1.7 g of thermosetting epoxy resin and carbon fiber tape may be additionally provided as element 250 to reinforce the stepped lap joint. Thus, a net savings of about 47 g may be realized and added to the weight budget of head 200, thereby enabling further improvements to the finished club head's mass properties.

[0053] Yet another exemplary club head in accordance with the principles outlined herein may have a volumetric displacement of about 337 cm³, and proportions generally consistent with those of a conventional metal wood head displacing about 420 cm³. In this embodiment of the invention, illustrated in Figure 25, all of major crown portion 208, part of minor crown portion 210 and the majority of sole portion 204 and skirt portion 206 may form auxiliary body 232, which may be manufactured entirely from a carbon fiber reinforced plastic material including three plies of high fracture toughness, uni-directional prepreg roving oriented at +45°, -45°, and 0°, an exterior-most ply of a light-weight bi-directional prepreg weave oriented at 0°/90°, and a thermosetting epoxy-resin matrix comprising about 40% and about 55% of the above-mentioned prepreg types, respectively, by weight. Using this lay-up schedule and a compression-molding proc-

ess, auxiliary body 232 may have a finished thickness that may be generally uniform at about 1.0 mm. Striking face portion 202 may be manufactured from a high-strength titanium alloy including about 4.5% aluminum, about 3% vanadium, about 2% molybdenum, about 2% iron, and up to about 0.15% oxygen, and may have a constant thickness of about 2.9 mm. To form primary body 230, the striking face portion may be welded to the remaining portions, which may be integrally cast from, e.g., a Ti 6Al4V alloy using thin wall casting techniques to yield a generally uniform thickness of about 1.2 mm throughout. In this embodiment, auxiliary body 232 may occupy about 198 cm² of the exterior surface area of the club head and have a mass of about 28.5 g. If made from the same Ti 6Al 4V alloy used in the primary body, the auxiliary body would have a mass of about 108 g. As shown in Figure 25, a reinforced step lap joint configuration may be employed to join the auxiliary body 232 to primary body 230, additionally requiring about 10.5 g of titanium to form lap surface 238. Further, about 1.3 g of thermosetting epoxy resin and carbon fiber tape may be additionally provided as element 250 to reinforce the stepped lap joint. Thus, a net savings of about 68 g may be realized and added to the weight budget of head 200, thereby enabling further improvements to the finished club head's mass properties.

[0054] Given the three previous examples, it is evident that the greater the amount of surface area auxiliary body 232 occupies, the greater the benefit will be to the weight budget of head 200. In determining the surface area of auxiliary body 232, additional factors, including effects to the acoustical response of head 200, consumer acceptance/marketability, and cosmetic considerations should be taken into account. Therefore, any combination of club head 200's portions, except striking surface portion 202, may be included in the auxiliary body. Further, it may be considered advantageous to provide more than one auxiliary body, as shown, by way of example only, in Figure 26. Further still, it should be apparent that the auxiliary body (or bodies) need not incorporate entire portions of head 200, but rather may incorporate any fraction of those portions. In accordance with the preceding, it should be apparent that there are many possible permutations for configuring head 200, each of which are not discussed in thorough detail within this application to avoid unnecessarily obscuring the invention, yet all of which may be manufactured according to the principles disclosed herein.

[0055] In addition to improving mass properties through the placement of mass within head 200, weight budget may also be expended to incorporate structural improvements which may have been heretofore impossible due to weight limitations. Such structures include stiffening means such as internal ribs, columns, or truss-like members, which locally stiffen head 200 at various locations to improve acoustical performance, and/or to improve the energy transfer efficiency from head 200 to a golf ball during use. In general, any combination of any

of the club head's portions may be constrained to one another to assist in manipulating the frequency response of the head. It may be particularly advantageous to use one or more ribs, columns, or truss-like members to constrain crown 211 to sole portion 204. Figure 27 (a) shows, by way of example only, an exemplary rib 252 constraining the major crown portion 208 to the sole portion 204. Alternatively, crown 211, sole portion 204 and skirt portion 206 may all be constrained to one another with one or more ribs or truss-like members. Figure 27 (b) shows, by way of example only, an exemplary rib 254 constraining major crown portion 208 and skirt portion 206 to sole portion 204. Additionally, minor crown portion 210 may be constrained to major crown portion 208 and optionally to striking face portion 202. Figure 27 (c) shows, by way of example only, an exemplary rib 256 constraining minor crown portion 210 and major crown portion 208 to striking face 202. Figure 27 (d) shows, by way of example only, an exemplary rib 258 constraining major crown portion 208 to minor crown portion 210. It should be noted that any combination of the above examples may be produced in a single embodiment to achieve the qualities desired by the club head designer.

[0056] The above-mentioned stiffening means may also include locally improving one or more composite portions' material properties by tailoring the lay-up schedule to suit the structural requirements necessary to gain a certain desired performance advantage. This may require locally stiffening one or more of the portions in a certain direction or several directions, which may be accomplished by incorporating layers of prepreg sheet in addition to that which is required for the minimum strength as given in the preceding examples. The additional sheets may be locally oriented in any direction which will enhance the properties of the head in the manner desired. How the lay-up schedule is to be fine tuned may readily be determined by using finite element analysis methods to simulate impacts between head 200 and a golf ball and to identify problematic structural responses in the various portions of the club head, or localized areas that may benefit from further changes.

[0057] There may be particular benefits when the above techniques are adapted to produce a metal wood head that maintains the general proportions of a contemporary metal wood head having volumes from about 330 cm³ to about 470 cm³. Such heads are commonly referred to as drivers, and have loft angles ranging from about 5 to about 20 degrees. Face widths, W_f (shown in Figure 12), for such drivers typically range from about 8.89 to about 11.43 cm (3.5 to about 4.5 inches), and face heights range from about 4.57 to about 5.59 cm (1.8 to about 2.2 inches), yielding typical face surface areas of about 33.9 to about 51.6 cm² (5.25 to about 8.0 square inches). Overall maximum heel-to-toe dimensions, W_h , range from about 10.8 to about 12.7 cm (about 4.25 to about 5 inches), whereas maximum front-to-back dimensions, L_h (as shown in Figure 12), range from about 8.3 to about 10.8 cm (about 3.25 to about 4.25 inches). Club

heads with displacements in these ranges typically have total surface areas ranging from about 258 to about 355 cm² (from about 40 to about 55 square inches), with crown surface areas accounting for about 77 to about 103 cm² (about 12 to about 16 square inches).

[0058] Club heads manufactured according to the techniques of this invention may retain all the dimensional characteristics given above, but with volumes in the range of 280 cm³ to about 400 cm³, and total surface areas in the range of about 226 to 335 cm² (about 35 to about 52 square inches). The crown area accounts for about 84 to about 116 cm² (about 13 to about 18 square inches), with the major crown portion generally contributing between 52 and 90 cm² (between 8 and 14 square inches).

[0059] The novel crown configuration disclosed for head 200 may be of particular benefit when applied to a metal wood golf club head having the following characteristics:

- a W_h value greater than 11.18 cm (4.40")
- A major crown portion having a surface area of about 50 to about 80 cm²
- A volume between 300 and 375 cm³ in combination with a major crown portion surface area of about 50 to about 80 cm²
- a W_h value greater than 11.18 cm (4.40") in combination with an L_r value between 1.27 to about 3.81 cm (about 0.5 to about 1.5 inches)
- a volume in the range of about 300 to about 375 cm³ in combination with an L_r value between about 1.27 to about 3.81 cm (about 0.5 to about 1.5 inches)
- an L_h value greater than 3.40" in combination with an L_r value between about 1.27 to about 3.81 cm (about 0.5 to about 1.5 inches)
- a volume in excess of 300 cm³ in which the ratio of striking face portion surface area to head volume exceeds 0.105 cm⁻¹.
- a volume in excess of about 300 cm³ in which the ratio of major crown portion surface area to head volume exceeds 0.140 cm⁻¹
- a volume in excess of 300 cm³ in which the ratio of W_h to head volume exceeds 0.030 cm⁻².
- a volume in excess of 300 cm³ in which the ratio of L_h to volume exceeds 0.0095 cm⁻².
- a total volume to total surface area ratio having a value between about 1.05 and about 1.15.

[0060] The principles discussed herein enable about 10 to about 45 grams to be added to a metal wood's weight budget, and results in finished head center of gravity heights being lowered about 1 to about 10 mm. Furthermore, the moments of inertia of club head 200 are comparable to modern metal wood heads having correspondingly larger displacements. Therefore, club head 200 maintains the forgiveness of contemporary large displacement metal wood heads, but due to improved mass properties at the minimum structural mass coupled with

an increased weight budget, may be configured to provide better launch characteristics. Alternatively, club head 200 may be produced with launch characteristics consistent with those of a modern metal wood club head, and excess discretionary weight may be utilized to increase moments of inertia and therefore the forgiveness of club head 200.

[0061] Accordingly, the metal wood head configurations disclosed herein demonstrate improved ball launching characteristics at impact resulting in increased carry. This is accomplished primarily by the lowering of the major crown portion, which yields improved mass characteristics at a metal wood club head's minimum structural mass in comparison to conventionally configured club heads having similar proportions. Further, this configuration makes more mass available for strategic placement within the club head, thereby affording the club head designer greater freedom to manipulate a head's mass properties, i.e. center of gravity location, and inertial moments about certain axes, parameters which define a club head's performance potential and forgiveness, respectively.

[0062] The above-described embodiments of the club head are given only as examples. Therefore, the scope of the invention should be determined not by the illustrations given, but by the appended claims and their equivalents.

30 Claims

1. A hollow wood-type golf club head comprising:

- a striking face portion;
- a sole portion;
- a skirt portion;
- a crown portion having a major crown portion and a minor crown portion, said major crown portion defining a major surface area and said minor portion defining a minor surface area, said major surface area being greater than said minor surface area, said major surface area defining a generally concave first contour and said minor surface area defining a generally convex second contour, said head having a volume greater than about 280cm³.

2. The hollow wood-type golf club head of claim 1, wherein said volume is less than about 400 cm³.

3. The hollow wood-type golf club head of claim 1 wherein said volume is greater than about 300 cm³.

4. The hollow wood-type golf club head of claim 3 wherein said volume is less than about 400 cm³

5. The hollow wood-type golf club head of claim 1, wherein the minor crown portion peripherally sur-

rounds the major crown portion.

6. The hollow wood-type golf club head of claim 1 further comprising a generally parabolic tail edge.

7. The hollow wood-type golf club head of claim 1 further comprising a return portion having a length L_r between about 1 cm and about 4 cm.

8. The hollow wood-type golf club head of claim 7 wherein L_r varies along the transverse direction of the head.

9. The hollow wood-type golf club head of claim 1 comprising a heel end and a toe end and wherein the major crown portion is generally upwardly inclined toward said toe end.

10. The hollow wood-type golf club head of claim 1 comprising a transverse midpoint, a heelmost extent, a toemost extent, and at least one point located on said major surface area that is vertically lower than a remainder of said major surface area, wherein said at least one point is located between said heelmost extent and said transverse midpoint.

11. The hollow wood-type golf club head of claim 1, wherein:

the striking face portion has a maximum height, $H_{f_{max}}$; a horizontal datum plane intersects said head at a vertical distance of $H_{f_{max}}$; and about 95% or more of the major surface area resides below the datum plane.

12. The hollow wood-type golf club head of claim 1, wherein:

the striking face portion has a maximum height, $H_{f_{max}}$; a horizontal datum plane intersects said head at a vertical distance of $0.8 H_{f_{max}}$; and about 80% or more of the major surface area resides below the datum plane.

13. The hollow wood-type golf club head of claim 1, wherein:

the striking face portion has a maximum height, $H_{f_{max}}$; a horizontal datum plane intersects said head at a vertical distance of $0.65 H_{f_{max}}$; and about 60% or more of the major surface area resides below the datum plane.

14. The hollow wood-type golf club head of claim 1, wherein:

the striking face portion has a maximum height, $H_{f_{max}}$; a horizontal datum plane intersects said head at a vertical distance of $0.5 H_{f_{max}}$; and about 30% or more of the major surface area resides below the datum plane.

15. The hollow wood-type golf club head of claim 1, wherein:

the striking face portion has a maximum height, $H_{f_{max}}$; a horizontal datum plane intersects said head at a vertical distance, d , ranging from 0 to $H_{f_{max}}$; and about 95% or more of the major surface area resides below the datum plane when $d = H_{f_{max}}$; about 80% or more of the major surface area resides below the datum plane when $d = 0.8 H_{f_{max}}$; about 60% or more of the major surface area resides below the datum plane when $d = 0.65 H_{f_{max}}$; and about 30% or more of the major surface area resides below the datum plane when $d = 0.5 H_{f_{max}}$.

16. The hollow wood-type golf club head of claim 1., wherein:

the striking face portion has a maximum height, $H_{f_{max}}$; a horizontal datum plane intersects said head at a vertical distance of $0.8 H_{f_{max}}$; and about 85% or more of the major surface area resides below the datum plane.

17. The hollow wood-type golf club head of claim 1, wherein:

the striking face portion has a maximum height, $H_{f_{max}}$; a horizontal datum plane intersects said wood head at a vertical distance of $0.65 H_{f_{max}}$; and about 70% or more of the major surface area resides below the datum plane.

18. The hollow wood-type golf club head of claim 1, wherein:

the striking face portion has a maximum height, $H_{f_{max}}$; a horizontal datum plane intersects said wood head at a vertical distance of $0.5 H_{f_{max}}$; and about 50% or more of the major surface area resides below the datum plane.

19. The hollow wood-type golf club head of claim 1, wherein:

- the striking face portion has a maximum height, $H_{f_{max}}$;
 a horizontal datum plane intersects said head at a vertical distance of $0.35 H_{f_{max}}$; and about 25% or more of the major surface area resides below the datum plane.
- 20.** The hollow wood-type golf club head of claim 1, wherein:
- the striking face portion has a maximum height, $H_{f_{max}}$;
 a horizontal datum plane intersects said head at a vertical distance, d , ranging from 0 to $H_{f_{max}}$; and
 about 95% or more of said major surface area resides below said datum plane when $d = 1.0H_{f_{max}}$, about 85% or more of said major surface area resides below said datum plane when $d = 0.8H_{f_{max}}$, about 70% or more of said major surface area resides below said datum plane when $d = 0.65H_{f_{max}}$, about 50% or more of said major surface area resides below said datum plane when $d = 0.5H_{f_{max}}$, and about 25% or more of said major surface area resides below said datum plane when $d = 0.35H_{f_{max}}$.
- 21.** The hollow wood-type golf club head of claim 1 having a plurality of vertical cross sections, each of said cross sections intersecting said major crown portion longitudinally and having a perimeter length, L_p , defining an enclosed sectional area, A_x , wherein L_p/A_x for each of said cross sections is greater than about 0.65.
- 22.** The hollow wood-type golf club head of claim 21 having a transverse midpoint, said major crown portion having a heel-most extent and a toe-most extent, wherein L_p/A_x has a maximum variance of about 0.03 for said plurality of vertical cross sections taken in a region spanning from said midpoint to said tomost extent.
- 23.** The hollow wood-type golf club head of claim 21 having a transverse midpoint, said major crown portion having a heel-most extent and a toe-most extent, wherein L_p/A_x has a maximum variance of about 0.07 for said plurality of vertical cross sections taken in a region spanning from said midpoint to said tomost extent.
- 24.** The hollow wood-type golf club head of claim 1 wherein a part of said head has a higher specific strength than the rest of said head.
- 25.** The hollow wood-type golf club head of claim 24 wherein said part of said head comprises at least a part of said crown portion.
- 26.** The hollow wood-type golf club head of claim 24 wherein said part of said head comprises at least a part of said major crown portion.
- 27.** The hollow wood-type golf club head of claim 24 wherein said part of said head comprises at least a part of said minor crown portion.
- 28.** The hollow wood-type golf club head of claim 24 wherein said part of said head comprises at least a part of said skirt portion.
- 29.** The hollow wood-type golf club head of claim 24 wherein said part of said head comprises at least a part of said sole portion.
- 30.** A hollow wood-type golf club head comprising:
- a striking face portion;
 - a sole portion;
 - a skirt portion;
 - a crown portion having a major crown portion and a minor crown portion, said major crown portion comprising a first contour, said minor crown portion comprising a second contour; wherein a plurality of vertical cross sections intersect said golf club head, each of said cross sections having a perimeter length L_p defining an enclosed sectional area A_x , L_p/A_x for each of said cross sections exceeding about 0.65.
- 31.** The hollow wood-type golf club head of claim 30, wherein said first contour is generally concave and said second contour is generally convex.
- 32.** The hollow wood-type golf club head of claim 30 having a transverse midpoint, said major crown portion having a heel-most extent and a toe-most extent, wherein L_p/A_x has a maximum variance of about 0.03 for said plurality of vertical cross sections taken in a region spanning from said midpoint to said toe-most extent.
- 33.** The hollow wood-type golf club head of claim 30 having a transverse midpoint, said major crown portion having a heel-most extent and a toe-most extent, wherein L_p/A_x has a maximum variance of about 0.07 for said plurality of vertical cross sections taken in a region spanning from said midpoint to said toe-most extent.
- 34.** The hollow wood-type golf club head of claim 30, wherein the major crown portion is entirely visible from an address position.
- 35.** The hollow wood-type golf club head of claim 30 wherein said head has a volume greater than about 280 cm^3 .

36. The hollow wood-type golf club head of claim 35 wherein said volume is less than about 400 cm^3 .
37. The hollow wood-type golf club head of claim 30, wherein the minor crown portion peripherally surrounds the major crown portion.
38. The hollow wood-type golf club head of claim 30 further comprising a generally parabolic tail edge.
39. The hollow wood-type golf club head of claim 30 further having a return portion having a length L_r between about 1 cm and about 4 cm.
40. The hollow wood-type golf club head of claim 39 wherein L_r varies along the transverse direction of the head.
41. A hollow wood-type golf club head comprising:
- a striking face portion;
 - a sole portion;
 - a skirt portion;
 - a crown portion having a major crown portion and a minor crown portion,
- wherein:
- the striking face portion has a maximum height, $H_{f_{\max}}$;
 - a horizontal datum plane intersects said head at a vertical distance, d , ranging from 0 to $H_{f_{\max}}$;
 - and
 - about 95% or more of the major surface area resides below the datum plane when $d = H_{f_{\max}}$;
 - about 80% or more of the major surface area resides below the datum plane when $d = 0.8H_{f_{\max}}$;
 - about 60% or more of the major surface area resides below the datum plane when $d = 0.65H_{f_{\max}}$;
 - and about 30% or more of the major surface area resides below the datum plane when $d = 0.5H_{f_{\max}}$.
42. The hollow wood-type golf club head of claim 41, wherein the major crown portion is entirely visible from an address position.
43. The hollow wood-type golf club head of claim 41 wherein said head has a volume greater than about 280 cm^3 .
44. The hollow wood-type golf club head of claim 43 having a volume less than about 400 cm^3 .
45. The hollow wood-type golf club head of claim 41, wherein the minor crown portion peripherally surrounds the major crown portion.
46. The hollow wood-type golf club head of claim 41 further comprising a generally parabolic tail edge.
47. The hollow wood-type golf club head of claim 41 further comprising a return portion having a length L_r between about 1 cm and about 4 cm.
48. The hollow wood-type golf club head of claim 47 wherein L_r varies along the transverse direction of the head.
49. A hollow wood-type golf club head comprising:
- a striking face portion;
 - a sole portion;
 - a skirt portion;
 - a crown portion having a major crown portion and a minor crown portion, said major crown portion defining a major surface area, said minor portion defining a minor surface area, said major surface area being greater than said minor surface area, said major surface area defining a generally concave first contour, said minor surface area defining a generally convex second contour, wherein a part of said head has a higher specific strength than the rest of said head.
50. The hollow wood-type golf club head of claim 49 wherein said head has a volume greater than about 280 cm^3 .
51. The hollow wood-type golf club head of claim 50 wherein said volume is less than about 400 cm^3 .
52. The hollow wood-type golf club head of claim 49, wherein the minor crown portion peripherally surrounds the major crown portion.
53. The hollow wood-type golf club head of claim 49 further comprising a generally parabolic tail edge.
54. The hollow wood-type golf club head of claim 49 further comprising a return portion having a length L_r between about 1 cm and about 4 cm.
55. The hollow wood-type golf club head of claim 54 wherein L_r varies along the transverse direction of the head.
56. The hollow wood-type golf club head of claim 49 having a heel end and a toe end and wherein the major crown portion is generally upwardly inclined toward said toe end.
57. The hollow wood-type golf club head of claim 49 wherein said part of said head comprises at least a part of said crown portion.

- 58. The hollow wood-type golf club head of claim 49 wherein said part of said head comprises at least a part of said major crown portion.
- 59. The hollow wood-type golf club head of claim 49 wherein said part of said head comprises at least a part of said minor crown portion. 5
- 60. The hollow wood-type golf club head of claim 49 wherein said part of said head comprises at least a part of said skirt portion. 10
- 61. The hollow wood-type golf club head of claim 49 wherein said part of said head comprises at least a part of said sole portion. 15

20

25

30

35

40

45

50

55

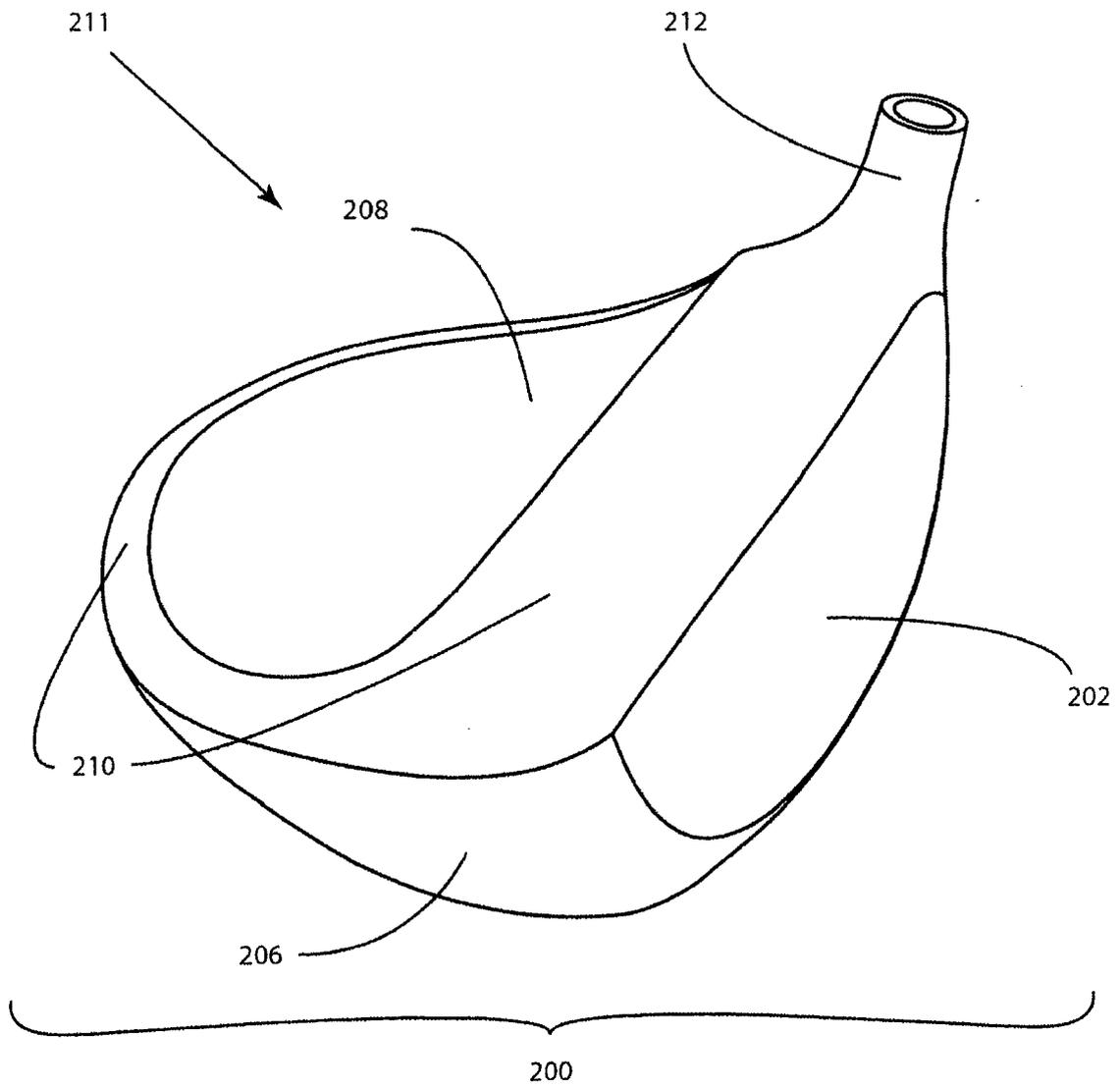


Figure 1

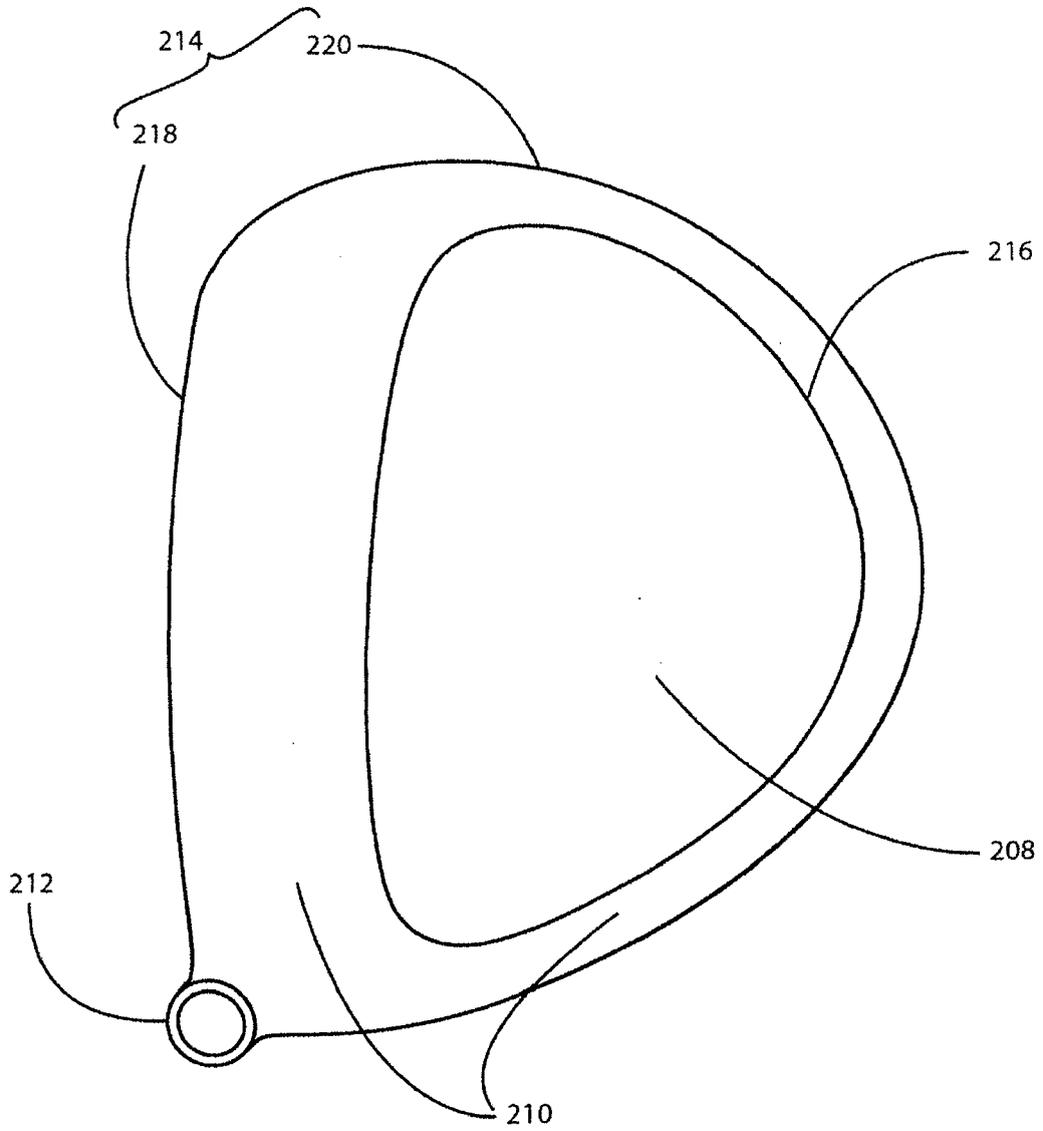


Figure 2

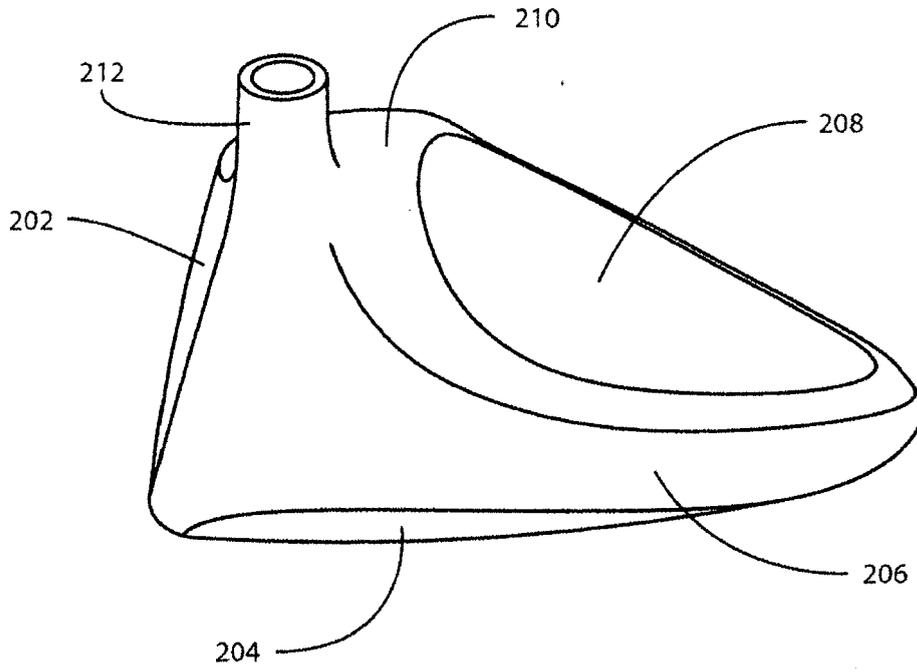


Figure 3

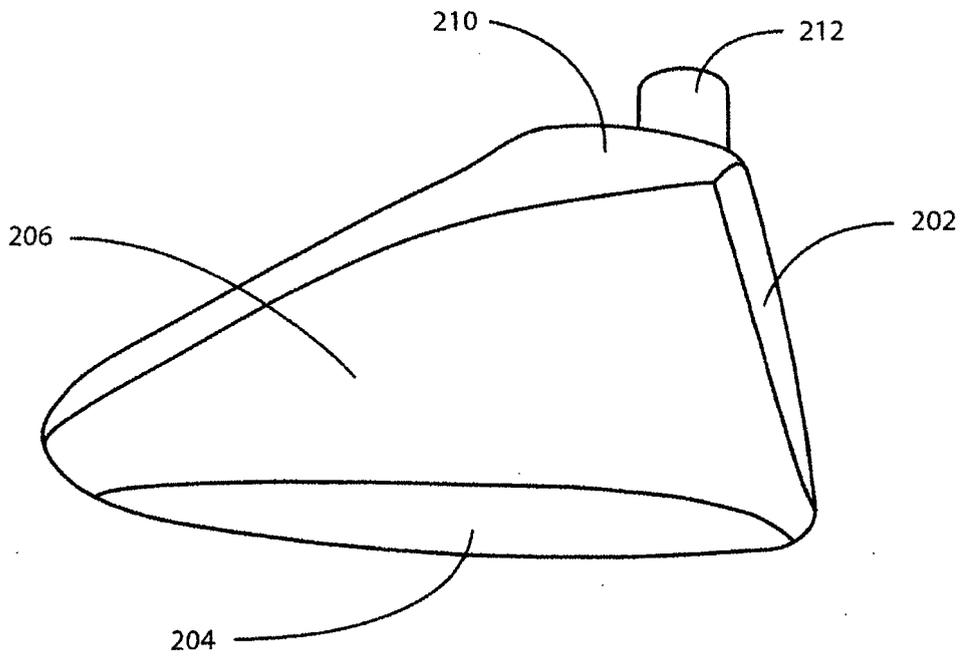


Figure 4

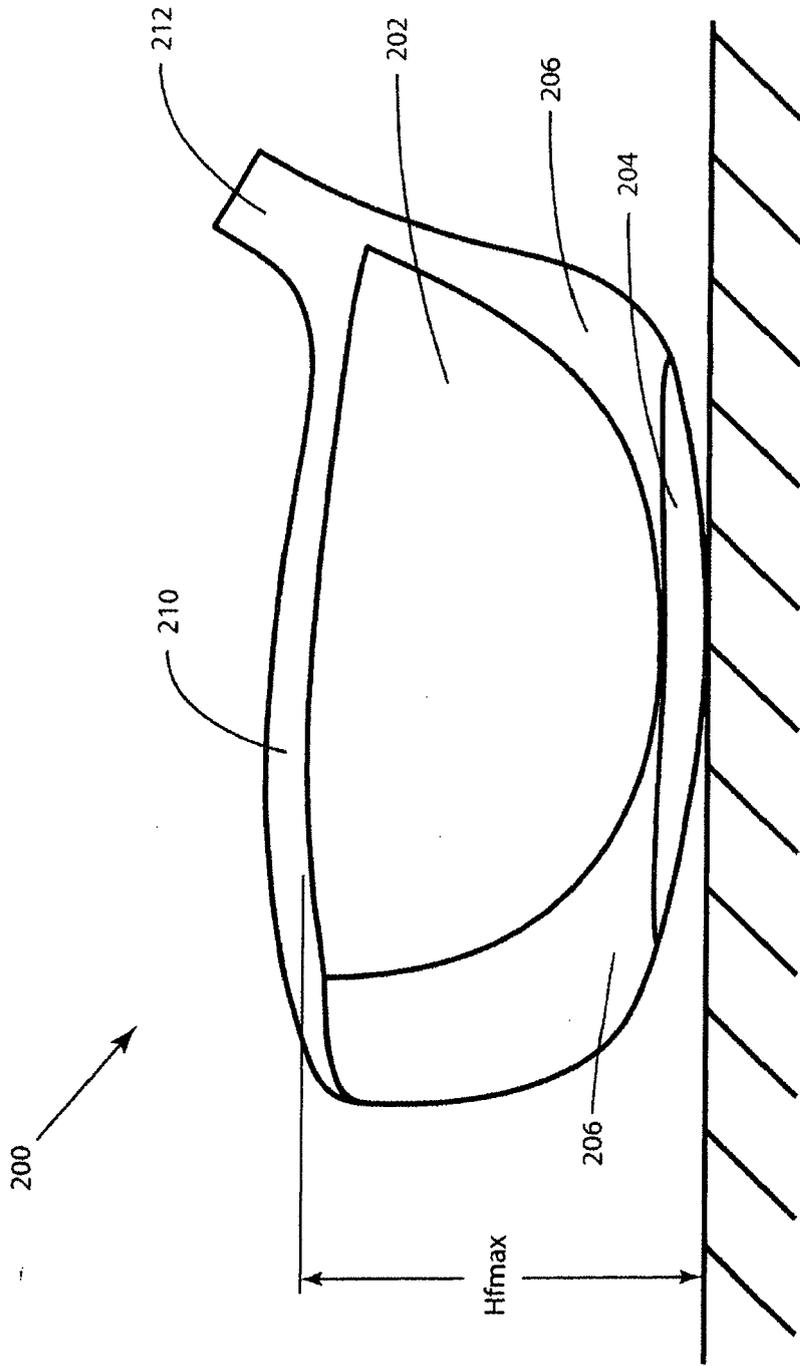


Figure 5

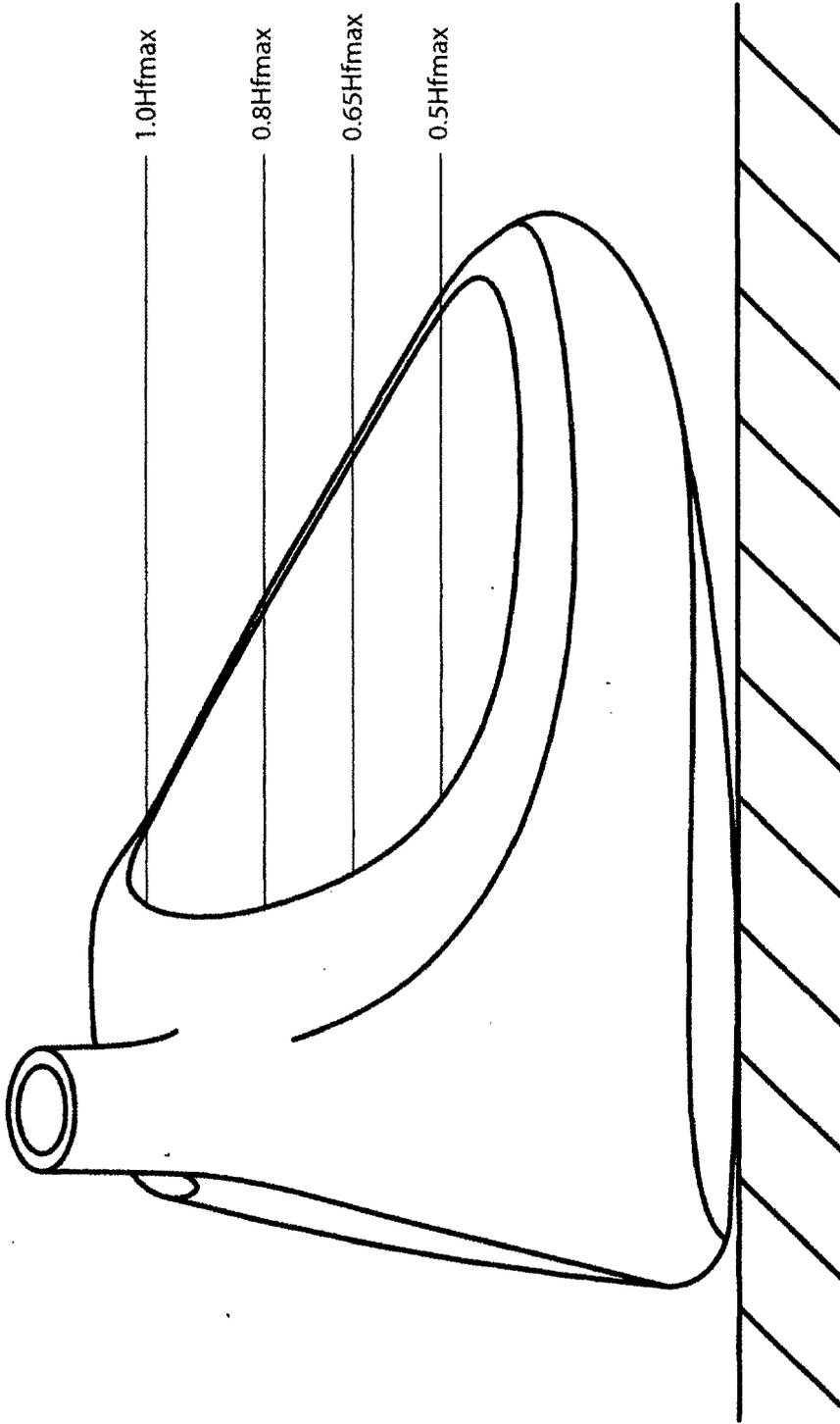


Figure 6

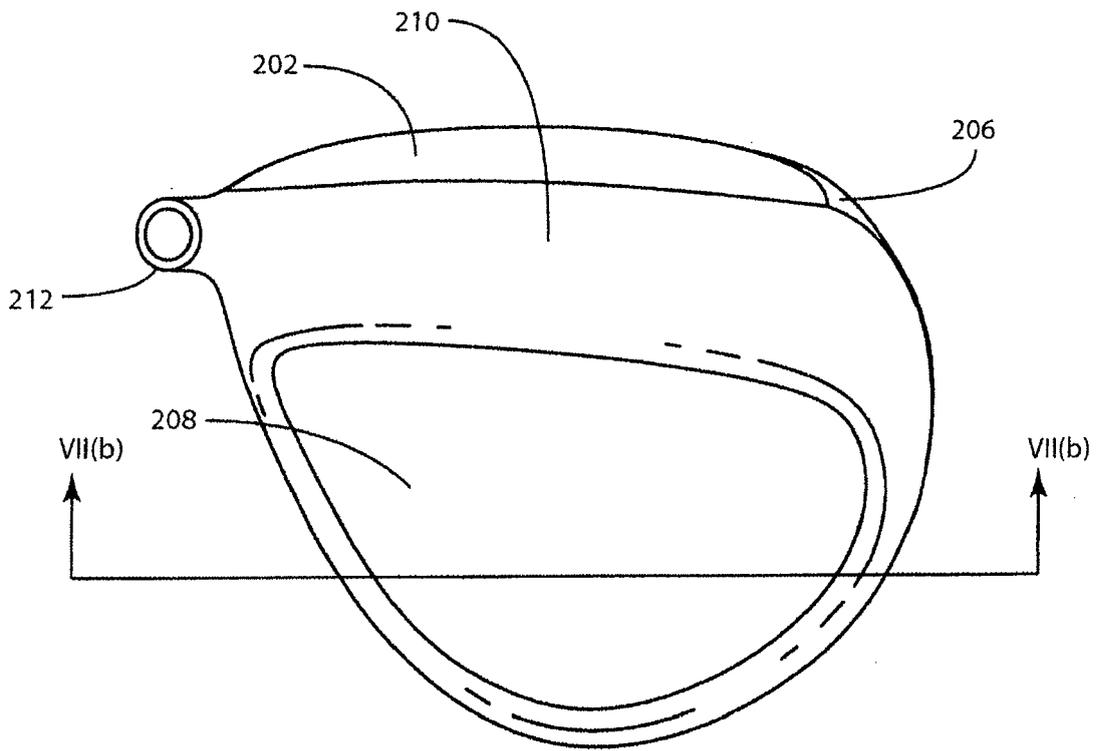


Figure 7 (a)

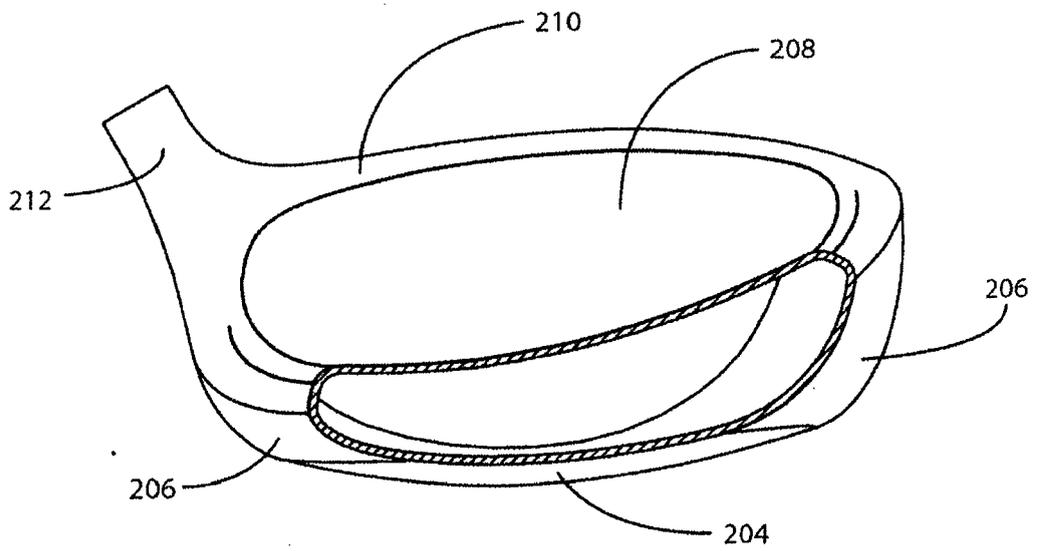


Figure 7 (b)

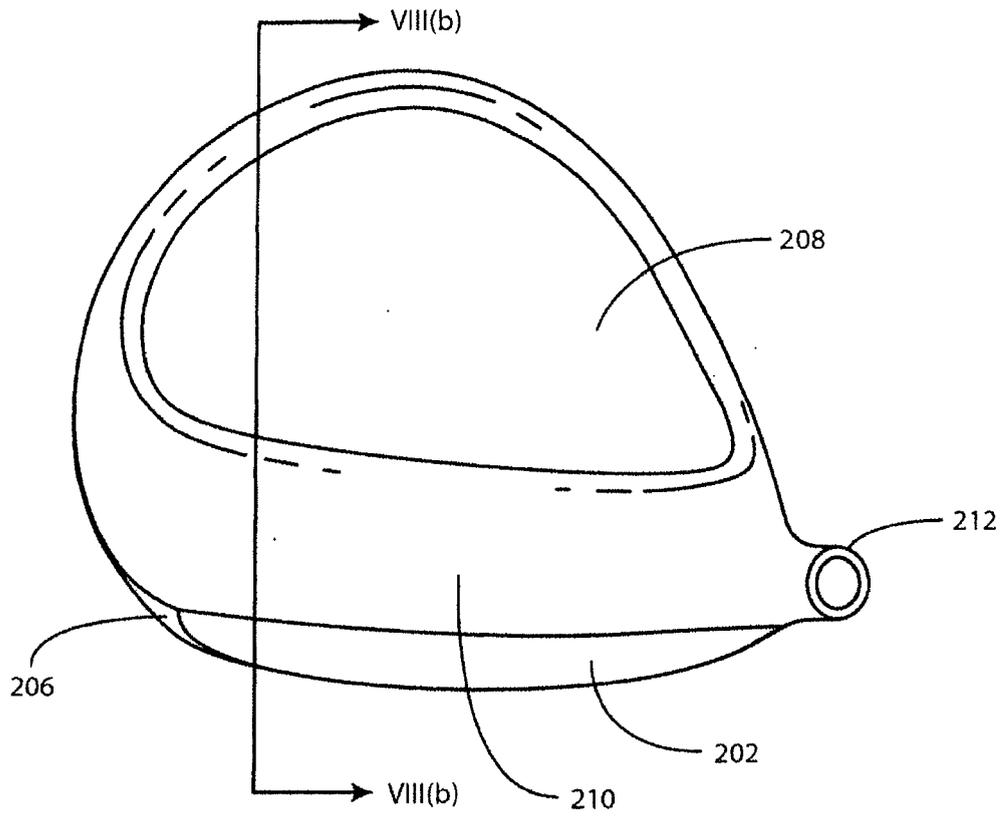


Figure 8 (a)

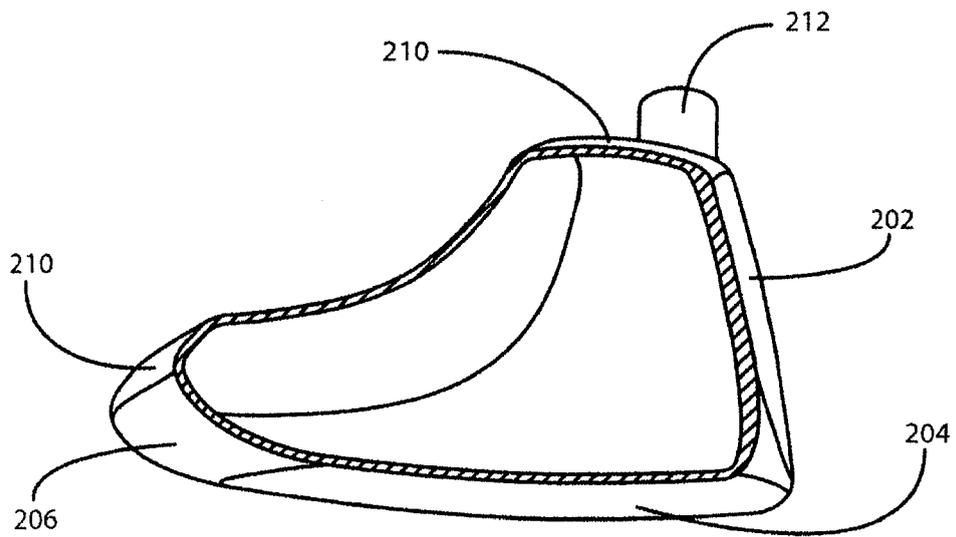


Figure 8 (b)

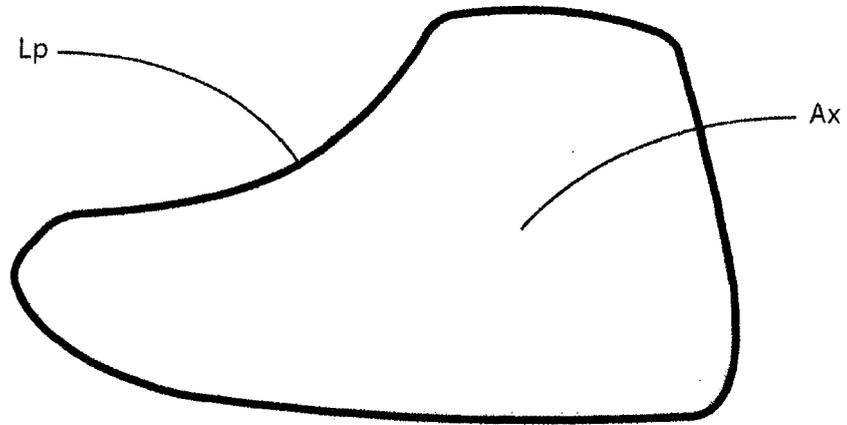


Figure 9 (a)



Figure 9 (b)

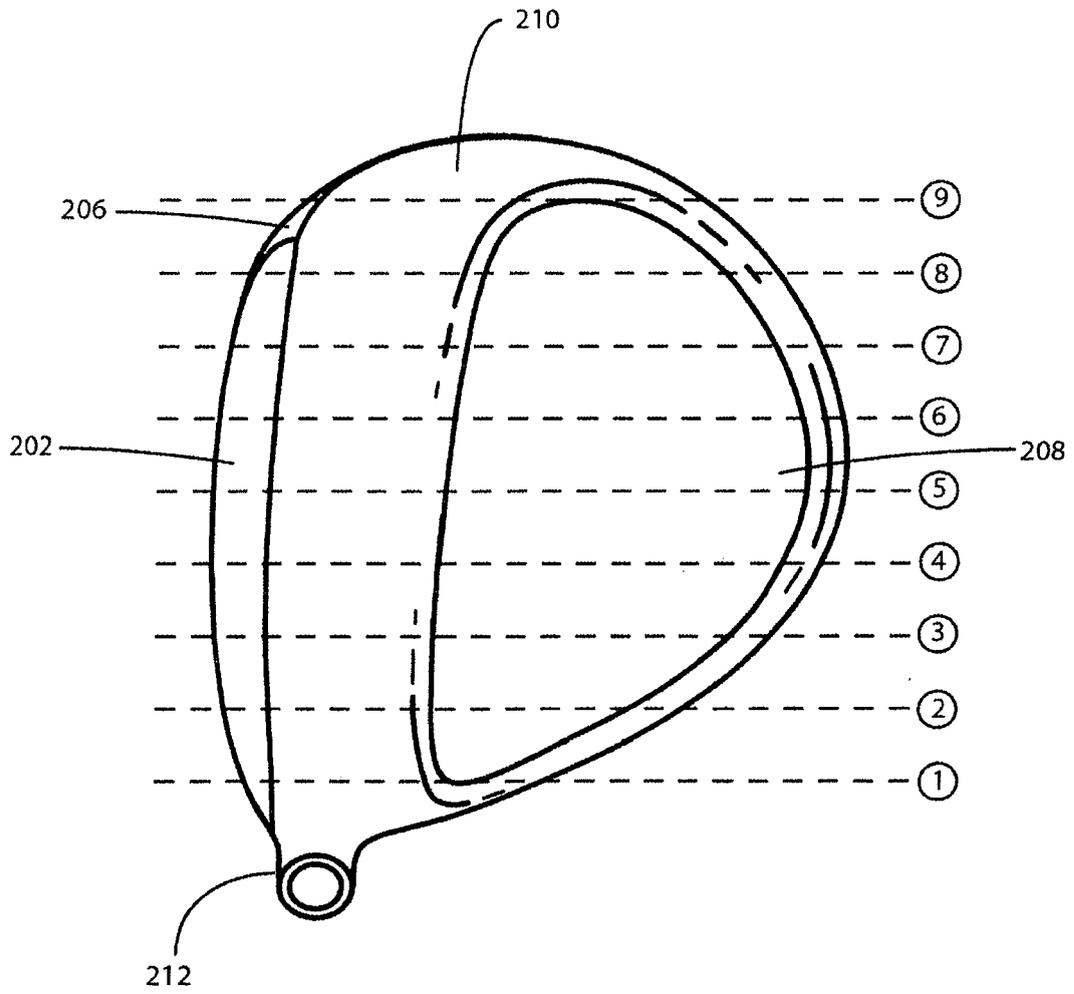


Figure 10

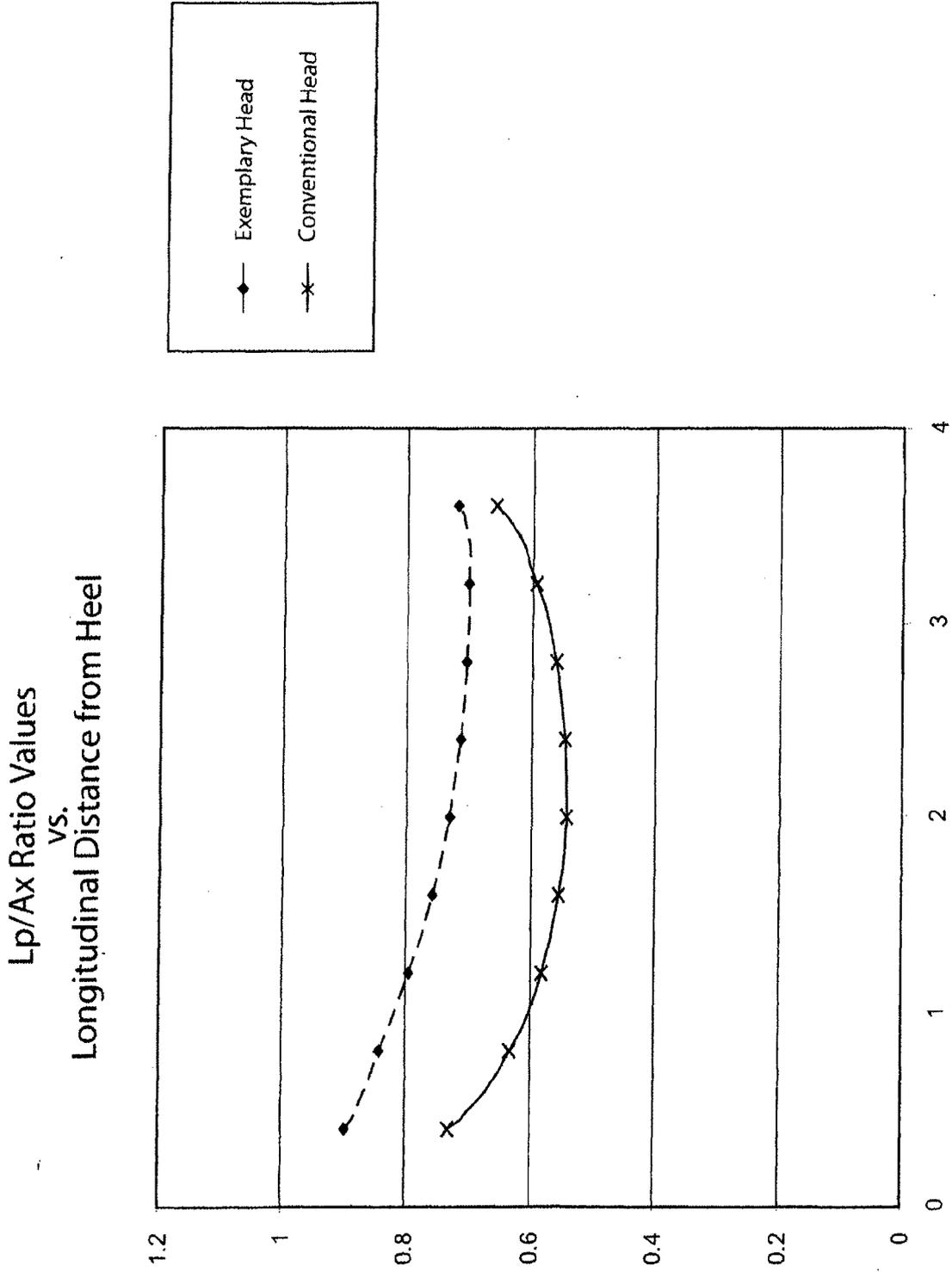


Figure 11

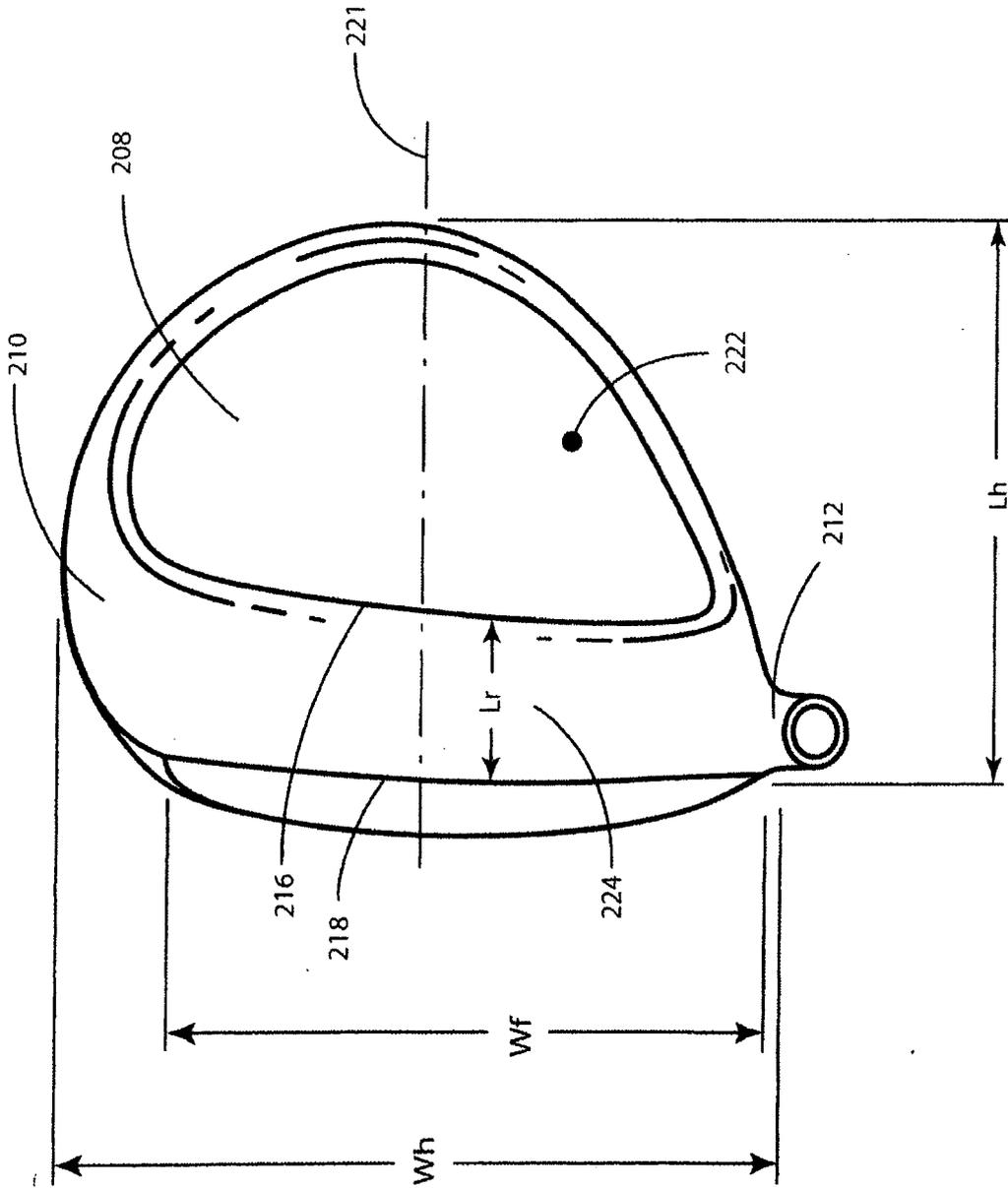


Figure 12

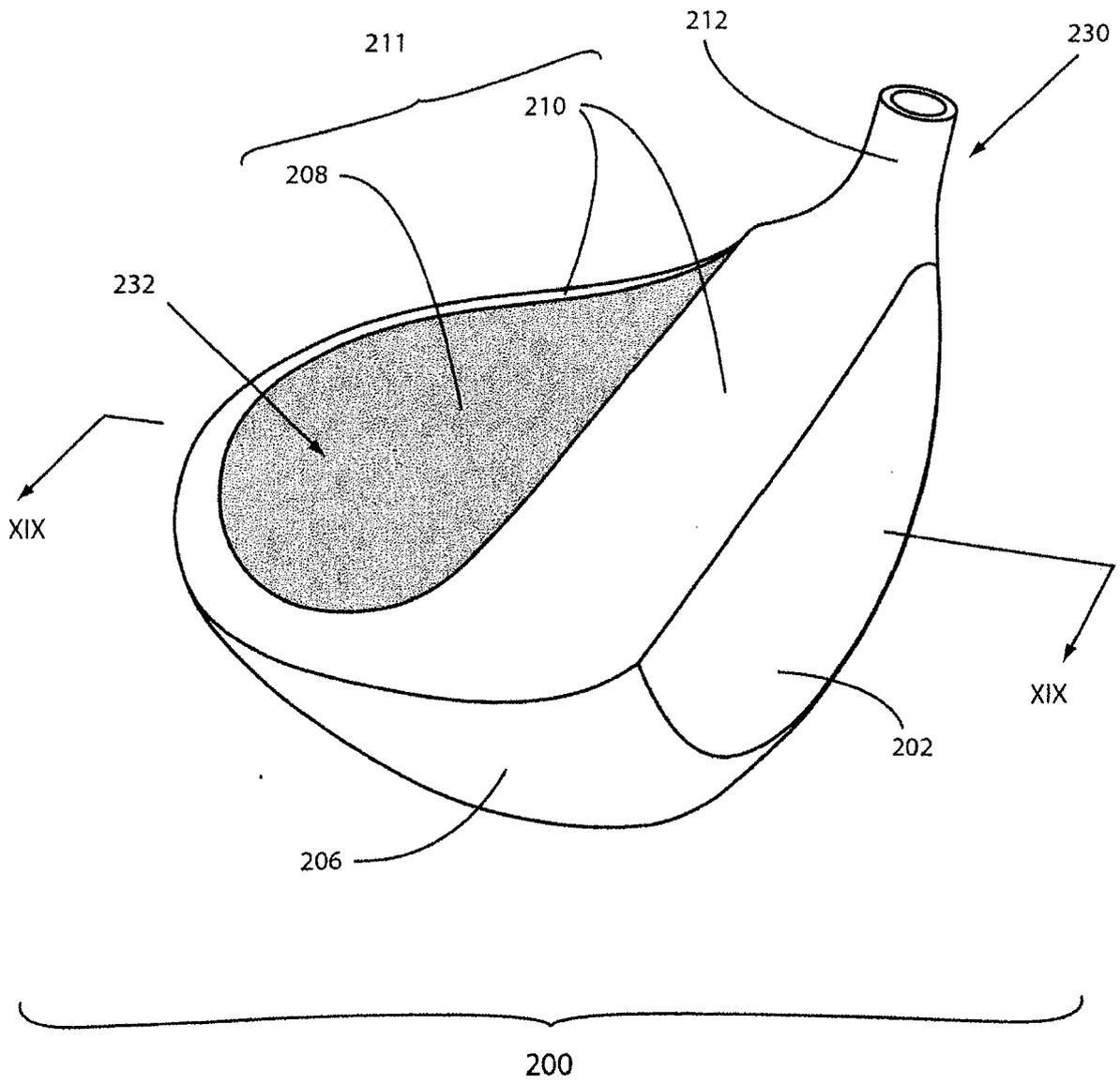


Figure 13

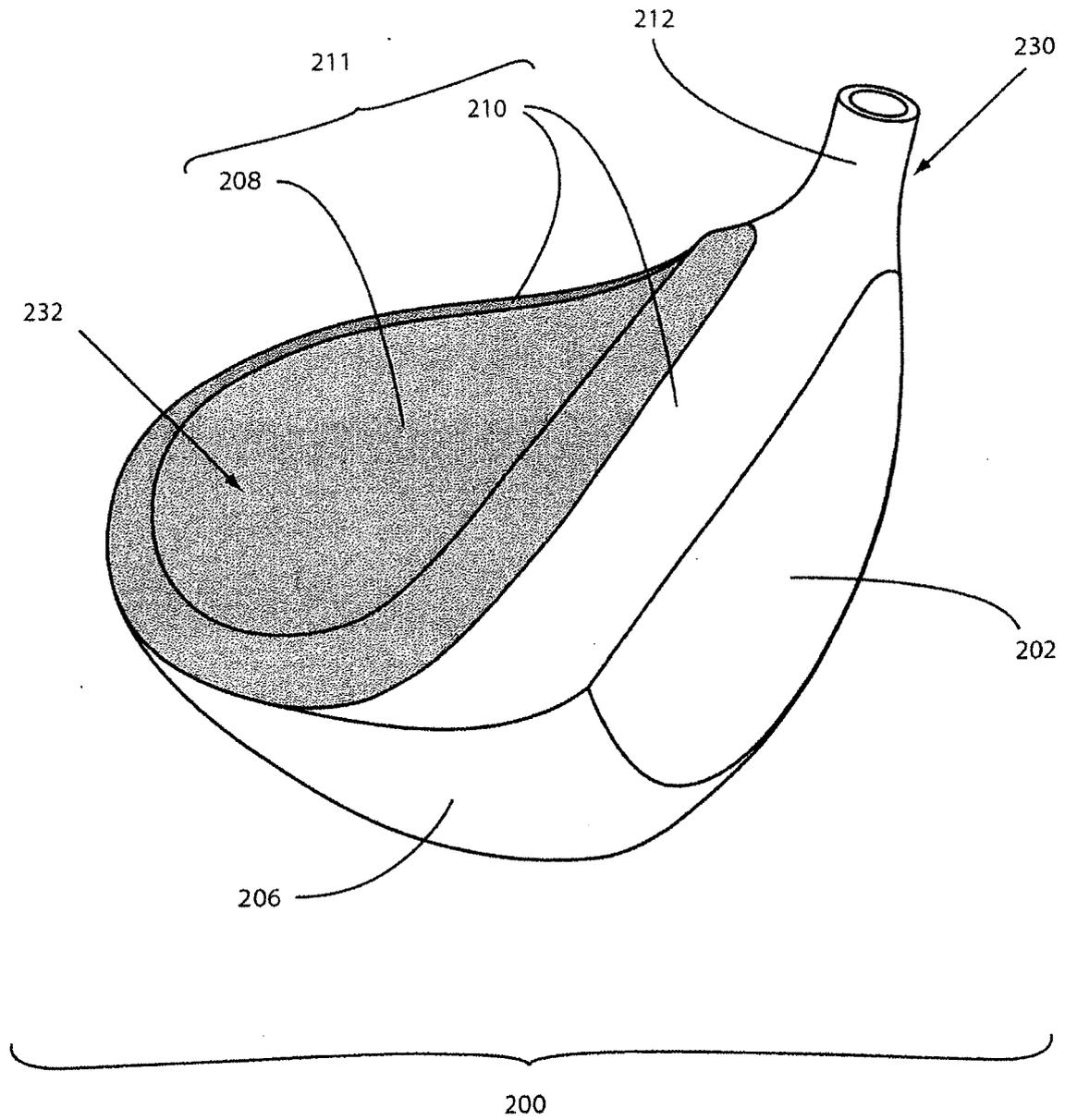


Figure 14 (a)

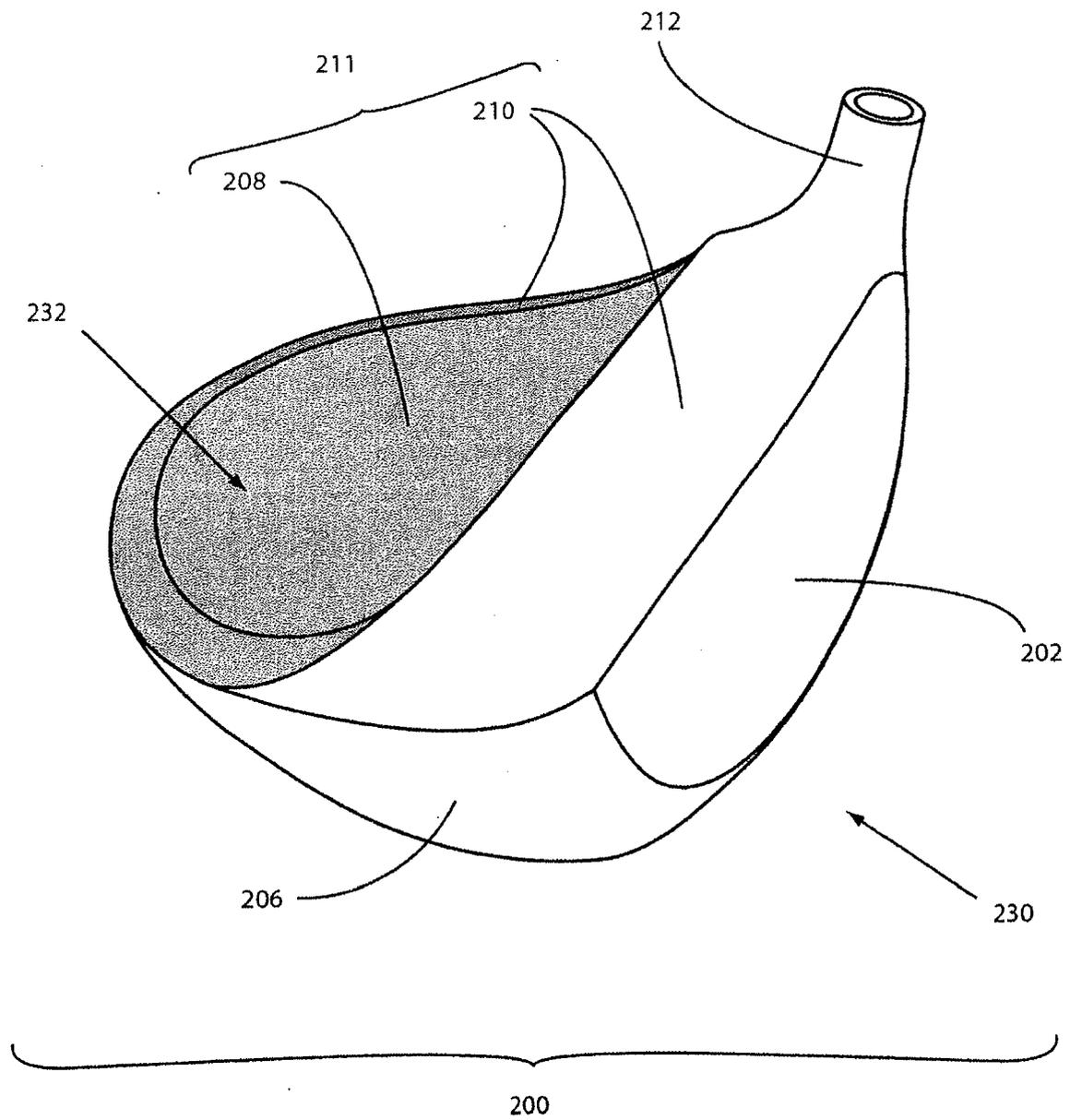


Figure 14 (b)

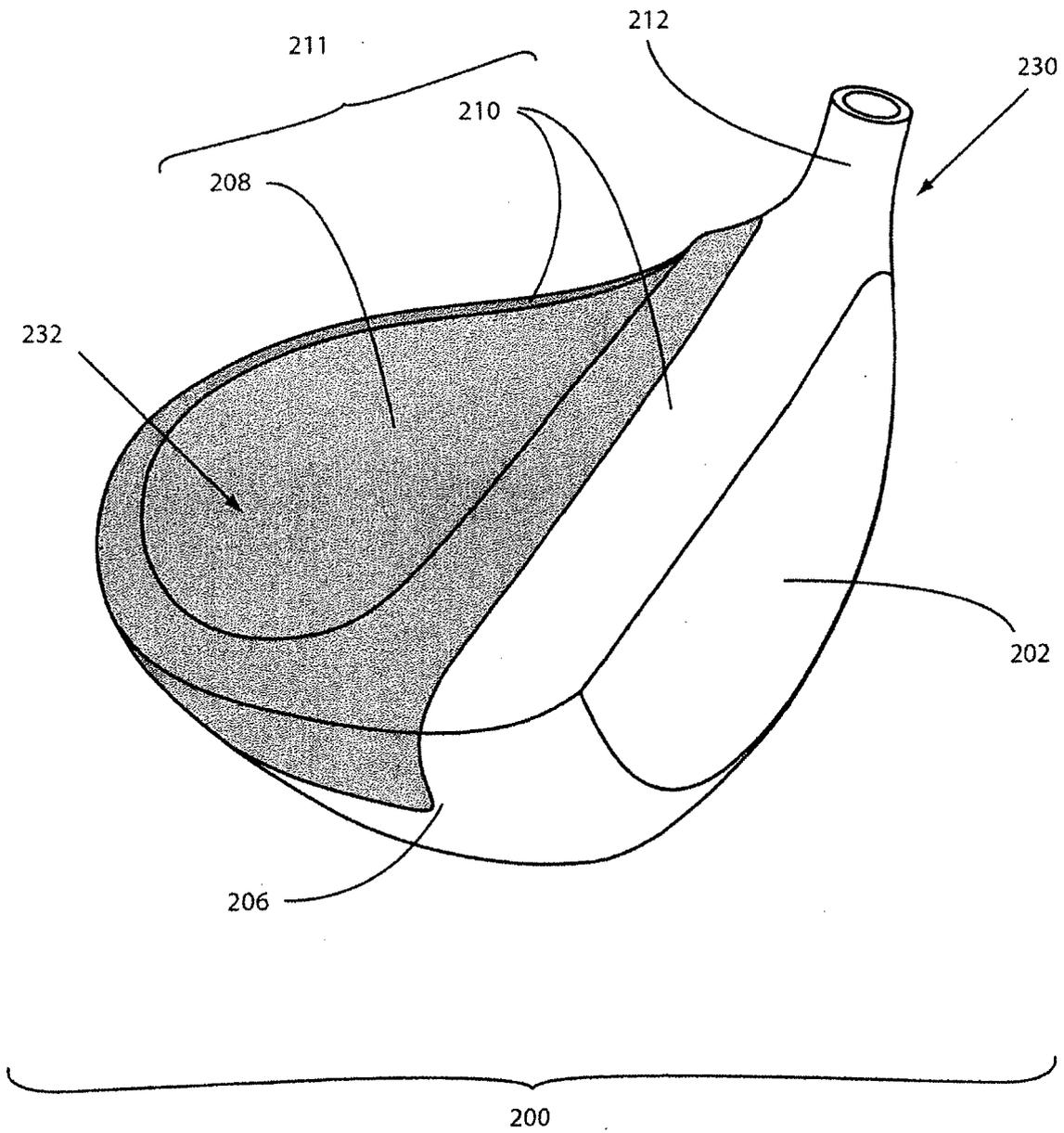


Figure 15 (a)

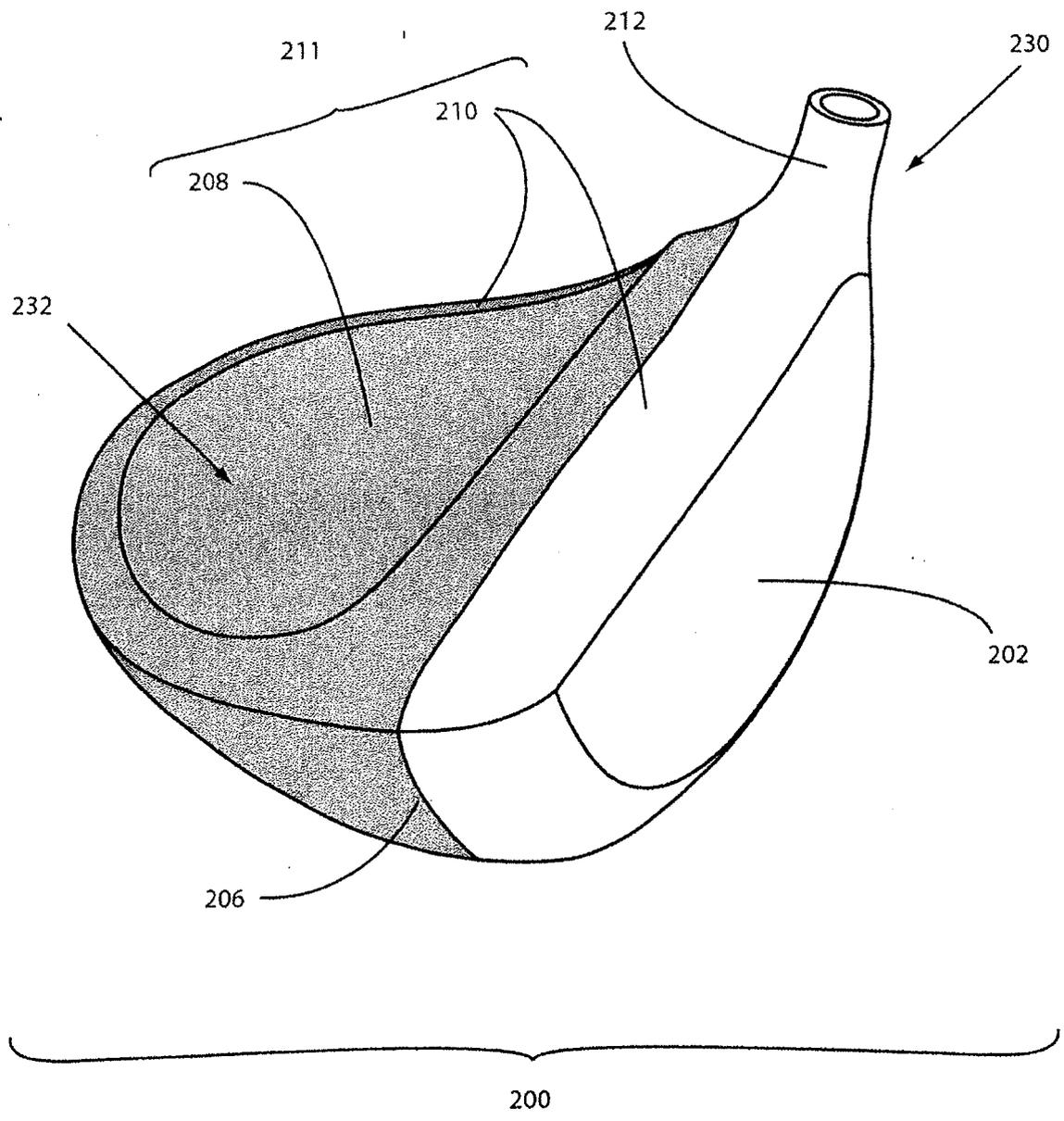


Figure 15 (b)

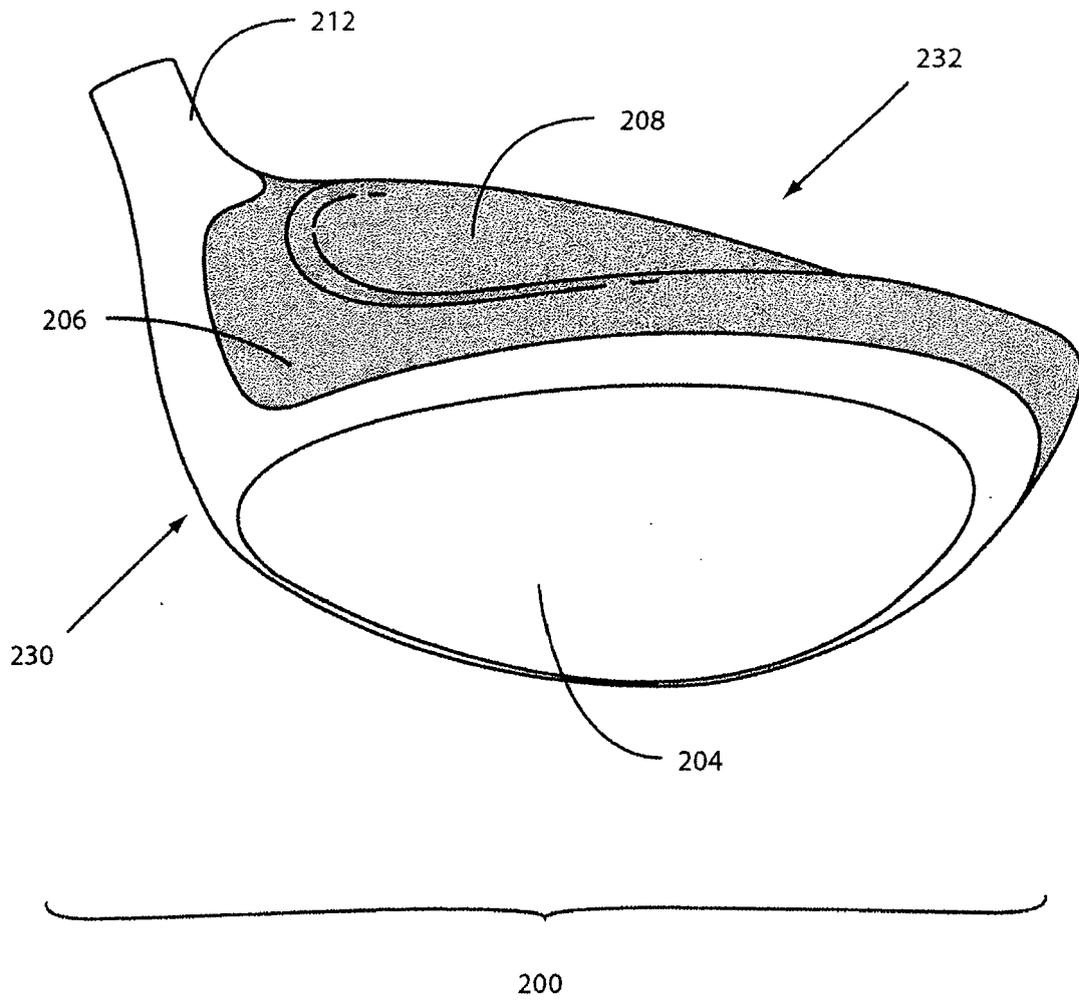


Figure 16 (a)

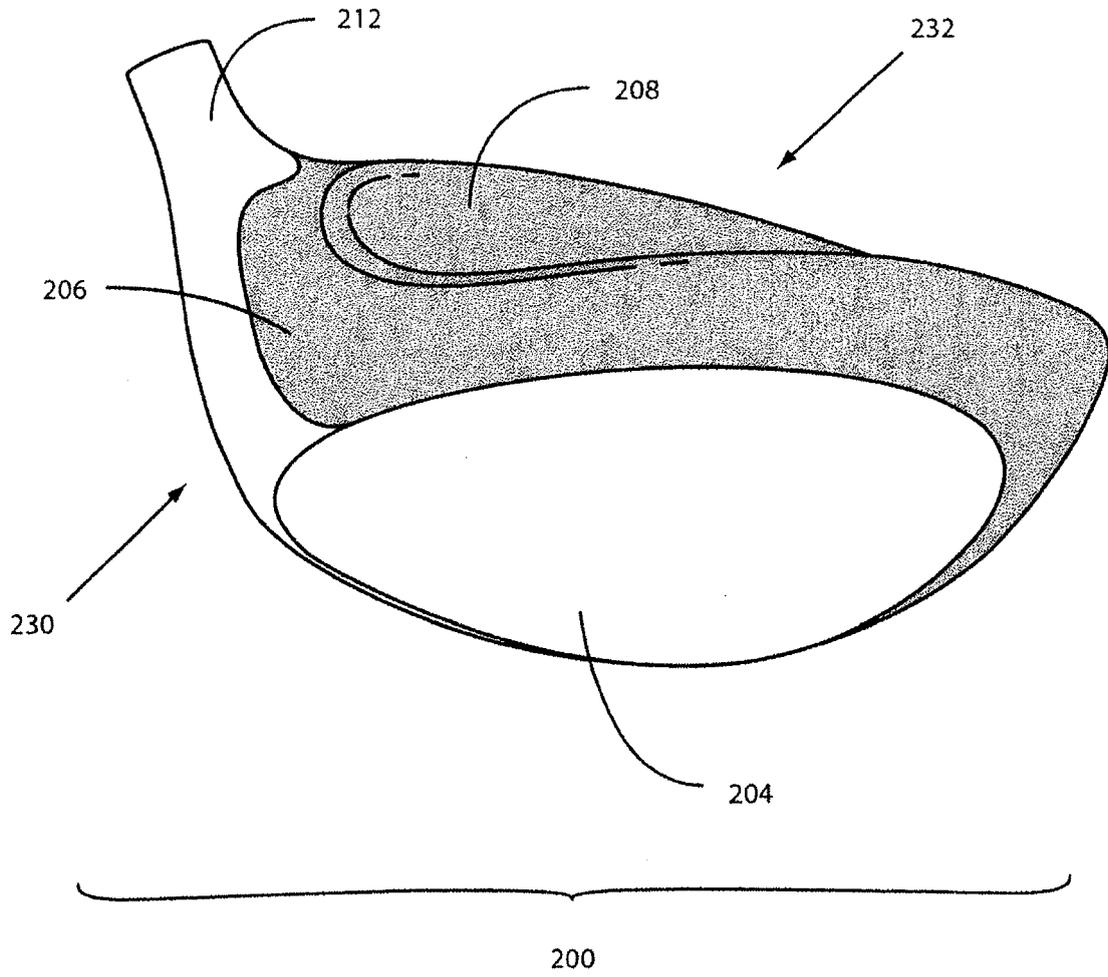


Figure 16 (b)

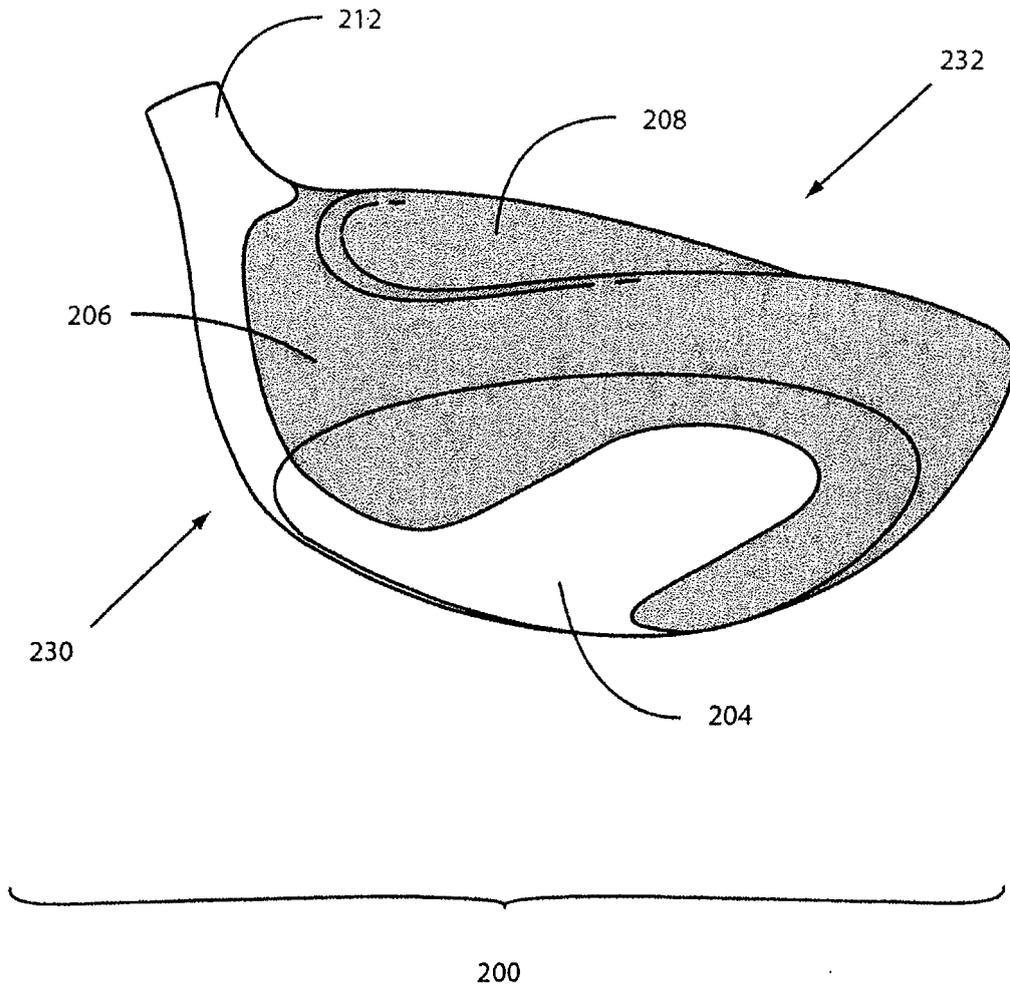


Figure 17 (a)

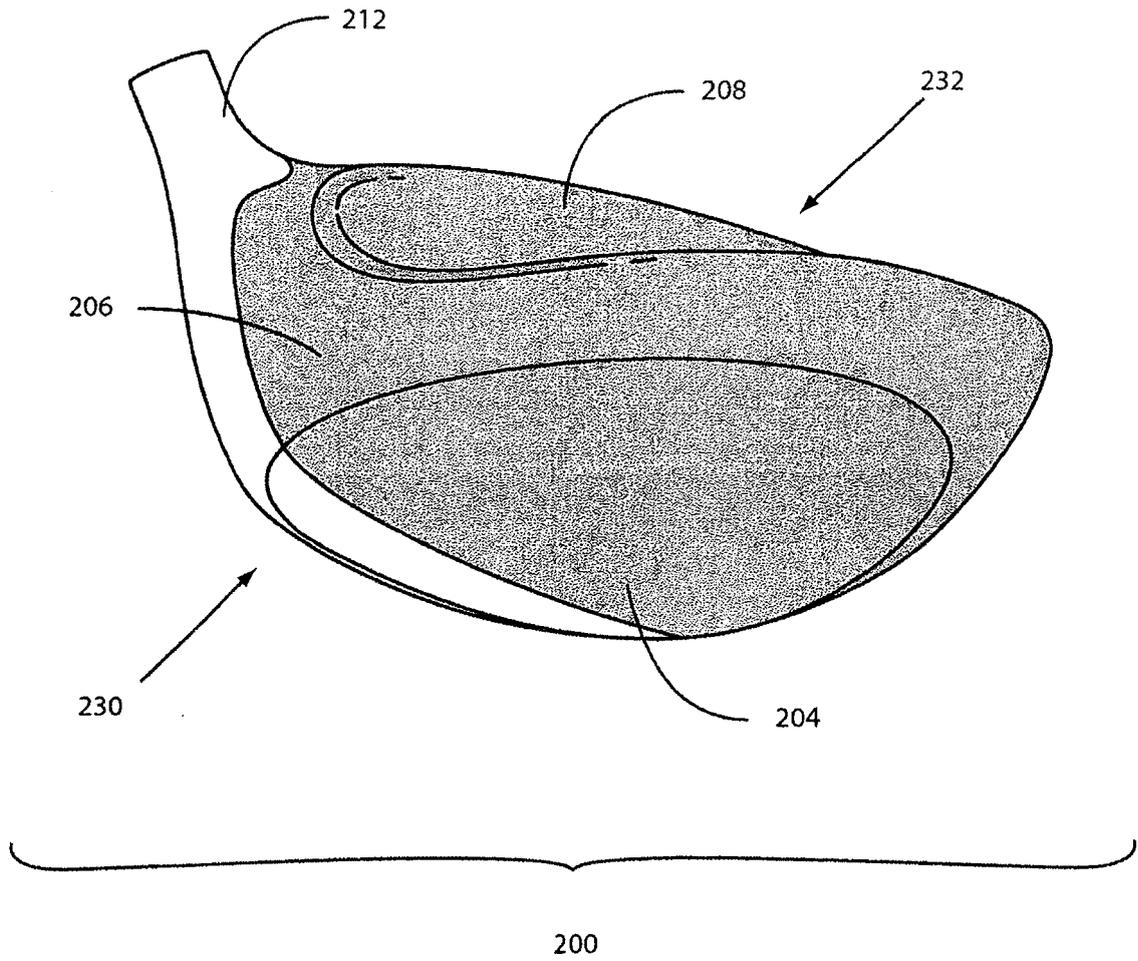


Figure 17 (b)

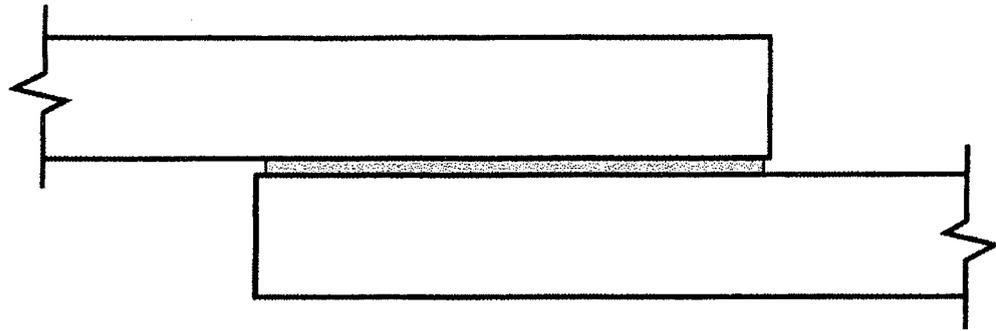


Figure 18 (a)

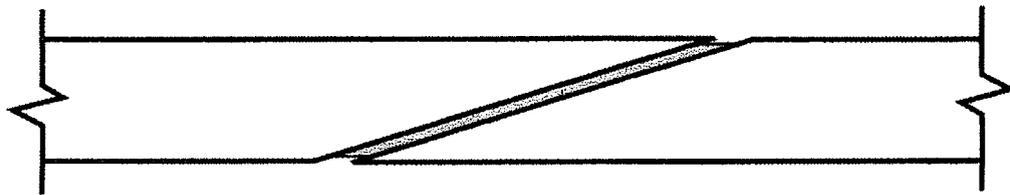


Figure 18 (b)

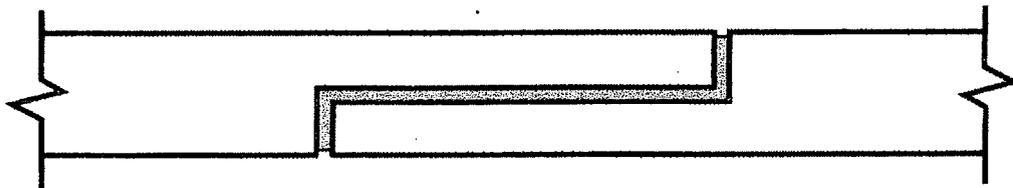


Figure 18 (c)

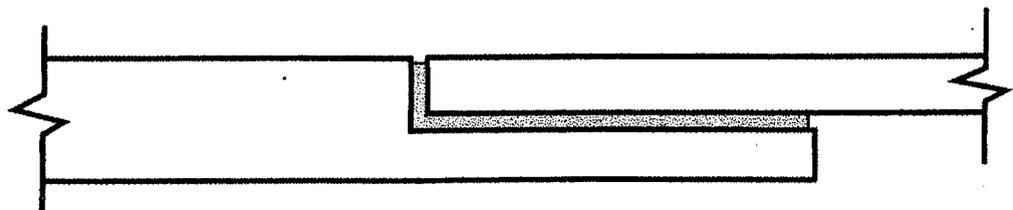


Figure 18 (d)

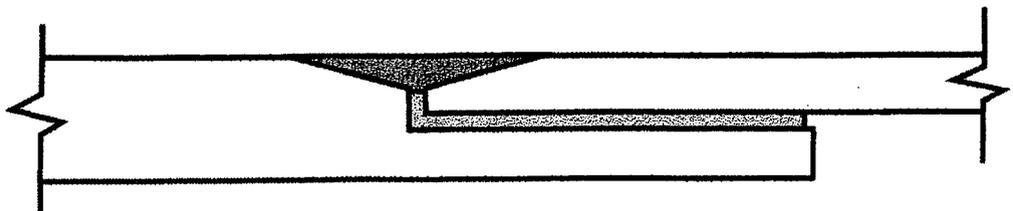


Figure 18 (e)

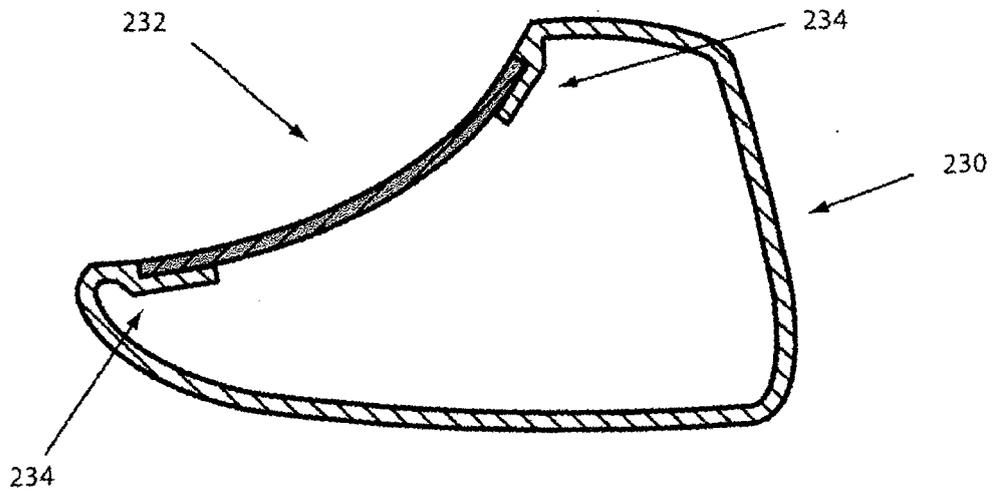


Figure 19 (a)

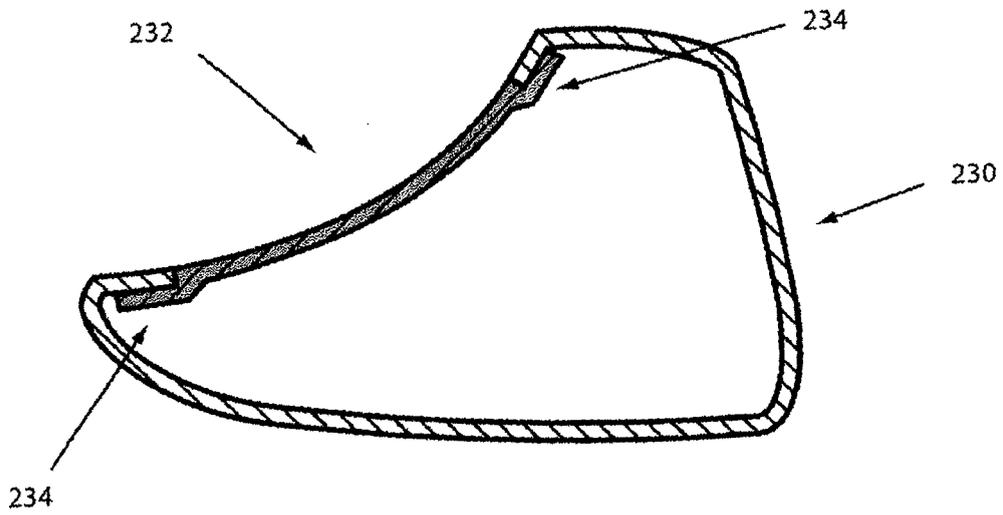


Figure 19(b)

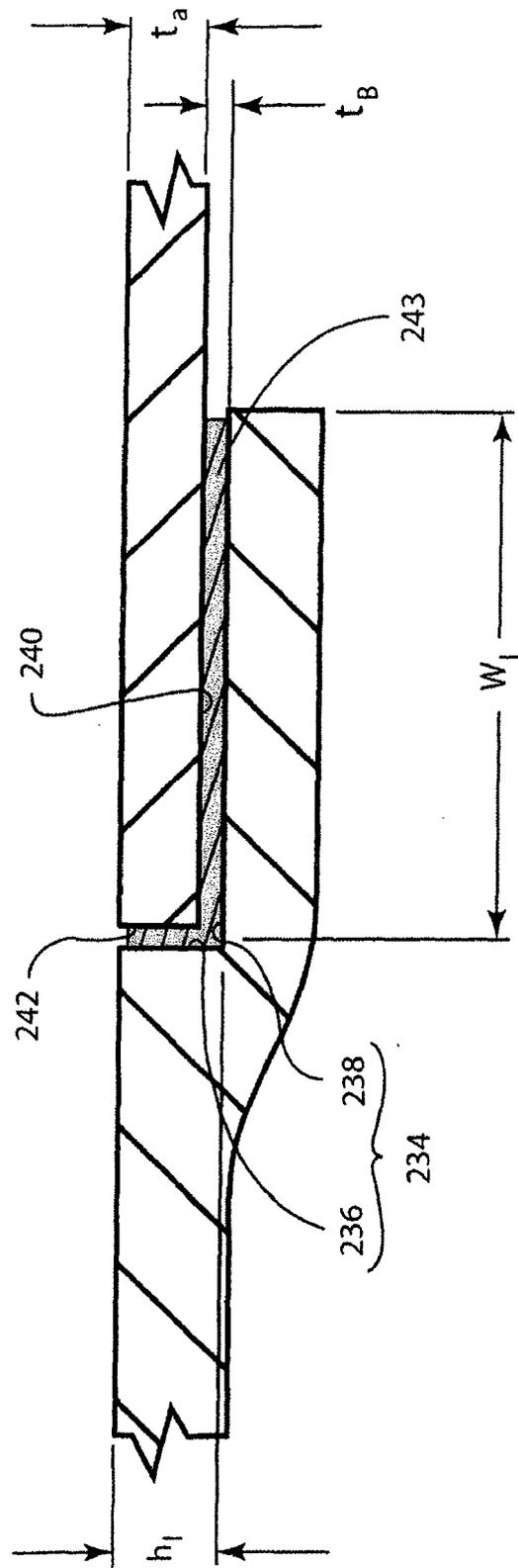


Figure 20 (a)

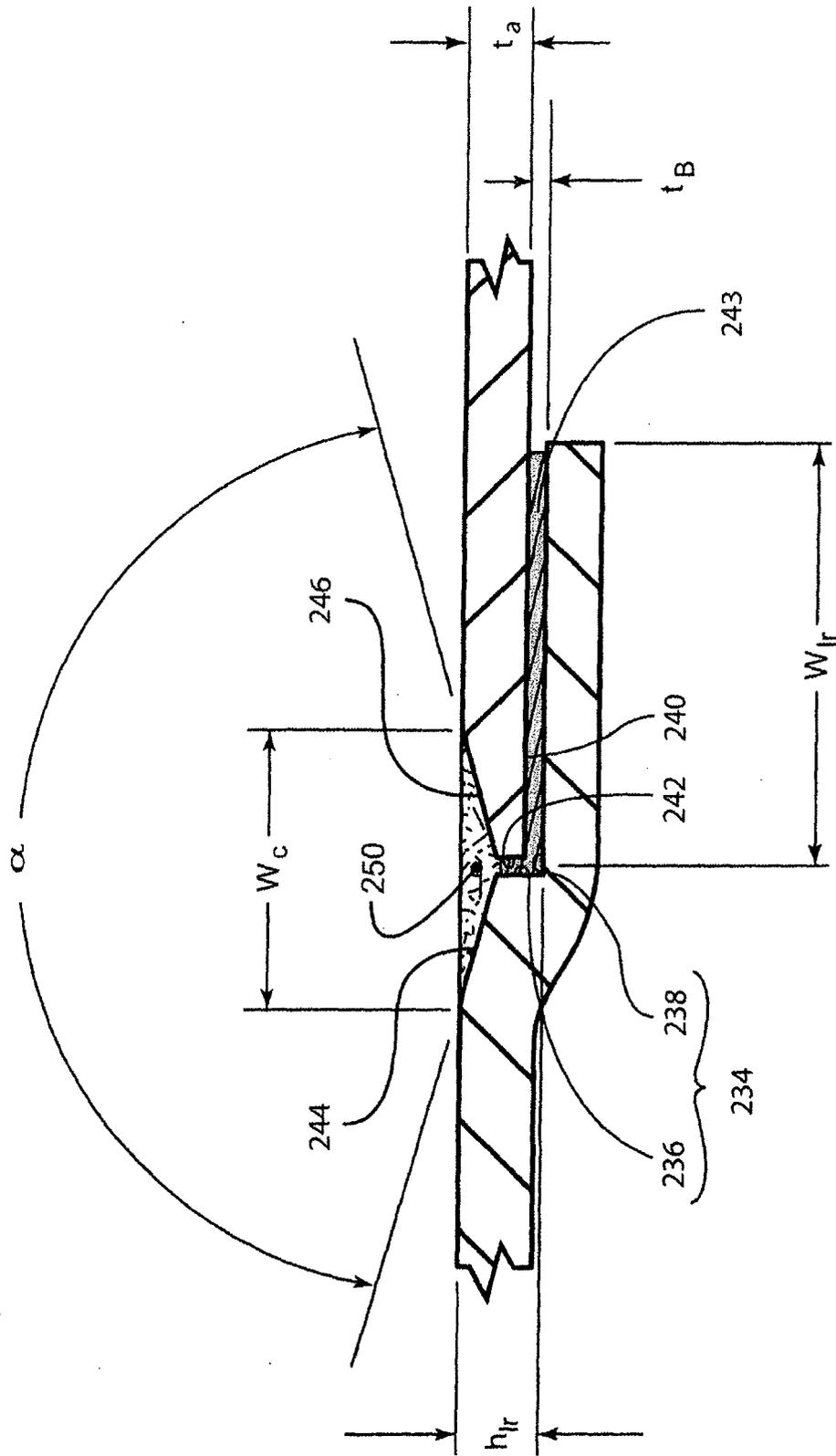


Figure 20 (b)

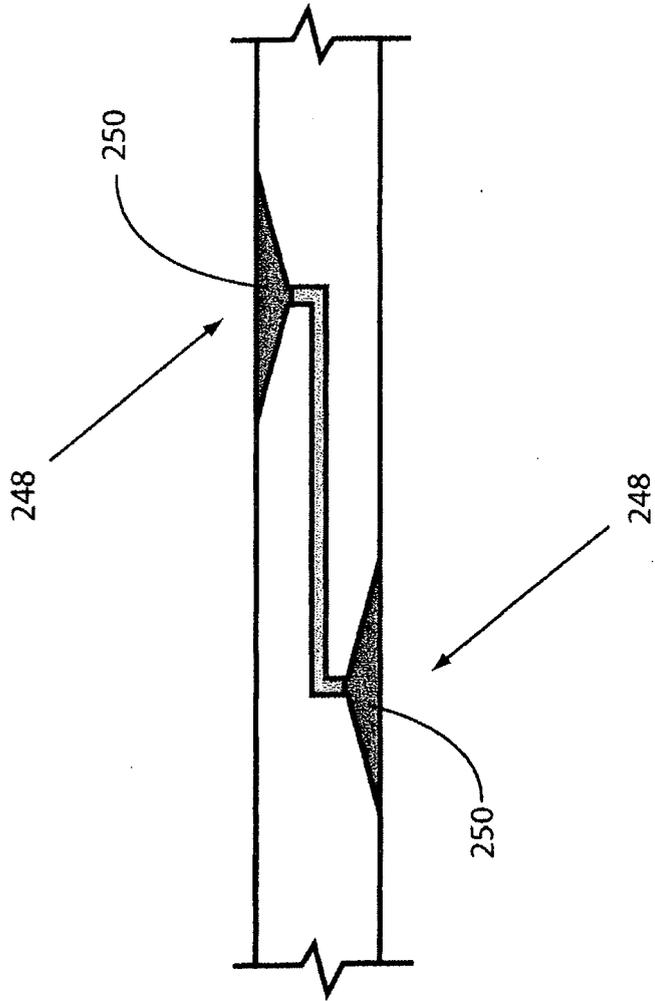


Figure 20 (c)

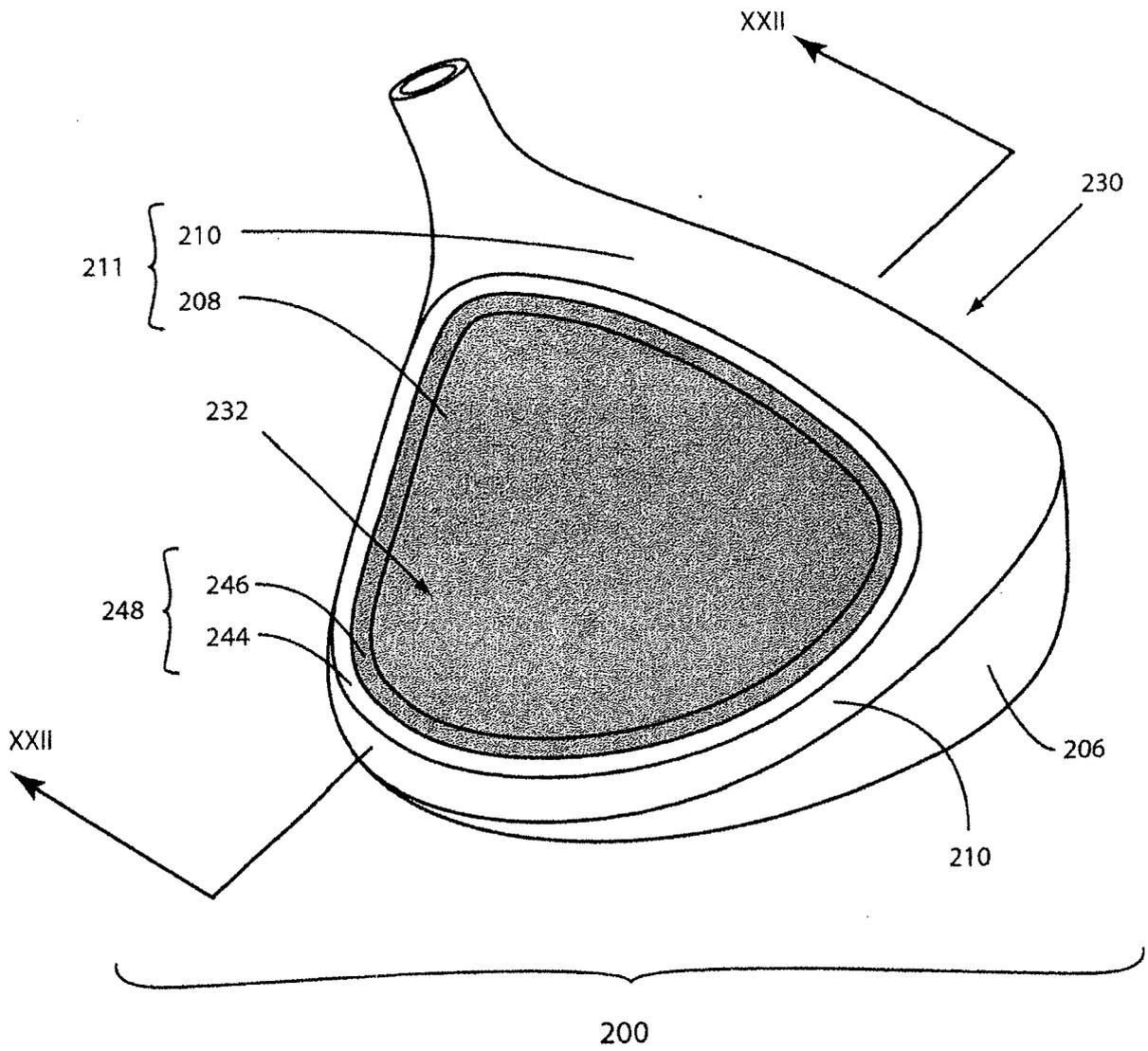


Figure 21

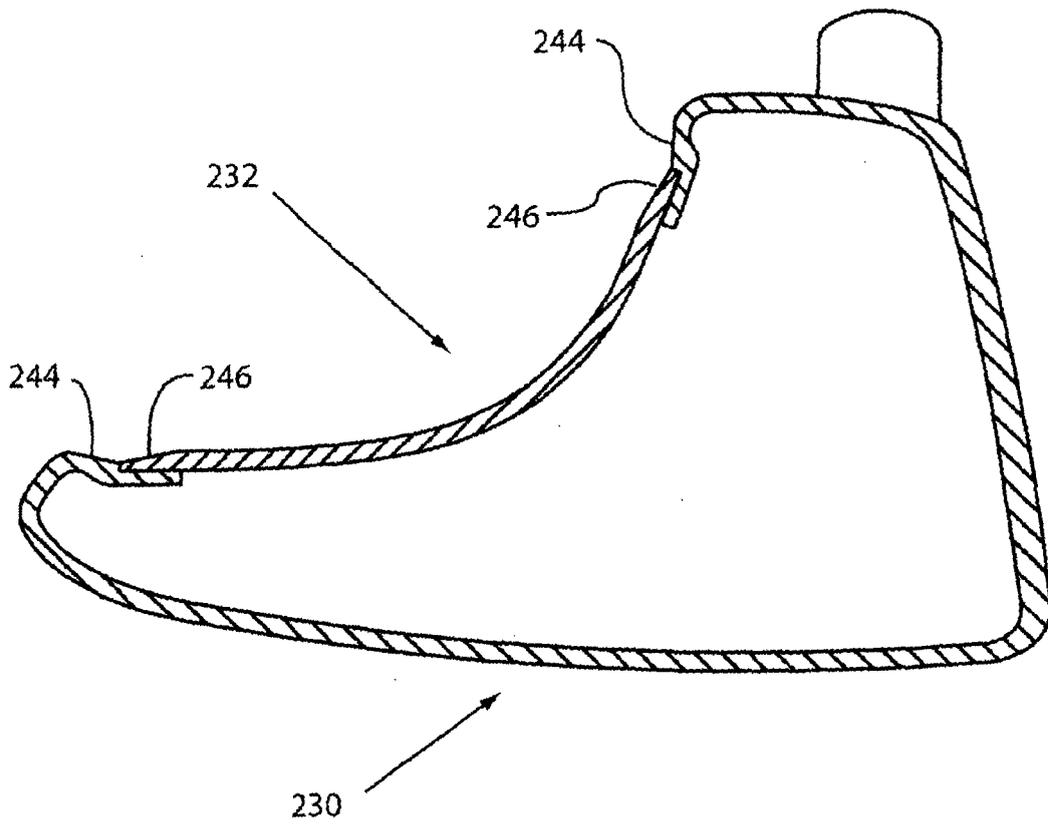


Figure 22

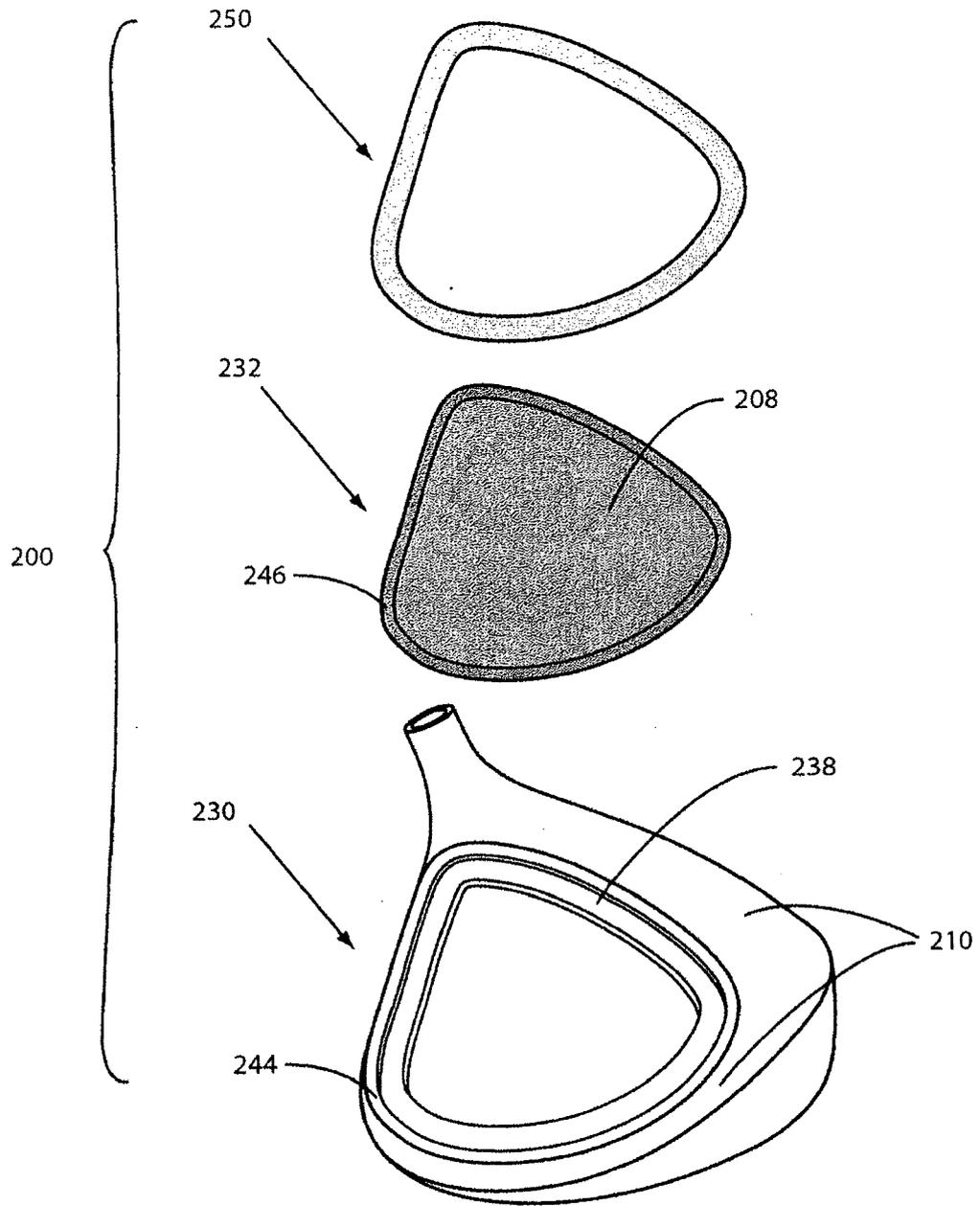


Figure 23

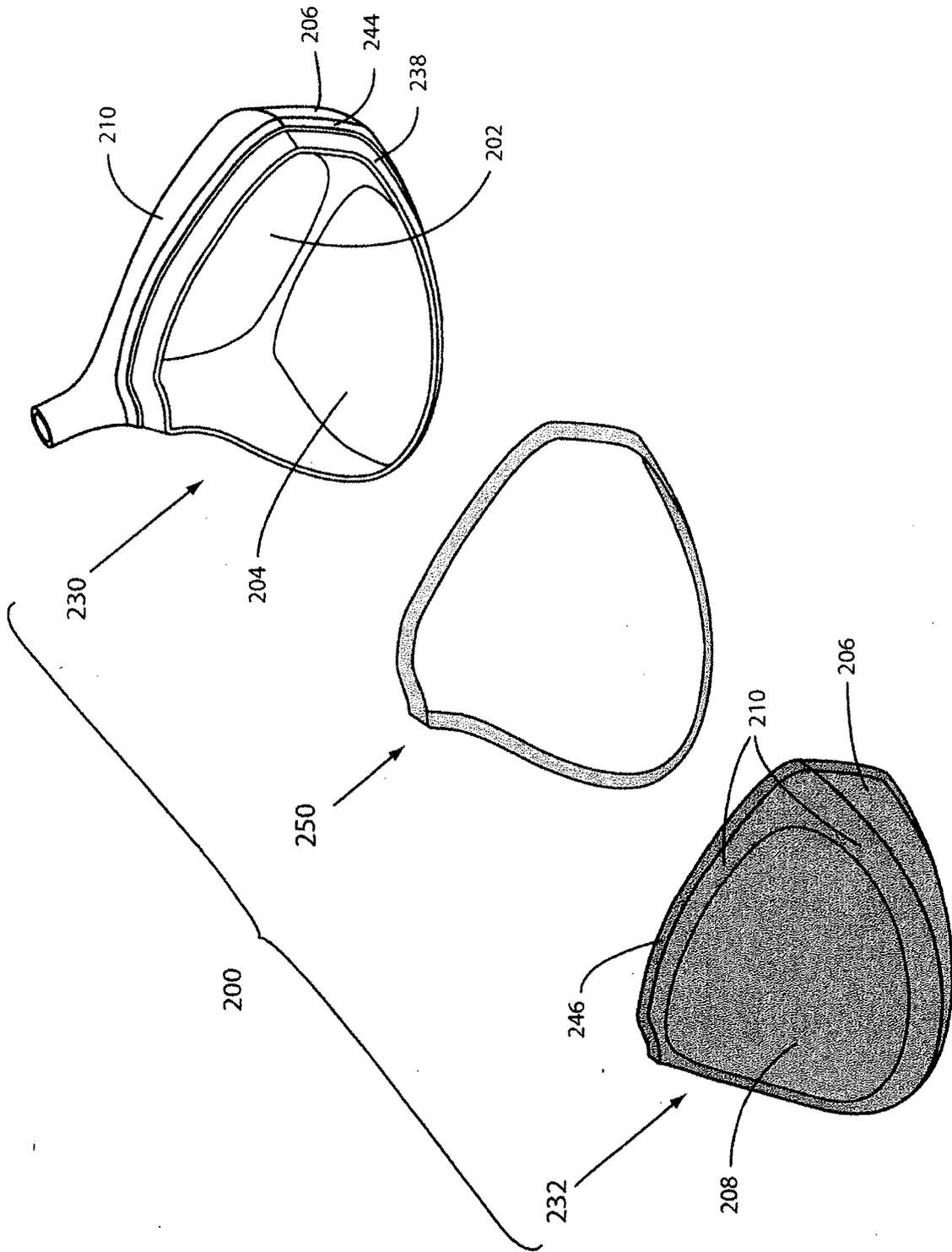


Figure 24

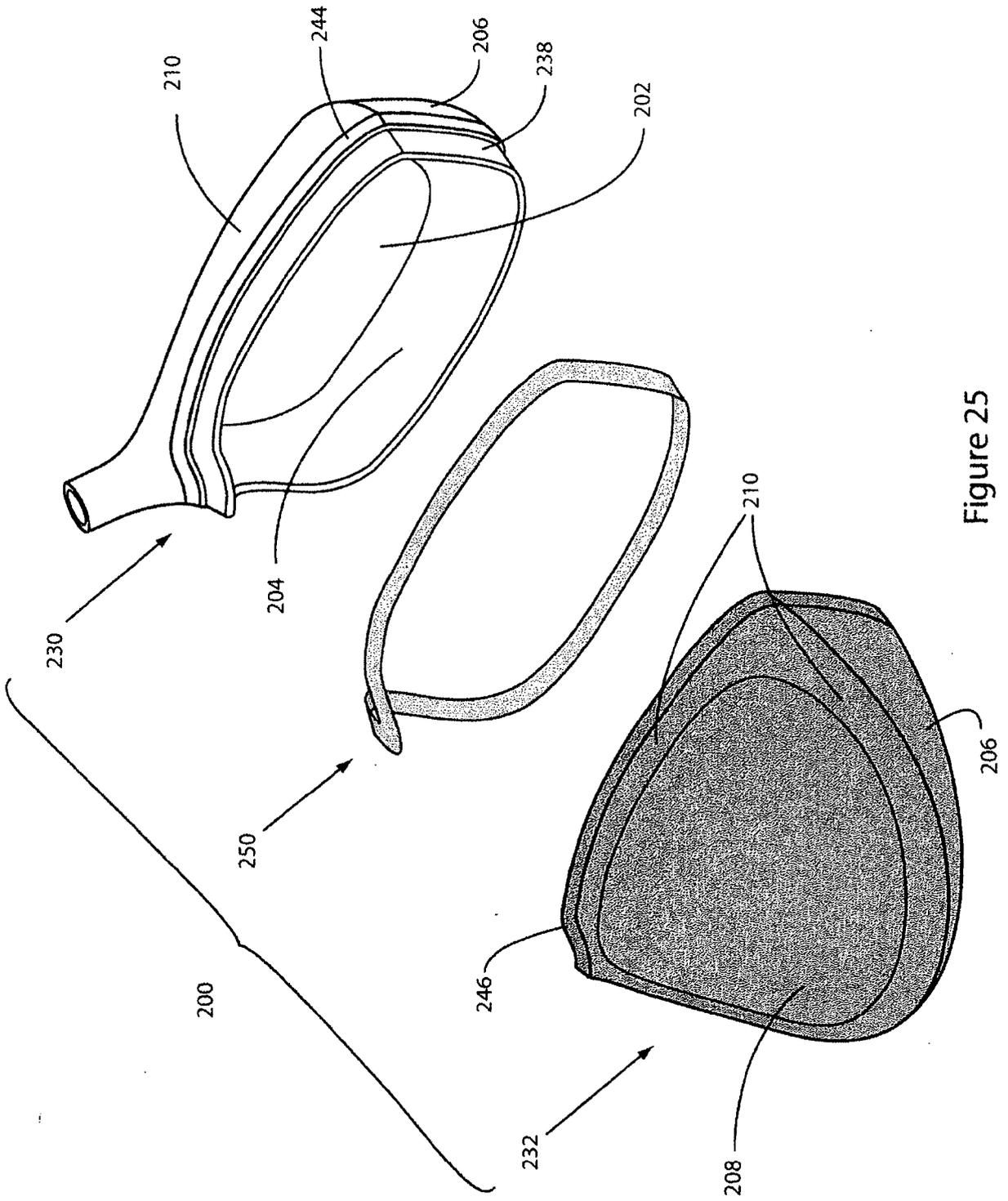


Figure 25

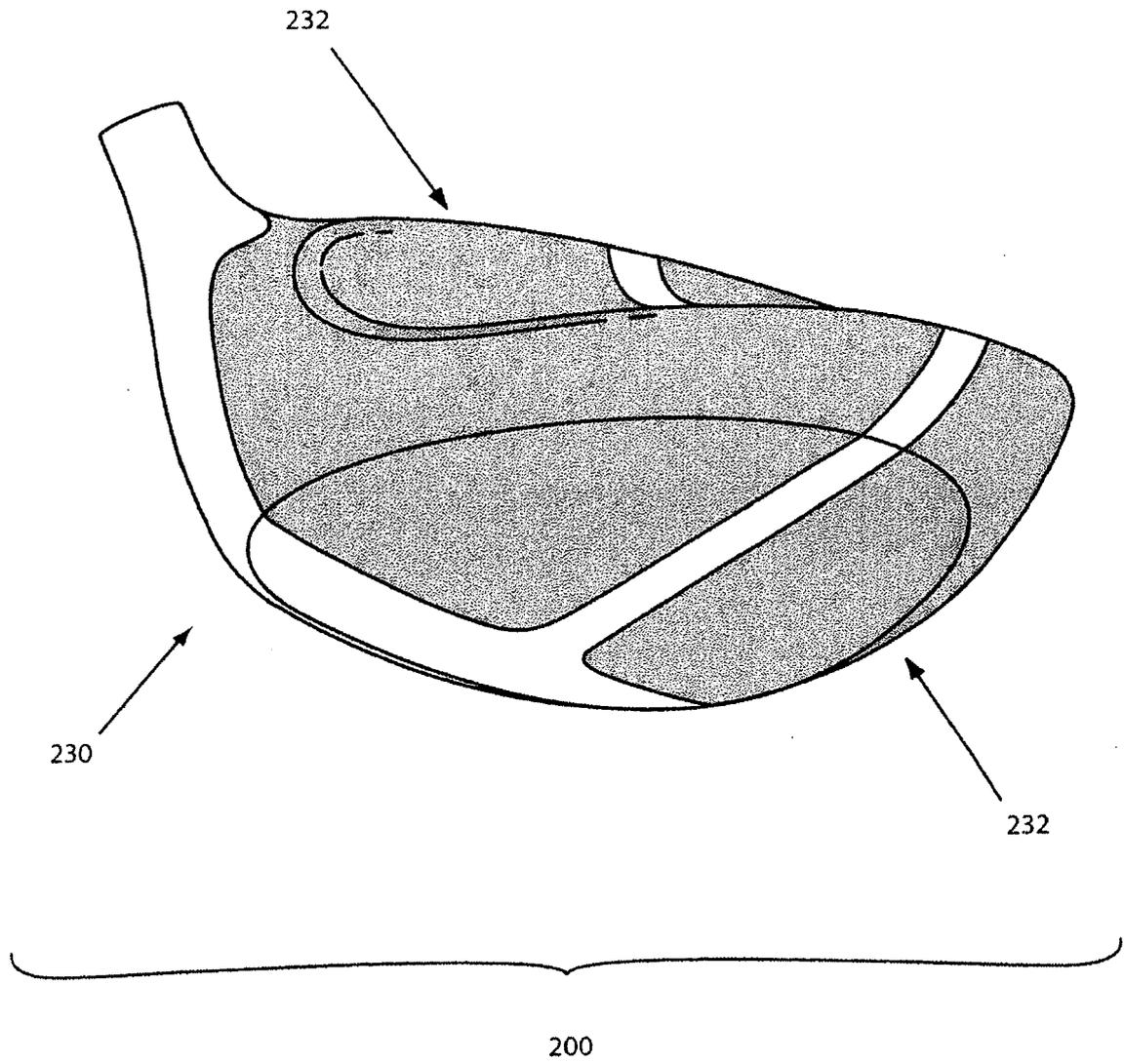


Figure 26

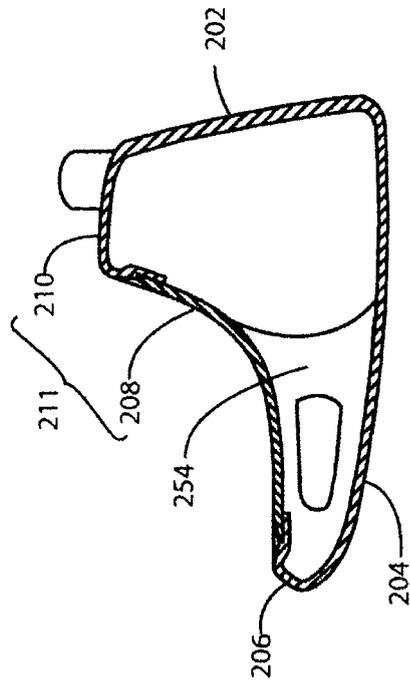


Figure 27 (b)

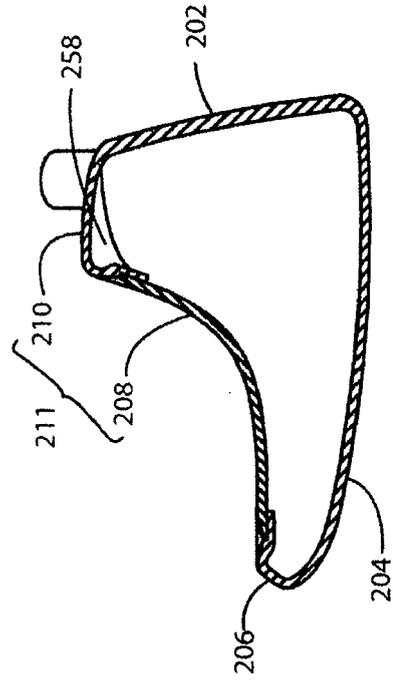


Figure 27 (d)

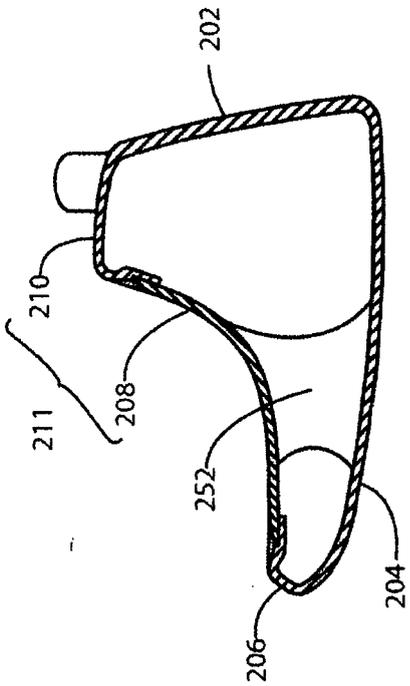


Figure 27 (a)

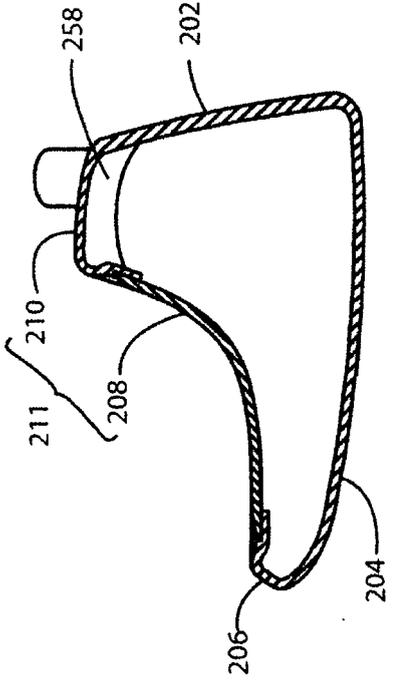


Figure 27 (c)



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2003/228931 A1 (ANTONIOUS ANTHONY J) 11 December 2003 (2003-12-11)	30-34, 37,38, 41,42, 45,46, 52,53,56	A63B53/04
Y	* paragraph [0109]; figures 38,39 *	1-29,35, 36,39, 40,43, 44, 47-51, 54,55, 57-61	
Y	----- US 2003/207727 A1 (KAKIUCHI HISASHI) 6 November 2003 (2003-11-06) * paragraph [0021] *	1-6, 9-23,35, 36,43, 44,50,51	
Y	----- US 2003/032500 A1 (NAKAHARA NORIHIKO ET AL) 13 February 2003 (2003-02-13) * paragraph [0027] - paragraph [0028] *	24-29, 49,57-61	TECHNICAL FIELDS SEARCHED (IPC)
Y	----- US 6 676 536 B1 (JACOBSON DANIEL R) 13 January 2004 (2004-01-13) * column 7, line 15 - line 28; figure 5 *	7,8,39, 40,47, 48,54,55	A63B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 January 2006	Examiner Jekabsons, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

1
EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 05 02 2374

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

10-01-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003228931 A1	11-12-2003	AU 8498101 A	04-03-2002
		EP 1313534 A2	28-05-2003
		TW 552148 B	11-09-2003
		WO 0215991 A2	28-02-2002
		US 6530847 B1	11-03-2003
US 2003207727 A1	06-11-2003	JP 2003320061 A	11-11-2003
US 2003032500 A1	13-02-2003	NONE	
US 6676536 B1	13-01-2004	US 6602149 B1	05-08-2003